MINISTRY OF ECOLOGY AND NATURAL RESOURCES
REPUBLIC OF KAZAKHSTAN

Draft National Report of the Republic of Kazakhstan on the inventory of anthropogenic emissions from sources and absorption by absorbers greenhouse gases, not regulated by the Montreal Protocol, for 1990-2021

Astana

APPROVAL SHEET

«Draft National Report of the Republic of Kazakhstan on the inventory of anthropogenic emissions from sources and absorption by absorbers greenhouse gases, not regulated by the Montreal Protocol, for 1990-2021»

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The national report of the Republic of Kazakhstan on the inventory of anthropogenic emissions from sources and removals by sinks of greenhouse gases not regulated by the Montreal Protocol on the inventory of greenhouse gases is submitted in accordance with the obligations of the Republic of Kazakhstan under the UN Framework Convention on Climate Change and the Kyoto Protocol.

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Conventions

ASPIR - Agency for Strategic Planning and Reforms of the Republic of Kazakhstan
Wetlands - wetlands
GDP - gross domestic product
ERT - UNFCCC Secretariat Review Group
LULUCF – land use, land use change and forestry
HWP - harvested timber
KP - Kyoto Protocol
COP/MOP - Conference of the Parties to the UNFCCC and the Meeting of the Parties to the Kyoto Protocol
KRS - cattle
LF - forest fund
MIA - Ministry of Internal Affairs
IPCC - Intergovernmental Panel on Climate Change
MOH - Ministry of Health
MIIR - Ministry for Investment and Development
MRS - small cattle
MNE RK - Ministry of National Economy of the Republic of Kazakhstan
MOA RK - Ministry of Agriculture
ICSRIAP RK - Ministry of Digital Development, Innovation and Aerospace Industry
IEA - International Energy Agency
ME RK - Ministry of Energy of the Republic of Kazakhstan
MENR RK - Ministry of Ecology and Natural Resources of the Republic of Kazakhstan
NIR - National Greenhouse Gas Inventory Report
research institute TK - Research Institute of Transport and Communications of the Republic of Kazakhstan
refinery - oil refinery
CRF - common reporting format
GHG - greenhouse gases
GWP - global warming potential
UNFCCC - United Nations Framework Convention on Climate Change
LPG - liquefied petroleum gas
AFOLU - agriculture, forestry and other land uses
TNZ - net calorific value
FEB - fuel and energy balance of the Bureau of Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan
FER - fuel and energy resources
HFCs - hydrofluorocarbons
PFCs - perfluorocarbons
STO - solid waste dump
NMVOC - non-methane volatile organic compounds
UE - carbon units
UNO - authorized national body

Chemical symbols and units

CO_2 - carbon dioxide
CO_2 -eq. – CO_2 equivalent
CH_4 - methane
CO - carbon monoxide
N_2O - nitrous oxide
SO_2 - sulfur dioxide
PD f - petajoule, 10^{15} J
TD g - terajoule, 10^{12} J
Gg - gigagram, 10^{9} grams, thousand tons, kiloton (Kt)
t - ton
Tg - teragram, 10^{12} g, million tons

FOREWORD

The Republic of Kazakhstan is a party to the UN Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol to it. One of the main obligations of the Republic of Kazakhstan is to conduct an annual national inventory of greenhouse gas emissions, the results of which are provided in the National report on the inventory of anthropogenic emissions from sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol (NIR) and in spreadsheets reporting on emissions and removals of greenhouse gases by sectors of the economy.

Methodologies, content and format for national reporting are mandated by the IPCC (IPCC, 2006) in its Guidelines and decisions of the Conferences of the Parties to the UNFCCC. Electronic spreadsheets of data on national emissions and removals of greenhouse gases are presented in the format established for all member countries of the UNFCCC and the Kyoto Protocol (Common Reporting Format - CRF).

This report has been prepared and submitted in accordance with Decision 24/CP.19 (FCCC/CP/2013/10/Add.3) on the revision of the guidelines for annual inventory reporting for Parties included in Annex I to the UNFCCC. The tables of the common reporting format are prepared in accordance with Annex II, and the values of the global warming potential are taken from Annex III of this decision.

The structure of the report complies with the requirements for National Inventory Reports of Annex 1 countries of the UNFCCC in accordance with Decision 24/ CP .19 of the Conference of the Parties to the UNFCCC. Chapters 1 and 2 of the National Report include general information on the NIR preparation process and temporal trends in greenhouse gas emissions in each sector of economic activity. Sector chapters 3–7 of the NIR provide data on greenhouse gas emissions and removals, and describe the methodology used to estimate greenhouse gas emissions and removals and inventory results for 1990-2021. for five sectors of the economy whose activities lead to greenhouse gas emissions (*Energy activities* , *Industrial processes* , *Agriculture* , *Forestry and other land uses* , *Waste*). The sector chapters also provide information on the recalculation of emissions and removals of greenhouse gases based on the results of the review of the National Report of the Republic of Kazakhstan by a group of experts of the UNFCCC Secretariat conducted in previous years.

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1. INTRODUCTION

1.1. Background information on greenhouse gas inventories of the Republic of Kazakhstan

The Republic of Kazakhstan ratified the UN Framework Convention on Climate Change (UNFCCC) in 1995 and became a Party to it as a non-Annex 1 country. After signing the Kyoto Protocol to the UNFCCC on 23 March 2000, the Government of Kazakhstan notified the UN Secretary General its intention to comply with the obligations under paragraphs 2 a) and 2 c) in accordance with paragraph 2 g) of Article 4 of the UNFCCC. At subsequent Conferences of the Parties (COPs) of the UNFCCC, Kazakhstan has repeatedly stated its desire to make voluntary quantitative commitments under the Kyoto Protocol. At the Seventh COP in Marrakesh (Morocco), it was decided that Kazakhstan, in accordance with paragraph 7 of Article 1 of the Kyoto Protocol, began to be considered a Party to Annex I of the UNFCCC for the purposes of the Kyoto Protocol, as it provided a notification in accordance with paragraph 2 g) Article 4 of the Convention. ***However, it continues to be considered a non-Annex 1 Party for the purposes of the Convention*** .

On March 26, 2009, the President of the Republic of Kazakhstan signed the Law of the Republic of Kazakhstan No. 144-IV “On Ratification of the Kyoto Protocol to the United Nations Framework Convention on Climate Change”. September 17, 2009 The Kyoto Protocol officially entered into force for Kazakhstan

After the ratification of the Kyoto Protocol, Kazakhstan began to develop national legislation aimed at accounting, regulation and reduction of greenhouse gas emissions in the country. On December 3, 2011, Kazakhstan adopted the Law “On Amendments and Additions to Certain Legislative Acts of the Republic of Kazakhstan on Environmental Issues”, which for the first time introduced norms for regulating greenhouse gas emissions into the Environmental Code of the Republic of Kazakhstan.

At COP18 in 2012 in Doha (Qatar), Kazakhstan announced its intention to participate in the second period of the KP as an Annex B country of the Kyoto Protocol and proposed to undertake obligations to reduce greenhouse gas emissions in relation to the base year 1990 in in the amount of 5% and 7% in case of expansion of ambitions. After that, new articles were introduced into the Environmental Code of the Republic of Kazakhstan, on the basis of which, from January 1, 2013, the basis for regular accounting and reporting on greenhouse gas emissions was adopted in the country, and the internal carbon market began to function.

In 2016, Kazakhstan, under the Paris Agreement, submitted its Intended Nationally Determined Contributions (Intended National determined contributions - I NDC, or INDC). Thus, the Republic of Kazakhstan has committed itself to reducing greenhouse gas emissions by 15–25% by 2030 compared to the base year 1990 (15% is an unconditional target, 25% is a conditional target, achievable if international support is received).

Within the framework of the UNFCCC, Kazakhstan annually submits the NIR and CRF tables to the UNFCCC Secretariat by April 15th.

The national report of the Republic of Kazakhstan includes emissions of six main gases with a direct greenhouse effect (carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6)). Additionally, for some source categories, emissions of four indirect greenhouse gas pollutants – carbon monoxide (CO), nitrogen oxides (NO_x), non-methane volatile organic compounds

(NMVOCs) and sulfur dioxide (SO_2) are assessed. They are not included in total national GHG emissions.

The preparation of the NIR is based on the methodology of the Intergovernmental Panel on Climate Change (IPCC), adopted and agreed by the Conference of the Parties to the UNFCCC and set out in the IPCC Guidelines (RP), 2006.[1]

1.2 Description of national inventory preparation activities

Institutional, legal and procedural arrangements

After the ratification of the Kyoto Protocol in 2009 as a country. included in Annex 1 of the UNFCCC for the purposes of the Kyoto Protocol, Kazakhstan began to submit National Reports on annual national greenhouse gas emissions inventories to the UNFCCC Secretariat in the form of National Inventory Reports (NIRs) and spreadsheets of the common reporting format CFR (Common Reporting Format - CRF). This is one of the main obligations of the RK under the UNFCCC. All NIRs and CRF spreadsheets are posted on the website of the UNFCCC Secretariat.

The authorized national body for the coordination and implementation of the Kyoto Protocol is the relevant state body that implements the state policy in the field of low-carbon development and the implementation of the national inventory of emissions and removals of greenhouse gases, which has different names in the following periods since 2009, namely:

- 2009-2013 – Ministry of Environmental Protection of the Republic of Kazakhstan;
- 2014 - Ministry of Environment and Water Resources of the Republic of Kazakhstan;
- 2015 - June 2018 - Ministry of Energy of the Republic of Kazakhstan;
- Since June 2019 - Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan;
- Since 2022 - Ministry of Ecology and Natural Resources of the Republic of Kazakhstan.

Since 2009, the preparation of the National Report on the Inventory of Greenhouse Gas Emissions in the Republic of Kazakhstan and the CRF Tables has been carried out annually by Zhasyl Damu JSC, which is the working body for the implementation of the provisions of the UNFCCC. These types of work are carried out within the framework of the Agreements on public procurement of services between JSC "Zhasyl Damu" and UNO.

Until 2021, work on the preparation of the NIR and the CRF Tables was carried out on a competitive basis and due to the annual delay in holding competitions for the preparation of National Reports, Zhasyl Damu JSC was forced to start preparing national reports under the UNFCCC and the Kyoto Protocol after the expiration of its submission to the UNFCCC Secretariat, which led to the failure of the submission of National Reports in the Republic of Kazakhstan to the UNFCCC Secretariat.

With the adoption of the new Environmental Code of the Republic of Kazakhstan and its entry into force on July 1, 2021, the preparation and submission of annual reports are carried out on time - by April 15 of each year

The preparation of the NIR in Kazakhstan is carried out in accordance with the Annex to decision 24/CP.19 “Revision of the UNFCCC guidelines for reporting information on annual inventories of Parties included in Annex I to the Convention”.

[1] https://www.ipcc.ch/report/2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/

Since 2015, according to the decision of COP19, all Annex 1 countries, including Kazakhstan, have been preparing NIRs in accordance with the Greenhouse Gas Inventory Guidelines (IPCC RP 2006). Until this year, the 1996 IPCC RP was used. Also, since 2015, reporting spreadsheets CRF (Common Reporting Format) in accordance with the new software (CRF Reporter (v6.0.5) User Manual, version dated March 25, 2018).

Normative base

Until 2015, the regulatory framework for the annual preparation of the NIR was Article 158-2 of the Environmental Code of the Republic of Kazakhstan dated January 9, 2009 and Decree of the Government of the Republic of Kazakhstan dated July 17, 2012 No. 943 "On Approval of the Rules for Maintaining and Maintaining the State Inventory of Sources of Emissions and Removals of Greenhouse Gases". On March 18, 2015, a new order of the Minister of Energy of the Republic of Kazakhstan No. 214 was adopted to replace Decree No. 943 [2].

As the requirements for compiling the NIR increase, as well as in response to the comments of the Expert Review Group (ERG) of the UNFCCC Secretariat since 2017, the national greenhouse gas inventory system in Kazakhstan is constantly being improved and improved.

Currently, the basis for the development and preparation of the NIR is Article 302 of the new Environmental Code of the Republic of Kazakhstan [3], which entered into force on January 2, 2021, and the Rules for Controlling the Completeness, Transparency and Reliability of the State Inventory of Greenhouse Gas Emissions and Removals, approved by Order of the Minister of Ecology, Geology and Natural Resources Republic of Kazakhstan dated February 22, 2022 No. 46 [4](Regulation No. 46).

Regulation No. 46 was developed following the recommendations of the ERT and includes activities on the functions and requirements of the National Greenhouse Gas Inventory System and the development of NIR, in order to address the comments of the ERT of the review of the National Inventory Report of the Republic of Kazakhstan conducted by the UNFCCC Secretariat Review Group in 2019, p on the results of which Kazakhstan was recognized as a Party that does not comply with the requirements of the Kyoto Protocol.

Main remarks on the functioning of the national system on the requirements and functions set out in the annex to Decision 19/CMP.1, on non-implementation of points of paragraphs 10 (a , b , d) in terms of institutional, legal and procedural mechanisms for the preparation of the NIR and cooperation between government agencies and other bodies providing source data, as well as paragraph 12 (c-e) of Decision 19/CMP.1, regarding inventory planning as part of the NIR development process, as well as from the QA/QC processes and the processes for formal review and approval of the NIR.

Regulation No. 46 was developed taking into account the above comments of the ERT .

In particular, Rule 46 provides for measures to address the following provisions:

(1) conclusion of additional agreements and mechanisms for improving interdepartmental cooperation and support - Regulation No. 46 provides for the creation of an interdepartmental

[2] https://adilet.zan.kz/rus/docs/V1500011090

[3] https://adilet.zan.kz/rus/docs/K2100000400

[4] https://adilet.zan.kz/rus/docs/V2200026905

Working Group on the functioning of the state greenhouse gas inventory system chaired by the Authorized Body in the field of environmental protection, which is a single national body bearing overall responsibility for the National cadastre in accordance with paragraph 10.c) of Decision 19/CMP.1 and organizing and coordinating the functioning of the state inventory system for emissions and removals of greenhouse gases in accordance with paragraph 3 of Article 302 of the Environmental Code of the Republic of Kazakhstan [5].

Also, the composition of the Working Group was determined, consisting of representatives of state bodies and organizations involved in the process of providing initial data, developing, providing a QA / QC plan, using calculation factors and checking the National Cadastre.

Regulation No. 46 develops provisions for the development of a Quality Assurance and Quality Control Plan, its consideration at a meeting of the Working Group and verification of the National Inventory data by third parties, as well as representatives of the Working Group.

For the rest of the articles of decision 19/CMP.1, no claims were made by the ERT. Inventory preparation and management functions are generally performed as required.

In 2021, the NDK 1990-2019 was also audited. Based on the results of the last audit, the ERT sent to the UNFCCC Compliance Committee questions for inclusion in the Plan for exiting the non-compliance regime, on which Kazakhstan has been conducting relevant work over the past years:

- Failure to provide information on planned capacity building measures or specific arrangements for data exchange and data transfer;
- Uncertainty table not presented in accordance with Table 3.3 of the 2006 IPCC Guidelines (Vol. 1, p. 3.42);
- the NIR does not include a chapter on recalculations and planned improvements;
- Improvement of the inventory archiving system, and the ability to access archival information located from remote locations;
- Development and submission of a communication plan for the period of the GER review;

These questions and questions based on the results of the review of subsequent years were included in the Plan for the Republic of Kazakhstan to exit the non-compliance with the Kyoto Protocol, which was prepared by the Department of Climate Policy and Green Technologies of the Ministry of Ecology and Natural Resources of the Republic of Kazakhstan.

The first progress report on the implementation of the plan to exit the non-compliance regime was submitted by Kazakhstan and submitted to the Compliance Committee of the UNFCCC Secretariat in January 2021 [6]. Over the past year, two Progress Reports have been sent to the IP Compliance Committee of the UNFCCC Secretariat on the progress of the non-compliance recovery plan. The last Report was submitted by July 15, 2022. During 2023, it is planned to provide additional information on the progress in the implementation of measures in accordance with the requirements of the Kyoto Protocol.

There are no financial sanctions under the Kyoto Protocol for Kazakhstan, as well as no consequences associated with the loss of loans (although there is a loss of access to the carbon market).

[5] https://adilet.zan.kz/rus/docs/K2100000400

[6] https://unfccc.int/sites/default/files/resource/2021-1-5_Kazakhstan_1st%20progress%20report.pdf

National inventory system for greenhouse gas emissions in Kazakhstan

The organization and coordination of the functioning of the national inventory system is carried out by the Authorized body in the field of environmental protection.

The results of the annual operation of the national greenhouse gas inventory system in Kazakhstan are carried out by a specialized organization determined by the National Authorized Body [7]. For a number of years after the ratification of the Kyoto Protocol to the UNFCCC, the specialized organization that prepares the NIR is Zhasyl Damu JSC, a subordinate organization in the field of environmental protection.

Zhasyl Damu JSC performs the functions of the Working Body for the collection, processing and storage of initial information, the development and calculation of emissions and removals of greenhouse gas emissions according to the categories of the National Report, support and interaction with the SER during the NIR review. Also, during the year, various works are carried out on an ongoing basis to submit and develop reports, reports on the national inventory at the request of the UNO, the Government of the Republic of Kazakhstan and the UNFCCC Secretariat.

The functioning of the national greenhouse gas inventory system and the preparation of the NIR is carried out annually, starting from April of the year following the reporting year, after the submission of the previous NIR to the UNFCCC Secretariat.

The scheme of the national system for preparing the National Report on the Inventory of Greenhouse Gas Emissions and Removals in the Republic of Kazakhstan in accordance with the UNFCCC and the KP is shown in Figure 1.

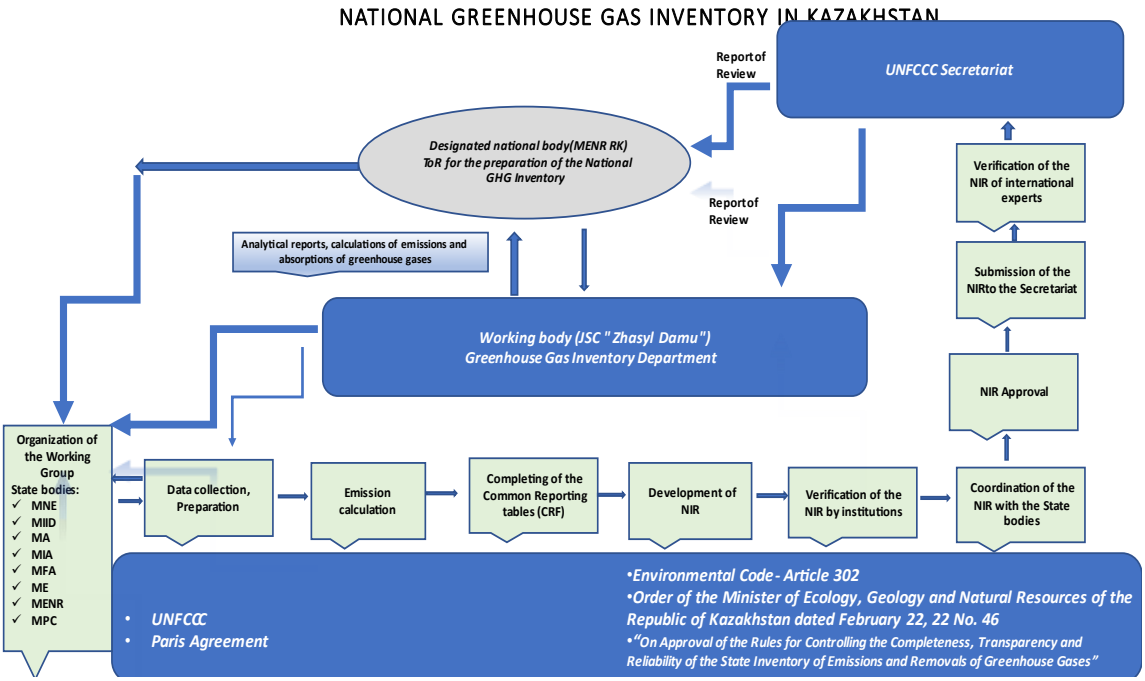


Figure 1 – National Greenhouse Gas Inventory System in the Republic of Kazakhstan

[7]Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan

The functioning of the national greenhouse gas system is carried out in accordance with Article 302 of the Environmental Code of the Republic of Kazakhstan and Rules No. 46 [8].

Rules No. 46 provide for the creation of an interdepartmental Working Group on the functioning of the state greenhouse gas inventory system chaired by the Authorized Body in the field of environmental protection.

The working group consists of representatives of the authorized body, Zhasyl Damu JSC, state bodies and organizations responsible for performing all functions in accordance with subparagraph a) of paragraph 10 of Decision 19/CMP.1 and involved in the process of providing initial data, developing, ensuring the plan QA/QC, use of calculation factors and verification of the National Report.

Representatives of the Working Group are representatives of state bodies. The Working Group includes the following state bodies:

- Ministry of Ecology and Natural Resources of the Republic of Kazakhstan;
- JSC "Zhasyl Damu";
- Ministry of Agriculture of the Republic of Kazakhstan;
- Ministry of Internal Affairs of the Republic of Kazakhstan;
- Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan;
- Ministry of Digital Development, Innovation and Aerospace Industry of the Republic of Kazakhstan;
- Ministry of Energy of the Republic of Kazakhstan;
- Ministry of Health of the Republic of Kazakhstan.

In accordance with the Rules, 4 Meetings of the Working Group are indicated.

The first meeting of the Working Group was held on April 22, 2022 with the assistance of the UNDP project "Preparation of the Eighth National Communication and the Fourth Biennial Report" [9]. At the first Meeting, the representatives of the Working Group approved the dates of subsequent Meetings, reviewed and approved the QA/QC Plan.

The second meeting of the Working Group was held on June 29, 2022. At the second Meeting, the submission of initial data was considered and distributed among the representatives of the Working Group.

Then the approved requests were officially sent from the authorized body to the representatives of the Working Group responsible for providing the initial data according to the second Meeting.

After the second meeting, the working body for the preparation of the NIR - JSC "Zhasyl Damu", collected all the initial data, while collecting the data, preliminary quality assessment / quality assurance activities were carried out, the initial data were analyzed for completeness and quality of the data.

At the third Meeting, the responses to the provision of background information were considered.

Then Zhasyl Damu JSC assessed emissions and removals of greenhouse gases by sectors, categories and sources. After the assessment, the tables of the General Reporting Format were filled in, QA / QC procedures were carried out. More information on QA/QC procedures is provided in Section 1.2.1. of the present NDK. After that, a draft National Report was developed and presented to UNO.

[8] https://adilet.zan.kz/rus/docs/V2200026905

[9] https://www.youtube.com/watch?v=Oko7CqQznNI .

The UNO submitted the draft NIR for verification and approval to the state bodies that are members of the Working Group.

The Fourth Meeting of the Working Group was held on April 7, 2023. At this meeting, based on the results of preliminary coordination with state bodies, the draft NTC was considered and approved by the members of the Working Group.

During the preparation of the NIR, quality assurance and quality control procedures (hereinafter - QA / QC) are also carried out. These procedures are described in Section 1.2.1 of the NIR.

Thus, the main steps in the preparation of national GHG inventory reporting, consisting of the National Greenhouse Gas Emissions and Removals Inventory Report (NIR) and the Common Reporting Format (CRF) reporting tables, include:

1. Organization and meetings of the Working Group, distribution of the provision of initial data among representatives of the Working Group;
2. collection of information containing initial data for the quantitative assessment of emissions and absorption of greenhouse gases from enterprises, organizations, government agencies;
2. analysis and processing of the received data, calculations and preparation of the state cadastre;
3. quality control and quality assurance of the state cadastre;
4. Coordination of the NDK with state bodies;
5. Approval of the NIR by representatives of the working group;
6. Submission of the state cadastre for the assessment procedure in accordance with the requirements of the UNFCCC.

1.2.1 Description of the quality assessment/quality control system

When conducting an inventory of greenhouse gases, the main elements of quality assurance and quality control procedures (hereinafter referred to as QA/QC) are used that meet the requirements of the IPCC Good Practice Guidance.

The adopted QA/QC system in Kazakhstan has several stages of approval and control by the departments involved in the functioning of the national greenhouse gas inventory system and the UNO.

The procedures follow those of the methodological level or Tier 1 of the Good Practice Guidance, with selected Tier 2 quality control elements for key categories. The implementation of QA/QC procedures is an integral part of the NIR preparation process.

The QA/QC of the National Report is carried out in accordance with paragraph 1 of Order No. 46 [10]. In accordance with these Rules, Zhasyl Damu JSC develops an annual QA/QC plan.

The QA/QC plan is based on the methodology of the Intergovernmental Panel on Climate Change and decisions of the COP/MOP and should be reviewed periodically to improve the NIR.

At the first Meeting of the Working Group, which took place on April 22, 2022, the QA/QC Plan was considered and approved. This QA/QC plan outlines the roles and responsibilities for QA/QA and data verification.

The QA/QC plan contains the following activities:

[10] https://adilet.zan.kz/rus/docs/V2200026905

1) the schedule for the preparation of work from the start of development to its submission to the Secretariat of the UNFCCC;

2) a description of the verification procedures;

3) a list of assigned persons for quality control procedures and the timing of their implementation by sector.

The plan contains the following procedures for quality control of the state inventory:

1) appointment of assigned persons for the inspection;

2) establishment of the calendar plan of works and terms of check;

3) checking the correctness of the initial data;

4) cross-control of calculations between experts in individual sectors.

Below is a diagram of the QA/QC Procedures

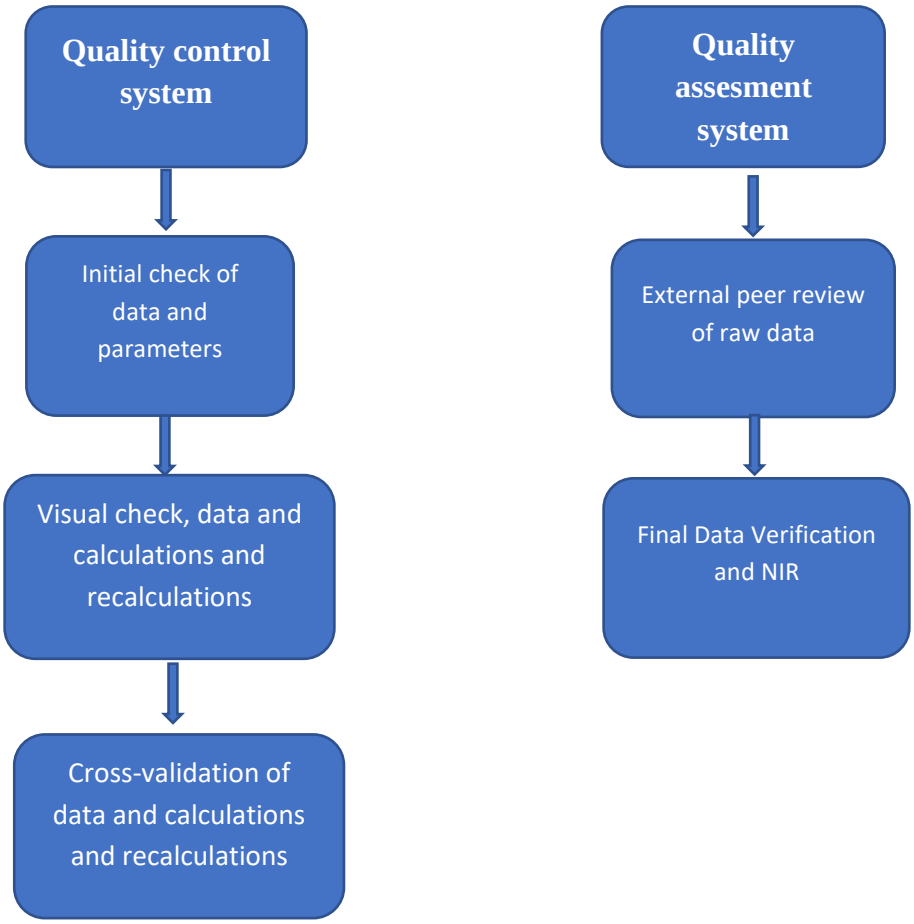


Figure 2 – Scheme of quality assurance and quality control of the national GHG inventory of the Republic of Kazakhstan

Quality control procedures

The initial check of data and parameters is to provide a preliminary check of the data upon receipt of the initial data and bring them into line with the data necessary for calculating emissions and removals of greenhouse gases according to the IPCC. According to the established procedures, control begins with the provision of initial data, which are received in general form by Zhasyl Damu JSC. Next, national experts conduct internal verification by sampling data and parameters for calculating greenhouse gas emissions and removals. UNO provides general control over the presentation of data and the completeness of the source data.

- Visual verification of these calculations and recalculations consists in checking emission factors and inventory results by conducting an internal review of the performed calculations to identify anomalous fluctuations in the time series of emission estimates and inventory values.

The main QA procedures were prepared in accordance with Table 8.1 of the Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (IPCC, 2003) and consist of the following operations:

Types of jobs	Description of basic operations	Responsible executor	Periodicity
Validation of Activity Data Dimension and Parameters	— Checking the dimension of calculation formulas. — Validate the dimension of activity data and parameters from start to finish.	Қ asenov Ө . (Energy, category "Transport", "Fugitive sources"), Cherednichenko A.V. (Energy, categories "Energy activities", "Manufacturing", "Other sectors", "Other sources"), Ermakhanova E.M. (IPIP, categories “Non-energy products and solvent use”, “Assessment of ODS fluorine substitutes”, “Metered aerosol inhalers”, “Sulfur hexafluoride”), Shorman A. T. (IPIP, categories "Mineral materials", "Chemical industry", "Metallurgical industry", "Magnesium production", "Zinc production",) Tokpaev Z.R. (Agriculture), Kasenova D.A.	Annually, for each source category

Types of jobs	Description of basic operations	Responsible executor	Periodicity
		(LULUCF), Abdrakhim S.G.(Waste), Shorman A.T. (Waste)	
Verification of calculations of emissions and removals of greenhouse gases	— Analysis of the consistency of time series of calculations, activity data and parameters. Identification of discrepancies and explanation of their causes. — Analysis of the compliance of the calculation formulas with the IPCC methodology. Assessment of the validity of the application of national methods and parameters. — Selective repetition of calculations (if necessary). Identification of errors, elimination of them and recalculation.	Қ asenov Ә .(Energy), Cherednichenko A.V. (Energy), Ermakhanova E.M.(PPIP), Shorman A. T. (PPIP) Tokpaev Z.R. (Agriculture), Kasenova D.A. (LULUCF), Abdrakhim S.G.(Waste), Shorman A.T. (Waste)	Annually, for each source category
Checking recalculations	— Comparison of cadastral data of adjacent years. Identification of inconsistencies and their causes. — Checking the validity of changes in methodologies, corrections and recalculations performed	Қ asenov Ә .(Energy), Cherednichenko A.V. (Energy), Ermakhanova E.M.(PPIP), Shorman A. T. (PPIP) Tokpaev Z.R. (Agriculture), Kasenova D.A. (LULUCF), Abdrakhim S.G.(Waste), Shorman A.T. (Waste)	Annually, for each sector
Checking the completeness and integrity of the submitted data	— Analysis of the completeness and consistency of the presentation of activity data, parameters and calculations. — Analysis of the correctness of the presentation of data and their descriptions	Қ asenov Ә .(Energy), Cherednichenko A.V. (Energy), Ermakhanova E.M.(PPIP), Shorman A. T. (PPIP) Tokpaev Z.R. (Agriculture), Kasenova D.A. (LULUCF), Abdrakhim S.G.(Waste), Shorman A.T. (Waste)	Annually, for each sector

- Cross-checking consists of checking against key source categories by experts from specialized organizations, as well as third-party research and industry organizations in relevant sectors.

After filling in the spreadsheets, each expert conducts an initial check of the table material in the text of the NIR tables and CRF tables, and then cross-checks the calculation results prepared by other specialists in the sectors. This check helps to identify and correct errors.

Cross-checking the quality of the national greenhouse gas inventory and quality assessment is carried out in accordance with the following types of work:

Types of jobs	**Description of individual operations**	**Responsible executor**	**Periodicity**
Verification of activity data, parameters and assumptions	Analysis of descriptions of selection of activity data and parameters. Analysis of the validity of the assumptions and assumptions adopted in the calculations	Energy – Cherednichenko A.V., PPIP Tokpaev Z.R. Agriculture - Ermakhanova E.M., LULUCF - Tokpaev Z.R., Waste - Shorman **A.T.**	Annually, when preparing the inventory report
Checking data consistency across source categories	Establishment of parameters common to several source categories. Checking the consistency of values obtained using common parameters. Checking the correctness of data transfer between individual source categories	Energy – Cherednichenko A.V., PPIP Tokpaev Z.R. Agriculture - Ermakhanova EM .., LULUCF - Tokpaev Z.R., Waste - Shorman **A.T.**	Annually, when preparing the inventory report
Verification of inventory content	Checking the availability and correct presentation of the bibliography and references to the materials used. Selective reconciliation of the values of the Common Report Form and the Inventory Report	Energy – Cherednichenko A.V., PPIP Tokpaev Z.R. Agriculture - Ermakhanova EM .., LULUCF - Tokpaev Z.R., Waste - Shorman **A.T.**	Annually, after the preparation of the inventory report
Checking the completeness of	Checking the presentation of estimates for all source categories and all years	Energy – Cherednichenko	Annually, after the

Types of jobs	Description of individual operations	Responsible executor	Periodicity
the cadastre	from the base year onwards. Identification of gaps in data and emission estimates by source category and verification of their appropriate documentation	A.V., PPIP Tokpaev Z.R. Agriculture - Ermakhanova EM .., LULUCF - Tokpaev Z.R., Waste - Shorman **A.T.**	preparation of the inventory report

Quality assurance procedures

- external review is provided through the verification of the original data by government agencies and departments that provide the original data. Experts from other state bodies are involved in external review.

During the development of this National Report, measures were taken to strengthen the QA / QC procedures and within the framework of cooperation of Zhasyl Damu JSC with international projects, to attract international specialists for external review of the NIR by involving specialists in checking the CRF tables and describing the sectors of the National Report. Thus, arrangements were made for external review, verification of the CRF tables and sectoral chapters of the National Report.

- Final Data Verification and NIR

Acceptance and consideration of the national report on the inventory of greenhouse gases by the Authorized body is carried out after agreement with external reviewers.

General QC procedures

General cadastre QC procedures contain the following activities:

1. Checking the documentation of assumptions and selection criteria for activity data, emission factors and other estimation parameters: correct recording and archiving.
2. Checking for errors associated with copying the source data, correctness of references to data sources, clarification of the source data.
3. Checking the correctness of the calculation results, the correctness of the calculation formulas.
4. Checking the correctness of units of measurement, parameters, conversion factors and emissions.
5. Checking the integrity of the database files.
6. Checking the consistency of data between categories.
7. Checking the consistency of the estimate and the uncertainty of the initial data.
8. Time series consistency check: comparison of emission estimates with previous inventories and data from Table 8 of CRF recalculations.
9. Checking the completeness of data in the CRF tables, the presence and filling of gaps, comments, analysis of time factors of emissions in order to check for errors, typos.

10. Check for trends in activity data and whether there are explanations for unusual trends in activity data, emission factors and estimates.

11. Conducting a review of internal documentation and archives, the presence of duplication of internal documentation and streamlining of source data.

Quality control procedures are carried out during the preparation of the NDK by its developers with the involvement, if necessary, of specialized specialists from other organizations to obtain the necessary additional information. QA/QC procedures are carried out with the involvement of external organizations, relevant ministries and departments. For this purpose, the NIR with a cover letter from the Department of Climate Policy and Green Technologies of the MEGNR RK is sent to state bodies and subordinate organizations to check for errors and agree on the estimates of GHG emissions / removals.

Changes in the national system

On January 2, 2021, a new Environmental Code of the Republic of Kazakhstan was approved, which entered into force on July 1, 2021 in terms of state regulation of emissions and removals of greenhouse gases, including the functioning of the National Greenhouse Gas Inventory System.

As part of the new Environmental Code, new Rules for monitoring the completeness, transparency and reliability of the state inventory of emissions and removals of greenhouse gases were developed and entered into force on February 22, 2022 [11]. These Rules take into account the main recommendations of the GER on the functioning of the National Greenhouse Gas Inventory System, which were included as measures for non-compliance with the requirements of the Kyoto Protocol by the decision of the Committee in 2019.

Another important qualitative improvement is the timely submission of the National Inventory and CRF tables. In previous years, there was a late submission of the National Inventory and CRF tables due to lengthy competitive processes that laid the foundation for the development of the National Inventory and CRF tables.

To address the issue of untimely submission and withdrawal from the competitive environment of the development of the National Cadastre and CRF tables, the new Environmental Code legislated the functions of the Operator of the carbon units trading system, which include the implementation of the state inventory through the development of the National Report, CRF tables and maintenance of the state system greenhouse gas inventory.

As part of the implementation of the above provisions of the Environmental Code, the development of the National Report and CRF tables was excluded from the competitive environment, as a result of which the preparation of the National Report and CRF tables was carried out on time, according to the QA/QC Plan.

Timely submission of the National Report of the Republic of Kazakhstan 1990-2021 in accordance with international requirements is expected - by April 15, 2023.

Implemented Capacity Building Measures and Progress on Capacity Building Activities

To improve the quality of the National Report in Kazakhstan, national experts undergo various trainings to improve and improve the national greenhouse gas inventory.

[11] https://adilet.zan.kz/rus/docs/V2200026905

In 2022, a number of training seminars and trainings were held aimed at increasing the capacity of national experts with international consultants to improve national reporting in problem sectors.

Within the framework of cooperation with the UNDP project #00117909 "Assistance in updating Kazakhstan's Nationally Determined Contributions (NDC)", a training was conducted by the Institute of Ecology and Global Climate named after. Academician Yu.A. Israel (Russia) on the topic "Methodological recommendations for calculating greenhouse gas emissions and preparing reports for the countries of Central Asia, taking into account the Paris Agreement."

Al sher Қasenov , an expert in the Energy sector, successfully completed the UNFCC-GIR-CAST Program courses on General Approaches and Energy .

In 2022, within the framework of cooperation with UNDP under the project “Development of the Eighth National Communication of the Republic of Kazakhstan under the UNFCCC and preparation of two (fourth and fifth) biennial reports”, a field training was held for all sectors of the national greenhouse gas inventory.

Within the framework of the new Rules 46, which regulate the functioning of the national inventory of greenhouse gases of the Republic of Kazakhstan, a Working Group was organized, which included state bodies that provide initial data for calculating greenhouse gas emissions and participate in the implementation of QA / QC procedures that determine emission factors and other parameters for the inventory .

Through the organization of the Working Group and meetings, it is planned to strengthen the coordination of interaction between state bodies, improve the quality of the provision of initial data and improve the functioning of the national system as a whole. This will allow Kazakhstan to ensure regular and timely submission of NIR to the UNFCCC Secretariat in accordance with the national system.

1.3 Inventory preparation, data collection, processing and storage (archiving)

The preparation of the NIR in Kazakhstan is carried out annually in accordance with the data collection requirements for estimating greenhouse data emissions and the UNFCCC guidelines. Since 2015, Kazakhstan, like other countries participating in the Kyoto Protocol, has been using the updated "Guidelines for the preparation of national communications of Parties included in Annex I to the Convention, Part I: UNFCCC Guidelines for reporting information on annual greenhouse gas inventory. These guidelines are contained in annex I to decision 24/CP.19 adopted in Warsaw by the 19th Conference of the Parties to the UNFCCC [12](FCCC/CP/2013/10/Add.3). From the same year, the revised tables of the common reporting format (CRF) and the values of global warming potentials contained in annex III to the said decision are also used.

Data collection was carried out on the basis of official requests by sending letters to the relevant Ministries, Committees, and industrial enterprises. The data received from state bodies is archived and stored in Zhasyl Damu JSC.

[12] FCCC/CP/2013/10/Add.3

The working body for the preparation of the annual NIR, within the framework of the national system, is Zhasyl Damu JSC, which is tasked with improving reporting on the inventory of greenhouse gases by improving the collection of initial information and calculations of greenhouse gas flows in all sectors of the country's economy, including the forestry sector and other land uses (LULUCF) as a source of greenhouse gas emissions and removals.

In order to retain the experience of the cadastre staff, the staff periodically undergo technical training or themselves participate in courses or lectures for nature users or representatives of enterprises as lecturers.

For the purposes of preparing annual GHG inventories, Zhasyl Damu JSC archives and stores inventory data, including initial data, and maintains correspondence with organizations supplying data and reporting information:

a) data for the annual inventory are stored both in electronic form and on paper. A special data storage room has been allocated, with shelves for storing the inventory reports of enterprises that have been collected since 2010 under the internal Emissions Trading System. There are also printed methodological materials, statistical yearbooks, correspondence with suppliers of initial information for calculations and reporting materials for recent years;

b) data and calculation results of GHG emissions by sector are stored in a dedicated database in the file storage system in printed and electronic form.

The archive and server room are isolated rooms on the fifth floor, access to which only the system administrator has. Protection from natural disasters, fires and floods is provided by service personnel. Fire safety is maintained. The archive is equipped with a fire extinguisher. A responsible person for fire safety has been appointed.

c) For security purposes, the server is accessed using a password issued by the server administrator on behalf of the Director of the Greenhouse Gas Inventory Department.

Documentation and archiving procedures

Documentation and archiving of all initial information and results of calculations of emissions and removals of greenhouse gases is carried out in accordance with the following procedures:

1. Administrative and organizational support for the preparation of the national greenhouse gas inventory:

- Collection and storage of data on the qualifications of persons responsible for the preparation of the national greenhouse gas inventory;
- Collection and storage of job descriptions for specialists responsible for the preparation of individual sections of the national greenhouse gas inventory;
- Accounting and registration of administrative, structural, official and other changes occurring during the preparation of the national inventory of greenhouse gases;
- Accounting, registration and storage of materials for ensuring and quality control of the greenhouse gas inventory.

2. Control of internal documentation, activity data and emission factors, parameters and procedures for calculating greenhouse gas emissions and removals:

- Registration of data on activities, parameters and other information materials received by Zhasyl Damu JSC for the preparation of the national inventory of greenhouse gases;
- Accounting and control of the distribution of information received for the preparation of the national inventory of greenhouse gases and its presentation to consumers;

- Checking the availability and storage of descriptions of procedures for collecting data on activities and parameters, calculation procedures, assumed assumptions, digital and text materials of calculations and other internal information necessary for the preparation of individual sections of the national greenhouse gas inventory.

Information on actions to improve the inventory archiving system, and providing access to archival information from remote locations

Rules 46 also developed clauses to ensure the following conditions for archiving information, in accordance with clause 16 of Decision 19/ CMP .1:

1) archiving of information used in the preparation of the National Report: activity data used to calculate greenhouse gas emissions and removals, internal documentation of quality control and quality assurance procedures, data on key and non-key emission source categories, as well as planned improvements to the National Report;

2) access to archived information by representatives of the authorized body, national experts, independent experts during the annual verification of the National Report initiated by the Convention Secretariat.

3) development of responses of national experts to the questions of the auditors during the international review, and the introduction of recommendations based on the results of the audit in the National Report.

Providing access to archived information is carried out by national experts of Zhasyl Damu JSC at the request of the authorized body or during the verification of the state inventory of greenhouse gases by the International Group of Experts.

An activity is currently being developed to actually enable the improvement of the inventory archiving system and improve access to archived information from remote locations for national experts and ERTs when going through the country review through the use of a cloud storage tool.

CHAPTER 3 GREENHOUSE GAS EMISSIONS IN THE ENERGY SECTOR

3.1 Overall assessment of greenhouse gas emissions in the sector "Energy activities" (sector 1 CRF)

Energy activities are the main source of greenhouse gas emissions in the Republic of Kazakhstan, since about 60% of all greenhouse gas emissions in the country are produced annually in this sector.

According to the 2006 IPCC Guidelines, the Energy Activities sector includes the following categories:

- Energy industry (1.A.1 CRF),
- Manufacturing industry and construction (1.A.2 CRF),
- Transport (1.A.3 CRF),
- Other sectors (1.A.4 CRF),
- Other sources (1.A.5 CRF) ,
- Fugitive Emissions. (1.In OFO).

In 2021, the total greenhouse gas emissions in the "Energy activities" sector amounted to 285.038 million tons of CO_2-eq. which is less than the level of 1990 by 14 % and 7.2 % less than emissions in 2020 (Table 3.1, Figure 3.1).

It should be noted that the category “Energy industry (1.A.1 CRF)” produces the largest emissions in the “Energy activities” sector, since, according to the results of calculations, it accounts for at least 52.9% of all greenhouse gas emissions (according to data for 2021 year). **Greenhouse gas emissions in the category "Energy industry (1.A.1 CRF)" in 2021 amounted to 144.383 million tons of CO_2-eq., which is 1.4% more than in 1990 and 0.1% less than the level 2020 _**

The second in terms of contribution to total emissions from the sector "Energy activities" is the category "Other sectors (1.A.4 CRF)". In 2021, the contribution of this category was 12.3%. **In relation to 2020, emissions from the category “Other sectors (1.A.4 CRF)” in 2021 decreased by 20.7% and amounted to 33.429 million tons of CO_2-eq. Compared to the base year 1990, emissions also decreased by a significant 40.7%.**

In terms of the level of emissions in the Energy sector, emissions from the category Manufacturing and Construction (1.A.2 CRF) are in third place, with a share of 9.2%, or 25.130 million tons of CO_2 $_{-eq}$. in 2021, emissions in this category exceed the base year of 1990 by 44.2%, and the previous 2020 by 1.4%.

Table 3.1 - Total greenhouse gas emissions in the "Energy" sector in the Republic of Kazakhstan for the period 1990 ... 2021 (million tons of CO_2-eq.)

Source	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Energy *(energy activities)*, total	**310.349**	**300.989**	**273.160**	**240.931**	**207.640**	**198.117**	**190.569**	**186.372**	**185.443**	**140.320**	**168.992**
Energy, including fuel combustion and transport (sectoral approach)	*242.098*	*235.777*	*213.068*	*188.199*	*158.987*	*151.091*	*138.639*	*126.586*	*123.187*	*97.535*	*120.303*
Energy industry	*142.369*	*140.085*	*117.446*	*108.204*	*95.769*	*96.573*	*88.457*	*82.087*	*78.213*	*53,400*	*60.805*
Manufacturing industry and construction	*18.863*	*18.478*	*33.556*	*26.423*	*17.801*	*15.565*	*13,490*	*13.825*	*12,950*	*20.359*	*22.107*
Transport	*21.581*	*18.683*	*15.438*	*12.403*	*10.402*	*8.829*	*7.687*	*7.145*	*6.623*	*6.707*	*9.471*
Other sectors	*49.386*	*51.770*	*44.692*	*39.327*	*33.258*	*28.439*	*27.355*	*21.816*	*15.509*	*7.006*	*8.156*
Other sectors	*8.934*	*5.914*	*1,460*	*1.466*	*1,440*	*1.414*	*1.419*	*1.476*	*9.672*	*9.869*	*19.522*
Fugitive Emissions	*68.251*	*65.212*	*60.092*	*52.732*	*48.654*	*47.026*	*51.930*	*59.787*	*62.256*	*42.784*	*48.689*

Continuation of table 3.1

Source	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**

Energy *(energy activities)*, total	**161.761**	**184.180**	**202.518**	**216.697**	**227.097**	**243.312**	**243.805**	**241.624**	**237.072**	**260.459**	**249.114**
Energy, including fuel combustion and transport (sectoral approach)	*114.121*	*131.671*	*147.630*	*157.006*	*169.922*	*188.525*	*193.921*	*195.351*	*192.818*	*217.931*	*207.180*
Energy industry	*63.297*	*67.701*	*76.408*	*87.896*	*92.263*	*99.443*	*94.848*	*89.713*	*96.062*	*103.753*	*104.898*
Manufacturing industry and construction	*24.670*	*26.050*	*27.196*	*24.907*	*28.532*	*29.249*	*31.435*	*28,900*	*28.368*	*28.707*	*29.595*
Transport	*10,460*	*12.679*	*14.190*	*14.618*	*16.474*	*18.554*	*21.212*	*22.171*	*21.660*	*21.076*	*21.696*
Other sectors	*8.599*	*10,898*	*13.410*	*12.319*	*11.275*	*14.574*	*18,930*	*15.332*	*13.610*	*15.244*	*18.262*
Other sectors	*6.798*	*13.985*	*16.046*	*16.888*	*20.979*	*26.201*	*26.913*	*38.673*	*32.546*	*48.549*	*32.098*
Fugitive Emissions	*47.640*	*52.509*	*54.887*	*59.691*	*57.175*	*54.787*	*49.884*	*46.273*	*44.254*	*42.528*	*41.934*

Continuation of table 3.1

Source	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Energy *(energy activities)*, total	**254.851**	**262.222**	**279.574**	**279.906**	**280.771**	**299.512**	**314.666**	**279.887**	**257.160**	**285.038**
Energy, including fuel combustion and transport (sectoral approach)	*214.369*	*219.699*	*240.003*	*243.320*	*245.369*	*260.948*	*276.270*	*244.952*	*224.694*	*246.528*

Energy industry	*110.894*	*115.523*	*114.552*	*108.152*	*111.271*	*118.474*	*125.237*	*123.545*	*124.318*	*120.699*
Manufacturing industry and construction	*29.565*	*27,500*	*34.913*	*37.207*	*36.245*	*36.915*	*35.918*	*25.549*	*26.326*	*41.133*
Transport	*25.118*	*23.292*	*24.434*	*22.045*	*23.202*	*24.618*	*26.434*	*26.903*	*19.342*	*25.166*
Other sectors	*15.691*	*14.089*	*25.634*	*27.449*	*27.190*	*30.461*	*31.471*	*40.059*	*32.430*	*40.574*
Other sectors	*33.100*	*39.295*	*40.471*	*48.467*	*47.462*	*50.481*	*57.210*	*28.896*	*22.279*	*18.956*
Fugitive Emissions	*40.482*	*42.524*	*39.570*	*36.586*	*35.402*	*38.563*	*38.396*	*34.935*	*32.465*	*38.510*

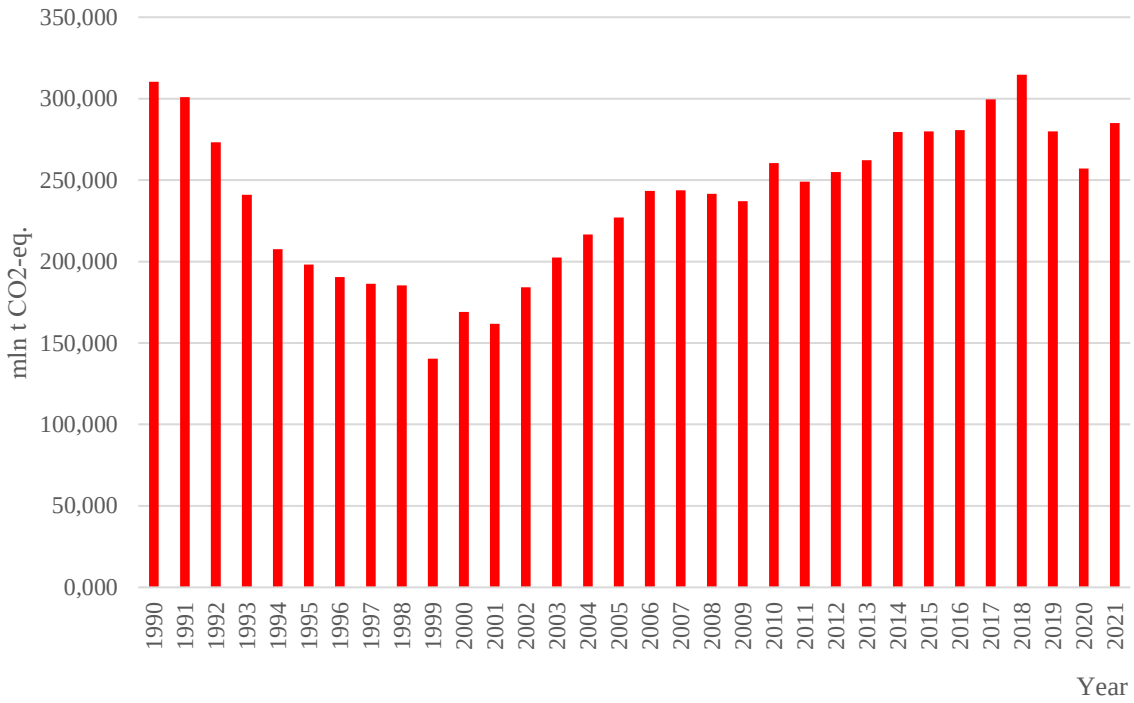
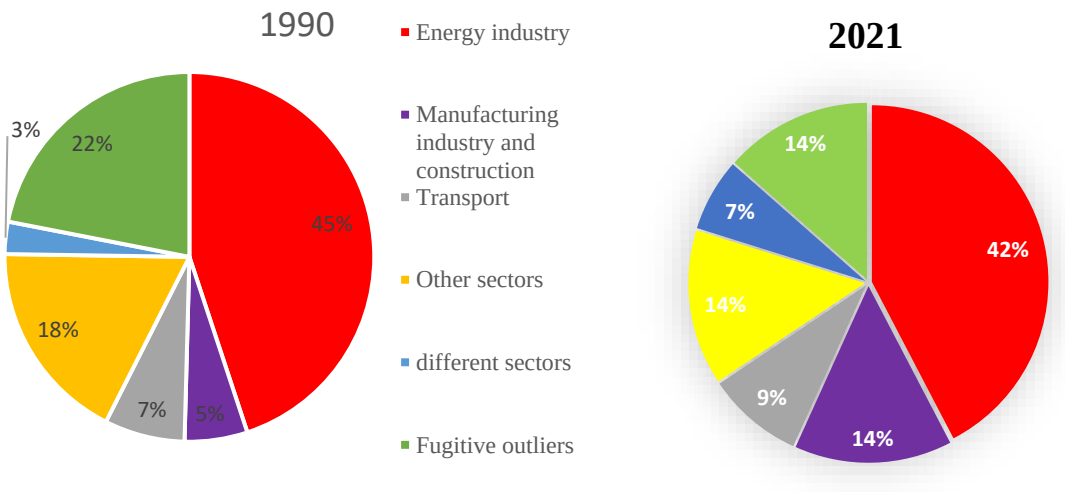


Figure 3.1 - Dynamics of total greenhouse gas emissions in the "Energy activities" sector in the Republic of Kazakhstan for 1990 ... 2021 (million tons of CO_2-eq.)

Figure 3.2 - Share of greenhouse gas emission sources in the sector "Energy activities" (sector 1 CRF)



The share of greenhouse gas emissions from the “Transport (1.A.3 CRF)” category in the “Energy” sector tended to increase over the study period: **greenhouse gas emissions in the “Transport (1.A.3 CRF)” category in 2021 amounted to 18.726 million tons of CO_2-eq** ., which is 16.1% more than the level of 1990 and 29.7% less than the level of 2020.

The share of greenhouse gas emissions from the category " Other sources (1.A.5 CRF) " in the "Energy" sector over the study period tended to increase, from 3% (1990) to 8% (2021). **Greenhouse gas emissions in the category " Other sources (1.A.5 CRF) " in 2021 amounted**

to 22.279 million tons of CO_2-eq., which is 2.5 times more than in 1990 and 22.9% less 2020 level

Share of greenhouse gas emissions from the category “ Fugitive emissions. (1. In the CRF) " in the "Energy" sector over the study period had a downward trend - from 22% (1990) to 10% (2021). **Greenhouse gas emissions in the Fugitive Emissions category. (1. In OFO)" in 2021 amounted to 28.553 million tons of CO_2-eq.,** which 2.4 times less **relative** to the level of 1990 and 7.3% more than in 2020.

Greenhouse gas emissions in the "Energy" sector in the context of individual gases for the period 1990 ... 2021 are presented in table 3.2. CO_2 emissions account for 99% of all greenhouse gas emissions.

Table 3.2 - Greenhouse gas emissions in the sector "Energy activities" in the context of individual gases for 1990 ... 2021

Year	Greenhouse gas, million tons						
	CO2 _	CH 4	N2O _ _	NOx	CO	NMVOC	SO2 _
1990	245.375	2.532	0.006	58.242	461.762	55.735	1.084
1991	239.364	2.402	0.005	49.798	382.610	45.999	1.063
1992	216.348	2.227	0.004	48.533	373.560	44.702	0.936
1993	191.409	1.942	0.003	37.331	293.513	34.943	0.833
1994	162.240	1.783	0.003	31.916	255.847	30.297	0.658
1995	154.317	1.722	0.003	26.559	214.483	25.276	0.643
1996	142.272	1.904	0.002	22.658	181.572	21.308	0.578
1997	130.705	2.201	0.002	20.542	164.324	19.199	0.519
1998	128.011	2.272	0.002	19,880	156.992	18.271	0.493
1999	102.618	1.487	0.002	21.413	136.065	18.304	0.372
2000	126.398	1.678	0.002	26.967	179.756	20.868	0.428
2001	120.979	1.604	0.002	30098.684	194.393	22.516	0.425
2002	139.541	1.755	0.003	36.696	238.576	27.501	0.480
2003	156.225	1.818	0.003	39.252	254.687	29.240	0.513
2004	166.752	1.963	0.003	43.087	277.250	31.714	0.510
2005	179.991	1.848	0.003	53.440	341.005	38.866	0.577
2006	199.192	1.724	0.003	62.742	396.245	45.007	0.628
2007	204.615	1.523	0.004	74.088	475.833	53.794	0.625
2008	206.756	1.351	0.004	74.458	473.752	53.380	0.609
2009	204.901	1.242	0.004	75.883	469.948	52.824	0.621
2010	230.548	1.147	0.004	76.974	494.321	55.257	0.648
2011	219.808	1.123	0.004	81.019	469.642	52.559	0.701
2012	227.023	1.060	0.004	96.762	523.625	59.075	0.727
2013	233.362	1.101	0.004	87.669	509.140	56.565	0.688
2014	252.161	1.039	0.005	89.848	544.394	60.419	0.736
2015	254.988	0.945	0.004	84.511	500.656	55.197	0.695
2016	254.987	0.979	0.004	86.593	541.646	59.275	0.680
2017	270.180	1.119	0.005	89.001	610.544	66.493	0.687
2018	285.101	1.126	0.005	97.761	653.689	70.717	0.706
2019	251.989	1.062	0.005	97.688	653.579	70.742	0.651
2020	231.205	0.989	0.004	70.534	471.811	51.064	0.578
2021	254.061	1.186	0.004	93.359	624.954	0.104	0.593

3.2 Comparative assessment of CO_2 emissions by baseline and sectoral approaches in the Energy sector (1. AS OFO)

3.2.1 Dynamics of CO_2 emissions by baseline and sectoral approaches for 1990…2021

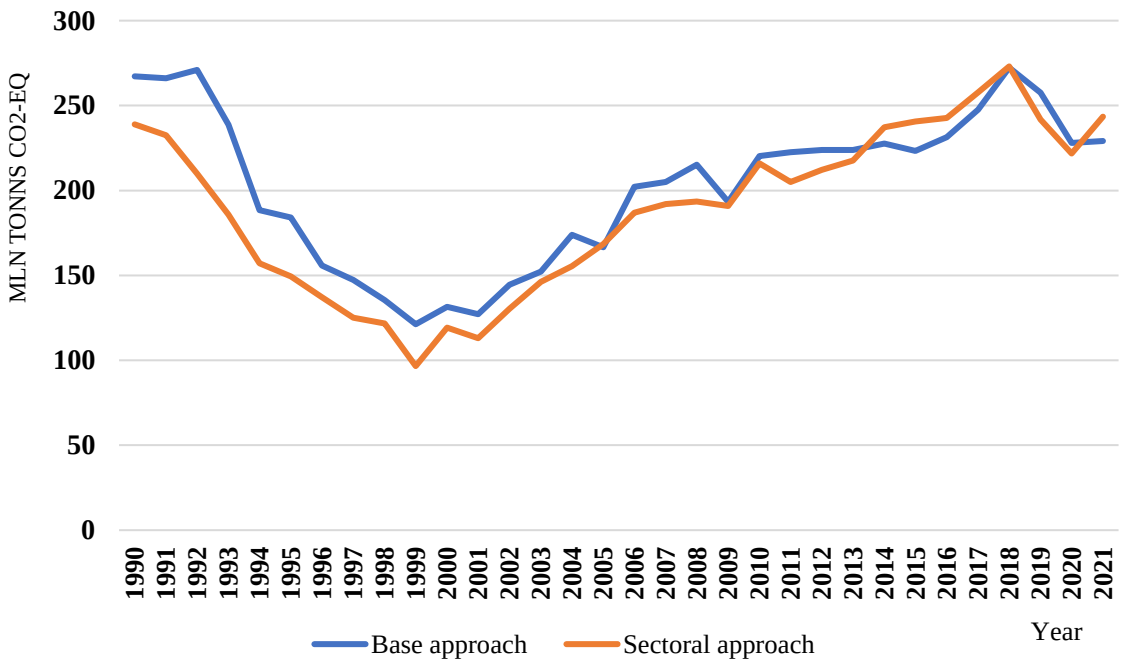
In order to control the calculated values of greenhouse gas emissions in the "Energy" sector, according to the IPCC RP 2006, a comparative assessment of CO_2 emissions was carried out according to the basic and sectoral approaches. The reference approach provides an estimate of CO_2 emissions on fuel resources in the country, the sectoral approach - on fuel consumption.

$_2$ emissions according to two approaches, and their percentage difference for the period 1990…2021 are presented in Figure 3.3 and Table 3.3.

Figure 3.3 - Dynamics of CO_2 emissions in the "Energy" sector according to the basic and sectoral approaches for 1990 ... 2021, million tons

Mainly for the period 1990-2013. CO_2 emissions according to the baseline approach exceed emissions from the sectoral approach, i.e. fuel resources in the fuel and energy balance of [13]national statistics are greater than fuel consumption . This is confirmed by the balance of primary fuels (Appendix 1).

In recent years, the gap between the two approaches has narrowed significantly. WITH From 2014 to 2021, the opposite trend is observed: CO_2 emissions according to the sectoral approach exceed the baseline. In 2021, the difference between the two approaches was 5.2% in favor of the sectoral approach.



3.2.2 Factors affecting the difference in estimated CO_2 emissions between the baseline and sector approaches

Largest gap in CO_2 emissions between the two approaches falls on 1991 ... 1999. due to the lack of TEB RK. Due to the collapse of the Soviet Union, which included the Kazakh SSR, and

[13] Published on the website of the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan http://stat.gov.kz

the formation of the new state of the Republic of Kazakhstan, national statistics did not form the Fuel and Energy Balance. During this period, national statistics provided data on fuel consumption in the form of various reference books and bulletins. Among them are the reference book "Balance of production and distribution of the most important types of raw materials", which reflected the production, export and import of certain types of fuel resources; Bulletin "On balances, receipts and consumption of fuel in the Republic of Kazakhstan", which reflected the domestic consumption of fuel and energy resources by type of economic activity and others. Many data for calculating greenhouse gas emissions were missing from these sources of information. For example, there was no data on fuel consumed for raw materials and non-fuel needs.

Since 1999, national statistics have begun to form a fuel and energy balance, which tracks the resources and costs of all types of fuel. In this regard, the difference between the calculated $CO_{2\ emissions}$ for the two approaches has significantly decreased. However, for a number of reasons it is not yet possible to reduce this difference to zero. As noted in the 2006 IPCC Guidelines, [14]for countries that produce and export large amounts of fossil fuels (which includes Kazakhstan), the uncertainty in the residual supply can be significant and affect the baseline approach.

Some of the reasons why there are still difficulties in reducing the difference in approaches include the following:

1. The number of enterprises and organizations reporting on fuel used to national statistics is not always the same over the years, not all enterprises transparently report on fuel used due to various reasons;

2. The inter-annual difference of some TEB data of national statistics varies greatly. This applies to the production, export and import of certain types of fuel. Data on exports of primary fuels in some years in the FEB of national statistics do not match the data of the Ministry of Energy of the Republic of Kazakhstan and the customs data of the State Revenue Committee of the Republic of Kazakhstan. For example, the export of natural gas in the fuel and energy balance of national statistics differs greatly from the data of the Ministry of Energy of the Republic of Kazakhstan. National statistics explain this by the fact that they have adopted a different format for accounting for natural gas exports. They take into account the entire volume of natural gas that goes to Russian gas processing plants for processing. But then this volume of processed gas is returned to Kazakhstan and again exported to third countries. Thus, there is a double accounting of fuel;

3. In the country, accounting for crude oil is not at the proper level due to the lack of automated accounting for oil production and modern oil write-off standards. The reports of the Ministry of Energy of the Republic of Kazakhstan on the volumes of oil production and processing differ from the data of the customs authorities on oil exports;

4. Since 2014, $CO_{2\ emissions}$ under the sectoral approach began to exceed the baseline. First of all, this is due to the fact that the national statistics changed the format of the fuel and energy balance in accordance with the requirements of the EAEU, which includes Kazakhstan. Data on solid fuels began to be provided in a disaggregated form (coking coal, energy coal, hard coal with a high ash content, other hard coal, coal concentrate). However, the quality of data on solid fuels has declined markedly. Not all coal companies still report correctly to national statistics;

5. Since 2009, the TEB of national statistics does not contain data on other types of fuel consumption, which were provided from 1990 to 2008. In order to improve the reporting of the inventory of greenhouse gas emissions, data on the consumption of other fuels were repeatedly

[14]https://www.ipcc-ngip.iges.or.jp/public/2006gl/russian/vol2.html

requested from the statistics agency. However, for objective reasons, the requested data cannot be provided;

6. Big problems are observed with the FEB data of the Bureau of National Statistics under the item “Other consumption” (until 2015, the item “Sold to enterprises and organizations”). National statistics include in this article all fuels that do not belong to any source of greenhouse gas emissions. According to the IPCC Guidelines, such fuel belongs to category 1.A.5 "Other sources". The volumes of solid and gaseous fuels under this item are very significant and give large emissions in category 1.A.5 and in general according to the sectoral approach in the Energy sector. The amount of fuel consumed under this item was recalculated in connection with the provision of data on the consumption of coking coal by ArcelorMitall Temirtau JSC.

Table 3.3 - Comparative assessment of $CO_{2\ emissions}$ in the "Energy" sector according to the basic and sectoral approaches for the period 1990…2021

An approach	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Basic, million tons	267.277	266.025	270.932	238.709	188.390	184.015	155.822	147.364	135.527	121.235	131.583	127.130	144.410	152.182	173.974	166.473
Sector, million tons	238.899	232.613	209.935	185.706	157.147	149.406	137.070	125.090	121.771	96.608	119.249	112.982	130.393	146.206	155.423	168.397
Difference, %	**11.9**	**14.4**	**29.1**	**28.5**	**19.9**	**23.2**	**13.7**	**17.8**	**11.3**	**25.5**	**10.3**	**12.5**	**10.8**	**4.1**	**11.9**	**-1.1**

Continuation of table 3.3

An approach	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Basic, million tons	202.264	205.068	215.264	193.253	220.183	222.537	223.810	223.868	227.692	223.257	231.316	247.506	272.339	257.555	228.055	229.078
Sector, million tons	186.858	192.077	193.456	190.927	215.851	204.930	212.145	217.542	237.245	240.676	242.633	257.832	273.040	241.817	221.811	243.409
Difference, %	**8.2**	**6.8**	**11.3**	**1.2**	**2.0**	**8.6**	**5.5**	**2.9**	**-4.0**	**-7.2**	**-4.7**	**-4.0**	**-0.3**	**6.5**	**2.8**	**-5.9**

Note: Difference of CO_2 emissions values with sign (+) – $CO_{2\ emissions}$ under the baseline approach are greater than under the sectoral approach; $_2$ emissions under the sector approach are greater than those under the baseline approach.

Table 3.3a - Comparative assessment of $CO_{2\ emissions}$ in the "Energy" sector according to the baseline and sectoral approaches by fuel type for 2021

Type of fuel	An approach		
	Basic, million tons	Sector, million tons	Difference, %
Liquid fuel	50.337	61.153	-17.69
solid fuel	142.842	143.766	-0.64

gaseous fuel	35.899	38.427	-6.58

3.3 Estimation of carbon dioxide emissions in the "Energy" sector according to the basic approach for 1990…2021 (1. AB OFO)

3.3.1 Fuel consumption and CO_2 emissions in the Energy sector according to the baseline approach for the period 1990…2021

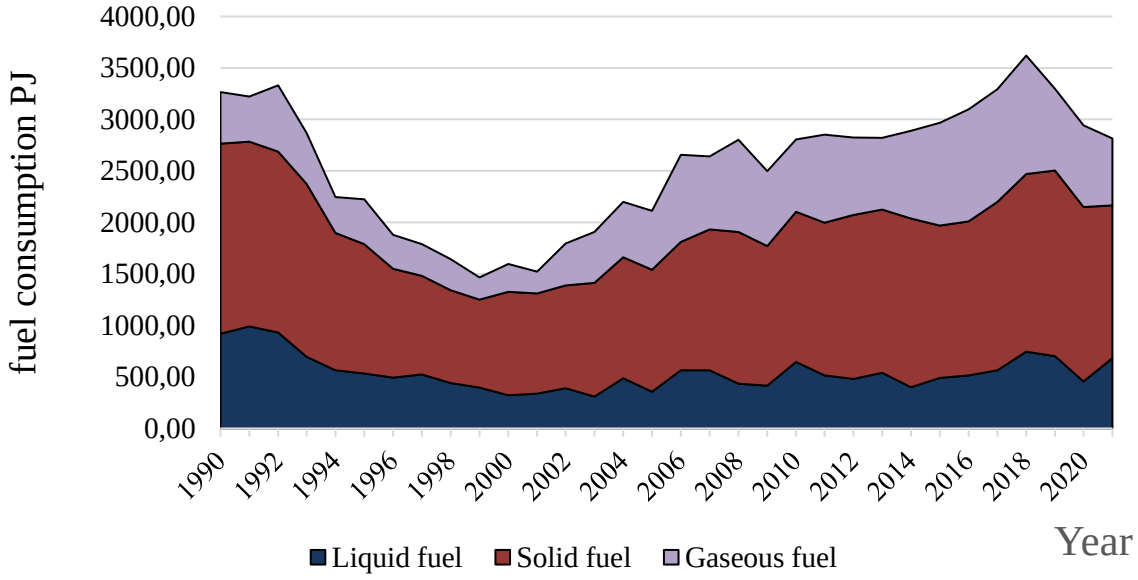
The total volume of fuel consumption in the Energy sector according to the basic approach in 2021 amounted to 2946.735 PJ, which is 10% more than in 1990 and 10.9% less than in 2020 (Table 3.4, Figure 3.4).

Table 3.4 - Dynamics of fuel consumption in the "Energy" sector according to the basic approach for 1990 ... 2021

Year	Total,	By type of fuel, PJ		
	PJ	Liquid fuel	solid fuel	gaseous fuel
1990	**3265.13**	917.51	1847.90	499.72
1991	**3221.67**	990.65	1794.12	436.91
1992	**3329.64**	930.01	1758.81	640.81
1993	**2869.02**	693.35	1679.11	496.55
1994	**2245.91**	565.12	1332.22	348.57
1995	**2223.70**	531.60	1258.26	433.84
1996	**1879.20**	492.21	1056.10	330.88
1997	**1788.58**	523.86	956.93	307.78
1998	**1643.65**	439.84	901.44	302.37
1999	**1464.34**	395.20	855.14	214.00
2000	**1596.97**	321.48	1003.17	272.31
2001	**1521.50**	337.27	973.46	210.77
2002	**1796.33**	388.91	997.72	409.69
2003	**1906.84**	308.43	1103.59	494.82
2004	**2200.90**	486.30	1174.44	540.17
2005	**2113.60**	356.87	1184.81	571.92
2006	**2656.00**	565.24	1245.09	845.66
2007	**2642.12**	565.34	1366.15	710.63
2008	**2803.11**	434.77	1473.57	894.77
2009	**2496.62**	416.51	1353.73	726.38
2010	**2805.89**	646.01	1455.72	704.16
2011	**2853.72**	514.69	1482.65	856.38
2012	**2824.06**	480.58	1591.87	751.61
2013	**2820.10**	539.99	1584.41	695.70
2014	**2890.15**	398.34	1639.92	851.89
2015	**2968.29**	489.30	1479.41	999.58
2016	**3096.80**	515.07	1495.96	1085.77
2017	**3293.33**	565.52	1633.94	1093.87
2018	**3619.97**	744.21	1727.13	1148.63

2019	**3298.27**	701.10	1803.66	793.51
2020	**2941.50**	454.20	1697.04	790.25
2021	**2814.08**	682.55	1483.45	648.08

Figure 3.4 - Dynamics of fuel consumption in the



"Energy" sector according to the basic approach
for 1990…2021, PJ

In 2021, in the Energy sector, according to the basic approach, the contribution of liquid, solid and gaseous fuels was **15.6%, 57.6% and 26.8%,** respectively.

In 2021, CO_2 emissions in the Energy sector according to the basic approach amounted to 228.429 million tons, which is less than the level of 1990 by 14.7% and less than the level of 2020 by 11.5% (Table 3.5, Figure 3.5) .

Table 3.5 - $CO_{2\ emissions}$ in the "Energy" sector according to the basic approach for 1990 ... 2021, million tons

Year	Total CO_2, million tons	CO_2 emissions by fuel type, million tons		
		Liquid fuel	solid fuel	gaseous fuel
1990	**267.277**	64.423	175.081	27.773
1991	**266.025**	68.145	173.369	24.511
1992	**270.932**	65.050	169.933	35,950
1993	**238.709**	48.360	162.492	27.857
1994	**188.390**	40.415	128.420	19.555
1995	**184.015**	38.319	121.358	24.339
1996	**155.822**	35.385	101.875	18.562
1997	**147.364**	37.858	92.239	17.267
1998	**135.527**	31.692	86.872	16.963
1999	**121.235**	28.375	81.043	11.816
2000	**131.583**	22.767	93.632	15.184
2001	**127.130**	23.919	91.565	11.646
2002	**144.410**	27.638	94.063	22.709
2003	**152.182**	21.634	103.823	26.725
2004	**173.974**	34.623	111.637	27.714
2005	**166.473**	24.975	111.465	30.034
2006	**202.264**	40.155	117.020	45.088
2007	**205.068**	39.772	127.548	37.747
2008	**215.264**	29.368	136.607	49.289
2009	**193.253**	27,840	126.897	38.517
2010	**220.183**	45.854	136.168	38.161
2011	**222.537**	36.239	139.323	46.976
2012	**223.810**	34.002	149.534	40.275
2013	**223.868**	37.994	148.590	37.284
2014	**227.692**	27.746	153.200	46.746
2015	**223.257**	30.433	137.789	55.036
2016	**231.316**	32.192	139.664	59.461
2017	**247.506**	35.290	152.267	59.948
2018	**272.339**	48.028	161.174	63.136
2019	**257.555**	45,550	168.577	43.427
2020	**228.055**	27.363	158.155	42.536
2021	**229.078**	50.337	142.842	35.899

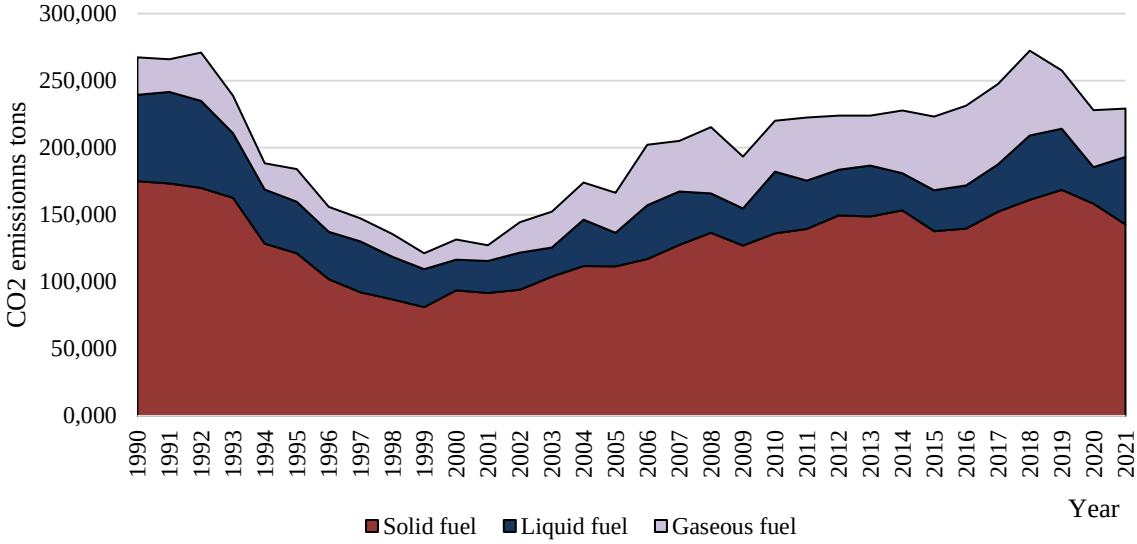


Figure 3.5 - Dynamics of $CO_{2\ emissions}$ for 1990…2021 in the energy sector according to the basic approach, million tons

In 2021, CO2 emissions from liquid fuels amounted to 27.738 million tons, which is 57.4% less than in 1990 and 39.9% less than in 2020. The reduction in CO_2 emissions relative to 2020 is associated with a decrease in the production of crude oil , a decrease in imports of motor gasoline and diesel fuel, and an increase in imports. According to data provided by the Bureau of Statistics of the Agency for Strategic Planning and Reforms of the Ministry of National Economy of the Republic of Kazakhstan, crude oil production in 2020 amounted to 78.6 million tons [15]. tons, while in 2021 the production of crude oil decreased to 73 million [3] .

Emissions of CO_2 from the combustion of solid fuels for the period 1990…2021, in accordance with the dynamics of consumption of solid fuels, showed a prevailing downward trend. In 2021, $CO_{2\ emissions}$ from solid fuels amounted to 158.155 million tons, which is 9.7% less than in 1990. Relative to 2020, there is a reduction in $CO_{2\ emissions}$ by 6.2%. Reduction emissions relatively 2020 level due to increase export coal stone energy and coal stone other things .

CO_2 emissions from combustion of gaseous fuels for the period 1990…2021, in accordance with the dynamics of consumption of gaseous fuels, showed a general upward trend. A slight decrease in emissions is associated with a decrease in the production and export of natural gas.

$_2$ emissions in the "Energy" sector according to the basic approach for the period 1990 ... 2021. the share of solid fuel prevails, which indicates the still significant use of coal for the production of heat and electricity (Figure 3.6). There is a steady decrease in the share of liquid fuels in $CO_{2\ emissions}$ and an increase in the share of gaseous fuels, without taking into account the decrease in fuel consumption in the Energy sector.

[15] Bureau of National Statistics, Agency for Strategic Planning and Reform. Energy and Commodity Market Statistics http://stat.gov.kz

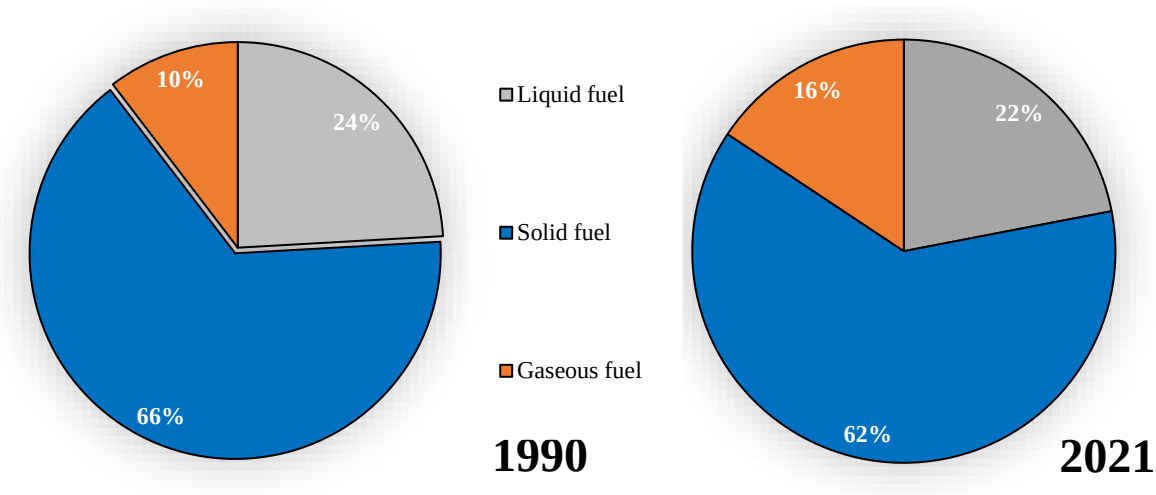


Figure 3.6 - Dynamics of the fuel structure in the "Energy" sector according to the basic approach for 1990 and 2020, %

0

The percentage of annual $CO_{2\ emissions}$ relative to the base year 1990 is presented in Table 3.6. In 2021, CO2 emissions according to the baseline approach from 1990 amounted to 96.3% (liquid fuel - 70.1%, solid fuel - 96.3%, gaseous fuel - 156.4%).

Table 3.6 - The ratio of $CO_{2\ emissions}$ to the base year 1990, %

Year	Total, %	Liquid fuel, %	Solid fuel, %	Gaseous fuel, %
1990	**100%**	**100%**	**100%**	**100%**
1991	100%	106%	99%	88%
1992	101%	101%	97%	129%
1993	89%	75%	93%	100%
1994	70%	63%	73%	70%
1995	69%	59%	69%	88%
1996	58%	55%	58%	67%
1997	55%	59%	53%	62%
1998	51%	49%	50%	61%
1999	45%	44%	46%	43%
2000	49%	35%	53%	55%
2001	48%	37%	52%	42%
2002	54%	43%	54%	82%
2003	57%	34%	59%	96%
2004	65%	54%	64%	100%
2005	62%	39%	64%	108%
2006	76%	62%	67%	162%
2007	77%	62%	73%	136%
2008	81%	46%	78%	177%
2009	72%	43%	72%	139%

2010	82%	71%	78%	137%
2011	83%	56%	80%	169%
2012	84%	53%	85%	145%
2013	84%	59%	85%	134%
2014	85%	43%	88%	168%
2015	84%	47%	79%	198%
2016	87%	50%	80%	214%
2017	93%	55%	87%	216%
2018	102%	75%	92%	227%
2019	96%	71%	96%	156%
2020	85%	42%	90%	153%
2021	86%	78%	82%	129%

3.3.2 Excluded carbon (1. AD CRF)

In accordance with the IPCC Guidelines for Adjusting Total Carbon from Fuel Combustion in the Energy Sector, carbon removed was calculated using the baseline approach.

Table 3.7 - Fuel used for non-energy purposes (baseline approach, PJ)

Year	Fuel, PJ										
	Petrol	Kerosene	Diesel fuel	heating oil	LPG	Bitumen	Lubricants	Coal stone energy	Lignite	Coke	natural gas
1990	0.709	0.221	0.344	1.091	1.703	28.622	0.241	0.851	0.024	30.964	4.661
2000	0.832	0.17	1.74	0.953	0.048	2.059	0.159	13.396	0	16.975	1.65
2001	0.527	0.022	1.092	0.782	0.114	4.964	0.314	5.157	0.21	17.356	3.177
2002	0.475	0.351	0.848	1.343	0.062	8.041	0.81	5.334	0.449	15.655	4,901
2003	0.61	0.036	1.622	1.754	0.106	7.235	0.561	5.451	0.449	20.392	18.438
2004	0.704	0.025	1.877	1.531	0.074	7.938	0.488	5.618	0.452	10.7	46.162
2005	0.565	0.017	1.85	1.05	0.077	7.838	0.474	7.127	0.443	20.3	36.553
2006	2.03	0.037	3.828	0.513	0.053	8.073	0.517	7.342	0	22.562	41.961
2007	1.064	0.378	1.303	0.512	0.087	11.651	0.737	16.957	0.032	23.985	37.712
2008	0.184	0.192	2.156	0.903	0.594	11.491	0.251	30.425	0.05	22.97	16.175
2009	1.547	0.014	0.475	0.555	0.084	10.612	0	17.644	0.038	18.381	39.806
2010	0.101	0.187	0.349	0.191	5.388	11.248	0	17.032	0.029	23.909	23.934
2011	0.046	0.043	0.466	0.147	5,861	11.8	0	9.787	0.056	27.112	19.013
2012	0.031	0.014	0.215	0.127	0.292	15.658	0	10.261	0.447	27.193	33.705
2013	0.121	0.039	2.6	0.083	0.318	11.669	0	10.021	0.172	29.584	31.106
2014	0.636	0.024	1.448	0.322	0.23	12.869	0.185	1.289	0.037	32.069	18.629
2015	0.042	0.03	0.223	0.249	0.122	9.452	0.136	7.413	0.354	30.209	18.553
2016	0.011	0.027	0.263	0.368	0.076	8.503	1.31	6.408	0	27.943	25.872
2017	0.027	0.008	0.277	0.439	0.028	12.897	0.143	7.149	0.088	33.047	25.274
2018	0.01	0.319	1.423	0.711	0.035	14.679	0.137	7.666	0.102	30.729	23.207
20 19	0.008	0.235	1.528	0.611	0.046	12.385	0.139	7.679	0.163	33.397	19.402
2020	0.014	0.431	1.408	0.665	0.179	14.473	0.12	7.902	0.046	31.625	32.033
2021	0	0	0	0	0	0	5.25	0	0	0	8.18

Note: Gasoline, including aviation gasoline, jet gasoline, petroleum distillates; Kerosene, including jet kerosene; Diesel fuel, including domestic stove fuel; Liquefied petroleum gas, including purified gases ; Coal, including coal with high ash content, coking coal, coal for power generation and other coal; Natural gas, including associated petroleum gas; ND - no data.

The data of the Fuel and Energy Balance of the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Ministry of National Economy of the Republic of Kazakhstan served as the initial data for calculating the excluded carbon: fuel as a raw material [16]for chemical, petrochemical and other non-fuel products and fuel as a material for non-fuel needs.

[16] Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, Statistics of Energy and Commodity Markets http://stat.gov.kz

The volumes of fuel used for non-energy purposes are presented in Table 3.7. The excluded carbon was estimated for 1990 and for the period 2000–2021. For the period 1991 ... 1999. evaluation was not carried out due to lack of baseline data.

According to the IPCC Guidelines (2006) [4] carbon removed was subtracted from total net carbon emissions under the baseline.

3.3.3 Methodological approaches

Calculation methodology

$_2$ emissions in the "Energy" sector according to the basic approach for 1990…2021 was carried out in accordance with the IPCC Guidelines (2006) [17], according to formula (1):

E \u003d M * k $_{tnz}$ * k $_1$ * k $_2$ * 44/12 (1)

where: *E* – annual CO $_{2\ emission}$ (tons/year);

M is the actual fuel consumption for the year (tons/year);

k $_{tn}$ – net calorific value (J/ton);

k $_1$ – coefficient of carbon oxidation in fuel (fraction of burned carbon);

k $_{2\ –\ carbon}$ emission factor (ton C/J);

44/12 is the conversion factor for carbon to carbon dioxide.

$_1$ method based on national energy statistics and default emission factors from the 2006 IPCC Guidelines was used to calculate CO 2 emissions.

Activity data includes domestic consumption of each fuel type for each inventory year:

- quantity of produced primary fuel;
- quantity of imported primary and secondary fuels;
- the amount of exported primary and secondary fuel;
- changes in fuel reserves at the beginning and end of the cadastral year;
- fuel used for non-energy purposes (“decarbonised”).

To eliminate double counting, data on the production of secondary species, according to the IPCC Guidelines, fuels are not used.

Initial data

The source of data for calculating greenhouse gas emissions in the Energy sector according to the basic approach is the data of the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan on the resources of all types of fuel in the country.

The source of data on fuel resources in the country for 1990 was the Fuel Balance of the USSR, in the part that concerns the Kazakh SSR.

Due to the absence of the fuel balance of the Republic of Kazakhstan, various reference books and bulletins of national statistics served as the source of fuel resource data for 1991 ... 1998, which reflected the production, export, import and change in fuel residues for the inventory year.

The main source of fuel resources for 1999…2021 - Fuel and Energy Balance (FEB) of the Republic of Kazakhstan, which is formed annually by the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Ministry of National Economy of the Republic of Kazakhstan . The information base of the TEB is the developed and approved form of statistical reporting No. 1-TEB (annual periodicity), which tracks all types of FER (Fuel and Energy Resources) in the republic.

[17] IPCC Guidelines for National Greenhouse Gas Inventories, 2006. Volume 2 https://www.ipcc-nggip.iges.or.jp

To control the data of the resource part of the fuel and energy unit, data from the Ministry of Energy of the Republic of Kazakhstan, the Committee for Customs Revenues of the Republic of Kazakhstan, enterprises of the Republic of Kazakhstan for the extraction of fossil fuels and fuel processing are used.

When calculating greenhouse gas emissions, the initial data on fuel consumption in natural units of measurement (tonne, thousand cubic meters, thousand kWh, thousand Gcal) were used.

Greenhouse gas emission factors

For calculation of $CO_{2\ emissions}$ in the "Energy" sector according to the basic approach for the period 1990 ... 2021. default net calorific values, carbon emissions and oxidized carbon fractions recommended by the 2006 IPCC Guidelines (Table 3.8) were used.

An exception is the coefficient of the net calorific value of the lowest for domestic stove fuel. Source of information - LLP "Atyrau Oil Refinery" - the main producer of domestic stove fuel in the country. The letter from the enterprise on the calorific value of the produced household furnace fuel was attached in the responses to the expert team for the Greenhouse Gas Inventory Review (Provisional main findings_CR_2020_Kazakhstan) . _ _ _

Table 3.8 - Greenhouse gas emission factors in the "Energy" sector[18]

Fuel	k_{tnz}		k2 _		k_1	
	Calorific net value	Source _	Carbon emission factor, tC /TJ	Source _	Fraction oxidized-carbon _	Source - Nick
Liquid fuel						
Crude oil	42.3 TJ/10 ^{3} tons	D	20.0	D	1	D
Gas condensate	44.2 TJ/10 ^{3} tons	D	17.5	D	1	D
Aviation gasoline	44.3 TJ/10 ^{3} tons	D	19.1	D	1	D
Automobile gasoline	44.3 TJ/10 ^{3} tons	D	18.9	D	1	D
Petroleum distillates light	44.3 TJ/10 ^{3} tons	D	19.1	D	1	D
Jet Gasoline	44.3 TJ/10 ^{3} tons	D	19.1	D	1	D
Kerosene for jet engines	44.1 TJ/10 ^{3} tons	D	19.5	D	1	D
Kerosene for technical purposes	43.8 TJ/10 ^{3} tons	D	19.6	D	1	D
Diesel fuel	43.0 TJ/10 ^{3} tons	D	20.2	D	1	D
Domestic stove fuel	42.8 TJ/10 ^{3} tons	PS	20.2	D	1	D
heating oil	40.4 TJ/10 ^{3} tons	D	21.1	D	1	D
LPG	47.3 TJ/10 ^{3} tons	D	17.2	D	1	D
Bitumen	40.2 TJ/10 ^{3} tons	D	22.0 _	D	1	D
Lubricants	40.2 TJ/10 ^{3} tons	D	20.0 _	D	1	D
Petroleum coke	32.5 TJ/10 ^{3} tons	D	26.6 _	D	1	D
Gas refinery	35.6 4TJ/ 10 ^{6} cu. m	D	15.7	D	1	D
gaseous fuel						
natural gas	34.78 TJ/ 10 ^{6} cu. m	D	15.3	D	1	D
Associated petroleum gas	34.78 TJ /10 ^{6} cu. m	D	15.3	D	1	D
Stripped gas	34.78 TJ/ 10 ^{6} cu. m	D	15.3	D	1	D
solid fuel						
Coking coal	28.2 TJ /10 ^{3} tons	D	25.8	D	1	D
coal concentrate	28.2 TJ /10 ^{3} tons	D	25.8	D	1	D
Coal stone energy	18.9 TJ/10 ^{3} tons	D	26 , 2	D	1	D
Coal with high ash content	18.9 TJ/10 ^{3} tons	D	26.2	D	1	D
Other hard coal	18.9 TJ/10 ^{3} tons	D	26.2	D	1	D

[18] IPCC Guidelines for National Greenhouse Gas Inventories, 2006. Volume 2, Tables-1.2, 1.3, 1.4 https://www.ipcc-nggip.iges.or.jp

Continuation of table 3.8

Fuel	k_{tnz}		k2 _		k_1	
	Calorific net value	Source _	Carbon emission factor, tC /TJ	Source	Fraction of oxidized carbon	Source - Nick
Lignite	11.9 TJ/10 ^{3} tons	D	27.6	D	1	D
Briquetted coal	20.7 TJ/10 ^{3} tons	D	26 , 6	D	1	D
Furnace and lignite coke	28.2 TJ/10 ^{3} tons	D	29, 2	D	1	D
Resin from coal	28.0 TJ/10 ^{3} tons	D	22.0	D	1	D
Other fuels						
Solid biomass, firewood	15.6 TJ/10 ^{3} tons	D	30.5 _ _	D	1	D

3.3.4 Uncertainty assessment

The main source of data on fuel combustion in the "Energy" sector according to the basic approach is the national statistical data of the Republic of Kazakhstan, which are subject to quality control procedures. National data, according to the 2006 IPCC Guidelines, are recognized as sufficiently accurate. The uncertainty in activity data in countries with well-developed statistical systems is in the range of ±5% for a particular fuel. Kazakhstan can be classified as a country with a good data collection system, so the overall uncertainty in data on combustion activities for a particular fuel is taken as 7 %.

For fuel combustion, the uncertainties in CO2 emission factors relative to small. For the Energy sector, the total uncertainty for the coefficients CO_2 by all types of fuel, according to the IPCC Guidelines 2006 , taken as 7%.

3.3.5 QA/QC procedure for calculating CO_2 emissions

In accordance with the recommendations of the IPCC, in order to eliminate errors in the transfer of national statistical data to the calculation tables, a TEB form in Excel format has been developed , where data for each type of fuel used is checked in several stages.

At the first stage, when entering the initial data into the calculation tables, the sum of the total volume of fuel (resource part) is automatically calculated taking into account production, imports and balances at the beginning of the year, which is compared with the data of the fuel and energy balance. At the second stage, when entering the initial data, the sum of the total fuel consumption in the country (distribution part) is automatically calculated taking into account exports, balances at the end of the year and losses, which is also compared with the FEB data. At the third stage, the balance of the resource and distribution parts is checked. At the fourth stage, the distribution of final consumption by type of economic activity is checked. These measures allow you to identify errors in the input of initial data.

3.3.6 Time series recalculations

In the "Energy" sector, according to the basic approach for 1990 ... 2017. time series were recalculated.

In connection with the comments of the Secretariat Expert Group (2020 KAZQA 371), CRF tables , category 1. AB reference Approach - Other Liquid fossil , position " tar ", the following should be noted. Previously, values for tar as a product of petroleum products processing were entered in this position. After consultations with specialists from the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Ministry of National Economy of the Republic of Kazakhstan, it turned out that the tar is a product of the distillation of coal. Therefore,

data on the consumption of resin and greenhouse gas emissions from it for 2014…2017. were transferred from liquid fuels to solid fuels. In the CRF tables in category 1.AB for resin, changes were made and comments were given. In accordance with these changes, the total $CO_{2\ emissions}$ in category 1. AB for liquid and solid fuels for 2014…2017 have changed slightly. These data were provided by national statistics only from 2014. For the period 1990–2013 . there is no such data.

In connection with the comments of the expert group of the Secretariat (Provisional main findings _ CR_2020_Kazakhstan, Table 1, E6) and in order to improve reporting and transparency of data in the CRF tables in categories 1.AB and 1.AD data on consumption and greenhouse gas emissions for crude oil and gas condensate (natural gas liquid) divided for 1990…2017. In this regard, the time series for consumption and $CO_{2\ emissions\ of\ crude\ oil\ changed\ and\ time\ series\ for\ consumption\ and\ CO_{2\ emissions}}$ of gas condensate appeared . In the CRF tables , in categories 1 AB and 1 AD , comments are given in connection with these changes. In accordance with these changes, for 1990 ... 2017. the total emissions for liquid fuels in these categories changed insignificantly.

As a comment from the Secretariat Expert Group (Provisional main findings _ CR_2021_Kazakhstan, Table 3, E12) found a discrepancy between coking coal consumption in the sectoral and baseline approaches. The data provided in the FEB by the Bureau of National Statistics did not fully reflect the total amount of coking coal consumption in the sectoral approach, which required additional calculations to be made and indicated under category 1.A.5 “Other sources”. This difference between the two approaches was reduced by using data on the consumption of coking coal by JSC ArcelorMittall Temirtau and the series were recalculated for category 1.A.5 "Other sources" and 1.A.1b " Production of oil , gas and solid fuel ."

3.3.7 Planned improvements

Improvement of the inventory of greenhouse gas emissions in the "Energy" sector according to the basic approach is planned by controlling the initial data of the resource part of the fuel and energy balance of national statistics with additional information from large enterprises of the Republic of Kazakhstan, taking into account information from the Ministry of Energy of the Republic of Kazakhstan, analytical and reference materials on fuel consumption in the country. It is also planned to improve the inventory of greenhouse gas emissions in the Energy sector according to the basic approach by taking into account, if possible, all the comments of the expert team on the Greenhouse Gas Inventory Review (GER).

In response to comments from the Secretariat Expert Group (2020KAZQA330), the following explanation was provided. Anthracite was not used in Kazakhstan for 1990…2020. The exception is insignificant imports (40 thousand tons) in 1990, which were used as raw materials in the production of petrochemical products. Therefore, this volume of anthracite is included in the CRF tables in category 1.AD and greenhouse gas emissions from it were not taken into account. In this inventory, the CRF for anthracite has "NO" values and comments. In previous inventories in the CRF , the position "Anthracite" included the values of hard coal, due to the absence of a special position in the CRF. Following comments from the Secretariat's expert group, a special position was opened for hard thermal coal.

In response to comments from the Secretariat Expert Team (019 KAZQA 186). In CRF tables in Category 1 AD Feedstock's , reductants and non - energy use of fuels, some types of fuel are missing (orimulsion , shale oil, ethane, oil, anthracite and others), but in column L 11 (Reported under) they must be specified. All of the above fuels are not used in Kazakhstan, so the key here is “ N O”. Box L 11 (Reported under) was filled in incorrectly. In CRF , category 1 AD , column L 11 has been corrected due to the lack of these fuels in Kazakhstan.

In response to the comments of the Secretariat expert team (2020 KAZQA 183, 2020 KAZQA 184) about the absence in category 1. AB Reference Approach data for domestic aviation, inland navigation. In category 1 AB according to the basic approach, according to the IPCC Guidelines, CO_2 emissions are estimated by fuel resources in the country for the inventory year (individual fuels). $CO_{2\ emissions}$ by fuel consumption (aviation, shipping) are estimated according to the sectoral approach in category 1.A.3 Transport.

In CRF in category 1AB. *Solid fuels* the keys for hard coal, coal with high ash content, coal concentrate and other coal for 1990 ... 2014 have been changed. Instead of the NA key, the IE key is affixed , because data on these types of coal for the period 1990 ... 2014. national statistics included in aggregated form sub-bituminous coal. The CRF has commented on this.

Based on the comments of the expert group, comments have been added to Table 9 of the CRF for those fuels included elsewhere as ' IE '.

3.4 Greenhouse gas emissions in the Energy sector by sectoral approach for 1990…2021 (1. AA OFO)

In the "Energy" sector, greenhouse gas emissions by types of economic activity in Kazakhstan from fuel combustion from stationary and mobile sources were estimated using a sectoral approach.

In accordance with the 2006 IPCC Guidelines, the assessment of greenhouse gas emissions (CO_2 , CH_4 , N_2O, NOx , CO, NMVOC and SO_2) was carried out by categories of greenhouse gas emission sources:

- 1.A.1 CRF Energy industry,
- 1.A.2 CRF Manufacturing and construction,
- 1.A.2 CRF Transport,
- 1.A.4 CRF Other sectors,
- 1.A.5 CRF Other sources.

3.4.1 Energy industry (1.A.1 CRF)

3.4.1.1 Overview

The main source of greenhouse gas emissions in the Energy sector is the Energy Industry category. This sector includes the following subcategories:

- Production of heat and electricity (1.A.1a),
- Oil refining (1.A.1 b)
- Production of oil, gas and solid fuels (1. A .1 c).

Every year, about half of all greenhouse gas emissions in the Energy sector are generated by the production of heat and electricity.

Currently, the production of electricity and heat in Kazakhstan is carried out by 179 power plants of various sizes and forms of ownership, the total installed capacity as of 01.01.2021 is 23,621.6 MW [19]. More than 90% of generation is provided by thermal power plants and thermal power plants. According to the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Ministry of National Economy of the Republic of Kazakhstan , the volume of electricity production in 2021 amounted to 96.69 billion kWh (+1.3% compared to 2020), the volume of heat energy amounted to 91.2 billion Gcal [3] (+1.3% by 2020). Most of the electricity generation comes from thermal steam turbine power plants that use solid fuels, which results in significant greenhouse gas emissions.

[19] C according to the data of the Kazakh Electricity Grid Operating Company KEGOC JSC https://www.kegoc.kz

Actual fuel consumption

The main consumer of fuel in the category "Energy Industry" - subcategory 1.A. 1 a "Production of electricity and heat" (table 3.9).

Table 3.9 - Detailed fuel consumption in the Energy Industry category in 2021 (sector approach)

Fuel consumed, PJ	1.A.1	1.A.1a	1.A.1b	1.A.1c
Crude oil	**70.131**	-	-	70.131
Gas condensate	**0.000**	-	-	-
Kerosene for technical purposes	**0.000**	-	-	-
Domestic stove fuel	**20.596**	20.596	-	-
heating oil	**23.786**	23.786	-	-
LPG	**0.015**	-	-	0.015
Coal stone energy	**1010.440**	1010.440	-	-
natural gas	**354.500**	345.994	-	8.506
Associated petroleum gas	**0.625**	-	-	0.625
Stripped gas	**0.000**	-	-	-

Note: 1. "– "fuel was not used.
2. To eliminate double counting, fuel used by mobile sources
(gasoline, kerosene and diesel fuel), categorized as Transport (1.A.3).

The total fuel consumption in 2021 in the Energy Industry category amounted to 1676.567 PJ, which is 1.04% more than in 1990, and 0.7% more than in 2020 (Table 3.10). For the period 1990 ... 1999. there is a downward trend in fuel consumption, and an increase in 2000 ... 2021, which corresponds to the economic situation in the country. In 2021, there is a slight decrease in fuel consumption by 47.76 PJ compared to the level of 2018 due to a decrease in the consumption of gaseous, liquid and solid fuels.

Table 3.10 - Fuel consumption in the category "Energy industry" for the period 1990 ... 2021 (sectoral approach)

Year	Total fuel, PJ	Fuel types, PJ				
		Liquid fuel	solid fuel	gaseous fuel	Other fossil fuels	Biomass
1990	**1659.19**	257.64	1068.98	291.73	39.76	1.08
1991	**1631.66**	263.58	1050.70	286.14	31.19	0.07
1992	**1351.46**	150.38	952.08	246.88	2.13	0.00
1993	**1239.20**	121.82	889.65	225.95	1.79	0.00

1994	**1106.17**	122.49	771.54	210.76	1.37	0.00
1995	**1118.61**	169.20	751.23	196.81	1.38	0.00
1996	**1031.97**	189.21	663.32	178.07	1.37	0.00
1997	**967.20**	213.44	586.22	166.05	1.49	0.00
1998	**923.11**	208.42	554.42	158.80	1.47	0.00
1999	**620.71**	58.69	430.31	131.37	0.34	0.00
2000	**707.43**	67.48	488.39	143.21	8.34	0.00
2001	**719.63**	60.65	535.99	113.92	9.07	0.01
2002	**789.19**	74.84	530.20	149.84	34.31	0.01
2003	**892.87**	82.31	590.56	167.80	52.19	0.00
2004	**1026.75**	110.72	680.98	191.76	43.29	0.00
2005	**1093.51**	116.79	670.40	213.33	92.99	0.00
2006	**1191.11**	124.47	735.41	297.90	33.33	0.00
2007	**1119.48**	100.24	736.06	251.47	31.72	0.00
2008	**1053.26**	107.71	685.72	201.61	58.21	0.00
2009	**1131.63**	100.97	763.99	266.66	0.00	0.01
2010	**1229.65**	112.01	815.32	302.32	0.00	0.00
2011	**1234.56**	97.52	839.68	297.36	0.00	0.00
2012	**1308.67**	102.21	881.86	324.60	0.00	0.00
2013	**1338.64**	144.25	940.42	253.97	0.00	0.00
2014	**1358.52**	96.55	909.91	351.65	0.00	0.41
2015	**1296.06**	114.64	832.30	348.77	0.00	0.34
2016	**1328.62**	115.44	863.16	349.60	0.00	0.42
2017	**1410.97**	120.61	928.32	361.56	0.00	0.48
2018	**1482.95**	112.24	996.41	374.21	0.00	0.09
2019	**1444.57**	108.47	1005.88	329.90	0.00	0.32
2020	**1465.52**	102.53	1003.43	359.20	0.00	0.36
2021	**1375.88**	160.28	1010.44	205.15	0.00	0.00

Emissions of direct greenhouse gases

Total greenhouse gas emissions in 2021 in the Energy industry category amounted to 144.383 million tons of CO_2 - eq ., which is 1.4% more than the level of 1990 and 0.1% less than the level of 2020 (table 3.11) **.** More than 99% of all greenhouse gas emissions are CO_2 emissions. In 2021, CO_2 emissions in this category amounted to 143.762 million tons, which is 1.4% more than in 1990 and 0.1% less than in 2020.

Table 3.11 - Dynamics of greenhouse gas emissions in the category "Energy industry" in terms of fuel types for the period 1990 ... 2021 (sectoral approach)

Year	**Total greenhouse gas emissions, million tons**	**CO_2 emissions (million tons)**

	CO_2 - equiv .	Total	Liquid fuel	solid fuel	gaseous fuel
1990	**142.369**	141.771	19.381	103.108	16.366
1991	**140.085**	139.499	19.813	101.346	16.052
1992	**117.446**	116.944	11.307	91.631	13,850
1993	**108.204**	107.741	9.312	85.622	12.676
1994	**95.769**	95.362	9.273	74.165	11.824
1995	**96.573**	96.165	12.731	72.292	11.041
1996	**88.457**	88.087	14.159	63.837	9.990
1997	**82.087**	81.746	15.905	56.416	9.315
1998	**78.213**	77.889	15.518	53.355	8.909
1999	**53,400**	53.175	4,350	41.430	7.370
2000	**60.805**	60.548	4.983	46.919	8.034
2001	**63.297**	63.020	4.473	51.491	6.391
2002	**67.701**	67.415	5.557	50.936	8.406
2003	**76.408**	76.086	6.110	56.736	9.414
2004	**87.896**	87.526	8.104	65.489	10.758
2005	**92.263**	91.882	8.614	64.481	11.968
2006	**99.443**	99.040	9.161	70.722	16.712
2007	**94.848**	94.453	7.257	70.763	14.107
2008	**89.713**	89.336	7.834	65.923	11.310
2009	**96.062**	95.661	7.204	73.498	14.959
2010	**103.753**	103.323	7.921	78.442	16.960
2011	**104.898**	104.461	7.011	80.768	16.682
2012	**110.894**	110.434	7.469	84.755	18.210
2013	**115.523**	115.028	10.435	90.345	14.248
2014	**114.552**	114.079	6.935	87.416	19.728
2015	**108.152**	107.710	8.188	79.956	19.566
2016	**111.271**	110.815	8.261	82.942	19.612
2017	**118.474**	117.985	8,500	89.201	20.283
2018	**125.237**	124.717	7.976	95.748	20.993
2019	**123.545**	123.030	7.869	96.653	18.507
2020	**124.318**	123.798	7.243	96.404	20.151
2021	**120.699**	120.170	11,592	97.070	11,509

Emissions CO2 _ from liquid fuel combustion for the period 1990…2021 showed a general downward trend. **In** 2021 CO_2 emissions from burning liquid fuels amounted to 7.243 million tons, which is 2.7 times less than in 1990 and 7.9% less than in 2020. The decrease in emissions relative to 2020 is due to a decrease in crude oil consumption.

CO_2 emissions from solid fuel combustion for the period 1990…2021 showed a general upward trend. In 2021, CO_2 emissions from the combustion of solid fuels amounted to 116.368 million tons, which is 12.9% more than in 1990 and less than in 2020 by 0.99%. A slight decrease

in greenhouse gas emissions from solid fuels in 2021 relative to 2020 is associated with a decrease in the consumption of lignite and hard coal (Figure 3.7).

Emissions of CO_2 from the combustion of gaseous fuels over the study period had a general upward trend. In 2021, $CO_{2\ emissions}$ from the combustion of gaseous fuels amounted to 20.151 million tons, which is 23.1% more than in 1990 and 8.9% more than in 2020. An 8.9% increase in emissions compared to the level 2020 is directly related to the growth in the consumption of associated petroleum gas in this category: in 2018, consumption of associated petroleum gas - 88.5 PJ, in 2020 - 47.1 PJ, in 2021 - 71.9 PJ .

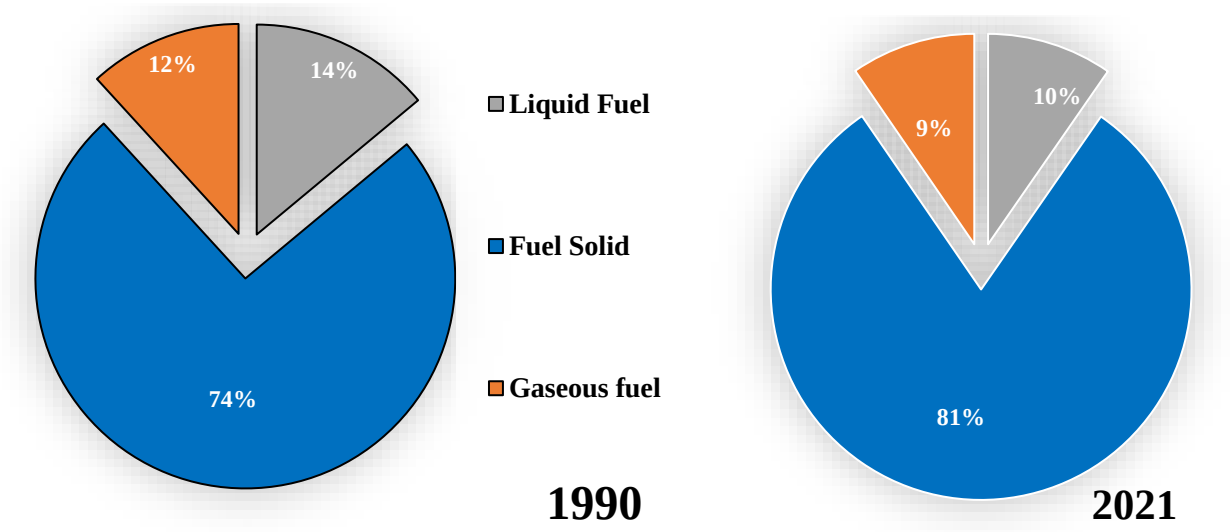


Figure 3.7 - Dynamics of the structure of greenhouse gas emissions in the category "Energy industry" (sectoral approach)

CO_2 emissions in the Energy Industry category by main sources is shown in Figure 3.8 and Table 3.12.

Table 3.12 - Greenhouse gas emissions in the category "Energy industry" for the period 1990 ... 2021 by main sources (sectoral approach)

greenhouse gases	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Total, million tons CO_2 - eq .	**142.369**	**140.085**	**117.446**	**108.204**	**95.769**	**96.573**	**88.457**	**82.087**	**78.213**	**53,400**	**60.805**	**63.297**	**67.701**	**76.408**	**87.896**	**92.263**
CO_2, ppm tons	141.771	139.499	116.944	107.741	95.362	96.165	88.087	81.746	77.889	53.175	60.548	63.020	67.415	76.086	87.526	91.882
a . Production of electricity and heat	112.393	110.108	108.041	101.018	87.282	85.261	75.030	65.951	62.340	44.809	53.558	57.403	58.418	64.343	72.235	70.614
b. Distillation oil	2.877	3.632	2.781	2.283	3,930	6.733	8.919	11.244	11.066	1.916	1.857	2.534	3.178	3.749	5.399	7.330
c . Production of oil, gas and solid fuels	26.501	25.759	6.122	4.439	4.150	4.171	4.138	4.551	4.483	6.449	5.133	3.082	5.819	7.994	9.892	13.938
CH_4, thous . tons	*2.277*	*2.229*	*1.658*	*1.488*	*1.346*	*1.436*	*1.396*	*1.405*	*1.335*	*0.743*	*0.855*	*0.858*	*1.002*	*1.162*	*1.335*	1.519
N_2O, thou.s tons	***1.815***	***1.782***	***1.543***	***1.432***	***1.253***	***1.248***	***1.126***	***1.025***	***0.974***	***0.694***	***0.791***	***0.855***	***0.875***	***0.983***	***1.132***	***1.153***

Continuation of table 3.12

greenhouse gases	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**20 19**	**2020**	**2021**
Total, million tons CO_2 - eq .	**99.443**	**94.848**	**89.713**	**96.062**	**103.753**	**104.898**	**110.894**	**115.523**	**114.552**	**108.152**	**111.271**	**118.474**	**125.237**	**123.545**	**124.318**	**120.699**
CO_2, ppm tons	99.040	94.453	89.336	95.661	103.323	104.461	110.434	115.028	114.079	107.710	110.815	117.985	124.717	123.030	123.798	120.170
a . Production of electricity and heat	75.926	77.865	74.269	81.463	86.838	89.356	95.916	95.702	99.406	92.319	93.369	102.297	109.111	109.872	110.429	111.432
b. Distillation oil	4,884	4.180	4.033	4.633	5.726	4,700	4,600	4,886	4.439	3.123	3.974	4.968	4.545	4.188	3.712	3.082
c . Production of oil, gas and solid fuels	18.229	12.408	11.035	9.565	10.759	10.405	9.918	14.439	10.233	12.268	13.472	10.720	11.061	8,970	9.656	5.656
CH_4, you . with tons	1.501	1.401	1.377	1.341	1.463	1.435	1.515	1.628	1,550	1.524	1,560	1.668	1.709	1.443	1.682	1.695
N_2O, thousand tons	***1.228***	***1.208***	***1.149***	***1.232***	***1.321***	***1.347***	***1.416***	***1.523***	***1.459***	***1.354***	***1.398***	***1.502***	***1.599***	***1.608***	***1.604***	1.633

Table 3.13 - Emissions of indirect greenhouse gases in the category "Energy industry" for 1990 ... 2021 (sectoral approach)

years	Greenhouse gases, thousand tons			
	CO	NOx	NMVOC	SO2 _
1990	32.68	423.94	8.29	711.54
1991	31.15	417.18	8.15	700.02
1992	26.27	353.16	6.76	537.79
1993	24.16	325.50	6.19	499.65
1994	21.50	287.85	5.53	410.83
1995	21.53	289.01	5.59	420.92
1996	19.69	263.82	5.16	372.66
1997	18.27	243.76	4.84	330.03
1998	17.41	232.14	4.62	312.09
1999	12.12	160.61	3.10	208.74
2000	13.77	183.15	3.53	223.64
2001	14.05	191.82	3.61	237.32
2002	15.24	203.37	3.94	259.47
2003	17.18	229.24	4.47	273.11
2004	19.76	263.86	5.14	302.80
2005	20.82	275.07	5.46	327.35
2006	23.03	296.86	5.96	332.59
2007	21.73	284.92	5.60	318.10
2008	20.23	269.13	5.27	308.32
2009	22.14	289.38	5.66	315.81
2010	24.04	312.34	6.15	327.89
2011	24.18	316.00	6.17	337.38
2012	25.65	333.62	6.54	368.29
2013	26.05	347.24	6.69	373.01
2014	26.68	345.04	6.79	357.59
2015	25.34	324.93	6.47	342.22
2016	25.99	334.47	6.63	351.54
2017	29.07	356.84	7.05	359.45
2018	29.10	377.51	7.41	384.60
20 19	28.34	372.94	7.22	366.15
2020	27.90	364.50	7.05	357.65
2021	26.03	356.81	6.65	414.31

In 2021, greenhouse gas emissions in the Energy Industry category were distributed as follows: **electricity and heat production - 76.8%, oil refining - 2.6%, oil, gas and solid fuel production - 20.6%.**

CH_4 emissions in the Energy Industry category in 2021 amounted to 1.89 thousand tons, which is 17% less than in 1990 and 13.8% more than in 2020.

N_2O emissions in the Energy Industry category in 2021 amounted to 1.922 thousand tons, which is 5.9% more than in 1990 and 0.7% less than in 2020.

Emissions of indirect greenhouse gases

For indirect greenhouse gases in the category "Energy Industry" there is a tendency to reduce emissions over the period 1990 ... 1999. and gradual, dominant growth since 2000 (table 3.13).

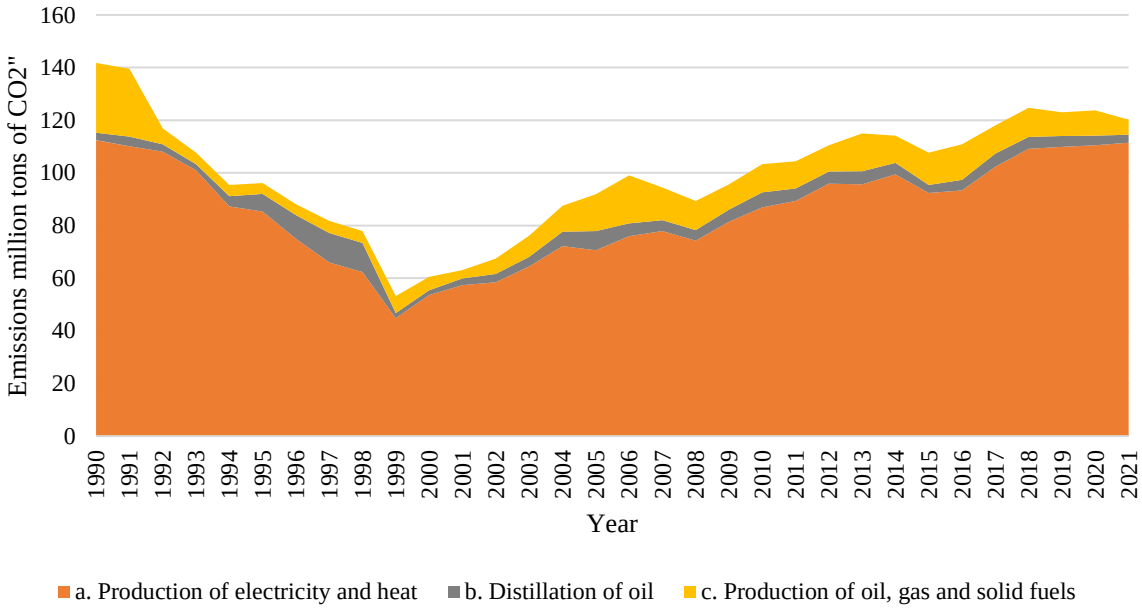


Figure 3.8 - Greenhouse gas emissions in the category "Energy industry" for 1990 ... 2021 by main sources (sectoral approach, million tons).

3.4.1.2 Methodological approaches

Calculation methodology

Estimation of direct emissions in the category "Energy industry" for the period 1990 ... 2021 was carried out in accordance with the 2006 IPCC Guidelines. For the calculation of greenhouse gas emissions, the Tier 1 method was used with statistical data on the volumes of all fuels burned in the energy industry and default emission factors (Table 3.8 - Emission Factors in the Energy Sector). An exception is the coefficient of the net calorific value of the lowest for domestic stove fuel. Source of information - LLP "Atyrau Oil Refinery" - the main producer of domestic stove fuel in the country. A letter from the enterprise on the calorific value of the produced household furnace fuel, which was determined by the laboratory, was attached in the responses to the expert team for the Greenhouse Gas Inventory Review (Provisional main findings_CR_2020_Kazakhstan) . _ _ _

Calculations of emissions of indirect greenhouse gases (CO , NOx , NMVOC) are carried out in accordance with the IPCC Guidelines 2006. The coefficients for these greenhouse gases are also assumed by default.

Calculations of SO_2 emissions are carried out at Tier 2 with coefficients that were calculated in accordance with the IPCC Guidelines (2006). The calculation was carried out for those types of fuel for which there were data on the sulfur content in the fuel, the sulfur content in the ash, and also there was information on the technologies used to reduce emissions of sulfur oxides.

In order to eliminate double counting of fuels in the Energy Industry category, gasoline, kerosene and diesel fuel used by mobile sources are classified as Transport (1.A.3).

Initial data

The source of data for calculating greenhouse gas emissions in the Energy Industry category is the data of the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan on the volume of fuel burned in the energy industry and during fuel extraction.

The source of data on the volumes of fuel burned for 1990 was the Fuel Balance of the USSR, in the part that concerns the Kazakh SSR.

Due to the absence of the fuel balance of the Republic of Kazakhstan, various reference books and bulletins of national statistics served as the source of data on the volumes of fuel burned for 1991 ... 1998, which reflected the consumption of fuel and energy resources in the context of economic activities.

Main data source for 1999…2021 - Fuel and Energy Balance (FEB) of the Republic of Kazakhstan, which is formed annually by the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Ministry of National Economy of the Republic of Kazakhstan. The information base of the TEB is the developed and approved statistical reporting form No. 1-TEB (annual periodicity), which tracks all types of fuel and energy resources in the republic.

To control the data of the expenditure part of the fuel and energy balance, data from large enterprises of the Republic of Kazakhstan on fuel consumption and the amount of products produced, obtained by written requests, are used.

When calculating greenhouse gas emissions, the initial data on fuel consumption in natural units of measurement (tonne, thousand cubic meters, thousand kWh, thousand Gcal) were used.

3.4.1.3 Uncertainty assessment

Activity data for estimating greenhouse gas emissions in the Energy Industry category is provided by national energy reporting. According to the 2006 IPCC Guidelines, national data are recognized as sufficiently accurate. In countries with a well-developed statistical system, the uncertainty of statistics on fuel combustion in the energy industry is less than 1%. The Republic of Kazakhstan can be attributed to countries with such a data collection system, so the total uncertainty in data on fuel combustion activities is taken as 1%.

Biomass data are not as reliable as fossil fuel data, so the uncertainty in biomass activity data is assumed to be 30%.

According to the IPCC Guidelines (2006) for the combustion of fossil fuels, the uncertainty in CO_2 emission factors is relatively small. For all categories of sources of the sector "Energy", the total value of the uncertainty of the $CO_{2\ coefficients}$ is taken as 7 %.

The emission factors for CH_4 and in particular N_2O are largely uncertain. The high uncertainty can be attributed to a lack of appropriate measurements and subsequent generalization, uncertainties in measurements, or a lack of understanding of the emission process. For the energy industry in Kazakhstan, the uncertainty estimate for CH_4 and N_2O is 50%.

3.4.1.4 QA/QC procedure

To eliminate errors when transferring national statistical data to calculation tables, a TEB form in Excel format was developed , where data for each type of fuel used is checked in several stages.

At the first stage, when entering the initial data into the calculation tables, the sum of the total volume of fuel (resource part) is automatically calculated taking into account production,

imports and balances at the beginning of the year, which is compared with the data of the fuel and energy balance. At the second stage of quality control, when entering the initial data, the sum of the total fuel consumption in the country (distribution part) is automatically calculated, taking into account exports, balances at the end of the year and losses, which is also compared with the FEB data. At the third stage, the balance of the resource and distribution parts is checked. At the fourth stage, the distribution of final consumption by type of economic activity is checked. These measures allow you to identify errors in the input of initial data.

To eliminate double counting of fuels and control data, consultations are held on an ongoing basis with specialists who calculate greenhouse gas emissions in the Transport and Fugitive Emissions categories, as well as in the Industrial Processes and Product Use sector.

3.4.1.5 Recalculations

Recalculations of the time series of greenhouse gas emissions by category "Energy industry" in the "Energy" sector were made for 1990-2017.

In connection with the comments of the expert group of the Secretariat (Provisional main findings_ CR_2020_Kazakhstan, table 1, E6) . In order to improve reporting and transparency of data in the CRF tables in category 1.A.1, data on consumption and greenhouse gas emissions for crude oil and gas condensate (natural gas liquid) divided for 1990...2020. In accordance with this, the time series of CO_2 emissions for crude oil was recalculated . A separate time series for gas condensate has been formed with its own greenhouse gas emission factors for 1990…2020. In this regard, the total values of greenhouse gas emissions for liquid fuels in these categories have slightly changed.

3.4.1.6 Planned improvements

Improvement of the inventory of emissions in the category "Energy Industry" is planned by taking into account information from the Ministry of Energy of the Republic of Kazakhstan, analytical and reference materials on fuel consumption in the country in order to control the data on the expenditure part of the fuel and energy balance of national statistics. In order to improve and improve transparency in the reporting of greenhouse gas emissions estimates in this category, it is planned to take into account, if possible, all the comments of the expert team on the Greenhouse Gas Inventory Review.

In response to comments from the Secretariat Expert Group (2020 KAZQA 380). CRF , category 1.A.1 - Other fuels, the following should be noted. In CRF for 2009…2017 for other types of fuel, the key was changed from “ IE ” to “ NA ”, since since 2009 there are no data on the consumption of other types of fuel in the fuel and energy balance of national statistics. Such data were provided by national statistics for the period 1990-2008. Since 2009, data have not been available in the TEB, due to the lack of a code in the statistical classifier for industrial products (SCPP). However, according to the experts who form the fuel and energy balance, other types of fuel are taken into account in the corresponding types of fuel (liquid, solid, gaseous). Thus, CO_2 emissions and consumption of other types of fuel for this period are taken into account in the "Energy" sector. In order to improve the reporting of the GHG inventory, data on the consumption of other fuels for these years was repeatedly requested from the national statistics. But for objective reasons, they cannot provide them.

CO_2 emission factors to more accurately estimate greenhouse gas emissions in the Energy category.

3.4.2 Manufacturing and construction (1.A.2 CRF)

3.4.2.1 Overview

The category "Manufacturing industry and construction" includes greenhouse gas emissions from fuel combustion in all industries of the Republic of Kazakhstan for own and technological needs:

- 1.A.2a "Ferrous metallurgy",
- 1.A.2 b "Non-ferrous metallurgy",
- 1.A.2 c "Chemical industry",
- 1.A.2 d "Pulp and paper industry",
- 1.A.2 e "Food industry"
- 1.A.2 f "Production of non-metallic mineral products"
- 1.A.2 g "All other industries" ("Mining", "Textiles and leather", "Manufacture of vehicles and equipment", "Machinery and mechanisms", "Timber and timber", "Construction", " Industries not listed.

Detailed fuel consumption in the category "Manufacturing industry and construction" in 2021 and the dynamics of fuel consumption for 1990…2021 are presented in tables 3.15, 3.15a and 3.16.

The dynamics of fuel consumption in the category "Manufacturing industry and construction" tends to decrease from 1990 to 1998, except for a large increase in fuel consumption in 1992 to 410.994 PJ from 243.113 PJ observed a year earlier. This is followed by a gradual increase from 233.288 PJ in 1999 to 434.615 PJ in 2017. In 2021, fuel consumption in this category amounted to 320.268 PJ, which is 22.8% more than the level of 1990, 4.3% more than the level fuel consumption recorded in 2020. The increase in fuel consumption in the category

"Manufacturing industry and construction" was due to the appearance of associated petroleum gas consumption in subcategory 1.A.2a "Ferrous metallurgy". The consumption of this type of fuel was completely absent in 2020, while starting from 2013 to 2018. data on the consumption of petroleum associated gas were present in the FEB.

Table 3.15 - Detailed fuel consumption in the category "Manufacturing and construction" in 2021 (sector approach, PJ)

Fuel	**1.A.2**	1.A.2a	1.A.2b	1.A.2c	1.A.2d	1.A.2e	1.A.2f	1.A.2g
Crude oil	**-**	-	-	-	-	-	-	-
Kerosene for technical purposes	**0.008979**	0.003	0.005	-	-	0.000	0.000	0.001
Domestic stove fuel	**15.845887**	14.917	-	0.150	0.058	0.516	0.204	-
heating oil	**13.661583**	1.831	8,940	0.524	0.212	1.232	0.795	0.128
LPG	**4.5115402**	1,840	0.080	0.183	0.482	1.070	0.856	0.002
Bitumen	**11.238111**	-	-	-	-	-	11.238	-
Lubricating oil	**0.553956**	0.097	0.074	0.021	-	0.067	0.289	0.007
Coal stone energy	**122.8122**	23.035	65.243	0.422	0.031	1.687	32.335	0.059
natural gas	**41.640808**	9.190	2.981	12.568	1.678	8.328	6.658	0.238

Note: 1. “– “fuel was not used.

2. In order to eliminate double counting, fuels used by mobile fuel sources (gasoline, kerosene and diesel fuel) are categorized as "Transport" (1.A.3).

3. In order to eliminate double counting, the consumption of coke and coal concentrate in ferrous and non-ferrous metallurgy is classified as sector "Industrial processes and use of products".

Table 3.16 - Fuel consumption in the category "Manufacturing industry and construction" for 1990 ... 2021 (sectoral approach)

Year	Total, PJ	Fuel consumption, PJ				
		Liquid fuel	solid fuel	gaseous fuel	Other fossil fuels	Biomass
1990	**233.968**	67.025	112.155	51.564	3.004	0.218
1991	**228.808**	66.576	110.827	50.886	0.309	0.211
1992	**410.944**	120.299	188.821	98.679	2.657	0.489
1993	**319.224**	100.458	151.177	65.134	2.089	0.367
1994	**212.859**	63.727	105.785	41.507	1.614	0.225
1995	**179.540**	55.741	90.910	31.124	1.616	0.150
1996	**153.247**	48.348	77.716	25.630	1.410	0.142
1997	**152.492**	50.921	75.799	23.791	1.795	0.186
1998	**143.521**	47.508	72.948	21.293	1.592	0.180
1999	**233.288**	29.733	153.226	13.303	36.999	0.025
2000	**261.819**	28,300	163.247	28.848	41.319	0.105
2001	**280.845**	26.730	183.435	20.496	50.079	0.104
2002	**310.804**	31.038	189.111	39.364	51.165	0.126
2003	**325.222**	33,950	200.041	38.913	52.217	0.101
2004	**292.155**	32.055	206.770	35,930	17.340	0.060
2005	**338.512**	39.713	213.796	44.072	40.835	0.095
2006	**381.990**	91.611	239.348	50.946	0.031	0.054
2007	**386.326**	43.015	277.239	63.486	2.523	0.063
2008	**352.565**	46.849	256.024	49.009	0.609	0.074
2009	**344.593**	39.001	258.073	47.448	0	0.072
2010	**344.295**	39.172	261.452	43.560	0	0.112
2011	**354.256**	33.519	273.693	46.809	0	0.234
2012	**354.550**	36.120	267.514	50.697	0	0.219
2013	**333.745**	37.281	240.517	55.839	0	0.107
2014	**413.076**	34.025	323.056	55.426	0	0.568
2015	**436.823**	47.831	334.149	54.793	0	0.050
2016	**422.339**	34,740	338.706	48.514	0	0.379
2017	**433.241**	41.259	339.281	52.317	0	0.384
2018	**423.884**	37.580	329.715	56.217	0	0.372
2019	**305.498**	41.552	228.241	35.323	0	0.382
2020	**318.929**	39.540	229.724	49.605	0	0.061
2021	**495.848**	195.355	173.691	126.782	0	0.021

Emissions of direct greenhouse gases

In 2021, the total greenhouse gas emissions in the Manufacturing and Construction category amounted to 25.130 million tons of CO_2-eq. which, relative to the level of 1990, is 44.2% more, and 1.4% more relative to the level of 2020 (Table 3.17).

Table 3.17 - Greenhouse gas emissions in the category "Manufacturing industry and construction" for 1990 ... 2021 by industries (sectoral approach)

Greenhouse gases	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Total, million tons of CO_2-eq.	**18.863**	**18.478**	**33.556**	**26.423**	**17.801**	**15.565**	**13,490**	**13.825**	**12,950**	**20.359**	**22.107**	**24.670**	**26.050**	**27.196**	**24.907**	**28.532**
***CO_2*, million tons**	18.764	18.380	33.387	26.288	17.708	15.485	13.421	13.757	12.875	20.239	21.981	24.531	25.905	27.044	24.757	28.368
Ferrous metallurgy	7.752	7.058	11.021	8.273	5.623	5.577	4.667	5.681	4,847	8.510	9.284	11.005	11.324	11.708	9.874	12.261
Non-ferrous metallurgy	2.497	2.280	4.551	4.423	3.857	4,000	4.124	4.108	4.543	7.685	7.255	5.953	6.083	6.290	6.152	7.740
Chemical industry	1.904	1.368	3,560	1,841	1.097	1.128	0.907	0.681	0.415	0.207	0.372	0.596	0.693	0.406	0.202	0.214
Pulp and paper industry	0.039	0.044	0.095	0.061	0.033	0.021	0.024	0.042	0.039	0.011	0.004	0.002	0.010	0.011	0.036	0.025
food industry	0.772	0.746	3.106	2.907	2.366	1.531	1.329	1.374	1.347	0.765	0.838	1.097	1.078	1.022	1.129	1.061
non-metal minerals	4,848	5.954	3.125	2.079	1.060	0.728	0.496	0.386	0.413	0.706	0.808	1.266	1.601	1.832	2.113	2.403
Other industries	0.951	0.931	7.929	6.704	3.671	2,500	1.874	1.485	1.271	2.355	3.419	4.612	5.116	5.776	5.252	4,664
*- mining industry**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.913	2.827	3.789	4.362	4,920	4.202	3.652
*- construction**	0.000	0.000	2.033	1.427	1,000	0.615	0.388	0.401	0.421	0.098	0.162	0.234	0.203	0.275	0.377	0.406
***CH_4*, thousand tons**	***1.386***	***1.374***	***2.365***	***1.894***	***1.304***	***1.124***	***0.971***	***0.950***	***0.897***	***1.567***	***1,580***	***1.713***	***1,801***	***1,840***	***1.867***	***2.072***
***N_2O*, thousand tons**	***0.216***	***0.212***	***0.369***	***0.294***	***0.203***	***0.173***	***0.149***	***0.149***	***0.178***	***0.271***	***0.290***	***0.323***	***0.336***	***0.357***	***0.344***	***0.375***

Continuation of table 3.17

Greenhouse gases	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total, million tons of CO_2-eq.	**29.249**	**31.435**	**28,900**	**28.368**	**28.707**	**29.595**	**29.565**	**27,500**	**34.913**	**37.207**	**36.245**	**36.915**	**35.918**	**25.549**	**26.326**	**41.133**
***CO_2*, million tons**	29.073	31.234	28.713	28.183	28.520	29.401	29.374	27.327	34.681	36.964	36.002	36.670	35.679	25.381	26.158	40.960
Ferrous metallurgy	7.607	10.064	8.426	9.757	8.423	8.469	9.627	9.518	17.874	19.483	20.443	20,870	20.556	10.576	11.007	9.106
Non-ferrous metallurgy	11,898	11.633	11.371	9.857	11.137	11,393	10.443	8.073	7.004	7.254	7.677	7.551	7.566	7.682	7.744	8.239
Chemical industry	0.354	0.407	0.384	0.534	0.333	0.721	0.727	0.695	0.603	0.698	0.444	0.518	0.589	0.359	0.517	2.012
Pulp and paper industry	0.029	0.043	0.013	0.028	0.031	0.012	0.010	0.034	0.006	0.044	0.045	0.057	0.053	0.041	0.043	0.478
food industry	1.056	1.945	1.434	0.996	1.416	0.391	0.669	0.645	0.674	1.159	0.734	0.719	0.737	0.824	0.721	1.256
non-metal minerals	2.751	2.414	2.156	2.476	2.997	3.691	3.067	3.863	4.149	3,894	2.972	3.421	3.293	3.242	3.283	4.915
Other industries	5.379	4.729	4,930	4.535	4.183	4.724	4,831	4.499	4.371	4.433	3.687	3.534	2.885	2.656	2.843	14.954
*- mining industry**	3.904	3.314	3.471	3.476	3.359	3.942	3.885	3.613	3.506	3.042	2.723	2.679	2.083	1.885	2.092	7,844
*- construction**	0.734	0.824	0.761	0.589	0.613	0.542	0.581	0.593	0.570	0.600	0.504	0.419	0.400	0.373	0.396	6.263
***CH_4*, thousand tons**	***2.292***	***2,680***	***2.447***	***2.448***	***2.496***	***2.558***	***2.508***	***2.276***	***3.126***	***3.290***	***3.339***	***3.376***	***3.324***	***2.293***	2.289	2.273
***N_2O*, thousand tons**	***0.397***	***0.449***	***0.419***	***0.416***	***0.420***	***0.436***	***0.431***	***0.390***	***0.514***	***0.538***	***0.536***	***0.539***	***0.524***	***0.372***	0.373	0.390

Note: * Mining and construction data are from 1999.
For the period 1990 ... 199 9 are included in the total amount "Other industries".

Over 99% of greenhouse gas emissions from manufacturing come from CO_2. According to the dynamics of fuel consumption, in the manufacturing industry there is a reduction in greenhouse gas emissions over the period 1990-1998. except for a significant increase in fuel consumption in 1992. From 1999 to 2017, as in the case of fuel consumption, greenhouse gas emissions tend to increase gradually. In 2020, there is a significant reduction in greenhouse gas emissions due to a sharp decrease in the consumption of coking coal in the industry 1.A.2a "Ferrous metallurgy" and then a slight increase in 2021. The source of greenhouse gas emissions is mainly the combustion of solid fuels (Figure 3.9).

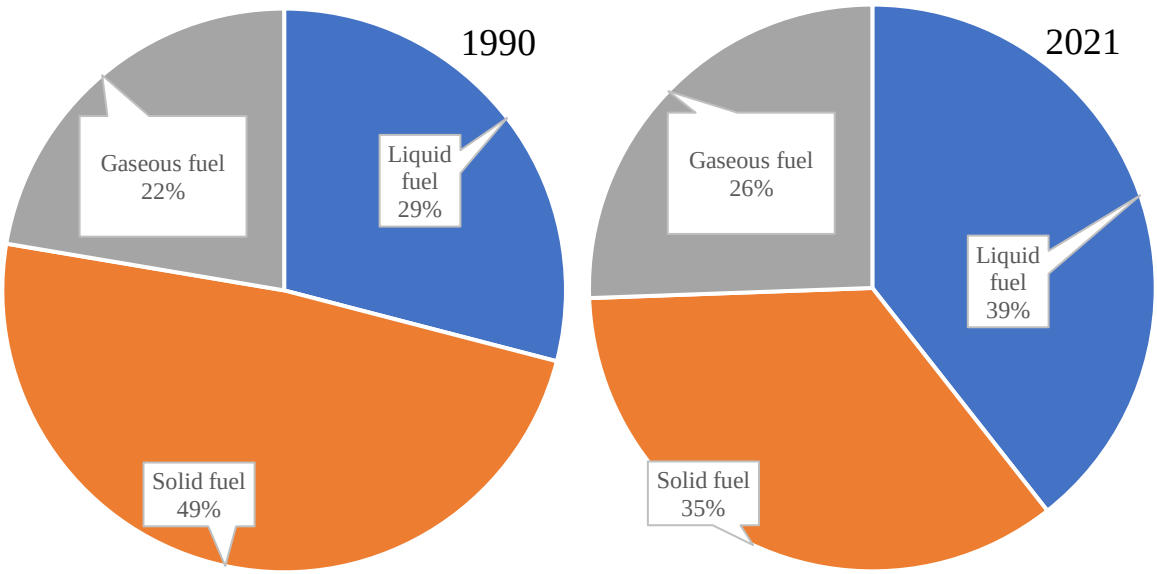


Figure 3.9 - Dynamics of the structure of greenhouse gas emissions in the category "Manufacturing industry and construction" (sectoral approach)

CO_2 emissions in the Manufacturing and Construction category in 2021 amounted to 24.961 million tons, which is 44.1% more than in 1990 and 1.4% more relative to the level of 2020 (Table 3.18).

CO_2 emissions from liquid fuel combustion for 1990…2021 over the study period showed a general downward trend. **In** 2021 CO_2 emissions amounted to 2.963 million tons: 41.5% less than in 1990, 5.1% less than in 2020. Reduced $CO_{2\ emissions}$ compared to the level of 2020 is associated with a reduction in the consumption of heating oil in the ferrous metallurgy.

CO_2 emissions from solid fuel combustion in 1990…2021 showed a general upward trend. In 2021, $CO_{2\ emissions}$ from solid fuel combustion amounted to 20.179 million tons: compared to the 1990 level, $CO_{2\ emissions}$ from solid fuel combustion in 2021 are slightly less than 2 times. Compared to 2020 levels, CO_2 emissions increased slightly (1%) due to an increase in fuel consumption in sub-category 1.A.2 g “All other industries”.

CO_2 emissions in the category "Manufacturing industry and construction" for 1990 ... 2021 (sectoral approach)

Year	Total greenhouse gas emissions, mln tons CO2-eq.	$_2$ emissions , million tons				
		Total	Liquid fuel	solid fuel	gaseous fuel	Other fossil fuels
1990	**18.863**	18.764	5.068	10,582	2.893	0.220
1991	**18.478**	18.380	5.025	10.478	2.855	0.023
1992	**33.556**	33.387	9.141	18.515	5.536	0.195
1993	**26.423**	26.288	7.636	14.845	3.654	0.153
1994	**17.801**	17.708	4,854	10.408	2.329	0.118
1995	**15.565**	15.485	4.240	9.381	1.746	0.119
1996	**13,490**	13.421	3.688	8.192	1.438	0.103
1997	**13.825**	13.757	3.874	8.417	1.335	0.132
1998	**12,950**	12.875	3.618	7.946	1.195	0.117
1999	**20.359**	20.239	2.292	14,730	0.503	2.713
2000	**22.107**	21.981	2.179	15.720	1.052	3.030
2001	**24.670**	24.531	2.047	17.662	1.150	3.672
2002	**26.050**	25.905	2.385	18.213	1.554	3.752
2003	**27.196**	27.044	2.609	19.229	1.377	3.829
2004	**24.907**	24.757	2.454	19.878	1.154	1.272
2005	**28.532**	28.368	3.040	20.552	1.782	2.995
2006	**29.249**	29.073	3.908	23.106	2.057	0.002
2007	**31.435**	31.234	3.261	25.065	2.723	0.185
2008	**28,900**	28.713	3.537	23.069	2.063	0.045
2009	**28.368**	28.183	2.974	23.090	2.119	0
2010	**28.707**	28.520	2.994	23.833	1.693	0
2011	**29.595**	29.401	2.544	25.010	1.847	0
2012	**29.565**	29.374	2.735	24.515	2.124	0
2013	**27,500**	27.327	2.811	22.051	2.465	0
2014	**34.913**	34.681	2.543	29.580	2.558	0
2015	**37.207**	36.964	3.525	30.680	2.759	0
2016	**36.245**	36.002	2.619	30.983	2,400	0
2017	**36.915**	36.670	3.110	30.996	2.563	0
2018	**35.918**	35.679	2.819	30.138	2.722	0
2019	**25.549**	25.381	3.121	20.763	1.496	0
2020	**26.326**	26.158	2.963	20.951	2.243	0
2021	**41.133**	40.960	14.774	19.667	6.519	0

In 2021, CO_2 emissions from the combustion of gaseous fuels amounted to 1.818 million tons, which is 32.9% less than in 1990. As for the 2020 level, greenhouse gas emissions increased by 21.5% due to an increase in associated petroleum gas consumption from 0 to 9.5 PJ.

Main sources of greenhouse gas emissions in the category "Manufacturing industry and construction": ferrous and non-ferrous metallurgy, production of non-metallic minerals, mining industry (Fig. 3.10 - 3.11).

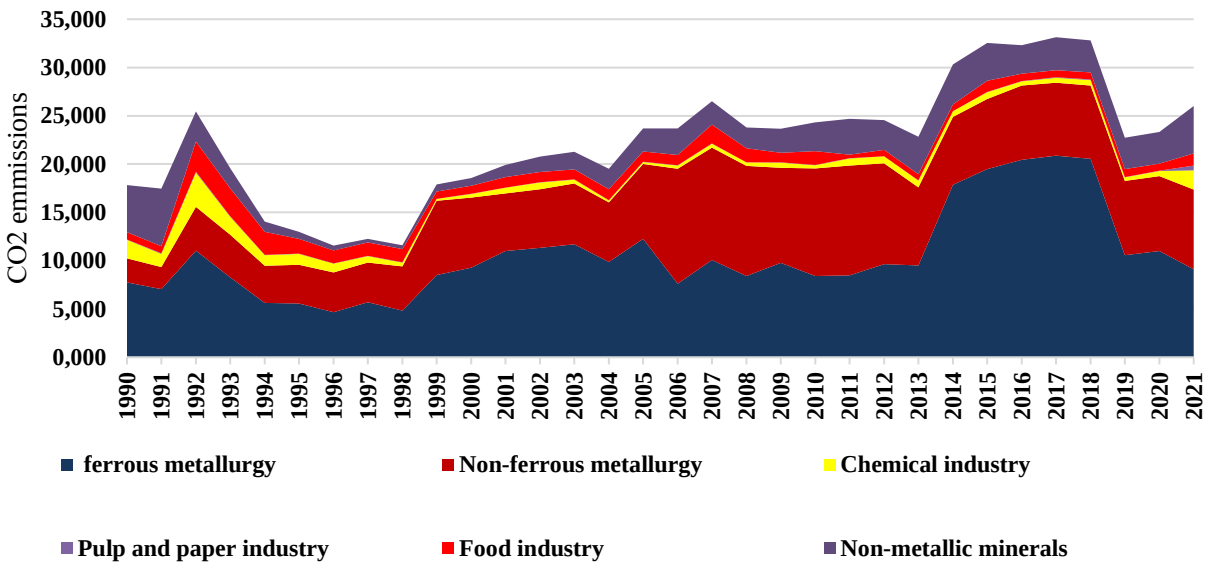


Figure 3.10 - Greenhouse gas emissions in the category "Manufacturing industry and construction" by main sources for 1990 ... 2021 (million tons of CO_2-eq.)

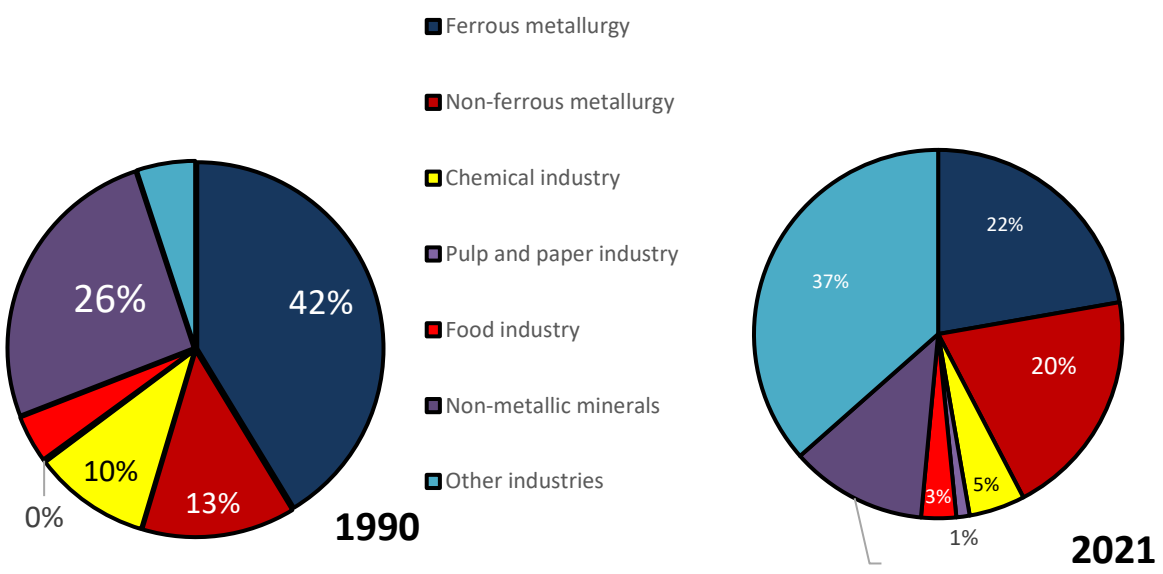


Figure 3.11 -Share of greenhouse gas emission sources in the Manufacturing and Construction category (1 - ferrous metallurgy, 2 - non-ferrous metallurgy, 3 - chemical industry, 4 - food industry, 5 - non-metallic minerals, 6 - other industries)

$_2$ emissions by greenhouse gas emission sources in 2021 amounted to:

- in the subcategory "Ferrous metallurgy" - 9.810 million tons, which is 55.3% more compared to the level of 1990, less than 0.1% compared to the level of 2020;

- in the non-ferrous metallurgy subcategory - 7.744 million tons, which is 3.1 times more than emissions for 1990, compared to the level of 2020 - practically unchanged (+0.8%);

- in the sub-category "Production of non-metallic minerals" - 3.283 million tons, which is 32.3% less compared to the level of 1990, and more than 1.3% compared to the level of 2020;

- in the subcategory "All other industries - 2.843 million tons, which is almost 3 times more than the level of 1990, compared to the level of 2020 - more by 7%. About 70% of greenhouse gas emissions in this sub-category come from the mining industry.

Emissions of CH_4 in the category "Manufacturing industry and construction" in 2021 amounted to 1.882 thousand tons, which is 32.8% more compared to the level of 1990, compared to the level of 2020, $CH_{4\ emissions}$ decreased by 18.4%.

Emissions of N_2O in the category "Manufacturing industry and construction" in 2021 amounted to 0.397 thousand tons, which is 80.5% more compared to the level of 1990, compared to the level of 2020, $N_2O_{emissions}$ increased by 5.9% .

Emissions of indirect greenhouse gases

For the period 1990 ... 2021. in the category "Manufacturing industry and construction" for emissions of indirect greenhouse gases, as well as for direct greenhouse gases, there is a general downward trend for the period 1990-1998. and gradual growth from 1999 to 2017 (table 3.19). In the period 2018-2021 a decrease is observed.

Table 3.19 - Emissions of indirect greenhouse gases in the category "Manufacturing industry and construction" for 1990 ... 2020 (sectoral approach)

years	Greenhouse gases, thousand tons			
	CO	NOx	NMVOC	SO2 _
1990	**20.144**	57.690	2.955	106.110
1991	**20.158**	57.040	2.946	100.910
1992	**33.035**	96.060	4,888	217.620
1993	**26.650**	77.310	3.951	180.890
1994	**18.754**	52.950	2.756	121.080
1995	**17.438**	48.180	2.564	106.320
1996	**15.582**	42.620	2.275	94.490
1997	**16.926**	45.780	2.468	98.820
1998	**15.982**	42.930	2.317	94.270
1999	**21.883**	61.310	3.221	102.560
2000	**22.661**	67.230	3,350	102.520
2001	**24.612**	74,550	3.660	104.680
2002	**25.475**	79.080	3.821	115.580
2003	**26.146**	83.090	3.961	123.790
2004	**27.247**	77.290	3.953	113.950
2005	**29.631**	86.870	4.362	133.730
2006	**33.405**	89.860	4.783	142.640
2007	**39.864**	102.210	5.624	144.090
2008	**36.178**	94,000	5.131	133.490

2009	**36.346**	92.750	5.123	134.700
2010	**37.256**	94.580	5.233	134,500
2011	**38.674**	97.730	5.401	128.770
2012	**37.574**	95.560	5.251	133.740
2013	**33.996**	88.390	4,803	118.850
2014	**47.720**	112.590	6.481	131.240
2015	**48.917**	118.550	6.814	145.780
2016	**49.645**	116.240	6.854	141.690
2017	**50.083**	118.280	6.939	147.993
2018	**49.510**	115.213	6.837	143.243
20 19	**33.080**	81.445	4,680	120.817
2020	**12.653**	35.216	1.811	51.318
2021	**3,950**	42.550	1.160	40.050

3.4.2.2 Methodological approaches

Calculation methodology

Assessment of direct greenhouse gas emissions in the category "Manufacturing industry and construction" for the period 1990 ... 2021 was carried out in accordance with the IPCC Guidelines (2006). The Tier 1 method was used to calculate greenhouse gas emissions, with statistics on the volumes of all types of fuels burned in industries and default IPCC emission factors (Table 3.8). An exception is the coefficient of the net calorific value of the lowest for domestic stove fuel. Source of information - LLP "Atyrau Oil Refinery" - the main producer of domestic stove fuel in the country. A letter from the enterprise on the calorific value of the produced household furnace fuel, which was determined by the laboratory, was attached in the responses to the expert team for the Greenhouse Gas Inventory Review (Provisional main findings_CR_2020_Kazakhstan) . _ _ _

Estimate of indirect greenhouse gas emissions in the category "Manufacturing industry and construction" for 1990 ... 2021. was carried out in accordance with the IPCC Guidelines (2006). Calculations of $SO_{2\ emissions}$ are carried out at Tier 2 with coefficients that were calculated in accordance with the IPCC Guidelines (2006).

In order to eliminate double counting in the category "Manufacturing industry and construction" , gasoline, kerosene and diesel fuel, which was used as a motor fuel, are classified as "Transport" (1.A.3).

In order to eliminate double counting, the volumes of coke consumption in the IPPU sector (ferrous and non-ferrous metallurgy) are not recorded in the Energy sector.

Initial data

The source of statistical data for calculating greenhouse gas emissions in the category "Manufacturing industry and construction" is the data of the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Ministry of National Economy of the Republic of Kazakhstan on the volume of fuel burned in all industries of the Republic of Kazakhstan.

The source of data on the volumes of fuel burned for 1990 was the Fuel Balance of the USSR, in the part that concerns the Kazakh SSR.

Due to the absence of the fuel balance of the Republic of Kazakhstan, various reference books and bulletins of national statistics served as the source of data on the volumes of fuel burned

for 1991 ... 1998, which reflected the consumption of fuel and energy resources in the context of economic activities.

Main data source for 1999…2021 - Fuel and Energy Balance (FEB) of the Republic of Kazakhstan, which is formed annually by the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Ministry of National Economy of the Republic of Kazakhstan. The information base of the TEB is the developed and approved statistical reporting form No. 1-TEB (annual periodicity), which tracks all types of fuel and energy resources in the republic.

To control the national energy reporting data for recent years, data from large enterprises of the Republic of Kazakhstan on fuel consumption and the amount of output obtained through written requests are used.

To avoid double counting in the calculation of $CO_{2\ emissions}$ in the sub-category Manufacturing and Construction (1.A.2 CRF) and the Industrial Processes and Product Use Sector 2 CRF, the amount of $CO_{2\ emissions}$ obtained from the combustion of gaseous fuel for pellet production calculated in the industrial processes sector was subtracted from sub-category 1.A.2 g "All other industries", namely from "Mining".

When calculating greenhouse gas emissions, the initial data on fuel consumption in natural units of measurement (tonne, thousand cubic meters, thousand kWh, thousand Gcal) were used.

3.4.2.3 Uncertainty assessment

The initial data for estimating greenhouse gas emissions in the Manufacturing and Construction category are provided mainly by national statistics. According to the 2006 IPCC Guidelines, national data are recognized as sufficiently accurate. The level of uncertainty of statistical data on fuel combustion in the category "Manufacturing industry and construction" in countries with a well-developed statistical system is 2-3%. Kazakhstan can be classified as a country with a good data collection system. Therefore, the overall uncertainty in fuel combustion activity data is assumed to be 3%.

Biomass data are not as reliable as fossil fuel data, so the uncertainty in biomass activity data is assumed to be 30%.

According to the IPCC Guidelines (2006) for the combustion of fossil fuels, the uncertainty in $CO_{2\ emission\ factors}$ is relatively small. For all categories of sources of the sector "Energy", the total value of the uncertainty of the $CO_{2\ coefficients}$ is taken as 7 %.

The emission factors for CH_4 and in particular N_2O are largely uncertain. The high uncertainty can be attributed to a lack of appropriate measurements and subsequent generalization, uncertainties in measurements, or a lack of understanding of the release process. In the absence of Kazakhstan-specific uncertainty estimates for CH_4 and N_2O emission factors , default values of uncertainty are used, which are derived from indicators adopted in the EMEP / CORINAIR Guidelines (1999). For the manufacturing industry in Kazakhstan, the uncertainty estimate for CH_4 and N_2O is 50%.

3.4.2.4 QA/QC procedure

For assessment and quality control, standard procedures were used, including control of the initial data of the fuel and energy balance and a comparative assessment of greenhouse gas emissions for different years.

In accordance with the recommendations of the IPCC, in order to eliminate errors when transferring the initial data of the thermopile into the calculation tables, a form was developed where the data for each type of fuel used is checked in several stages. At the first stage, when entering the initial data into the calculation tables, the sum of the total volume of fuel (resource

part) is automatically calculated taking into account production, imports and balances at the beginning of the year, which is compared with the data of the fuel and energy balance. At the second stage of quality control, when entering the initial data, the sum of the total fuel consumption in the country (distribution part) is automatically calculated, taking into account exports, balances at the end of the year and losses, which is also compared with the FEB data. At the third stage, the balance of the resource and distribution parts is checked. At the fourth stage, the distribution of final consumption by type of economic activity is checked. These measures allow you to identify errors in the input of initial data.

To control national statistical data, data on fuel consumption and the amount of output produced by large enterprises in Kazakhstan were used.

3.4.2.5 Recalculations

Recalculations of the time series of greenhouse gas emissions were made for the category "Manufacturing industry and construction" in the "Energy" sector for 1990-2017.

In connection with the comments of the expert group of the Secretariat (Provisional main findings_ CR_2020_Kazakhstan, table 1, E6). In order to improve reporting and transparency of data in the CRF tables in category 1.A.2 (all types of activities), data on crude oil and gas condensate (natural gas liquid) are listed separately. In accordance with this, the time series of CO_2 emissions for crude oil was recalculated . A separate time series for gas condensate has been formed with its own greenhouse gas emission factors for 1990…2017. In this regard, the total values of greenhouse gas emissions for liquid fuels in these categories have slightly changed.

To avoid double counting in the calculation of $CO_{2\ emissions}$ in the sub-category Manufacturing and Construction (1.A.2 CRF) and the Industrial Processes and Product Use Sector 2 CRF, the amount of $CO_{2\ emissions}$ obtained from the combustion of gaseous fuels for the production of pellets and sinter , calculated in the sector of industrial processes, was subtracted from subcategory 1.A.2a "Ferrous metallurgy", thereby recalculating the time series. At the same time, in order to prevent double counting in emissions from solid fuel combustion , data on $CO_{2\ emissions}$ obtained from the combustion of coke breeze for the production of sinter were provided for subsequent subtraction from the total emissions (Table 3.20). This recalculation of time series is carried out in view of the observation made by the IPCC group for the industrial sector. More detailed information regarding the initial data and the formulas used is indicated in the sections dedicated to the industrial sector.

Table 3.20 - Recalculation data in sub-category 1A2a "Ferrous metallurgy" in 2023 (sectoral approach)

1A2a Ferrous metallurgy	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
The amount of coke oven gas required Aglom. furnace, million m3	65.088	65.268	64.908	65.629	64.187	67.070	61.304	75,500	98.947	77.491	57.473	52.280	43.409	44.617	35.512	51.746
amount of blast-furnace gas, million m3	151.865	152.292	151.451	153.133	149.763	156.496	143.042	176.166	230.877	180.813	181.867	183.838	152.273	166.383	160.290	152.211
Consumption of natural gas for the production of pellets, million m3	317.411	316.273	290.853	232.776	197.185	265.831	192.076	225.837	99.834	90.719	211.737	200.758	244.363	301.148	321.830	258.079

Table 3.20 continued

1A2a Ferrous metallurgy	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
The amount of coke oven gas required Aglom. furnace, million m3	52.935	56.251	40.934	47.236	36.955	46.457	55.558	47.932	58.169	63.776	49.680	49.230	42.967	37.912	47.968	65.453
amount of blast-furnace gas, million m3	150.535	150.526	116.377	144.537	106.623	110.596	108.204	103.224	107.075	98.814	104.525	76.283	76.167	123.384	124.735	104.820
Consumption of natural gas for the production of pellets, million m3	299.407	313.305	256.600	202.786	280.431	290.948	268.950	249.438	206.177	117.506	120.252	138.871	161.468	181.500	166.492	203.670

3.4.2.6 Planned improvements

Improvement of the inventory of greenhouse gas emissions in the category "Manufacturing industry and construction" was planned by taking into account information from the Ministry of Energy of the Republic of Kazakhstan, analytical and reference materials on fuel consumption in the country in order to control the data on the expenditure part of the fuel and energy balance of national statistics.

In order to improve the reporting and transparency of the assessment of greenhouse gas emissions in this category, the comments of the expert group on the Greenhouse Gas Inventory Review were taken into account, to the extent possible.

As commented by the Secretariat Expert Group (2020 KAZQA 335). In subcategory 1. A .2. D (Pulp and paper industry) for 1990 - 1998 gaseous fuel was not used, because this industry practically did not work during this period due to the severe economic crisis in the country. Many regions of the country in those years were not gasified due to the lack of gas pipelines. Mostly solid fuels were used. In this subcategory for 1990 - 1991. biomass was not used. Missing CH_4 and N_2O emissions from gaseous fuels for 1999, 2000 and 2001 listed in the CRF tables.

In response to the comments of the Secretariat Expert Group (2020 KAZQA 380) for category 1.A.2 - *Other fuels,* the following explanation was given. In CRF for 2009…2017 for other types of fuel, the indicator " IE " was replaced by " NA ", because since 2009, data on the consumption of other types of fuel in the fuel and energy balance of national statistics are not available. Such data were provided by national statistics for the period 1990-2008. Since 2009, data have not been available in the TEB, due to the lack of a code in the statistical classifier for industrial products (SCPP). However, according to the specialists who form the fuel and energy balance, other types of fuel are taken into account in the consumption of the corresponding types of fuel (liquid, solid, gaseous). Thus, in the "Energy" sector, $CO_{2\ emissions}$ and consumption of other types of fuel for this period are taken into account. To improve the reporting of the greenhouse gas emissions inventory, the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Ministry of National Economy of the Republic of Kazakhstan was repeatedly requested data on the consumption of other types of fuel for these years. But for objective reasons, they could not provide them.

3.4.3 Other Sectors (1. A.4 CRF) and Other Sources (1. A.5 CRF) categories

3.4.3.1 Overview

The category "Other sectors" includes subcategories:

- 1.A.4a “Commercial/institutional sector”,
- 1.A.4 b "Residential sector"
- 1.A.4 c Agriculture/Forestry/Fisheries.

According to the 2006 IPCC Guidelines, category 1.A.4 of the CRF includes emissions from fuel combustion in commercial and institutional buildings, the private residential sector, and agriculture. Subcategory 1.A.4.c includes the forestry and fishing industries.

The category "Other sources" includes sources of greenhouse gas emissions not included in any other categories:

- 1.A.5 a "Stationary sources" (Public administration and defence, compulsory social security)
- 1.A.5b Mobile sources.

Actual fuel consumption

Detailed volumes of fuel consumption by categories "Other sectors" and "Other sources" for 2021 and dynamics of fuel consumption for the period 1990…2021 are presented in tables 3.21 - 3.22.

Table 3.21 - Detailed fuel consumption in the categories "Other sectors" and "Other sources" in 2021 (sector approach, PJ)

Fuel	**1.A.4**	1.A.4a	1.A.4b	1.A.4c	**1.A.5**
Crude oil	**11.197**	-	-	-	11.197
Gas condensate	**0.000**	-	-	-	-
Kerosene for technical purposes	**0.523**	0.254	-	0.001	0.268
Domestic stove fuel	**10.361**	-	0.895	0.007	9.459
heating oil	**13.502**	4,464	-	-	9.037
LPG	**71.372**	23.937	14.680	0.917	31.838
Bitumen	**8.703**	0.127	-	-	8.576
Petroleum coke	**0.009**	-	-	-	0.009
Lubricating oil	**1.059**	-	0.481	0.116	0.462
Coal stone energy	**239.552**	34.031	131.862	4.407	69.252
Lignite	**29.729**	6.124	15.045	0.065	8.495
natural gas	**331.094**	43.521	166.069	24.472	97.031

Note: In order to eliminate double counting, fuels used by mobile sources (gasoline, kerosene and diesel) are categorized as Transport (1.A.3).

Table 3.22 - Fuel consumption in the categories "Other sectors" and "Other sources" for 1990 ... 2021 (sectoral approach)

years	Fuel, PJ											
	Category "Other sectors"						Category "Other sources"					
	Total	**Liquid fuel**	**solid fuel**	**gaseous fuel**	**Other fossil fuels**	**Biomass**	**Total**	**Liquid fuel**	**solid fuel**	**gaseous fuel**	**Other fossil fuels**	**Biomass**
1990	**562.194**	80.087	388.446	82.637	2.026	8.997	**114.192**	18.110	53.140	39.267	3.396	0.281
1991	**585.218**	80.533	411.808	82.484	2.027	8.366	**77.319**	18.706	29.575	25.239	3.508	0.290
1992	**504.421**	59.167	349.816	88.201	0.299	6.938	**20.621**	1.030	6.030	11.212	2.345	0.005
1993	**458.691**	49.844	292.741	109.688	0.297	6.121	**20,700**	1.034	6.053	11.255	2.354	0.005
1994	**405.291**	40.789	229.334	129.676	0.324	5.169	**20.324**	1.015	5.943	11.050	2.311	0.004
1995	**331.457**	36.296	216.604	73.341	0.312	4.903	**19.965**	0.997	5.838	10.855	2.270	0.004
1996	**315.441**	34.630	213.384	62.269	0.311	4,846	**20.032**	1,000	5.858	10,891	2.278	0.004
1997	**258.026**	34.339	156.882	61.581	0.320	4.904	**20.836**	1.040	6.093	11.329	2.369	0.005
1998	**193.361**	33.361	92.843	62.058	0.326	4.773	**109.167**	18.906	75.965	11,820	2.472	0.005
1999	**88.692**	17.625	43.690	22.459	0.246	4.672	**111.044**	34.568	75.177	0.373	0.002	0.924
2000	**103.357**	23.833	47.722	28.782	0.215	2.806	**229.874**	56.555	135.744	31.175	6.317	0.081
2001	**105.370**	19.744	56.479	25.423	0.092	3.633	**80.014**	39.244	40.114	0.516	0.000	0.139
2002	**130.958**	23.082	76.467	27.688	0.091	3.629	**175.074**	96.548	43.943	1.112	33.310	0.160
2003	**158.425**	27.663	96.261	30.770	0.248	3.483	**198.663**	58.849	57.891	1,960	79.805	0.158
2004	**142.963**	26.308	84.930	29.658	0.050	2.018	**219.160**	172.737	35.199	8.724	2.343	0.158
2005	**136.381**	31.285	72.795	29.409	0.178	2.714	**263.091**	47.765	65.157	3.107	146.817	0.246
2006	**196.381**	53.371	61.413	79.179	0.216	2.203	**348.811**	191.869	41.003	38.572	77.244	0.122

2007	**246.428**	125.288	64.527	49.312	4.292	3.008	**333.224**	155.643	115.494	32.583	29.391	0.113
2008	**198.941**	38.464	77.455	70.658	9.131	3.233	**515.991**	156.024	152.740	167.981	38.965	0.280
2009	**171.526**	40.673	76.029	50.606	0	4.218	**414.641**	92.296	186.100	136.092	0	0.153
2010	**196.347**	44.471	83.184	64.259	0	4.433	**631.735**	236.063	215.805	179.458	0	0.409
2011	**222.030**	43.433	114.433	60.121	0	4.043	**454.891**	76.806	113.841	263.669	0	0.575
2012	**190.405**	40.542	97.252	49.541	0	3.070	**420.961**	31.397	214.855	174.512	0	0.196
2013	**173.676**	47.265	82.255	41.050	0	3.106	**521.382**	138.726	181.404	200.832	0	0.420
2014	**325.450**	43.145	146.700	132.482	0	3.122	**526.895**	45.402	245.227	236.165	0	0.102
2015	**352.569**	62.501	147.117	139.805	0	3.146	**672.405**	39.868	244.219	388.258	0	0.061
2016	**346.682**	50.286	155.309	137.862	0	3.225	**687.567**	68.941	186.340	432.170	0	0.116
2017	**371.316**	50.744	194.808	122.843	0	2.921	**776.302**	65.650	135.079	575.492	0	0.082
2018	**386.239**	58.359	196.923	128.773	0	2.183	**886.989**	107.081	131.992	647.837	0	0.079
2019	**531.991**	62.504	203.455	264.672	0	1.360	**425.208**	93.260	82.239	249.635	0	0.074
2020	**405.220**	58.684	192.015	152.599	0	1.922	**255.333**	101.100	152.117	2.045	0	0.071
2021	**556.691**	92.440	198.753	237.691	0.859	26.948	**258.111**	78.651	80.611	97.031		1.817

The general trend of fuel consumption in the category "Other sectors" for the period 1990 ... 2021 has a declining character. The general trend of fuel consumption in the category "Other sources" for the period 1990 ... 2021 has a growth pattern.

Emissions of direct greenhouse gases

Dynamics of greenhouse gas emissions from fuel combustion in the categories "Other sectors" and "Other sources" for the period 1990 ... 2021 are presented in tables 3.23-3.24 and in figure 3.13.

Table 3.23 - Greenhouse gas emissions by categories "Other sectors" and "Other sources" for the period 1990 ... 2021 (sectoral approach)

Continuation of table 3.23

Greenhouse gases	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Other sectors, million tons of CO2-eq.	49.386	51.770	44.692	39.327	33.258	28.439	27.355	21.816	15.509	7.006	8.156	8.599	10,898	13.410	12.319	11.275
CO_2, million tons	47.905	50.174	42.713	37.816	32.242	27.519	26.464	20.973	14.775	6.694	7.855	8.220	10.496	12,940	11.737	10.824
Commercial / Institutional Sector	28.952	29.908	15.704	15.702	15.329	14.969	14.920	9.719	4,534	1.787	2.474	2.297	4.274	5.737	2.982	3.799
residential sector	16.963	18.704	20.448	16.252	12.058	8.857	8.189	8.012	7.614	3.755	4.166	4.733	4,834	5.684	7.170	5.258
Agriculture/Forestry/Fishing	1.989	1.562	6.562	5,863	4.855	3.693	3.355	3.242	2.628	1.152	1.215	1.189	1.388	1.520	1.585	1.768
CH_4, thousand tons	***50.048***	***54.375***	***71.063***	***53.728***	***35.280***	***31,880***	***30.933***	***30.025***	***26.819***	***10.954***	***10.352***	***13.224***	***13.656***	***15.955***	***20.643***	***15.364***
N_2O, thousand tons	***0.774***	***0.795***	***0.678***	***0.564***	***0.449***	***0.411***	***0.397***	***0.311***	***0.212***	***0.127***	***0.142***	***0.162***	***0.201***	***0.239***	***0.221***	***0.224***
Other sources , million tons of CO2-eq.	8.934	5.914	1,460	1.466	1,440	1.414	1.419	1.476	9.672	9.869	19.522	6.798	13.985	16.046	16.888	20.979
CO_2, million tons	8.879	5,877	1.453	1.459	1.432	1.407	1.412	1.468	9.608	9.793	19.394	6.752	13,897	15.945	16.786	20.848
CH_4, thousand tons	***1.024***	***0.747***	***0.151***	***0.151***	***0.151***	***0.141***	***0.141***	***0.151***	***1.031***	***1.377***	***2.174***	***0.832***	***1.798***	***2.027***	***2.187***	***2.694***
N_2O, thousand tons	***0.097***	***0.061***	***0.012***	***0.012***	***0.012***	***0.012***	***0.012***	***0.012***	***0.127***	***0.138***	***0.245***	***0.085***	***0.145***	***0.171***	***0.160***	***0.216***

Greenhouse gases	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Other sectors, million tons of CO2-eq.	14.574	18,930	15.332	13.610	15.244	18.262	15.691	14.089	25.634	27.449	27.190	30.461	31.471	40.059	32.430	40.574
CO_2, million tons	14.140	18.430	14.789	13.068	14.666	17.432	15,000	13.511	24.552	26.356	26.041	29.030	30.011	38.529	30.975	38.995
Commercial / Institutional Sector	4.619	11.063	5.506	4,446	5.113	4,843	4.498	5.046	5.504	5.603	4.611	4.246	3.941	3.948	3.906	11,484
residential sector	7.781	5.520	7,500	6.879	7.862	10.822	8.517	6.710	17.387	19.306	19,850	23.199	24.422	32.927	25.031	24,534
Agriculture/Forestry/Fishing	1,740	1.847	1.783	1.743	1.692	1.768	1.985	1.755	1.662	1.448	1,580	1.585	1.647	1.655	2.038	2.978
CH_4, thousand tons	***14.592***	***16.461***	***18.461***	***18.437***	***19.723***	***29.100***	***23.617***	***19.612***	***39.218***	***39.374***	***41.936***	***52.497***	***53.565***	***56.062***	52.695	56.673
N_2O, thousand tons	***0.235***	***0.298***	***0.272***	***0.270***	***0.283***	***0.342***	***0.340***	***0.295***	***0.341***	***0.365***	***0.338***	***0.398***	***0.406***	***0.431***	0.462	0.542
Other sources , million tons of CO2-eq.	26.201	26.913	38.673	32.546	48.549	32.098	33.100	39.295	40.471	48.467	47.462	50.481	57.210	28.896	22.279	18.956
CO_2, million tons	26.050	26.747	38.447	32.354	48.266	31.940	32.908	39.074	40.243	48.219	47.235	50.269	56.972	28.760	22.128	18.835
CH_4, thousand tons	***3.327***	***3.198***	***4.404***	***3.509***	***5.543***	***3.402***	***3.389***	***4.326***	***4.113***	***4,800***	***4.748***	***4.911***	***5.643***	***3.025***	2.563	2.623
N_2O, thousand tons	***0.228***	***0.287***	***0.389***	***0.349***	***0.486***	***0.245***	***0.359***	***0.377***	***0.418***	***0.428***	***0.364***	***0.300***	***0.327***	***0.204***	0.290	0.185

$_2$ emissions in the categories "Other sectors" and "Other sources" for the period 1990 ... 2021 (sect approach)

years	$_2$ emissions , million tons							
	Category "Other sectors"				Category "Other sources"			
	Total	Liquid fuel	solid fuel	gaseous fuel	Total	Liquid fuel	solid fuel	gaseous fuel
1990	**8.879**	1.316	5.112	2.203	**47.905**	5,670	37.450	4.636
1991	**5,877**	1.359	2.845	1.416	**50.174**	5.711	39.687	4.627
1992	**1.453**	0.072	0.580	0.629	**42.713**	4.079	33.664	4.948
1993	**1.459**	0.073	0.582	0.631	**37.816**	3.456	28.185	6.153
1994	**1.432**	0.071	0.571	0.620	**32.242**	2.848	22.096	7.275
1995	**1.407**	0.070	0.561	0.609	**27.519**	2.516	20.866	4.114
1996	**1.412**	0.070	0.563	0.611	**26.464**	2.397	20.551	3.493
1997	**1.468**	0.073	0.586	0.636	**20.973**	2.378	15.117	3.455
1998	**9.608**	1.307	7.457	0.663	**14.775**	2.313	8.957	3.481
1999	**9.793**	2.424	7.348	0.021	**6.694**	1.206	4.210	1.260
2000	**19.394**	4.012	13.170	1.749	**7.855**	1.625	4.599	1.615
2001	**6.752**	2.731	3.992	0.029	**8.220**	1.354	5.433	1.426
2002	**13.897**	7.003	4.389	0.062	**10.496**	1.585	7.352	1.553
2003	**15.945**	4.186	5.796	0.110	**12,940**	1.939	9.257	1.726
2004	**16.786**	12.553	3.571	0.489	**11.737**	1.832	8.237	1.664
2005	**20.848**	3.495	6.411	0.174	**10.824**	2.162	7,000	1,650
2006	**26.050**	14.162	4.059	2.164	**14.140**	3.771	5.911	4.442
2007	**26.747**	11.507	11.257	1.828	**18.430**	9.130	6.219	2.766
2008	**38.447**	11.345	14.821	9.424	**14.789**	2.676	7.479	3.964
2009	**32.354**	6.724	17.995	7.635	**13.068**	2.858	7.371	2.839

2010	**48.266**	17.314	20.884	10.068	**14.666**	3.112	7.949	3.605
2011	**31.940**	5,833	11.314	14.792	**17.432**	3.060	11,000	3.373
2012	**32.908**	2.273	20.845	9,790	**15,000**	2.804	9.416	2.779
2013	**39.074**	10.141	17.667	11.267	**13.511**	3.266	7.943	2.303
2014	**40.243**	3.275	23.719	13.249	**24.552**	2.983	14.137	7.432
2015	**48.219**	2.869	23.569	21.781	**26.356**	4.333	14.180	7.843
2016	**47.235**	4.937	18.053	24.245	**26.041**	3.342	14.965	7.734
2017	**50.269**	4,837	13.147	32.285	**29.030**	3.351	18.788	6.892
2018	**56.972**	7.787	12.841	36.344	**30.011**	3.831	18.955	7.224
2019	**28.760**	6.671	8.084	14.005	**38.529**	4.096	19.585	14.848
2020	**22.128**	7.357	14.657	0.115	**30.975**	3.907	18.507	8.561
2021	**18.835**	5.573	7.819	5.443	**38.995**	6.387	19.210	13.334

In 2021, the total emissions of direct greenhouse gases in the category "Other sectors" amounted to 33.429 million tons of CO_2-eq., which is 40.7 % less than the level of 1990 and 20.7% less than the level of 2020. CO_2 emissions annually account for more than 99% of all greenhouse gas emissions.

In line with fuel consumption in the category “Other Sectors”, there is a general trend towards a reduction in greenhouse gas emissions due to a significant reduction in the consumption of liquid and solid fuels and an increase in the consumption of gaseous fuels. Figure 3.13 shows the change in the structure of greenhouse gas emissions over the period 1990…2021. This change is connected, first of all, with government programs aimed at complete gasification of the settlements of the republic, which is clearly shown in Figure 3.12 in the form of increased CO_2 emissions from the residential sector.

Also, according to the information announced at the briefing of the Ministry of Energy of the Republic of Kazakhstan on December 28, 2021, it follows that the level of gasification of settlements in the republic, at the expense of the allocated funds, is planned to be increased to 55%, by 2030 the gasification rate of the country is planned to be increased to 65% or 13.5 million . Human.

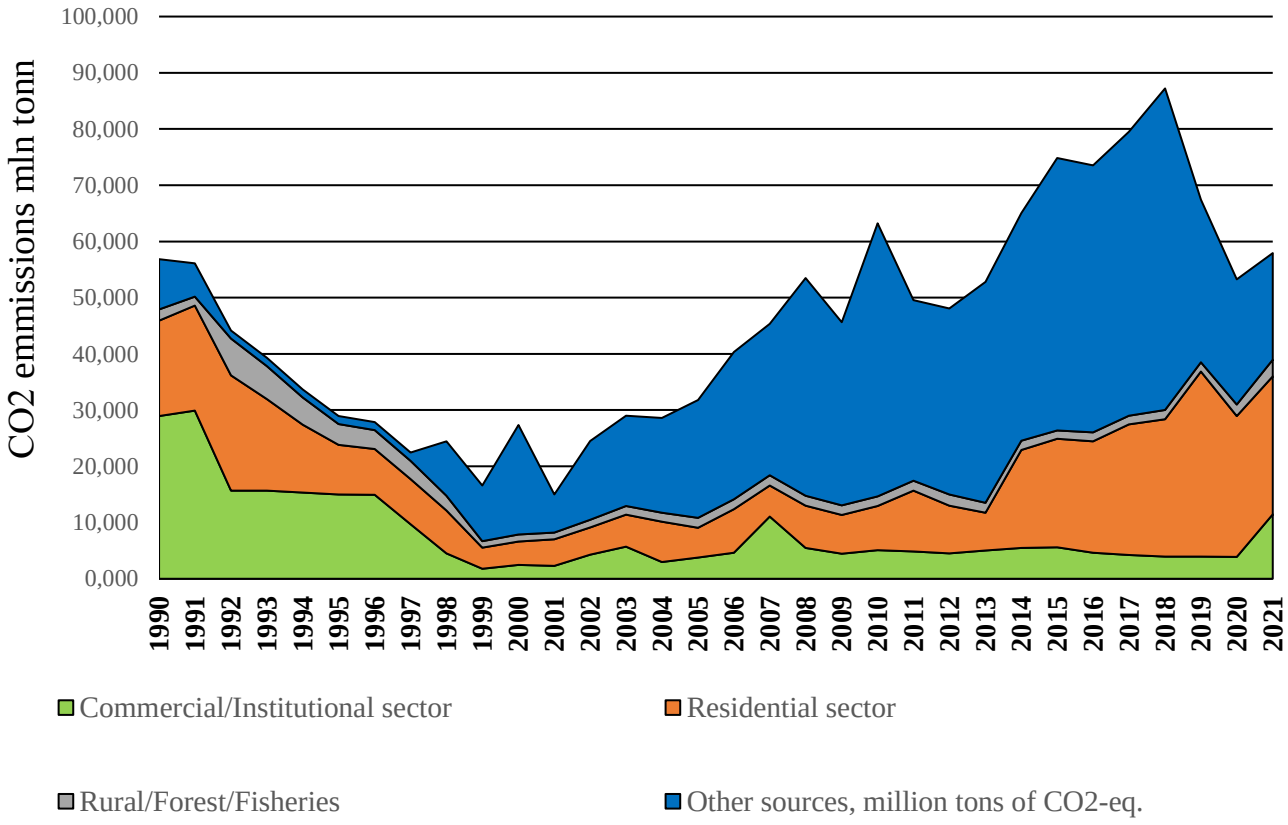


Figure 3.12 -Dynamics of greenhouse gas emissions in the categories "Other sectors" and “Other sources” by main sources (sectoral approach, Mt CO_2-eq.)

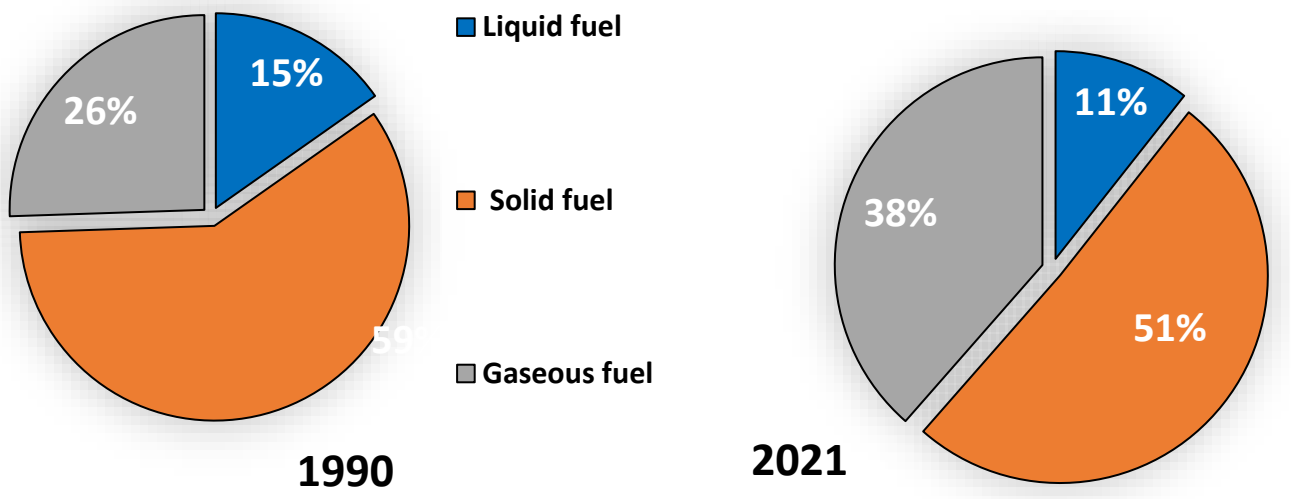


Figure 3.13 - Dynamics of the structure of greenhouse gas emissions in category "Other sectors" (sectoral approach)

CO_2 emissions in the category "Other sectors" in 2021 amounted to 31.971 million tons, which is less than the level of 1990 by 41.7% and less than the level of 2020 by 21.2%. The main source of greenhouse gas emissions in the Other Sectors category is the residential sector. Emission reductions relative to 1990 levels are due to a significant reduction in the consumption of solid, but mostly liquid fuels in sub-category 1.A.4 c "Agriculture/Forestry/Fisheries".

$_2$ emissions from liquid fuel combustion in 2021 amounted to 4.902 million tons, which is 2.5 times less than in 1990. Compared to the level of emissions in 2020, *$CO_{2\ emissions}$* decreased by 20.4% due to a decrease in consumption of other liquid fuels in sub-category 1.A.4 c "Agriculture/Forestry/Fishing".

CO_2 emissions from solid fuel combustion in 2021 amounted to 18.507 million tons, which is 50.6% less than in 1990. Compared to the level of 2020, CO_2 emissions decreased by 5.5%. The reduction in emissions is due to a decrease in the consumption of hard coal in subcategory 1.A.4 b "Residential sector".

CO_2 emissions from the combustion of gaseous fuels in 2021 amounted to 8.561 million tons, which is 84.6% more than in 1990. The level of emissions for the same year 2020 was much higher - the overall reduction reached the level of 42.3%. Such a serious reduction was due to a decrease in the consumption of associated petroleum gas in sub-category 1.A.4 b "Residential sector". Despite the downward trend in emissions in the mentioned subcategory, natural gas consumption continues to grow, which is consistent with the ongoing active policy of the state to gasify the country, the construction of the Saryarka gas pipeline , intended for gasification of the capital of the Republic of Kazakhstan, Nur-Sultan [7] .

Total emissions of direct greenhouse gases in the category "Other sources" in 2021 amounted to 22.279 million tons of CO_2-eq., which is 2.5 times more than in 1990 and 22.9% less than in 2020. CO_2 emissions more than 99% annually.

In accordance with fuel consumption in this category for the period 1990 ... 2021. there is a general upward trend in greenhouse gas emissions for all types of fuel except gaseous. Figure 3.14 shows the change in the structure of greenhouse gas emissions over the period 1990…2020.

The main emission source in the category "Other sources" is 1.A.5 b "Other fuel consumption".

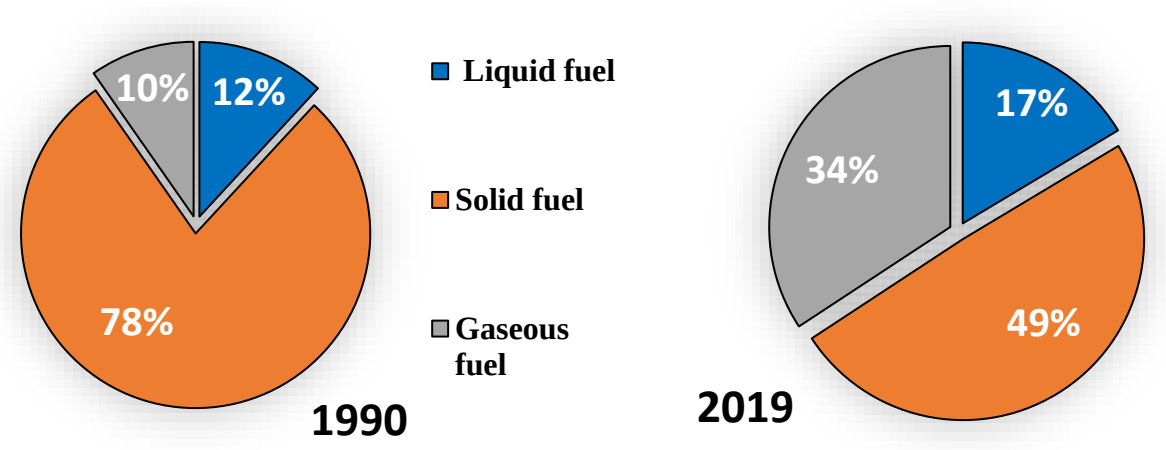


Figure 3.14 - Dynamics of the structure of greenhouse gas emissions in the category "Other sources" (sectoral approach)

CO_2 emissions in the category "Other sources" in 2021 amounted to 22.128 million tons, which is 2.5 times more than in 1990 and 23% less than in 2020.

CO_2 *emissions from liquid fuel combustion* in 2021 amounted to 7.357 million tons, which is 5.6 times more than in 1990 and 10.3% more than in 2020. Growth in emissions GHG compared to 2020 is mainly due to increased consumption of jet kerosene and fuel for slow-moving ships in sub-category 1.A.5b "Other fuel consumption".

CO_2 *emissions from solid fuel combustion* in 2021 amounted to 14.657 million tons, which is approximately 2.9 times more than in 1990 and 1.8 times more than in 2020. Increase in greenhouse gas emissions compared to 2020 associated with the consumption of coking coal in sub-category 1.A.5b "Other fuel consumption".

$_2$ *emissions from the combustion of gaseous fuels* in 2021 amounted to 0.115 million tons, which is significantly less than the level of emissions calculated for 1990 - the difference was 19.2 times. Compared to 2020, greenhouse gas emissions decreased even more - if in 2020 emissions from the combustion of gaseous fuels amounted to 14.005 million tons, then already in 2021 they were at the level of 0.115 million tons. Analyzing the data on fuel consumption in more detail, it can be seen that the data on the consumption of associated petroleum gas for 2021 is zero. This fact is the main one with such a sharp decrease in $CO_{2\ emissions}$ from the combustion of gaseous fuels. When compiling the last national report, national climate change experts faced a similar problem, namely, a sharp decrease in the consumption of gaseous fuel by 2.6 times, which is associated with a decrease in the consumption of associated petroleum gas. The decrease in the consumption of associated petroleum gas in the FEB data provided by the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan may be due to the analysis of gaseous fuel for 2020, during which it was revealed that associated petroleum gas was indicated by the enterprise in commercial form and not pure, as previously thought. Due to this difference in accounting and the possible decrease in the production of associated petroleum gas, a significant decrease in $CO_{2\ emissions}$ from the combustion of gaseous fuels is explained.

Emissions of indirect greenhouse gases

Emissions of indirect greenhouse gases in the categories "Other sectors" and "Other sources" are presented in Table 3.25.

Table 3.25 - Emissions of indirect greenhouse gases by categories "Other sectors" and "Other sources" for 1990 ... 2021 (sectoral approach)

years	Greenhouse gases, thousand tons							
	Category "Other sectors"				Category "Other sources"			
	CO	NOx	NMVOC	SO2	CO	NOx	NMVOC	SO2
1990	921.57	163.66	102.50	197.07	110.08	9.46	11.10	29.17
1991	931.44	125.71	100.04	206.10	62.31	6.47	6.33	21.09
1992	824.35	146.42	91.68	144.51	12.71	1.50	1.28	2.74
1993	699.66	132.19	78.36	125.51	12.76	1.51	1.29	2.75
1994	555.40	109.75	62.47	103.56	12.53	1.48	1.26	2.70
1995	510.00	86.43	56.32	96.05	12.31	1.45	1.24	2.65
1996	498.77	80.77	54.79	94.18	12.35	1.46	1.25	2.66
1997	384.92	73.79	43.30	74.48	12.84	1.52	1.30	2.77
1998	247.35	56.71	28.64	51.63	152.97	10.33	15.36	22.45
1999	129.28	27.86	15.13	22.52	155.68	11.09	15.76	23.83
2000	129.81	30.58	15.14	25.51	274.71	21.43	27.67	55.48
2001	158.67	39.85	18.85	29.65	81.74	7.98	8.31	29.20
2002	193.86	36.26	21.88	35.36	91.34	17.45	9.54	41.90
2003	233.41	39.36	25.86	51.54	119.44	19.77	12.38	35.11
2004	202.02	36.25	22.44	49.62	75.12	21.48	8.05	11.69
2005	185.47	40.44	21.28	44.04	135.59	26.15	14.17	32.30
2006	160.98	41.31	18.54	50.17	89.93	32.95	9.81	56.10
2007	174.38	51.39	20.14	61.77	236.88	31.69	24.25	47.93
2008	198.93	43.33	22.61	45.64	319.19	47.43	32.74	68.50
2009	197.67	38.98	22.32	45.84	381.62	34.66	38.45	70.30
2010	212.26	38.86	23.66	44.70	447.35	54.20	45.48	87.40
2011	278.92	49.28	30.93	69.16	245.27	32.31	24.82	105.18
2012	237.16	44.06	26.18	66.08	440.04	33.37	44.12	83.90
2013	207.46	43.48	23.52	58.89	377.73	42.10	38.23	73.53
2014	346.51	60.86	38.00	81.00	503.69	40.92	50.52	92.99
2015	342.51	56.44	37.05	55.88	508.95	47.88	51.02	92.62
2016	361.24	58.54	39.22	51.72	396.25	47.14	39.84	73.05
2017	440.32	64.61	47.36	68.90	300.65	48.85	30.27	56.56
2018	441.45	65.93	47.40	67.71	298.91	56.30	30.22	55.13
20 19	459.06	75.43	49.37	72.09	179.20	30.04	18.21	33.67
2020	391.80	30.20	39.44	73.34	306.71	25.43	30.98	53.72
2021	98.10	13.18	9.99	34.59	176.73	20.96	18.09	48.61

3.4.3.2 Methodological approaches

Calculation methodology

Estimated emissions of direct greenhouse gases in the categories "Other sectors" and "Other sources" for the period 1990 ... 2021 was carried out in accordance with the IPCC Guidelines (2006). For the calculation of greenhouse gas emissions, a Tier 1 method was used with statistics on the volumes of fuel burned in the production of electricity and heat for own use in the commercial-institutional sector, residential, agriculture, forestry and fisheries, as well as undefined categories. The default emission factors are taken from the 2006 IPCC Guidelines (Table 3.8). An exception is the coefficient of the lowest net calorific value for domestic stove fuel. Source of information - LLP "Atyrau Oil Refinery" - the main producer of domestic stove fuel in the country. A letter from the enterprise on the calorific value of the produced household furnace fuel, which was determined by the laboratory, was attached in the responses to the expert team for the Greenhouse Gas Inventory Review (Provisional main findings_CR_2020_Kazakhstan) . _ _ _

Estimate of indirect greenhouse gas emissions for 1990…2021 was carried out in accordance with the IPCC Guidelines (2006). Calculations of $SO_{2\ emissions}$ are carried out at Tier 2 with coefficients that were calculated in accordance with the IPCC Guidelines (2006).

In order to eliminate double counting in the categories "Other sectors" and "Other sources", gasoline, kerosene and diesel fuel, which was used as a motor fuel, are classified as "Transport" (1.A.3).

Initial data

The source of initial data for calculating greenhouse gas emissions in the categories "Other sectors" and "Other sources" is the data of the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Ministry of National Economy of the Republic of Kazakhstan on the volume of fuel burned.

The source of data on the volumes of fuel burned for 1990 was the Fuel Balance of the USSR, in the part that concerns the Kazakh SSR.

Due to the absence of the fuel balance of the Republic of Kazakhstan, various reference books and bulletins of national statistics served as a source of data on the volumes of fuel burned for 1991 ... 1998, which reflected the consumption of fuel and energy resources in the context of economic activities.

Main data source for 1999…2021 - Fuel and Energy Balance (FEB) of the Republic of Kazakhstan, which is formed by the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan. The information base of the TEB is the developed and approved statistical reporting form No. 1-TEB (annual periodicity), which tracks all types of fuel and energy resources in the country.

To control the national energy reporting data for recent years, data from large enterprises of the Republic of Kazakhstan on fuel consumption and the amount of output obtained through written requests are used.

When calculating greenhouse gas emissions, the initial data on fuel consumption in natural units of measurement (tonne, thousand cubic meters, thousand kWh, thousand Gcal) were used.

3.4.3.3 Estimating uncertainty

Activity data for estimating greenhouse gas emissions in the categories "Other sectors" and "Other sources" are provided by the national statistical office. According to the 2006 IPCC Guidelines, in countries with a well-developed statistical accounting system, the level of

uncertainty in statistics on fuel combustion in the commercial, institutional and residential sectors is 3–5%. Kazakhstan can be attributed to such countries. Therefore, the overall uncertainty of activity data in these categories is 5%.

Biomass data are not as reliable as fossil fuel data, so the uncertainty in biomass activity data is assumed to be 30%.

According to the 2006 IPCC Guidelines for the combustion of fossil fuels, the uncertainty in $CO_{2\ \text{emission factors}}$ is relatively small. For the "Energy" sector, the total value of the uncertainty for the $CO_{2\ \text{coefficients}}$ is assumed to be 7 %.

The emission factors for CH_4 and in particular N_2O are largely uncertain. The high uncertainty can be attributed to a lack of appropriate measurements and subsequent generalization, uncertainties in measurements, or a lack of understanding of the emission process. In the absence of Kazakhstan-specific uncertainty estimates for CH_4 and N_2O emission factors , the uncertainty values are taken from the IPCC Guidelines, 2006. For categories “Other sectors” and “Other sources”, the uncertainty estimate for CH_4 and N_2O is 50%.

3.4.3.4 QA/QC procedure

When calculating greenhouse gas emissions, national statistics on fuel combustion were used as input data. These data were checked for reliability and quality by the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan.

For assessment and quality control, standard procedures were used, including control of the initial data of the fuel and energy balance and a comparative assessment of greenhouse gas emissions for different years.

In accordance with the recommendations of the IPCC, in order to eliminate errors when transferring the initial data of the fuel and energy balance to the calculation tables, a form of the fuel and energy balance was developed, where the data for each type of fuel used is checked in several stages. At the first stage, when entering the initial data in the calculation tables, the sum of the total volume of fuel (resource part) is automatically calculated, taking into account production, imports and balances at the beginning of the year, which is compared with the data of the fuel and energy balance. At the second stage of quality control, when entering the initial data, the sum of the total fuel consumption in the country (distribution part) is automatically calculated, taking into account exports, balances at the end of the year and losses, which is also compared with the FEB data. At the third stage, the balance of the resource and distribution parts is checked. At the fourth stage, the distribution of final consumption by type of economic activity is checked. These measures allow you to identify errors in the input of initial data.

3.4.3.5 Recalculations

Based on the results of the ERT review of the UNFCCC Secretariat in 2020, in this inventory, recalculations of the time series of greenhouse gas emissions in the categories "Other sectors" and "Other sources" for 1990 ... 2017 were made.

In connection with the comments of the GER (Provisional main findings_ CR_2020_Kazakhstan, Table 1, E6). In order to improve reporting and transparency of data in the CRF tables in category 1.A.2 (all types of activities), data on crude oil and gas condensate (natural gas liquid) are listed separately. In accordance with this, the time series of CO_2 emissions for crude oil was recalculated . A separate time series for gas condensate has been formed with its

own greenhouse gas emission factors for 1990…2017. In this regard, the total values of greenhouse gas emissions for liquid fuels in these categories have slightly changed.

In accordance with the comments of the expert group of the UNFCCC Secretariat (2020 KAZQA 339), additional calculations of greenhouse gas emissions from the consumption of coking coal in the iron and steel industry for 2014…2020 were made. The recalculations were made due to the imbalance of coking coal consumption between the baseline and sectoral approaches in the Energy sector over these years. The calculations were carried out in accordance with the 2006 Guidelines and assigned, according to the recommendations of the expert group, to subcategory 1.A.5b. In this regard, the volumes of solid fuel emissions in category 1.A.5 "Other sources" for 2014…2017 have changed.

As a comment from the Secretariat expert group (Provisional main findings_ CR_2021_Kazakhstan, Table 3, E12), a discrepancy between coking coal consumption in the sectoral and baseline approaches was identified. The data provided in the TEB by the Bureau of National Statistics did not fully reflect the total amount of coking coal consumption in the sectoral approach, which required additional calculations recommended by the international panel on climate change to balance fuel consumption between the baseline and sectoral approaches and indicate the results in category 1.A .5 "Other sources". This difference between the two approaches was reduced by using data on the consumption of coking coal by JSC ArcelorMittall Temirtau and the series were recalculated for category 1.A.5 "Other sources" and 1.A.1 b "Production of oil, gas and solid fuel ."

3.4.3.6 Planned improvements

It is planned to improve the inventory of greenhouse gas emissions in the category "Energy Industry" by monitoring the TEB data of national statistics by requesting additional information from large enterprises of the Republic of Kazakhstan.

In response to comments from the Secretariat Expert Group (2020 KAZQA 380). CRF , category 1.A.4 and 1.A.5 - Other fuels in CRF for 2009…2017 for other types of fuel, the key was changed from " IE " to " NA ", because since 2009, data on the consumption of other types of fuel in the fuel and energy balance of national statistics are not available. Such data were provided by national statistics for the period 1990-2008. Since 2009, data have not been available in the TEB, due to the lack of a code in the statistical classifier for industrial products (SCPP). However, according to the experts who form the fuel and energy balance, other types of fuel are taken into account in the corresponding types of fuel (liquid, solid, gaseous). Thus, CO_2 emissions and consumption of other types of fuel for this period are taken into account in the "Energy" sector. To ensure transparency of reporting, data on the consumption of other fuels for the missing period was repeatedly requested. It is also planned to develop national CO_2 emission factors to more accurately estimate greenhouse gas emissions from the Energy category. Also, as a response to the comment of the expert group, table-3.26 " Detailed fuel consumption in the categories" Other sources "in 2021 (sector approach, PJ)" is provided.

Based on the comments of the expert group, comments have been entered in table 9 of the CRF for those fuels included elsewhere using the key " IE ".

3.4.4 Transport (1.A.3 CRF/ 1.A.3.a, 1.A.3.b, 1.A.3.c, 1.A.3.d, 1.A.3. e)

3.4.4.1 Current status of the sub-category "Transport (1.A.3) "

The transport infrastructure of the Republic of Kazakhstan is represented today by all known modes of transport. Each category has gone through a difficult period of restructuring associated with a change in economic relations and logistics, as well as a general change in the rolling stock in all categories without exception. First of all, we note the fact that the transport infrastructure that exists today is a legacy from the USSR. Accordingly, those transport tasks that were solved 30 years ago within the framework of a country like the Soviet Union are somewhat different today. In particular, this is a reorientation of economic tasks, and their scale, a change in the structure of goods transported, and directions. Secondly, this is a change in the status of the Republic of Kazakhstan, having gained independence, the country was forced to look for its own points of contact with its neighbors and reconfigure transport corridors. Another, third, important factor was the change in the structure of the industrial complex of the Republic. After the collapse of the USSR, many enterprises could not exist in the new model of the world for various reasons, most of them due to the refusal of the state in subsidies and tax incentives, as well as the violation of the logistics and technological chains that were built before independence.

These factors apply not only to the transport structure of the Republic of Kazakhstan, but are also characteristic of all other sectors of the country's economy without exception. It is these factors that explain the significant decline in production in the early and mid-nineties, the loss of certain types of economic activity, and, as a result, the decrease in overall activity for all categories of transport. We also add here the internal migration crisis, which was partly provoked by the deterioration of the economy and the lack of opportunities for the population to earn money, which also affected the general economic situation in the country in the early and mid-nineties.

Today, the transport industry of the Republic has almost completely adapted to the existing conditions, and in general fulfills its main tasks to ensure economic activity in the country. The updated transport system of Kazakhstan is a fairly developed infrastructure, which includes all known mass modes of transportation. For the period of 2021, the transport system included:

- 95,443.0 km of public roads (for comparison, in 1990 - 86,488 km), of which 84,387.4 km are paved roads (1990 - 80,263 km);
- 16 579.6 km of public railways (in 1990 - 14463 km), of which about 25% are electrified [20], which is 4237.5 km (filed in 2019));
- 24437.1 km of pipelines for pumping oil, gas and oil products (17088 km in 1990);
- 2169.3 km - navigable routes (in 1990 4002 km).

In addition, there is a fairly developed system of air communications (all cities of regional significance have their own air ports). Updated ground structure of transport hubs. The share of transport in the country's GDP in 2021 was about 5.9%.

Each type of transport has its own sphere of beneficial application, depending on the territorial, climatic conditions and characteristics of the goods transported, as well as the distance of the transportation. According to the Bureau of National Statistics of the ASPIR RK, the volume of transport in the country has been growing steadily in recent years [21], despite the ongoing restrictions due to the COVID 19 pandemic, this trend has continued for cargo, but passenger traffic is somewhat limited. Large reductions were made in aviation (international

[20] https://www.carecprogram.org/uploads/CAREC-RSA-RU-KAZ-FA_1JUL2021.pdf
https :// inbusiness . kz / ru / last / v - kazakhstane - elektrificirovano -40 - zheleznyh - dorog
21https://stat.gov.kz/official/dynamic

communications), rail (international and partly domestic communications), maritime transport (passenger traffic on the Caspian Sea), private road transport (international transit).

At present, it is difficult to determine the possible volumes of emission reductions in this area, but there is clearly a potential for this, both by optimizing the work of some subcategories, improving logistics, and by increasing the load on some other modes of transport, for example, on inland water transport, as well as to expand the share of pipeline transport of oil and gas, as well as rail transport for industrial goods. Switching to other types of fuel (LNG or LPG gas, hydrogen fuel) or using a different operating principle.

The main source of information for calculating emissions for the "Transport" subcategory for the entire series for all years was the following documents issued by the Bureau of National Statistics of the ASPIR RK [22]:

Bus transport of the Republic of Kazakhstan. Bureau of National Statistics Bulletin [3] 2021

Inland water transport of the Republic of Kazakhstan. Bureau of National Statistics Bulletin [3] 2021

Sea transport of the Republic of Kazakhstan. Bulletin of the Bureau of National Statistics 2021 [3]

Air transport of the Republic of Kazakhstan. Bulletin of the Bureau of National Statistics 2021 [3]

https://stat.gov.kz/edition/publication/collection

Table 3.24 - Greenhouse gas emissions from transport category in Kazakhstan

years	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Domestic Aviation aviation)																	
CO_2	1083.54	1175.50	1103.37	1147.37	697.44	703.87	709.13	653.15	512.15	200.95	178.44	147.72	200.40	148.04	199.76	264.07	427.92
CH_4	0.007	0.008	0.007	0.008	0.004	0.004	0.004	0.004	0.003	0.001	0.001	0.001	0.001	0.001	0.0014	0.0018	0.0030
N2O _ _	0.030	0.032	0.030	0.032	0.019	0.019	0.019	0.018	0.014	0.005	0.004	0.004	0.005	0.004	0.005	0.007	0.012
Road Transportation transport)																	
CO_2	14628.57	12292.17	11914.06	9179.34	7852.59	6522.75	5511.07	4958.67	4759.90	5046.08	6208.38	6915.03	8351.00	8888.45	9700.77	11970.2	13980.08
CH_4	6.02	4.96	4.76	3.71	3.18	2.65	2.21	1.96	1.86	1.88	2.18	2.37	2.88	3.06	3.306	4.03	4.67
N2O _ _	0.76	0.64	0.62	0.47	0.40	0.33	0.28	0.26	0.25	0.27	0.34	0.38	0.46	0.49	0.544	0.675	0.775
1.A.3.c Railways																	
CO_2	4860.58	4374.52	1708.29	1412.53	1213.84	1078.24	1009.87	1050.01	914.86	573.71	730.08	913.44	1065.04	1242.76	1012.80	668.31	993.70
CH_4	0.269	0.242	0.078	0.063	0.054	0.0485	0.043	0.050	0.045	0.027	0.036	0.048	0.056	0.065	0.054	0.035	0.054
N2O _ _	1.84	1.65	0.47	0.38	0.32	0.29	0.24	0.32	0.28	0.17	0.23	0.32	0.37	0.43	0.366	0.234	0.366
Domestic Navigation navigation)																	
CO_2	122.74	77.22	65.51	58.53	49.49	49.20	36.31	32.59	27.98	24.00	22.62	4.05	2.65	2.79	2.35	2.68	3.91
CH_4	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.0004	0.0004	0.0006
N2O _ _	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0000	0.0000	0.0000
Other Transportation kinds transport)																	
CO_2	465.33	412.32	307.44	347.04	368.78	294.16	269.08	314.22	278.22	729.309	2173.658	2306.85	2851.826	3688.25	3464.192	3277.65	2811.80
CH_4	0.041	0.034	0.026	0.025	0.022	0.021	0.019	0.0188	0.0176	0.066	0.19	0.206	0.257	0.0328	0.31	0.29	0.25
N2O _ _	0.001	0.001	0.001	0.004	0.002	0.003	0.017	0.002	0.003	0.012	0.004	0.041	0.05	0.008	0.007	0.006	0.499
1.A.3 Transport																	
CO_2 eq	22546.02	19530.47	15914.48	12778.27	10719.51	9100.60	7918.11	7381.39	6842.85	6902.11	9713.37	10758.27	13037.14	14568.73	14995.98	16871.8	19057.38

Continuation of Table 3.24

years	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Domestic Aviation aviation)															
CO_2	563.13	604.95	555.23	493.78	555.80	674.51	776.33	708.17	867.15	929.31	985.96	1074.04	1182.51	111.1925	191.4562
CH_4	0.0039	0.004261	0.0039	0.0034	0.0039	0.0047	0.0054	0.0049	0.0061	0.0065	0.0069	0.07545	0.00830	0.0007	0.0013639
N2O _ _	0.015	0.0170	0.0156	0.0139	0.0156	0.0189	0.0218	0.0199	0.0244	0.0261	0.0277	0.0301	0.0332	0.00315	0.0054562
Road Transportation transport)															
CO_2	16510.51	16516.73	16706.36	16994.86	17452.84	20419.18	18780.97	19851.61	18134.69	19110.73	20221.63	21324.35	21803.15	15704.23	20.815315
CH_4	5.55	5.53	5.51	5.73	5.40	5.94	5.80	6.06	5.80	6.39	7.92	8.79	8.80	6.57	8.692405
N2O _ _	0.912	0.914	0.929	0.938	0.989	1.179	1.064	1.137	1.018	1.062	1.091	1.143	1.179	0.84	1.103
1.A.3.c Railways															
CO_2	1108.47	1019.03	1079.75	1260.61	1436.1	1211.97	1646.65	1930.39	1200.07	1246.52	1502.74	1443.17	1437.15	1001.411	1068.547
CH_4	0.060	0.055	0.059	0.070	0.080	0.067	0.092	0.108	0.067	0.069	0.084	0.080	0.080	0.056	0.05984
N2O _ _	0.413	0.376	0.401	0.486	0.554	0.467	0.063	0.745	0.463	0.481	0.580	0.557	0.554	0.386	0.412
Domestic Navigation navigation)															
CO_2	9.82	20.82	26.62	27.95	13.85	11.65	11.55	9.52	20.06	14.44	8.74	9.77	6.91	3.022	4.6709
CH_4	0.0011	0.0023	0.0028	0.0029	0.0016	0.0014	0.00142	0.00186	0.00220	0.00169	0.00109	0.0011	0.0007	0.0004	0.00053
N2O _ _	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.00023
Other Transportation kinds transport)															
CO_2	2622.71	3615.500	2900.56	1898.25	1839.46	1618.66	963.295	789.70	838.625	811.839	749.19	1376.731	1242.067	1219.254	2368.452
CH_4	0.234	0.322	0.256	0.162	0.161	0.170	0.150	0.117	0.124	0.123	0.124	0.234	0.212	0.294	0.82336
N2O _ _	0.046	0.007	0.006	0.0051	0.004	0.027	0.0031	0.0028	0.003	0.002	0.002	0.003	0.003	0.003	0.00849
1.A.3 Transport															
CO_2 eq	21794.70	22733.23	22232.35	21678.07	22327.45	25117.53	23292.17	24433.92	22045.46	23201.67	24617.84	26434.20	26903.26	19341.54	25166.48

Freight road transport of the Republic of Kazakhstan. Bureau of National Statistics Bulletin [23]2021
Passenger motor transport of the Republic of Kazakhstan. Bureau of National Statistics Bulletin [24]2021
Availability of registered sea vessels of the Republic of Kazakhstan. Bureau of National Statistics Bulletin [25]2021
Availability of rolling stock of the Republic of Kazakhstan. Bureau of National Statistics Bulletin [26]2021
Railway transport of the Republic of Kazakhstan. Bureau of National Statistics Bulletin [27]2021
The main indicators of the transport of the Republic of Kazakhstan. Statistical compendium [28]2021
Transportation of goods in containers by all means of transport. Bureau of National Statistics Bulletin [29]2021
The length of the roads of the Republic of Kazakhstan. Bureau of National Statistics Bulletin 2021
The length of the communication lines of the Republic of Kazakhstan. Bureau of National Statistics Bulletin 2021
Information on transit traffic Bulletin of the Bureau of National Statistics 2021
Pipeline transport of the Republic of Kazakhstan. Bureau of National Statistics Bulletin 2021

Fuel and energy balance of the Republic of Kazakhstan, 2021;

In addition, to estimate the number of off-road vehicles, data were used on the availability of specific equipment in the country, published on the website of the Ministry of Agriculture of the Republic of Kazakhstan. These data are presented in this NIR under the subcategory Off-road vehicles (1.A.3.e ii).

Greenhouse gas emissions from the "Transport" category in the Republic of Kazakhstan are growing quite steadily. However, due to ongoing measures to contain the pandemic from COVID 19, 2021 is still not a typical year in terms of emissions, total emissions amounted to 25,166 thousand tons of CO_2-eq. It should be noted that the reduction in emissions was due to a decrease in passenger traffic by all national operators such as Kazakhstan Temir Zholy (railway transportation) Air Kazakhstan (air carrier) and others. Air travel has declined particularly drastically as some popular international flights have been cancelled, with the exception of a few destinations. The resumption of air communications, as well as railway communications, has not been fully restored, even at the time of 2023. However, freight traffic was carried out almost in full and even slightly increased for rail traffic.

Transport aviation carried out international and domestic flights, and road freight transportation was carried out. The volumes of gas pumped through the pipeline have increased significantly. Operations with oil actually remained at the usual level. Transportation volumes for water transport also decreased from the turnover of 2019-2020.

More detailed data on emissions for each of the categories are presented in Table 3.24 and reflected in Figure 3.15.

[23]https://stat.gov.kz/edition/publication/collection
[24]https://stat.gov.kz/edition/publication/collection
[25]https://stat.gov.kz/edition/publication/collection
[26]https://stat.gov.kz/edition/publication/collection
[27]https://stat.gov.kz/official/industry/18/statistic/6
[28]https://stat.gov.kz/official/industry/18/statistic/6

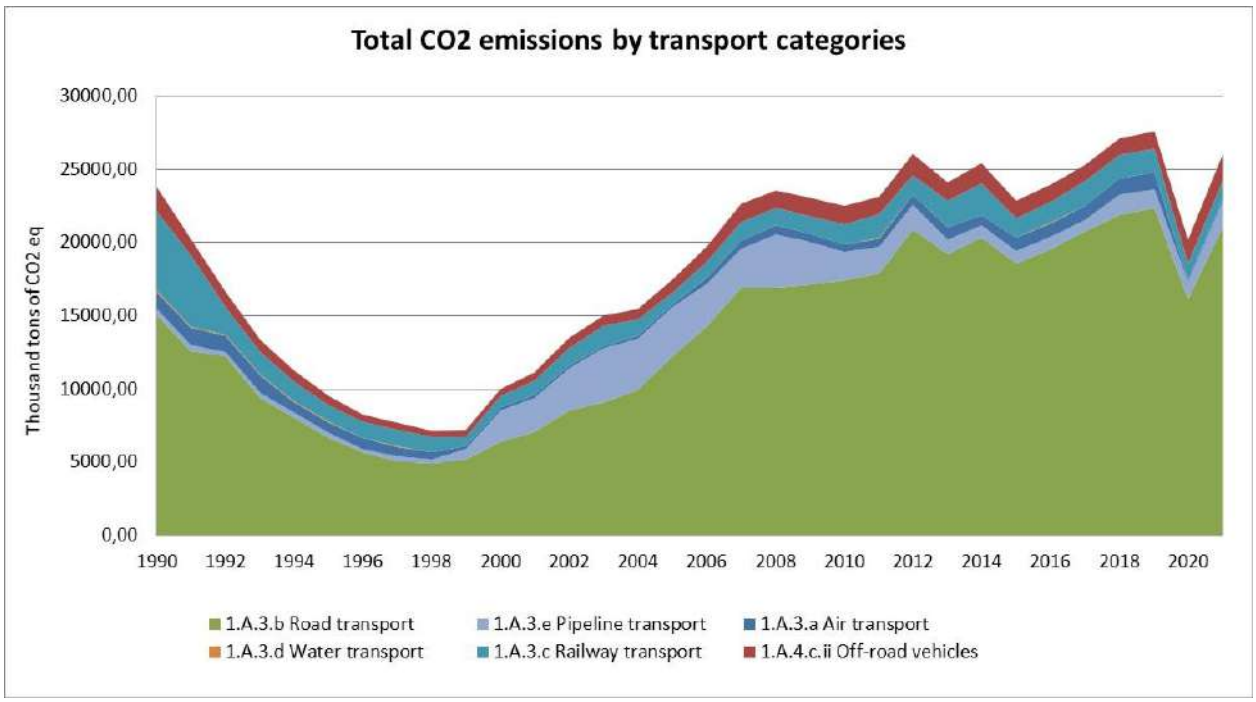


Fig. 3.15 - Greenhouse gas emissions from the transport sector in 1990 -2021 (Gg CO_2)
1.A.4.c. ii off-road vehicles

As can be seen from Figure 3.15 and Table 3.24, greenhouse gas emissions from the "Transport" category have slowed down, especially against the backdrop of significant positive dynamics in recent years. The acceleration in the growth of emissions has noticeably decreased compared to the middle of the first decade of the 2000s. Motor vehicles are the main source of greenhouse gas emissions in this category. Its share continues to remain at the level of 81% of all emissions in this category (Figure 3.16).

Figure 3.16 shows the contribution of each of the transport sub-categories to total emissions from this category in 2021 and 1990. for comparison. It can be seen that over the 30 years since 1990, the structure of this subcategory has changed significantly. So the share of the contribution of railway transport decreased from 23% to 4%, water transport decreased from 0.9% to 0.7%, pipeline transport increased from 2% to 7%. Aviation, despite the small annual growth dynamics, occupies an almost stable share of 4%, with the exception of the last two years.

Unfortunately, at present there are difficulties in obtaining data on motorcycles and motor vehicles (including bikes, scooters, mopeds and other vehicles using two-stroke and four-stroke internal combustion engines for movement). The ASPIR RK Bureau for National Statistics provides such data, despite the fact that the operating rules have been tightened, however, the process of registering these funds with the Ministry of Internal Affairs of the RK is slow, including obtaining numbers and paying the relevant taxes. This leads to the fact that today motor vehicles are not reflected in the data of the Bureau of National Statistics of the ASPIR RK. For this reason, expert-level estimates and sales status of new technology are presented, which were used in estimating greenhouse gas emissions.

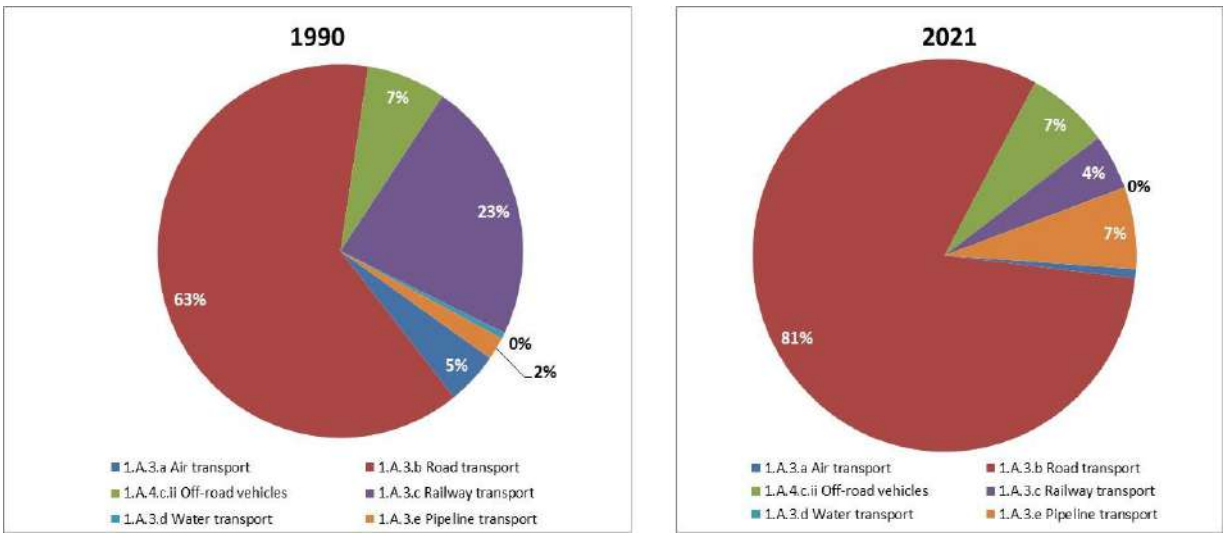


Figure 3.16 - Contribution of subcategories to GHG emissions from fuel combustion in the Transport subcategory in 1990 and 2021

It is impossible not to note one more important fact of the impact of COVID 19. Previously, experts assumed that the share of motor vehicles operated in the urban area would decrease, as electric scooters take their place in daily transportation as a more convenient, light and maneuverable means. This is especially important for residents of high-rise buildings, where the weight of a vehicle of 10 to 13 kg is critical when lifting into an apartment, and the ability to store when folded provides a lot of advantages. The growth in sales of electric samovars turned out to be stable due to the desire of citizens to avoid crowded places (public transport), as well as the need to be mobile. Recall that as part of the containment of the pandemic on Sundays and holidays, public transport in cities worked with severe restrictions, or did not work at all. At the beginning of the period of restrictions, there was a rather sharp demand for individual vehicles on electric traction. However, then the situation began to change. Against the backdrop of the continued growth in sales of electric samovars, there was suddenly an increase in demand for motor vehicles. As it turned out, with all the advantages of electric movement, a power reserve of 60-80 km per battery charge is not sufficient if you are engaged in courier activities. Therefore, motor vehicles were again in the trend, which provoked their widespread demand, and, accordingly, an increase in emissions.

A similar situation was observed in the category of passenger cars. The closure of borders and the inability to fly to ordinary vacation spots provoked a demand for domestic tourism in the country. Many holiday destinations that until that time experienced a shortage of vacationers even in the “hot season” were filled, and since the railroad and air services were limited, residents traveled to their destination on their own. Moreover, there is a large amount of evidence of the organization of a spontaneous movement of autotourism. When many residents of Kazakhstan, being online, traveled within the country, organizing their own tours and finding like-minded people on the Internet.

The new reality has set a number of regional challenges for the country's transport industry. Transport coped with most of the problems in meeting the needs of the economy. However, there were problems related to border closure issues, which caused congestion of vehicles near the checkpoints, and consequently limited their effective operation. At present, it is difficult to determine the possible volumes of emission reductions in this area, but there is clearly a potential for this, both by optimizing the work of some subcategories, improving logistics, and by increasing

the load on some other modes of transport, for example, on inland water transport, as well as to expand the share of pipeline transport of oil and gas, as well as rail transport for industrial goods.

3.4.5 Road transport (1.A.3.b)

3.4.5.1 Current status of the sub-category "Road transport"

This sub-category considers only greenhouse gas emissions from road transport in the Republic of Kazakhstan. Before proceeding to quantify emissions, it is necessary to consider the composition of Kazakhstan's vehicle fleet (Figure 3.17).

Figure 3.17 fully reflects the change in the dynamics of the number of cars in the Republic. Since 1990, when there were 1278.8 thousand cars in the republic, their number has increased 4 times, and in 2021 it reached 4386.8 thousand units. Since 2015, the number of vehicles has been decreasing. The maximum number of vehicles was in 2014, when 4533.7 thousand units were registered.

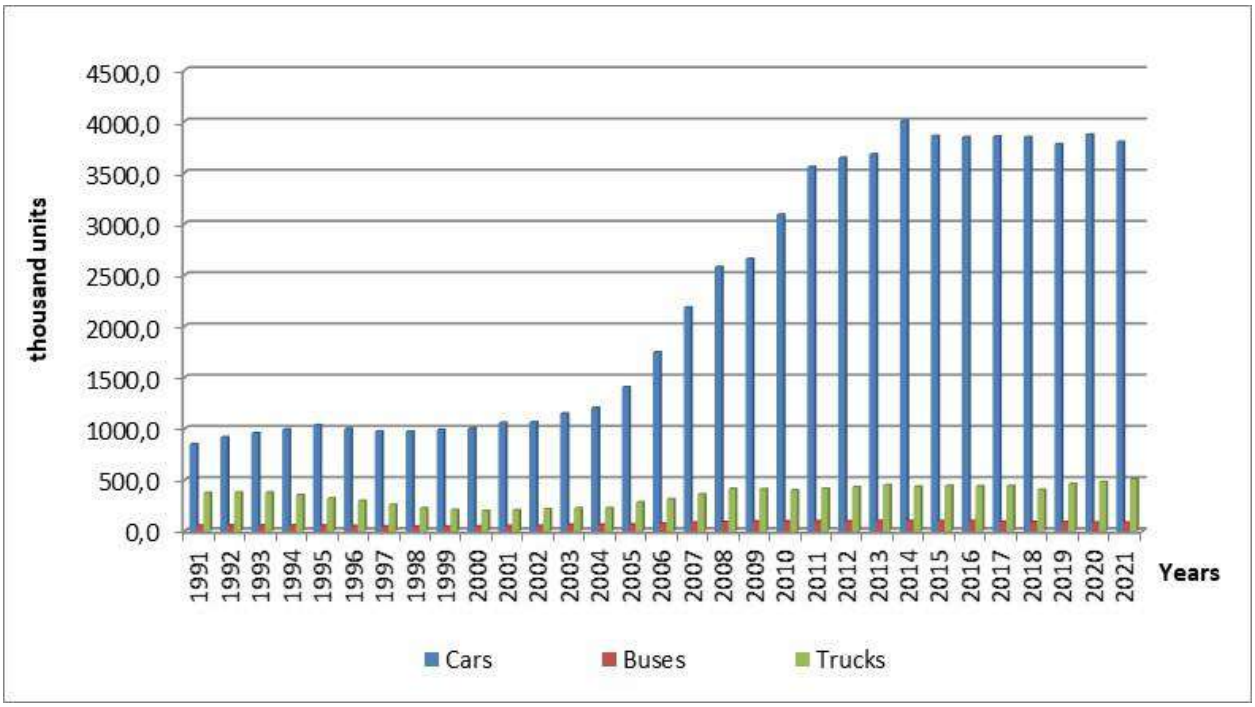


Fig.3.17 - Changes in the structure of the vehicle fleet of the Republic of Kazakhstan for the period from 1990 to 2021

According to the results of registration with the Ministry of Internal Affairs of the Republic of Kazakhstan, as well as in the opinion of local experts, the decrease in the fleet is the result of the activities of the Ministry of Internal Affairs of the Republic of Kazakhstan and the tax maneuvers of the financial police, as a result of which, cars that were not in operation, but at the same time were on the balance sheet of the Ministry of Internal Affairs, began to be deregistered for recycling. As a rule, these are cars, the period of operation of which is more than 25-30 years, or cars that, due to an accident, are not subject to further restoration and, accordingly, operation. The largest number of cars was deregistered in 2015 (136.4 thousand), in 2021 46.7 thousand cars of all categories were deregistered (meaning that deregistration applies not only to cars, but also buses and trucks, which may be due to fleet renewal or optimization).

It is also worth noting the fact that over the past six years the number of cars has changed slightly, within 120 thousand units per year, which indicates the saturation of the country's

domestic market. The observed decrease in the number of cars in 2021 is explained by the financial passivity of demand against the background of the pandemic, which leads to an increase in the share of imported used cars that were previously registered in Armenia, Azerbaijan and the Russian Federation, but were operated in Kazakhstan. The Ministry of Internal Affairs of the Republic of Kazakhstan several times postponed the terms of the amnesty for those cars that were supposed to leave the roads of Kazakhstan, but did not. Since the issue with the legalization of vehicles arose quite sharply, the owners of the vehicles were forced to register them within Kazakhstan. The issue has not yet been resolved, and the number of such cars may also increase slightly next year. The share of new cars with a service life of up to 7 years remains not very high in the country, as will be discussed below.

The internal structure of the fleet has also changed significantly (Figure 3.18).

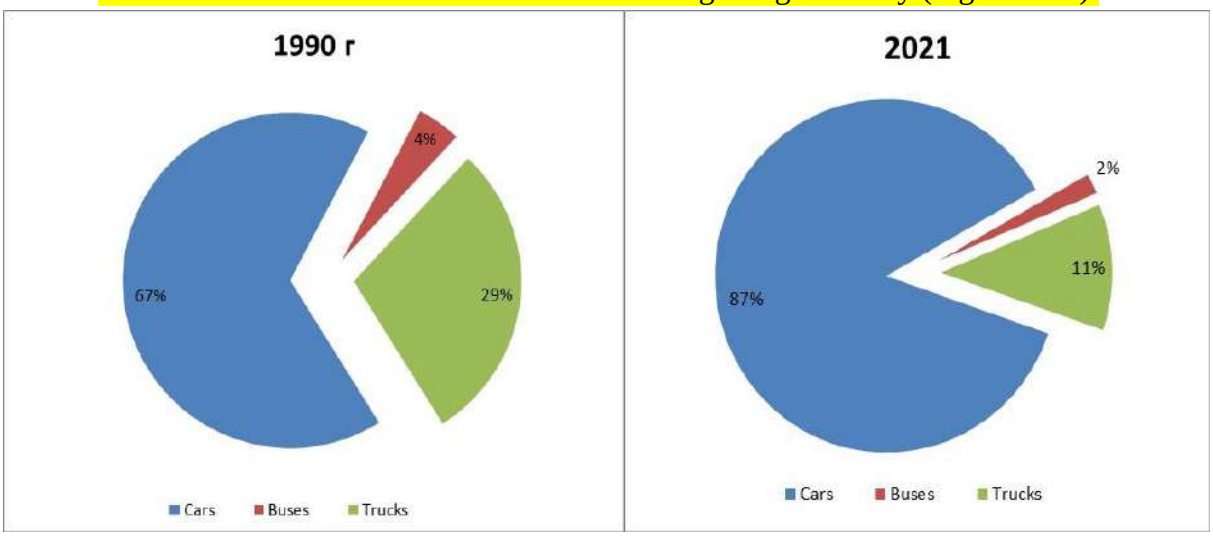


Fig. 3.18 - Internal structure of the vehicle fleet of the Republic of Kazakhstan in 1990 and 2021

The presented diagrams (Fig. 3.18) well demonstrate the changes that have taken place in the structure of the country's car park. In particular, the share of passenger cars has now increased significantly - from 67% in 1990 to 87% in 2021. The share of buses has not significantly decreased - by 2%. The number of trucks has increased: from 384 thousand units in 1990 to 506.6 thousand units in 2021. At the same time, in percentage terms, their number has decreased, as the share of cars has increased significantly.

In percentage terms, the number of motorcycles also changed from 200.6 thousand units in 1990 to 145.1 thousand units in 2021. Thus, the number of motorcycles has not yet reached the level of 1990.

2021 showed that, contrary to expectations of an increase in the number of motor vehicles, their number is significantly reduced due to the increasing demand for electric scooters and other personal vehicles. In an urban environment, these modes of transport are the most promising in terms of operation, storage and cost. However, as time has shown, motor vehicles are more preferable for courier activities, since the power reserve is determined not by the charging time and battery power, but by the filled fuel. For this reason, the number of motorcycles with internal combustion engines has suddenly increased, and the number of motorcycles with four-stroke engines up to 850 cm ^{3} has remained at about the same level, since the initial price for them competes with the cost of a used good car.

It should be noted that the operating cycle, both cars and motorcycles, has changed significantly. First of all, cars began to be used longer, both in terms of the “life” of the vehicle

and in terms of driving cycles. Sources indicate that, on average, cars have become more driven in urban areas, and the proportion of time spent on suburban trips has also increased. Motorcycles have increased the duration of one driving cycle. In addition, the number of motorcycles operated in urban areas has increased significantly compared to 1990, when the main concentration of motorcycles was in rural areas. This is partly due to the significant maneuverability of this vehicle, as well as its great mobility and high average speed than cars in the city.

It is also necessary to pay attention to the fuel structure of the park. Note that in 1990 there were no domestic cars with a diesel engine among the available passenger cars. At the same time, foreign-made cars were not imported, with the exception of isolated cases. This was due to the economic structure of that time. Diesel vehicles were used exclusively in agriculture and heavy work. Thus, all diesel vehicles were categorized as trucks at the beginning of the reference period. Starting from the 1990s, the number of diesel passenger vehicles began to grow (Figure 3.19).

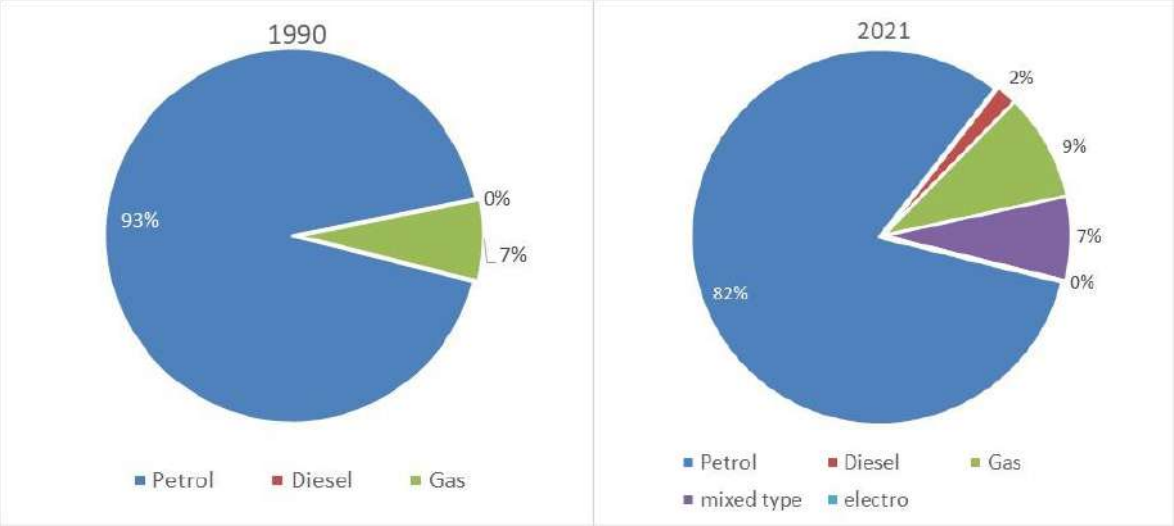


Fig 3.19 - Changing the ratio of fuel types. consumed by passenger cars in 1990 and 2020

Diagram 3.19 makes it possible to understand the changes that have taken place in the structure of the car park in Kazakhstan. Petrol transport remains the undisputed leader. Its presence in the market is kept within 82%. A feature of the diesel transport segment is that these are vehicles with an engine capacity of at least 2.5 liters, and, as a rule, these are cross-country vehicles. Separately, the situation is with cars equipped with gas-balloon equipment. According to the Bureau of National Statistics of the ASPIR RK, there are only 0.1% of such cars, however, the existing category of mixed fuel types allows us to say that this segment includes cars that can start and warm up the engine on gasoline, and further operation, including short stops and restart engine, carried out on gas. Thus, by default, when calculating greenhouse gas emissions, it is assumed that all these cars are gas-powered. As of 2021, their number reaches almost 9%.

And another trend of the times is the emergence of electric vehicles. There are currently about 500 cars on pure electric traction (without an internal combustion engine on board) in Kazakhstan [30]. According to some sources, it is not specified whether this includes exclusively electric vehicles, or whether this number includes so-called hybrid vehicles (i.e. having an internal

[30]Zakon Information System . kz (2018). *Since the beginning of the year, 33 electric vehicles have been registered in Kazakhstan* , June 3rd. Available at http :// www . laws . kz /4921504- v - kazakhstane - s - nachala - goda . html

combustion engine and an electric propulsion unit on board). [31]At the same time, it should be noted that this report uses only official data provided by the Ministry of Internal Affairs of the Republic of Kazakhstan.

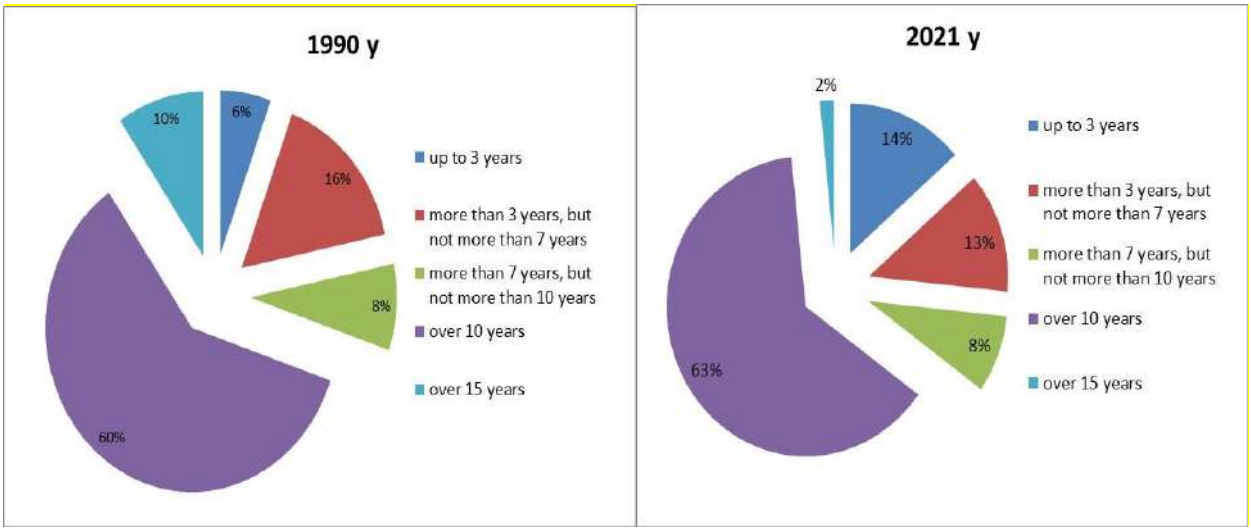


Fig. 3.20. Age composition of the car fleet of the Republic of Kazakhstan in 1990 and 2021

Separately, it is necessary to note the age of the car park in Kazakhstan, indicated in Figure 3.20. In 2021, the share of cars less than 3 years old was 14%. At the same time, the share of old cars (more than 10 years old) remains at a high level - 63% of the country's car fleet. At the same time, the share of cars older than 20 years out of 64% is, according to experts, at least 24% (only 2% according to the Bureau of National Statistics of the ASPIR RK), and 13% are cars aged 3 to 7 years, another 8% are cars aged 7 to 10 years [32]. Thus, the car park is quite old due to its age. A small share of environmentally friendly cars is concentrated, as a rule, in cities, but against the background of the average age of cars, it does not have a significant impact on reducing greenhouse gas emissions.

These data were synthesized on the basis of reports from enterprises in all sectors of the economy, providing information on the availability and operation of vehicles (own or rented).

The main source of information for calculating emissions for the "Transport" subcategory was the following documents issued by the Bureau of National Statistics of ASPIR RK [33]:

- fuel and energy balance of the Republic of Kazakhstan, 2021;
- annual bulletin "Motor transport of the Republic of Kazakhstan [34]" 2021;
- statistical collections "Transport of the Republic of Kazakhstan 2021";
- "Transport of the Republic of Kazakhstan 2017 - 2021";
- Reviews of local media;
- Analytical materials of the agency "Wheels";
- Analytical materials of local experts.

[31]Gorbunova, Arina (2018). *Owners of electric scooters in the Republic of Kazakhstan can receive preferences on the roads and tax benefits* , September 20. Available at https://forbes.kz/auto/vladeltsyi_elektrokarov_v_rk_mogut_poluchit_preferentsii_na_dorogah_i_nalogovyie_lgotyi
[32]Kim, Konstantin (2016). Power industry. Between past and future. *Kazakhstan business Magazine* , Vol. 1. Available at http://investkz.com/journals/108/1486.html . Date of access 13 April 2020
[33]https://stat.gov.kz/official/industry/18/statistic/6
[34]https://stat.gov.kz/official/industry/18/statistic/6

3.4.5.2 Methodological approaches

To estimate greenhouse gas emissions from road transport according to the 2006 IPCC methodology [35], the amount of fuel consumed was used. This approach is well suited for calculating $CO_{2\ emissions}$, but it has certain disadvantages in determining nitrous oxide and methane emissions.

The entire fleet of vehicles was divided into categories, taking into account:

- the classification of vehicles adopted by the Geneva Convention (E/ECE/324 rev.2.5 October 1995);
- classification of cars adopted by the Russian Federation (OH 025 270 - 66);
- grouping of cars (European Union, certain European countries, USA) according to the emission factors of harmful substances;
- grouping cars according to emission factors of harmful substances produced in the CIS countries;
- grouping of vehicles adopted by the Bureau of National Statistics of ASPIR RK;
- grouping of vehicles adopted by the State Revenue Committee of the Ministry of Finance of the Republic of Kazakhstan.

In addition, to estimate the number of off-road vehicles, data were used on the availability of specific equipment in the country, published on the website of the Ministry of Agriculture of the Republic of Kazakhstan. Data for the sub-category *Off-road vehicles* (1.A.3.e ii) are also presented in this report.

The following equation was used to calculate emissions:

$$Выбросы = \sum_{a} [Топливо_a \bullet EF_a] ,$$

$_2$ emissions (kg);

Fuel $_a$ = sold fuel (TJ);

EF $_a$ = emission factor (kg/TJ), equal to the carbon content of the fuel multiplied by 44/12.

a - type of fuel (e.g. gasoline, diesel fuel, natural gas, liquefied petroleum gas, etc.)

The same approach was used for calculations of other gases. Thus, the calculations in this subcategory are carried out according to the Tier 1 methodology (Figure 3.21).

[35]https://www.ipcc-nggip.iges.or.jp/public/2006gl/russian/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf

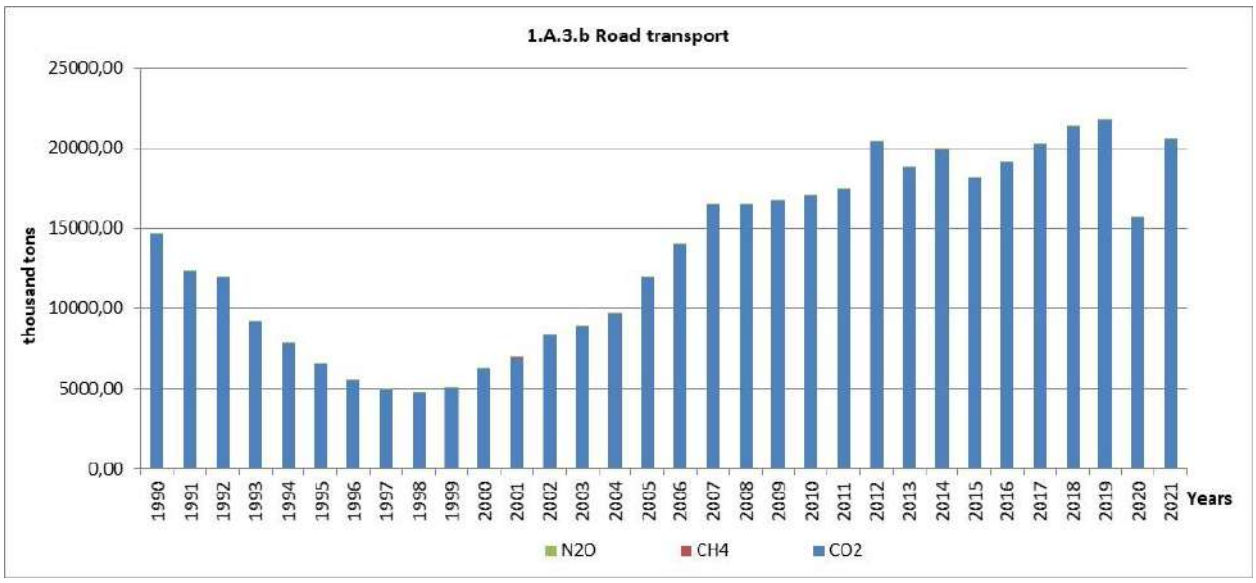


Fig. 3.21 - Dynamics of CO_2 emissions - eq. from the subcategory "Road transport" for 1990 - - 2021

Data on the use of biofuels were not used to calculate greenhouse gas emissions. This is due to the fact that the existing local production of biofuels were temporarily closed or unavailable for their intended use, since the price of it turned out to be incomparable with the price of fuel produced from oil, even despite the significantly increased cost of petroleum products after the modernization of all oil refineries republics. Thus, the main data are the amount of fuel sold: gasoline (regardless of the brand), diesel fuel (regardless of division into winter or summer) and the amount of butane-propane mixture for equipped engines.

At present, the entire series for road transport in Kazakhstan has been recalculated in the COPERT model for the first time, and the data generally have good agreement for the first half of the series and some differences for recent years (due to the influence of cars with technological improvements). However, since significant discrepancies have been identified for a number of years, which is apparently due to technical errors in modeling, the results of calculations in 2021 from using the COPERT model have so far been taken into account as an independent check of the data and for comparison of the entire series.

3.4.5.3 Inventory of urea converters for road transport

Accounting for additives (urea-based catalysts) for the automotive sector in Kazakhstan has been done for the fourth year (emissions are presented in the CRF tables in category 2. D .3 - Other). This task was not carried out as part of the National Greenhouse Gas Inventory until 2019, since it was believed that the car park of the Republic of Kazakhstan is quite old, while the need for such calculations makes sense for relatively “young” cars. However, following the recommendations of the Expert Review Group in 2019, this became one of the mandatory items. In this regard, several tasks were solved:

- Determination of the time period for which it makes sense to consider the use of catalytic converters;
- An estimate of the overall age of the country's car fleet;
- Estimation of the number of vehicles using different types of fuel;
- An estimate of the number of vehicles that use catalytic converter technology;
- Estimation of the amount of fuel used in vehicles equipped with catalytic converters;
- Estimation of the amount of additives used;

- Calculation of $CO_{2\ emissions}$ from the use of urea additives;
- Summation of $CO_{2\ emissions}$ from all types of vehicles using urea additive technology.

In fact, each of the presented subtasks, with the exception of the last two, is an independent study and is based on official statistics and partly on the assessment of independent experts. The data of official representatives of automobile companies, which are posted on Internet resources, were also widely used. The existing legal framework of the Republic of Kazakhstan was used, which regulates the norms and standards in the field of limiting emissions of pollutants, since the adoption of many existing provisions is directly related to limiting emissions of pollutants, and only secondarily - to greenhouse gas emissions in the country.

Time period definition . Despite the fact that the greenhouse gas inventory has been calculated since 1990, which is the base year for the country, technologies for the use of catalytic converters based on urea additives began to be used much later (Table 3.25).

Table 3.25 - Norms of emissions of pollutants from the operation of internal combustion engines (gasoline and diesel), at EURO standards (g / km) for passenger cars.

Substances \ Period actions		EURO 1	EURO 2	EURO 3	EURO 4	EURO 5	EURO 6
		1992–1995	1996–1999	2000–2004	2005–2008	2009–2013	2014
Diesel engines	SO	2.72 (3.16)	1	0.64	0.5	0.5	0.5
	NOx	-	-	0.5	0.25	0.18	0.08
	Carbon	-	-	-	-	-	-
	Volatile organic compounds (VOCs)	-	-	-	-	-	-
	HC+NOx	0.97 (1.13)	0.7	0.56	0.3	0.23	0.17
	PM	0.14 (0.18)	0.08	0.05	0.025	0.005	0.005
Gasoline engines	SO	2.72 (3.16)	2.2	2.3	1.0	1000	1000
	NOx	-	-	0.20	0.10	0.100	0.100
	Carbon	-	-	-	-	0.068	0.068
	Volatile organic compounds (VOCs)	-	-	0.15	0.08	0.060	0.060
	HC+NOx	0.97 (1.13)	0.5	-	-	-	-
	PM	-	-	-	-	0.005	0.005

Full electronic control of the entire process of work at all stages, from fuel preparation (injection and enrichment) to its subsequent combustion and the degree of purification of exhaust gases in the converter in front of the muffler, makes it possible to prevent the vehicle from operating in the event of a system malfunction. The application of technologies with catalytic converters came with the need for a large-scale fight against harmful substances and the tightening of environmental standards. They were implemented, as is known, by a series of EURO standards (Table 3.26).

Table 3.26 - Timing of implementation of EURO standards for trucks and buses in Europe

	EURO 1	EURO 2	EURO 3	EURO 4	EURO 5	EURO 6
Trucks weighing up to 3.5 tons	10.1994	01.1996	01.2000	01.2005	09.2010	09.2015

Trucks with gross weight from 3.5 to 12 tons	10.1994	01.1998	01.2001	01.2005	09.2010	09.2015
Trucks with gross weight over 12 tons and buses	1992	1995	1999	2005	2008	2013

On the territory of the Republic of Kazakhstan, the introduction of specific standards for vehicle emissions in accordance with the technical regulations was provided for in the following terms:

environmental stage of EURO-2 from 15 July 2009

environmental stage of EURO-3 from January 1, 2011

environmental stage of EURO-4 from 1 January 2014.

The main technical requirements for the characteristics of fuel for motor vehicles were put into effect in the following terms:

environmental stage of EURO-2 from 1 January 2010

environmental stage of EURO-3 from January 1, 2011

environmental stage of EURO-4 from 1 January 2014.

Assessment of the age of the country's car fleet. Taking into account the age of the car park is the most important stage of work, as mentioned above. The selective catalytic reduction (SCR) technology itself was introduced with the introduction of EURO 4 and 5, i.e., on all European cars, starting in 2005. This rule does not apply to used cars imported from neighboring countries, China, Korea, the United Arab Emirates, Japan and the USA, which were already seven years old or more at the time of import into the country. It is believed that if the technology for cleaning exhaust gases was installed on them, then by the time it was imported into the country, it had already fully developed itself.

An important condition is also the fact that when importing foreign cars manufactured before 2008 into Kazakhstan, most of them were 7 years old or more. Only a small percentage of cars sold in the country were brand new with zero mileage. To consider the internal growth of the fleet from 1990 to 2008 due to the import of new cars into the country, as some foreign experts think, is wrong. The average price for a new car at the time ranged from $8,000 to $12,000. The specified price range at that time was unaffordable for the majority of the population. Since 2008, it has become extremely unprofitable to import cars older than seven years into the country, due to the changed tax policy - now the tax has been charged inversely with the age of the imported car and engine size.

Starting in 2008, significantly newer cars began to be imported into the country, but not always completely new. Although it should be noted that from that period to the present, the park has been renovated, but there is no need to talk about a significant change in its internal age structure. Today, cars that were imported back in the period of the 2000s are massively operated. As already mentioned, by the time of importation, their age was at least 7–10 years. Thus, in terms of mass fraction, the average car today is at least 25–27 years old (see Figure 3.23).

Unfortunately, the Bureau of National Statistics of the ASPIR RK does not reflect this fact in the submitted reports. The entire fleet of cars is divided into categories:

up to 3 years;

at least 3 years, but not more than 7 years;

at least 7 years, but not more than 10 years

over 10 years;

others.

According to the presented diagram (Fig. 3.23), most of the Kazakh passenger car fleet falls into the category “more than 10 years” and “other”.

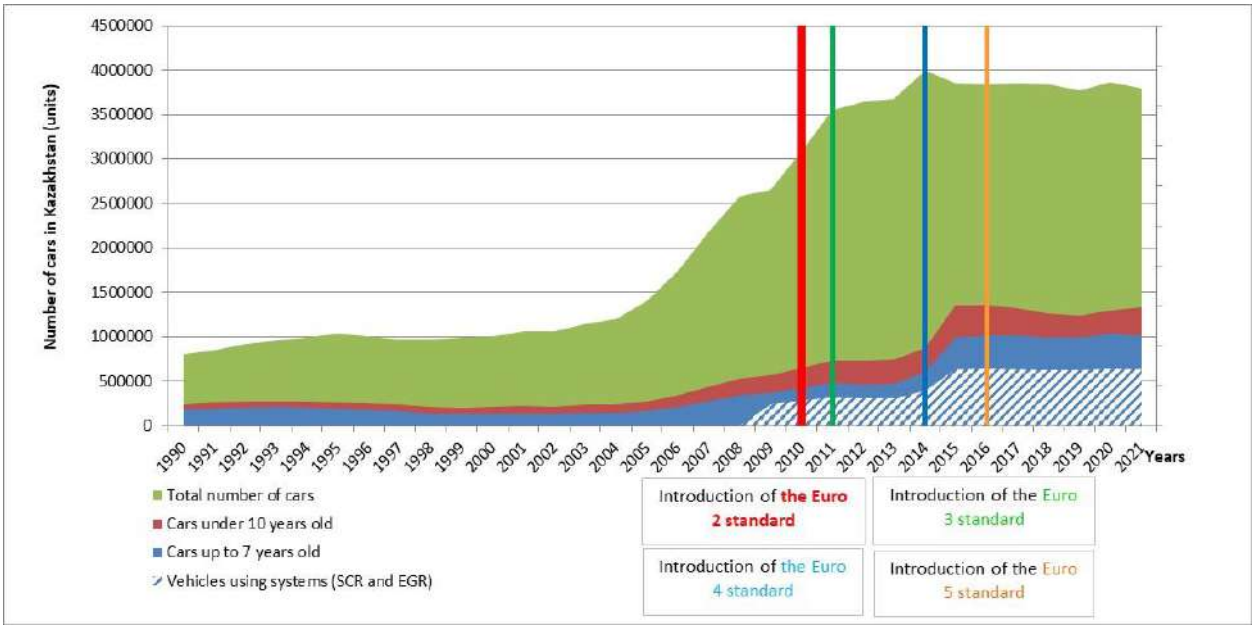


Figure 3.23. The number of passenger cars that have an integrated exhaust gas cleaning system (SCR and EGR) in Kazakhstan since 2009 (according to the Bureau of National Statistics ASPR RK)[36]

The timing of the introduction of EURO 2, 3 and 4 fuel standards is regulated by the Decree of the Government of the Republic of Kazakhstan dated December 29, 2007 No. 1372, which was supplemented by the Decree of the Government of the Republic of Kazakhstan dated January 30, 2017 No. 2 9. The Euro 5 standard was introduced in 2016 [37].

Thus, less than one quarter of the vehicles available can participate in the assessment of potential greenhouse gas emissions. However, this category also includes cars that use all types of fuel: gasoline, diesel and gas. To solve the problem of accounting for additional $CO_{2\ \text{emissions}}$, it is necessary to take into account only vehicles using urea additives used to reduce pollutant emissions, which, as indicated above, are used exclusively for diesel engines. Thus, from the presented number it is necessary to exclude cars running on gas and gasoline. Figure 3.24 shows a diagram of the share of diesel fuel that is taken into account for the calculation of urea additives for the car fleet of Kazakhstan.

[36]https://forbes.kz/process/kachestvo_na_urovne_k_voprosu_ob_otechestvennyih_gsm
[37]https://tengrinews.kz/kazakhstan_news/vvedenie-evro-5-avto-2016-godu-povliyaet-vtorichnyiy-ryinok-287905/

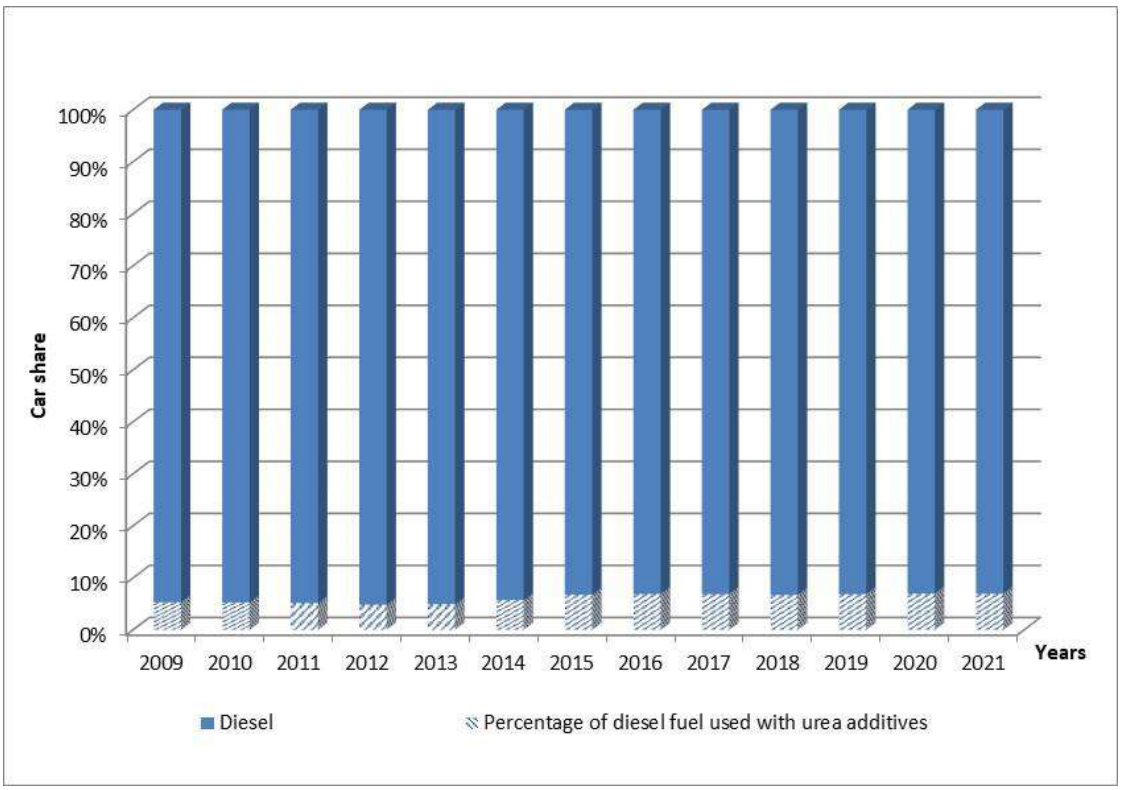


Figure 3.24 - Percentage of passenger cars using an exhaust gas treatment system.

It should be added that until 2010, Kazakhstan did not produce fuel, the quality of which would meet the European standards for SCR technology (according to the Government Decree of December 29, 2007 No. 1372). However, emissions estimates have been made since 2009 to account for all vehicles that potentially used the mentioned technologies.

Vehicles using urea additives were accounted for by their number and age, excluding the share of vehicles using gasoline and gas as fuel (Figure 3.24). This approach was applied both for passenger cars and for trucks along with buses. For trucks and buses, the Bureau of National Statistics of the ASPIR RK does not provide data on the age of the units in operation, which significantly complicates the calculations. Therefore, for an objective assessment, the year-to-year difference in the existing car park was calculated. Further, this difference was considered as new cars that already have a cleaning system. Cars and buses that use gasoline and gas as fuel were excluded from the resulting difference. This was especially important for a fleet of trucks up to 3.5 tons, since these vehicles often use gasoline engines, which can later be modified to run on gas. For trucks over 3.5 tons, such a division was not necessary, since they all run on diesel fuel (Figure 3.25).

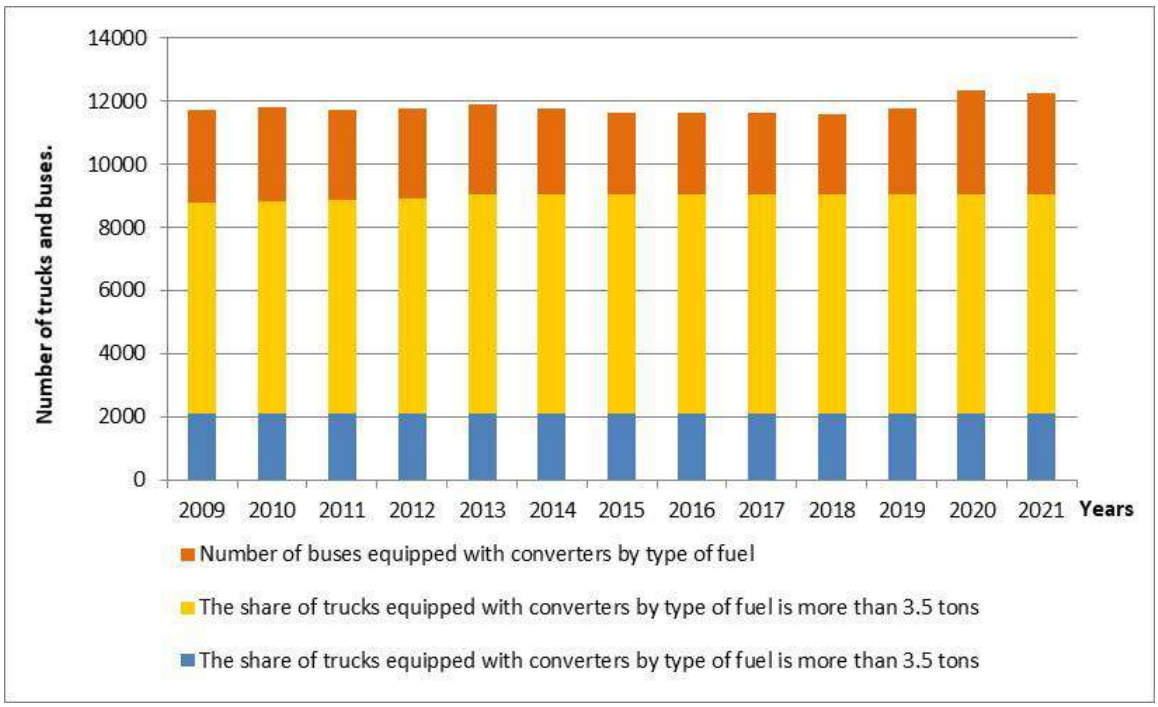


Figure 3.25 - Number of trucks and buses equipped with SCR type urea catalyst system

Certain difficulties arose when dividing the bus fleet by fuel type. In the context of the ongoing policy for the sustainable development of the urban environment, gas-powered buses have been introduced. For this reason, it was necessary to exclude the share of such buses from the total number in the assessment and leave only diesel units.

According to the 2006 IPCC Guidelines for Mobile Combustion, the following equation is used to calculate CO2 emissions $_{from}$ urea-based catalysts:

$$\text{Выбросы} = \text{Деятельность} \times \frac{12}{60} \times \text{Чистота} \times \frac{44}{12}$$

Where: Emissions - $CO_{2\,emissions}$ from the use of urea-based additives in catalytic converters (Gg CO_2);

Activity - quantity of urea-based additives used in catalytic converters (Gg);

Purity - weight fraction (percent/100) of urea in urea based additives, according to the Guidelines, it is recommended to use a value of 32.5%, the default, if more accurate data are not available.

The coefficient $\frac{12}{60}$takes into account the stoichiometric conversion from urea ($CO(NH_2)_2$) to carbon, in the equations presented by us it is reflected in the operation of the hydrolysis catalyst, by the equation:

$$CO(NH_2)_2 + H_2O \Rightarrow 2NH3 + CO_2.$$

The coefficient $\frac{44}{12}$converts carbon to CO_2.

To perform calculations, it was assumed that for the assessment of "Activity", which actually reflects the amount of consumption of additives, in our case, 7% of the amount of fuel used for trucks and 5% for cars were used. This is due to the fact that according to all the sources that were studied before the calculations, it was precisely such volumes of consumption of fuel

additives that were indicated in accordance with the technical regulations. Note that according to the IPCC 2006 RP, the level of "Activity" is proposed to be estimated within the range of 1 to 3% of the fuel consumed. Thus, the results obtained will be slightly higher, but at the same time more accurate. The value of "purity" of urea was used by default (32.5%), since the value proposed by IPCC RP 2006 fit into the mass fraction of additives used in the domestic market of Kazakhstan (Figure 3.26).

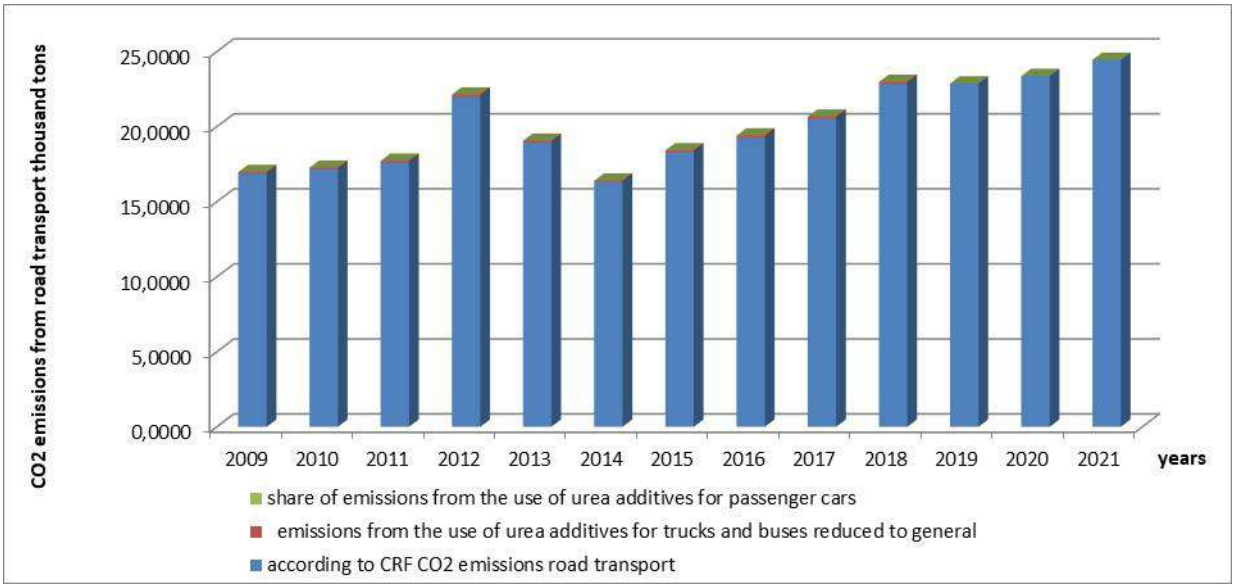


Fig. 3.26 - $CO_{2\ emissions}$ from urea catalysts compared to total $CO_{2\ emissions}$ from road transport.

The performed calculations allow us to say that the share of emissions from the use of urea additives is quite small and on average is about 0.24% of the emissions of CO_2 formed from direct combustion of fuel in the "Road transport" category. Recall that according to IPCC Decision 24/CP.19, paragraph 37, these emissions could be ignored. However, given the time spent and the work done, they are necessary, as an elimination of one of the comments of the 2019 review team.

It should also be added that despite the strict technical regulations for imported and manufactured cars, Kazakhstani oil refineries almost meet the requirements for the production of the corresponding fuel. [38].

On the other hand, a study of the technical literature showed that there are also additional $CO_{2\ emissions}$ from the operation of particulate filters, where additional soot combustion occurs with the support of warm exhaust gases. It can be assumed that this fraction of formed CO_2 is taken into account under the condition of complete combustion, which is currently accepted as a unit (in the framework of the IPCC Guidelines of 1996, the value of 0.99 was used). Unfortunately, the 2006 Guidelines do not provide any explanation in this regard. It also does not include some details. Thus, it is not stipulated that for the evaluation of urea catalysts it is necessary to take into account only diesel transport, and the generated $CO_{2\ emissions}$ must be taken into account as additional. This is because the specificity of the sub-category “Use of urea catalysts” for general pollution control can be understood as an abbreviation by default.

To reduce the share of uncertainty in the calculations, it is also necessary to revise the system for generating statistical reporting in Kazakhstan in the category of vehicles. Today, the submitted data is formed in the database of the Ministry of Internal Affairs of the Republic through

[38]https://forbes.kz/process/kachestvo_na_urovne_k_voprosu_ob_otechestvennyih_gsm

an annual sample, which forms the reporting category by the number of the total fleet of vehicles and its age. But if within the framework of national tasks there is a need to increase the detail of information, then it is necessary to revise the system for generating statistical reporting in the subcategory "Motor transport". In particular, we are talking about the share of cars using gas fuel.

At the same time, the presented calculations, in general, should not change significantly after taking into account all the uncertainties, and do not raise doubts about their objectivity.

3.4.6 Off-road vehicles (1.A.3.e ii)

3.4.6.1 Category description

This category includes vehicles used in agriculture, industry (including construction and maintenance), residential, airport ground support, agricultural machinery (tractors, harvesters, loaders, etc.) and construction. The engines of off-road vehicles are most often diesel, as well as gasoline four-stroke engines.

The most stable is the fleet of combine harvesters. The number of tractors is about one hundred and fifty thousand units. There are sixty-nine thousand units of special equipment involved in quarries and oil fields.

3.4.6.2 Method of calculation

First of all, in accordance with the 2006 IPCC Guidelines, it was assumed that complete combustion of the fuel takes place. Calculations were performed for the entire main group of greenhouse gases, CO_2, CH_4 and N_2O, as shown in Figure 3.27.

Data were also obtained on the fuel that was used in agriculture and off-road equipment used in construction, mining, and so on.

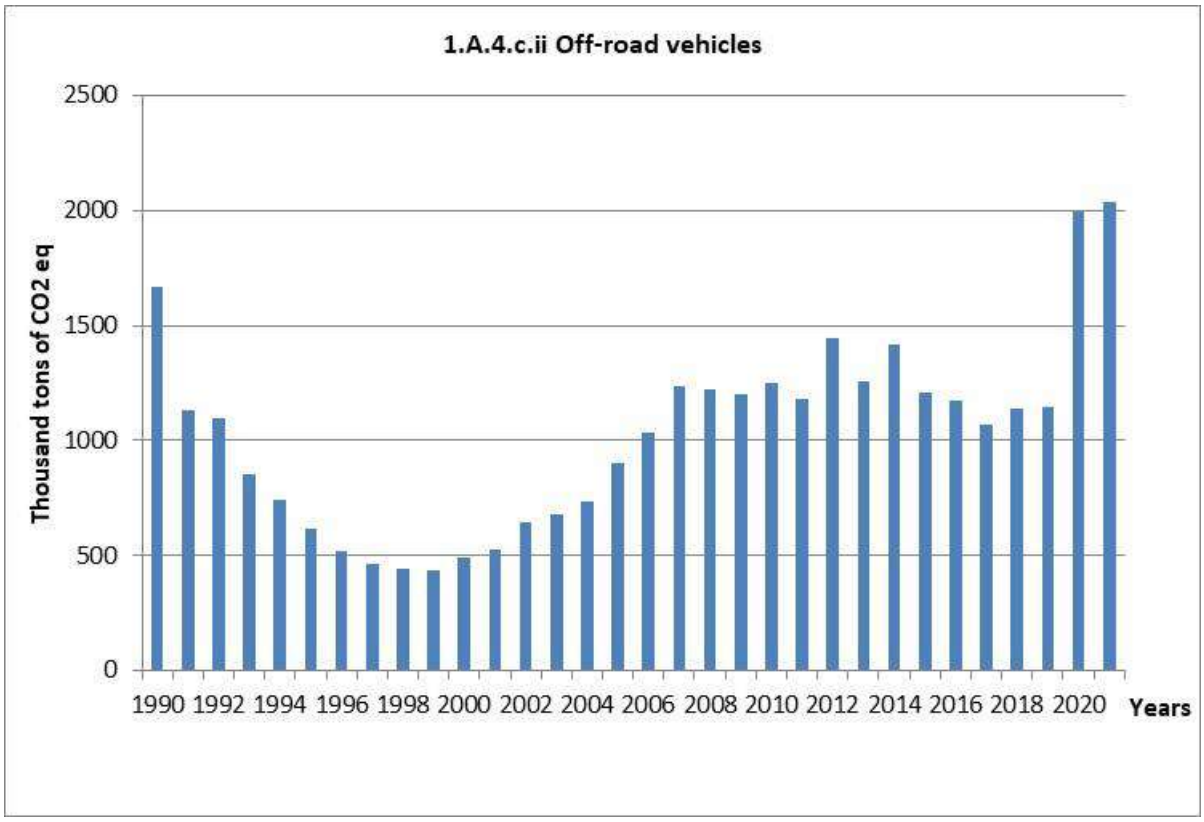


Figure 3.27. Emissions of CO_2-eq. from the subcategory "Off-road transport"

In Kazakhstan, there is no sufficient and complete information that would allow making calculations with great detail. For this reason, all calculations are made at Tier 1. Currently, the data is somewhat aggregated, however, in the 2021 inventory, all fuel categories are separated by

type and presented for the entire reporting period. Therefore, data are presented in categories 1.A.3.e. ii , 1.A.4. c . ii , 1.A.4. c . iii .

In the calculations, the default emission factors for CO_2 , CH_4 and N_2O by source and type of fuel, taken from the 2006 IPCC Guidelines, Volume 2, were used.

$_4$ and N_2O specific emission factors given in Table 3.2.2 of the IPCC SPM, Volume 2, 2006 shows that the CH_4 specific emission factor weakly depends on the off-road industry, and the N_2O specific emission factors on industries are independent.

General emissions. expressed in tons of CO_2 eq. from the work of off-road transport, in 2021 amounted to 2034.82 thousand CO - eq. One of the main reasons for the significant increase in emissions in the off-road transport category is the internal redistribution of economic tasks, after the pandemic. Part of the private sector has shifted from large cities to agriculture and near-industrial processes. In addition, the companies themselves partly increased their activities in the extraction of minerals and maintenance of production.

3.4.7 Pipeline transport (1.A.3.e)

Pipeline transport, which is called the transport of black gold and blue fire, is the most specialized in comparison with other types. This mode of transport is essential for the development of the oil and gas industry. Pipeline transport in terms of freight turnover came in second place after rail transport. The largest oil pipelines are: Omsk - Pavlodar-Shymkent, with a length of more than 2000 km across the territory of the republic, Ozen - Atyrau-Samara - 1500 km, Ozen-Zhetybay-Aktau - 141 km.

In Kazakhstan, export pipeline transport is a priority, which is associated with the prospect of increasing oil production.

The country has huge proven oil and gas reserves. About 24,437.1 km of oil and gas pipelines are used to transport hydrocarbons in the Republic.

Since the republic has practically no maritime borders, transportation is one of the main problems in the development of the Kazakhstani oil market.

3.4.7.1 Pipeline transport (1.A.3.e)

Calculations of CO_2 emissions are made, as well as for all other sectors, on the basis of national coefficients and data from the Bureau of National Statistics of ASPIR RK on the amount of fuel burned in this subcategory. For the calculation of CH_4 and N_2O emissions, the default factors given in the 2006 IPCC Guidelines were used. Thus, the calculations of CO_2 emissions are made at Tier 1.

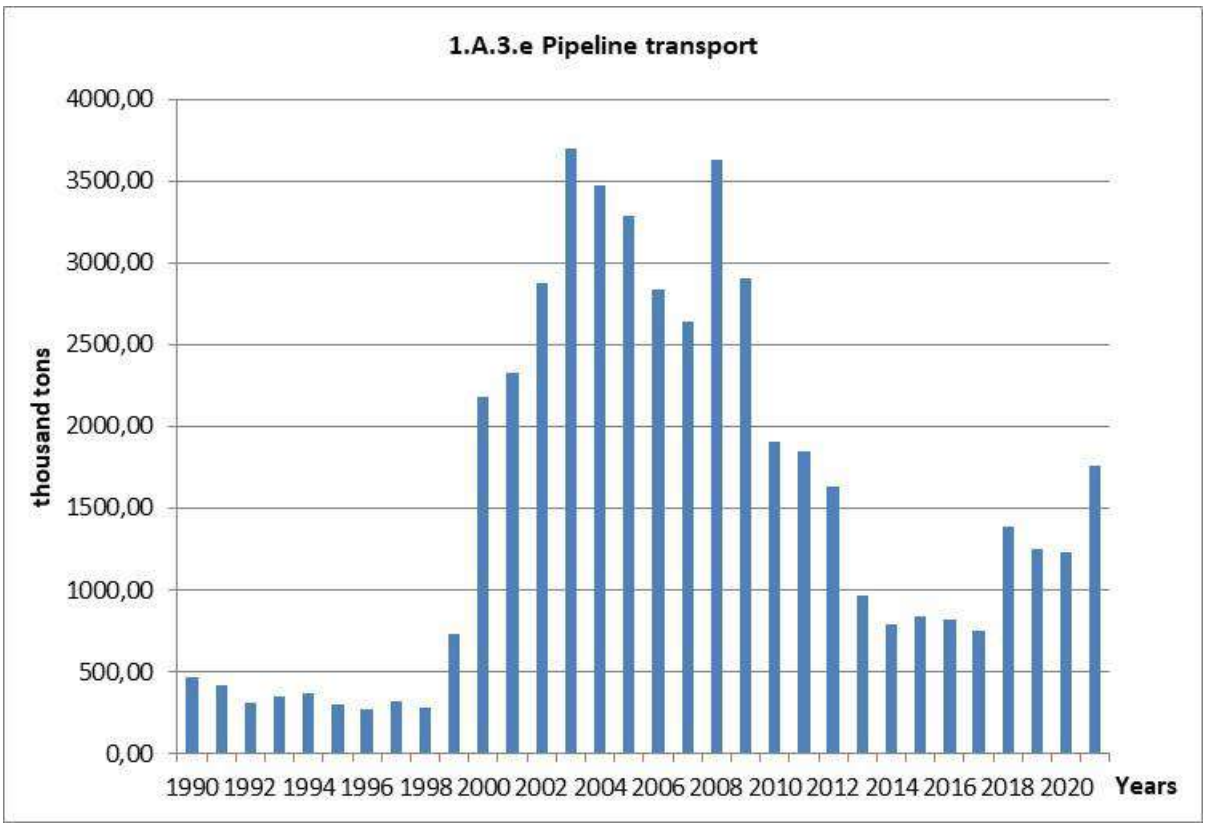


Figure 3.28 - Greenhouse gas emissions from pipeline transport for the period 1990–2021 (thousand tons of CO_2 .eq)

The results of calculations of all greenhouse gases from pipeline transport are shown in Figure 3.28. As can be seen, total emissions in the Pipeline Transportation sector have been fairly stable over the past four years. In 2021, there is a significant increase in GHG emissions CO_2 - eq. compared to 2020, which amounted to 1756.8 thousand tons. In 2021, emissions of CO_2 -eq. exceed the emissions of 1990 by 37.6%.

3.4.8 Civil aviation (1.A.3.a)

The aviation fleet of the Republic of Kazakhstan has changed significantly over the period of independence. The number of aircraft has almost halved (Figure 3.29), and the quality of the aircraft has also changed. Of course, we are talking primarily about large passenger aircraft, which account for more than 94% of all fuel consumption. If twenty years ago the aircraft fleet was dominated by TU and IL aircraft, now it is Airbus, Foker and Embrae r , as well as aircraft from other manufacturers. The structure of flights is mainly dominated by domestic lines. The number of companies operating regular flights on a national scale is five: Air Astana, Bek Air, Flyer, Skat and Jetesu. Let us note that information was previously given on six large companies, however, after the tragic incident with the aircraft of Qazaq Air , this carrier was liquidated. All its destinations were redistributed among other airlines. There are other companies, but the share of their flights in the total volume of passenger traffic is not very large - they are engaged in charter flights abroad or transport goods.

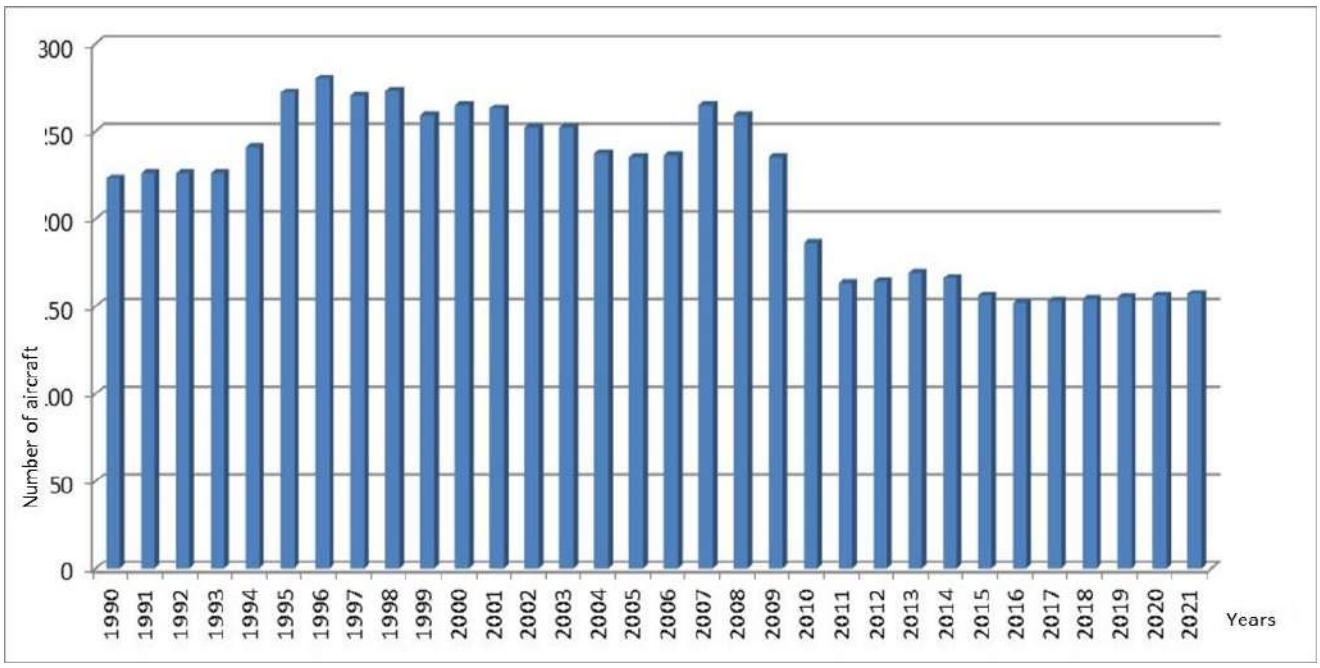


Figure 3.29 - Dynamics of changes in the number of large passenger aircraft in Kazakhstan.

Today, for the development of the industry, the airfields of local air lines (LA) are being repaired, the construction and reconstruction of airfields with a hard surface and several airfields with unpaved surfaces are envisaged. This points to the prospect of further growth in domestic traffic and, as a result, an increase in the aircraft fleet and an increase in greenhouse gas emissions.

3.4.8.1 Sub-category description (1.A.3.a)

Greenhouse gas emissions from aviation are mainly due to the combustion of jet kerosene and small amounts of aviation gasoline. Greenhouse gas emissions from aviation have their own specifics compared to other categories of mobile transport. Thus, aircraft engine emissions contain on average 70% CO_2, almost 30% water and less than 1% other components. Emissions of CH_4 and N_2O are very small or non-existent. This distinctive feature was reflected in the calculation method. All emissions, and these are, in fact, only $CO_{2\ emissions}$, are divided into two parts:

1) takeoff and landing cycle (L/L) emissions;

2) cruising emissions.

It was shown that about 10% of all emissions occur during takeoff and landing, the remaining 90% occur at high altitudes.[39]

In the dynamics of traffic in previous years, emissions have changed significantly due to the change in the air fleet of the Republic of Kazakhstan, which actually abandoned the operation of the air fleet that exists under the USSR and today, for the most part, uses aircraft manufactured in Europe or the USA. The number of aircraft has also changed. At the time of gaining independence, there were about 220 aircraft on the balance sheet of the Republic of Kazakhstan, while the number of aircraft for the inventory year 2020 was only 157 units. To date, the formation of a common database of all aircraft that belonged to Kazakhstan and operated over 29 years of independence has been completed. This base should contribute to a more detailed approach to the calculation of greenhouse gas emissions from civil aviation.

There were difficulties due to the fact that the Manual does not contain data on specific emission values for some types of aircraft that were common in the USSR and operated for some

[39]https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf

time after 1990. In this case, the specific emissions of other aircraft of this class and similar design were taken.

Change in emissions of CO_2-eq. in the Civil Aviation sector is shown in Figure 3.29. It can be seen from this figure that since 2001, emissions have been on the whole systematically increasing from year to year. In 2020, the situation has changed, as the number of passenger flights has been significantly limited. Most (90%) of international passenger flights have been cancelled. However, many companies transported medicines and equipment and operated the aircraft as cargo. So some activity took place. In the division of the ratio of international and domestic flights, domestic flights prevail. The ratio of domestic flights over international flights is approximately 90/10.

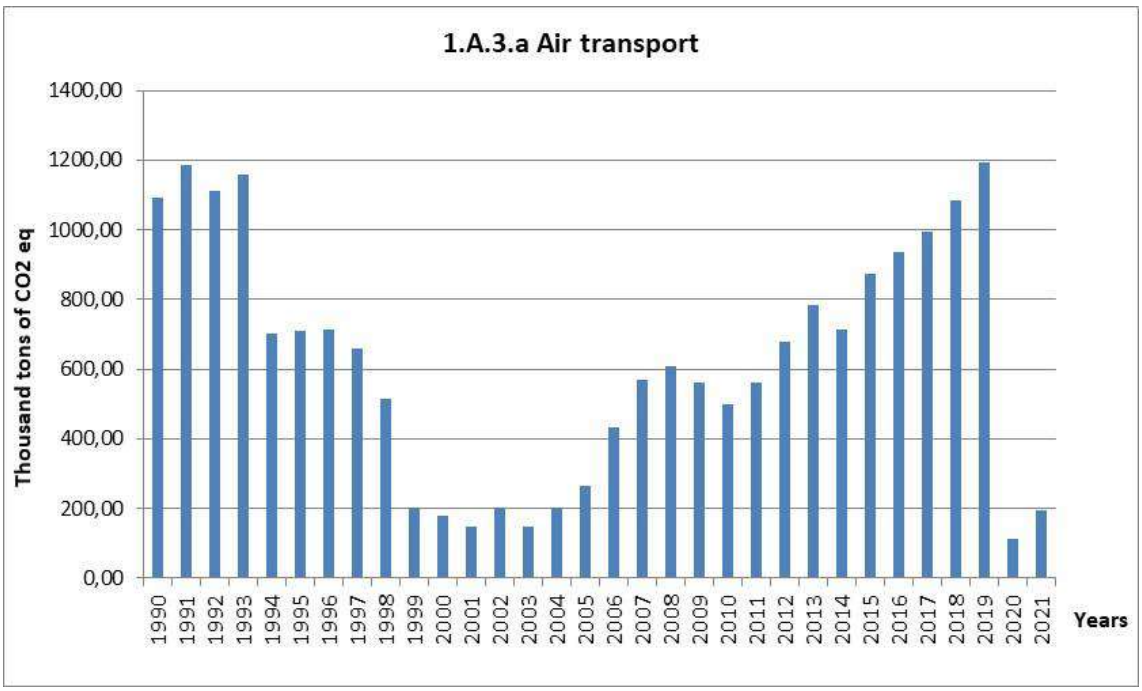


Figure 3.30 - Greenhouse gas emissions from the Civil Aviation sector for the period 1990–2021 (Gg CO_2-eq.)

Total greenhouse gas emissions from aviation in 2021 increased by 1.7 times from the level of 2020, and compared to 1990, they significantly decreased by 82%. As already noted, 2020 and 2021 are not typical for the aviation industry of the Republic, as restrictions were observed due to COVID 19, and many destinations were completely closed. Note that the sources of greenhouse gas emissions have changed significantly. This is partly due to the change in the aircraft fleet of the Republic of Kazakhstan, which actually abandoned the operation of the aircraft fleet that exists under the USSR and today, for the most part, uses aircraft manufactured in Europe or the USA. The number of aircraft has also changed. At the time of gaining independence, there were about 220 aircraft on the balance sheet of the Republic of Kazakhstan, while the number of aircraft for the inventory year 2021 was only 157 units. To date, the formation of a common database of all aircraft that belonged to Kazakhstan and operated over 30 years of independence has been completed. This base contributes to a more detailed approach to the calculation of greenhouse gas emissions from civil aviation.

Despite many limitations, the role of air transport cannot be underestimated. Over the entire period of independence, international flights have been made and emissions from this type of

activity have been calculated. The specificity of international flights is that all aircraft are refueled exclusively with kerosene, which is reflected in category 1. D .1. a . Accordingly, the category with aviation gasoline is designated by the key NO . In the general balance of emissions of the Republic of Kazakhstan, this volume is not taken into account, but all reporting is observed. In addition, the entire data series is homogeneous and has one reliable source: the Statistical Compendium on Transport [40], where fuel for refueling on international flights is presented separately.

3.4.8.2 Method of calculation

The calculations were performed at Level 2. For this, the following stages of work were carried out:

- Determine the amount of fuel consumed separately on domestic and international lines;
- Determine the number of takeoffs and landings (TO/L) for each type of aircraft, both for domestic and international flights;
- Estimate the fuel consumed separately for the V/L and for the cruise flight. At the same time, select bunker fuel, for which then separately calculate GHG emissions;
- Calculate GHG emissions for the V/L and cruise phases, which are then brought together;
- Present data on GHG emissions separately for bunker fuel and domestic flights.

All of the listed procedures were performed and calculated for Tier 2.

3.4.9 Rail transport

Over the past years, railway transport has provided about 58% of the total freight turnover and 10.8% of the passenger turnover in the country. JSC "Kazakhstan Temir Zholy" - the largest Kazakhstani company - ranks 7th in the world in terms of cargo transportation after the USA, China, India, the European Union, Russia and Ukraine.

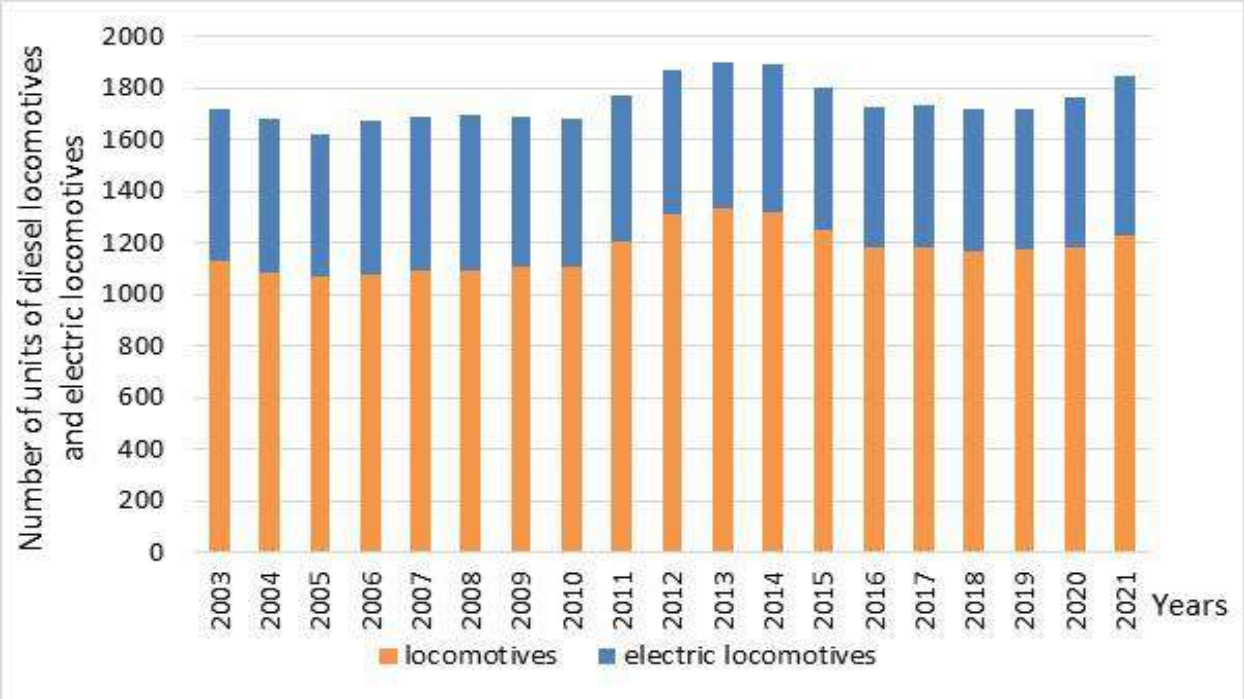


Figure 3.30 Number of locomotives of all categories operating in Kazakhstan[41]

[40]https://stat.gov.kz/official/industry/18/statistic/6

DBL[41] *There are no data on the number of electric locomotives for 2019, data from 2018 are used.*

The operational length of railways in Kazakhstan is 16,579.6 thousand km. The number of locomotives today is 1846 units, of which at least 618 units are directly diesel locomotives using diesel as fuel (Figure 3.30) . Note that the number of diesel locomotives does not change significantly, which indicates a fairly stable loading of railway tracks. Although it should be noted, the impact of restrictive quarantine measures in the past two years has been significant.

3.4.9.1 Sub-category description (1.A.3.c)

GHG emissions in this category are calculated from the work of the traction stock of the railway companies of the Republic of Kazakhstan. Currently, the most common type of locomotives are diesel. However, there are also electric and steam (steam locomotives). Emissions associated with the generation of electricity for electric locomotives should be accounted for in the Stationary Sources section and this type of locomotive is not presented in this section.

There are no steam locomotives that would be operated on the territory of Kazakhstan. Consequently, only diesel locomotives (diesel locomotives) are a source of greenhouse gas emissions. Diesel locomotives are divided into three categories: shunting, hauling and railcars. Shunting locomotives are used within railway stations. The rated power of the engines they have is from 200 to 2000 kW.

Railcars are used for short distances, usually suburban or urban routes, and are equipped with engines rated between 150 and 1000 kW. In Kazakhstan, railcars are not used on suburban routes.

Traction (linear) locomotives are used over long distances to transport goods and passengers. They are equipped with motors with rated power from 400 to 4000 kW.

In this sector, there is a steady decrease in CO_2-eq emissions compared to 1990 (Figure 3.31). This is partly due to a decrease in all rail traffic, as well as an increase in the length of electrified road sections.

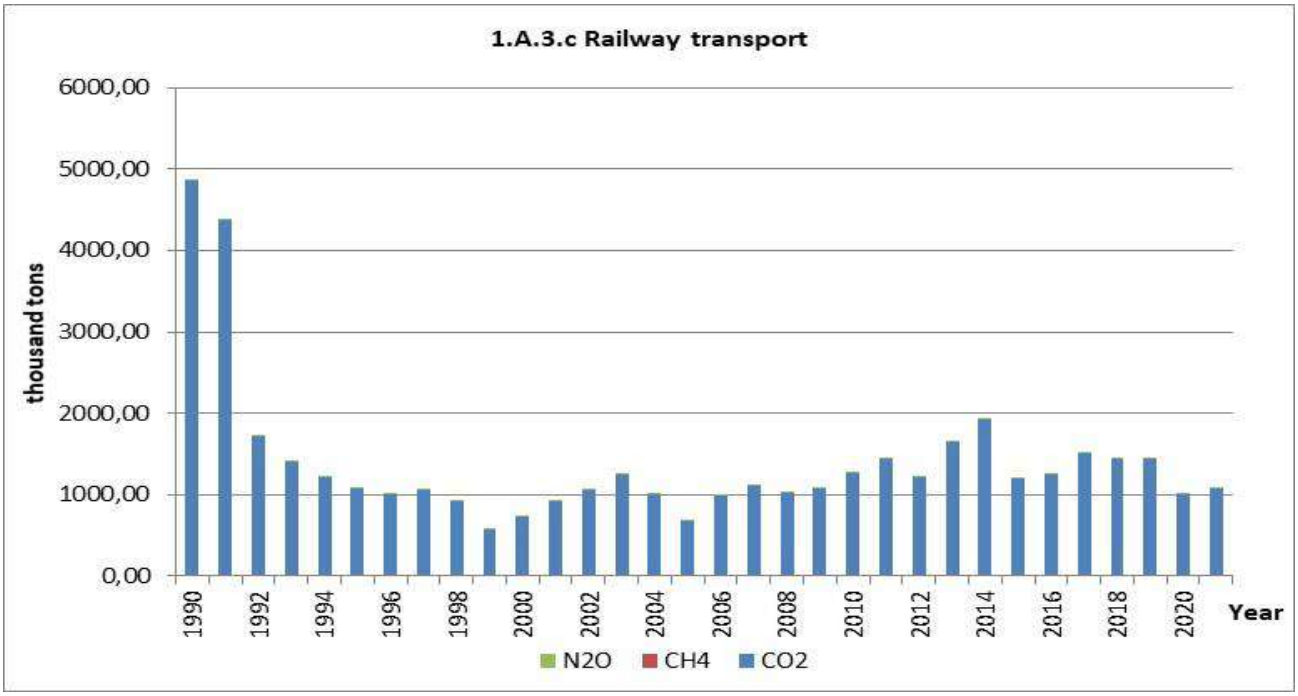


Figure 3.31 - Greenhouse gas emissions from the "Railway transport" sector for the period 1990–2021 (Tg CO_2-eq.)

GHG emissions from the operation of railway transport in 2021 amounted to 1192.94 thousand tons of CO_2, which is slightly more compared to 2020. Compared to 1990, emissions have decreased by almost 200%. A significant reduction in emissions is associated, as already mentioned, with quarantine measures due to COVID 19 and the restriction of transportation in general.

3.4.9.2 Method of calculation

The GHG emission factors CO_2, CH_4 and N_2O used to calculate emissions for the most common rail fuels are default factors. All listed procedures were performed and calculated for Tier 1.

3.4.10 Water transport

3.4.10.1 Subcategory description

Since Kazakhstan is landlocked, water transport plays a less significant role than other types of transport. However, it is a rapidly developing mode of transport, especially in the Caspian Sea.

For water transport, it is customary to separate the fuel used on international flights from the fuel used on domestic flights, and information on fuel types is also required. Using data on the number of transported goods and its composition provided by the Bureau of National Statistics, such a division was made. Accordingly, the division into domestic activity and international transportation is made taking into account the period of implementation of such detail and technical capabilities.

The main component of this category is the National Maritime Shipping Company (NMSC) Kazmortransflot Limited Liability Partnership, established by Decree of the Government of the Republic of Kazakhstan No. 1239 dated December 4, 1998 in the form of a Joint Stock Company.

By the Decree of the Government of the Republic of Kazakhstan, NMSC Kazmortransflot LLP in 2011 was assigned the status of the National Sea Carrier.

The sole founder of NMSC Kazmortransflot LLP is National Company KazMunayGas JSC.

The main goal of NMSC Kazmortransflot LLP is the development of the national merchant marine fleet of the Republic of Kazakhstan and the organization of international maritime transportation of domestic cargo on its own.

Thus, the official merchant fleet in Kazakhstan was created only in 1998. Until that moment, the operating activity was not carried out significantly by the ships of other countries. The second important point in the operational activity of the merchant fleet of the Republic of Kazakhstan is the appearance of the first own oil tanker only in 2005. Until that time, in 2004, 2 barges were purchased to transport containers and bulk materials. To date, a total of 54 vessels are in operation, with most of them involved in international transportation, not counting tugboats and other auxiliary vessels.

The third feature of the operation of the fleet is the maintenance of several transport transit corridors, which partly pass through the territory of Kazakhstan, and the marine part is a common component of the entire system of hydrocarbon transit to the world market. Thus, all flights carried out have an international status and the distribution of fuel is made accordingly. Figure 3.32 shows the main directions of maritime transport carried out by the international fleet of Kazakhstan.

Figure 3.32 - The main directions of maritime transport carried out by the merchant fleet of Kazakhstan

Inland waterways are public routes and are state-owned. Their maintenance and operation is carried out by seven Republican state enterprises of waterways, which are located in the cities: Ust-Kamenogorsk, Semipalatinsk, Pavlodar, Uralsk, Atyrau, Kapchagai and Balkhash. These enterprises are financed from the republican budget.

The waterways of the Republic of Kazakhstan are classified in the following order:

- Pools of category "O", which includes lakes Balkhash, Zaisan; reservoirs Kapchagai, Bukhtarma;

— Pools of category “P”, which includes the Ust-Kamenogorsk and Shulbinsk reservoirs;

- Pools of category "L", which includes the rivers: Irtysh, Black Irtysh, Ural, Ili, Ishim, Syr-Darya, other canals and rivers.

The condition of the dimensions of the ship's passages on the Ural, Ili, Ishim, Syrdarya rivers is determined by the natural water content in the basins, on the Irtysh river - by the size of water releases into the downstream of the hydroelectric power station from the Bukhtarma, Ust-Kamenogorsk and Shulbinsk reservoirs. The releases are determined by the decision of the commission of the Committee for Water Resources of the Ministry of Agriculture of the Republic of Kazakhstan from June 17, 1999 after the transfer of the Committee for Water Resources of the Ministry of Agriculture to the newly created Ministry of Ecology, Geology and Natural Resources).

The maintenance of navigable waterways on the Ural River is carried out by two Republican State State Enterprises (RGKP) of waterways:

Uralskoye, section of Rubezhka village → Inder village, 623 km long;

Atyrauskoye, section of Gory village → exit buoy of the Ural-Caspian Canal (marine part) with a length of 333 km. The total length of the river navigation section of the Ural-Caspian water basin is 956 km.

3.4.10.2 Method of calculation

Water transport produces emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), as well as carbon monoxide (CO), volatile non-methane organic compounds (NVOCs), sulfur dioxide (SO_2), particulate matter (PM) and nitrogen oxides (NO_x).

To calculate emissions, the Tier 1 Method was applied using the appropriate coefficients, taking into account fuel consumption by type of fuel, specifying the classification of ship types and the possibility of bunker fuel emission. Calculations were made according to the formula:

$$\textit{Emissions} = \Sigma(\textit{Fuel consumed}_{(ab)} \times \textit{Emission factor}_{(ab)}),$$

Where:

a- *Type of fuel (naval fuel oil, diesel, gasoline)*

b- *Vessel type*

Calculations of GHG emissions for domestic and international flights are made in accordance with the described approach. Taking into account the fact that gasoline is not taken into account for international activities, since there are no such vessels in the fleet. And for domestic activities, fuels such as fuel oil are not taken into account, since there is no need to operate such types of vessels. Thus, both domestic and international shipping by sea is taken into account.

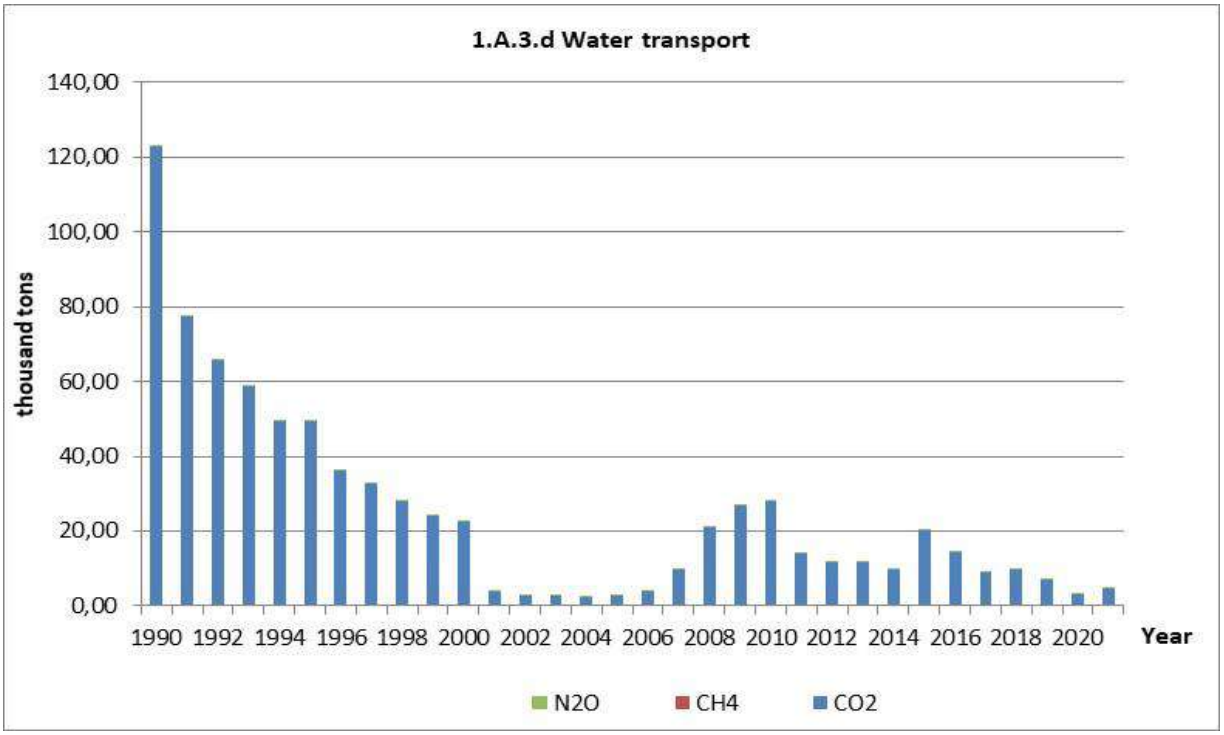


Figure 3.33 - Greenhouse gas emissions from the "Water transport" sector for the period 1990–2021, thousand tons of CO_2-eq.)

In the "Water transport" sector in 2021, there is a slight increase in CO_2-eq emissions compared to 2020 and amounted to 4.72 thousand tons of CO_2 eq. The overall decrease compared to 1990 was 92% (Figure 3.33). It should be noted that maritime transport turned out to be the most resistant to various restrictions, which is primarily explained by its small contribution to the total emissions from transport.

3.4.11 Uncertainties and consistency of time series

Since the presented methodology is simplified and covers the Tier 1 approach, the main sources of uncertainty are the composition of the fuel, its sulfur content, uncertainties arising from the state of the vehicle fleet, and associated with the use of the equipment being measured. The final uncertainty of the calculated data, therefore, for all designated GHGs according to the 2006 IPCC methodology varies from 2 to 5%.

3.4.11.1 QA/QC procedure for emissions calculations

The main criterion for the reliability and quality of data is the involvement of official data from the Bureau of National Statistics of the Ministry of National Economy of the Republic of Kazakhstan, the use of an approved methodology and constant GHG emission factors, data sources are constant, which guarantees the homogeneity of the series. The data of the joint-stock company Kazaernavigatsia and other specialized sources for each of the sectors were used as supporting information. In addition, control over quantitative data is applied by making primary calculations for each type of fuel. In addition, quantitative data control is applied by making initial calculations for each type of fuel, which are then compared with the results obtained by vehicle category.

The results of calculations and the quality of entering data into the CRF tables were controlled and verified by mutual checks, as well as by the balance method when compared with data for the entire energy sector.

Quality assurance and quality control in these subcategories are ensured using the coefficients for calculating GHG emissions recommended by the 2006 IPCC Guidelines. No significant differences in the overall fuel balance for 2021 have been identified.

3.4.11.2 Recalculations and changes for transport

Based on the recommendations of the ERT 2021 (E.31, E.32, E.33 and E.41), methodological and analytical additions were made to the presented sector. Recalculations for N_2O. Calculation results are shown in tables and figures. Corrections have been made for some years related to changes in the source data. The methodological part of the assessment of GHG emissions from the use of urea converters for the road transport category has been deepened, taking into account the proposed methodological approaches and national specifics.

Based on the recommendations of the ERT 2021, methodological and analytical additions to the presented sector (E.34, E.36) were made, as well as recalculations were made. For vehicles using diesel fuel and gas, the coefficients have been changed according to table 3.2.2. IPCC Guidelines 2006

At present, the coefficients for CH_4 and N_2O diesel are 3.9 kg / TJ, For cars equipped with gas equipment, a coefficient of 92 kg / TJ for CH_4, and 3.0 kg / TJ for N_2O is used .

Changed designation keys for gas fuels and biofuels in subcategories where this fuel is not used from NA to NO . The changes affected freight transport, gas fuel and biofuel for cars and buses running on biofuel.

Based on the results of the 2020 review and the recommendations received from the ERT (E 36 and others), recalculations were made taking into account the redistribution of off-road vehicles within the category by type of fuel. In particular, the initial data were revised and emissions were regrouped by fuel types and emission sources. The changes affected the categories: 1.A.4.c.iii and 1.A.4.

Based on the results of the 2020 review by the Compliance Panel (EPG) of the UNFCCC Secretariat and the recommendations made by them, the analytical part of the sector has been expanded in this report. Based on the recommendations (A.30, 31, etc.), this report recalculates GHG emissions for the entire range of pipeline transport. Some of the questions in this category have been removed.

In the national report for 2021, taking into account the comments made (E.30.), a partial recalculation of GHG emissions from the subcategory domestic aviation and international aviation was carried out. As part of these recommendations, several technical errors were found, in

particular, incorrectly used designation keys were corrected from NA to NO , the keys for category 1.1.A.4 were changed.

To carry out these works, all reports of the Bureau of National Statistics related to fuel were revised, as well as additional data on the number of aircraft fleet in the country. The database formed today has made it possible to synchronize the number of aircraft (only for the operated fleet) and updated data on aviation fuel. This approach made it possible to restore the series and separate from it aircraft that are operated exclusively within the country and that have the ability to make interstate flights. It is worth noting that we are talking exclusively about the civilian fleet. Military aircraft, especially the latest fourth generation fighters, use a special fuel other than kerosene.

In the current report, taking into account the comments and the results of the 2021 review, general comments have been made on this subcategory. The main comments from 2019 have been taken into account and some technical errors have been eliminated.

Taking into account the comments of experts on the NIR 2021 review (E.38, E.39, E.19, etc.), recalculations were made for part of the data related to international activities and the use of fuel oil as a fuel. The methodological approaches for collecting and analyzing data, the coefficients used for calculating greenhouse gases in the Navigation sector were supplemented. In particular, recalculated and re-archived in the CRF tables fuel oil for international activities.

3.4.11.3 Planned improvements for transport

All calculations of emissions from aviation were made according to Tier 2. In the future, some aspects related to the specification of the aircraft fleet in operation and the number of flights operated and their types at the level of individual air transport enterprises are expected to be clarified.

Implementing measures to improve the inventory and eliminate the comments of the SER (E. 18), a reassessment of the fuel used for domestic and international navigation carried out by Kazakh ships was carried out. As already mentioned, at present there are certain difficulties in the separation of fuel. However, after consulting with local experts and analyzing available information, including on the number of vessels used, length of routes, nature of cargo carried, as well as cargo turnover, a fuel separation approach based on all of the above factors was used. One of the most important criteria included in the calculation matrix is the balance of transported goods for domestic and international transportation. This information is open and published in the materials of the Bureau of National Statistics. The value of this information is that it is provided for the last 20 years and has a good correlation with other data used.

Directly for the calculation of GHG emissions from sea and river vessels, as already mentioned, the Tier 1 Method was used according to the IPCC Guidelines.

At present, the entire series for motor vehicles has been recalculated in the COPERT model , but there are some doubts in the data for individual years, which requires additional time. For this reason, it is planned to update the entire series next year . However, the comparison of approaches made it possible to verify the correctness of the calculation results, with the exception of recent years, when the car fleet has changed significantly.

3.5 Fugitive emissions (1 V)

3.5.1 Browse by category

The category “Fugitive Emissions” presented in this chapter (also referred to in the IPCC Guidelines as “Fugitive Emissions”) is one of the most complex in terms of its origin and the physics of possible accounting. In addition, the structure of the entire category is quite labor-intensive and covers both direct energy activities - the extraction and processing of raw materials, and a small part of the technological processes that occur in some processes related to the preparation and maintenance of equipment. The complexity is added by the absence of some coefficients, not only in the IPCC Guidelines, but also at the local level, as well as the ambiguity of dividing some types of emissions between categories.

In general, the category "Fugitive emissions" is divided into two large subcategories: "Solid fuels", all emissions of which are presented in the CRF tables under the nomenclature designation (1.V.1), and "Liquid, gaseous fuels", for which the results are reflected in the tables OFO (1.V.2). Each of the presented categories contains a number of subcategories, which will be presented in detail below.

The main greenhouse gas accounted for in Fugitive Emissions is methane, however, for some associated processes such as Gas Flaring, the presence of carbon dioxide can be significant and even higher than methane emissions. In addition, it must be taken into account that the density of carbon dioxide is almost three times greater than the density of methane, therefore, for some subcategories, with relatively small values of CO_2, its final value can be comparable to the presence of methane.

All calculations were carried out in accordance with the 2006 IPCC Recommendations, with the recommended coefficients, with the exception of several subcategories, where the National Experts had additional, verified data that fit into the general concept. All these points are reflected in detail in the description of the sub-sectors or in the methodological approaches, below.

The volume of emissions in the base year of 1990 from fugitive emissions amounted to 73047.67 thousand tons of CO_2 eq, in 2021 - 46628.4 thousand tons of CO_2 eq, thus reducing emissions in this sector amounted to 36.1%. The share of fugitive emissions accounted for 16.8% in 1990 and about 6.5% at present in the Energy Sector. Figure 3.50 shows the total greenhouse gas emissions from the Fugitive Emissions category, as well as a comparative chart for 1990 and 2021, where the shares of each subcategory in the total emissions are shown for comparison. It can be seen that despite the overall increase in oil and gas production now compared to the 1990 base year, emissions have declined. This situation is due to several reasons that require explanation.

Recall that at the time of 1990 the most developed industry was coal mining, from diagrams 3.501 and 3.502 it can be seen that the share of emissions from solid fuels (Fig. 3.502 shows the sum of all emissions from a combination of processes from solid fuels, including endogenous fires and mines) amounted to 49% or 33561.66 thousand tons of CO_2 eq. against 26% or 9688.14 thousand tons of CO_2 eq in 2021. Thus, the share of solid fuels decreased by 28%. One of the most important reasons for this decline is the partial abandonment of underground coal mining, as well as the gradual increase in open-pit coal mining, in which, as is known, such emissions occur much less. In the base period, the level of emissions was also affected by the relatively low rate of domestic oil and gas production, from diagram 3.501 it can be seen that in the base year the share of oil in this sector was 40%. Which is 10% less than emissions from the extraction of solid fuels.

At the same time, total emissions from gas production and flaring were also insignificant: 4 and 7%, respectively.

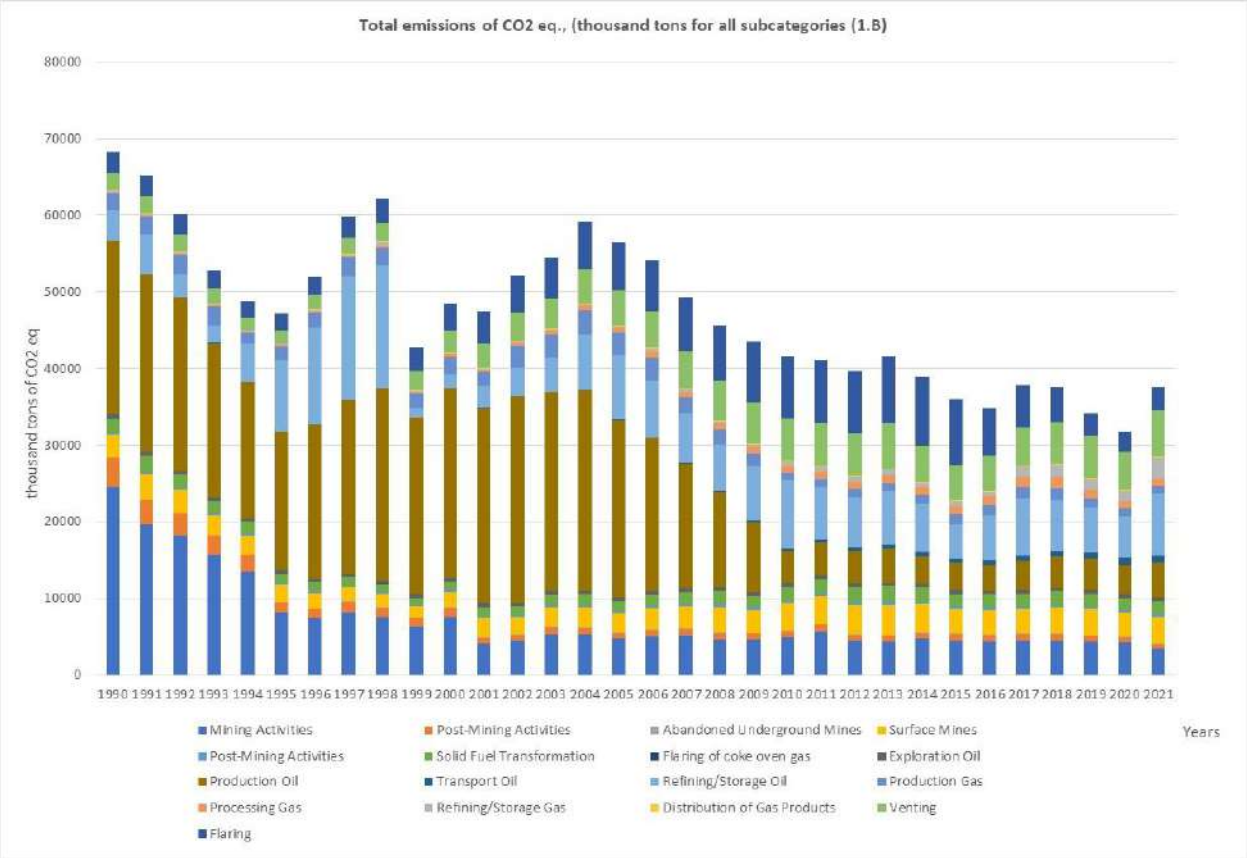
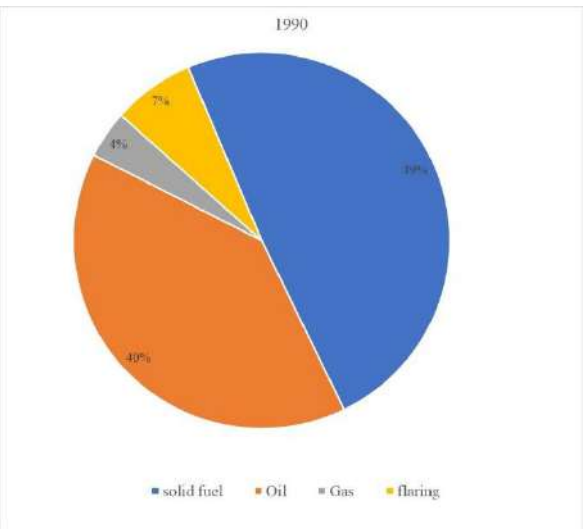


Fig. 3.50. C total emissions of CO_2 eq., (thousand tons) for all subcategories (1.B)

However, significant structural changes in the industries, as well as the modernization of the oil and gas sector, have significantly changed the volume of the share of emissions in the total balance of the category at present. The share of solid fuels decreased by 26%, The share of flaring and ventilation increased, up to 24%, which is some indicator of the oil and gas industry. The share of emissions from gas increased four times to 19% in 2021, against 4% in 1990.



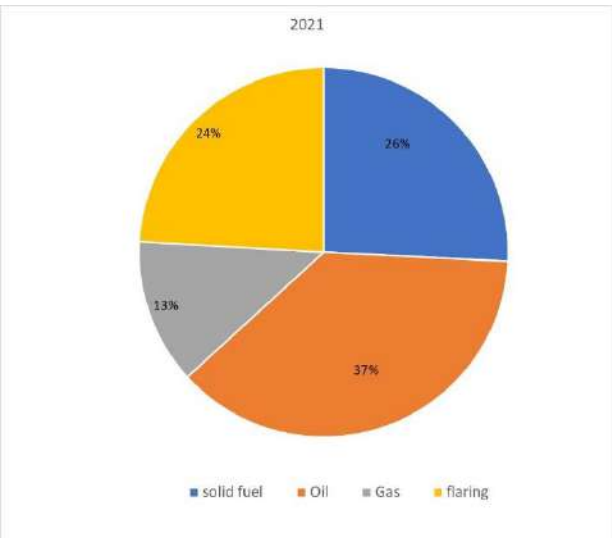
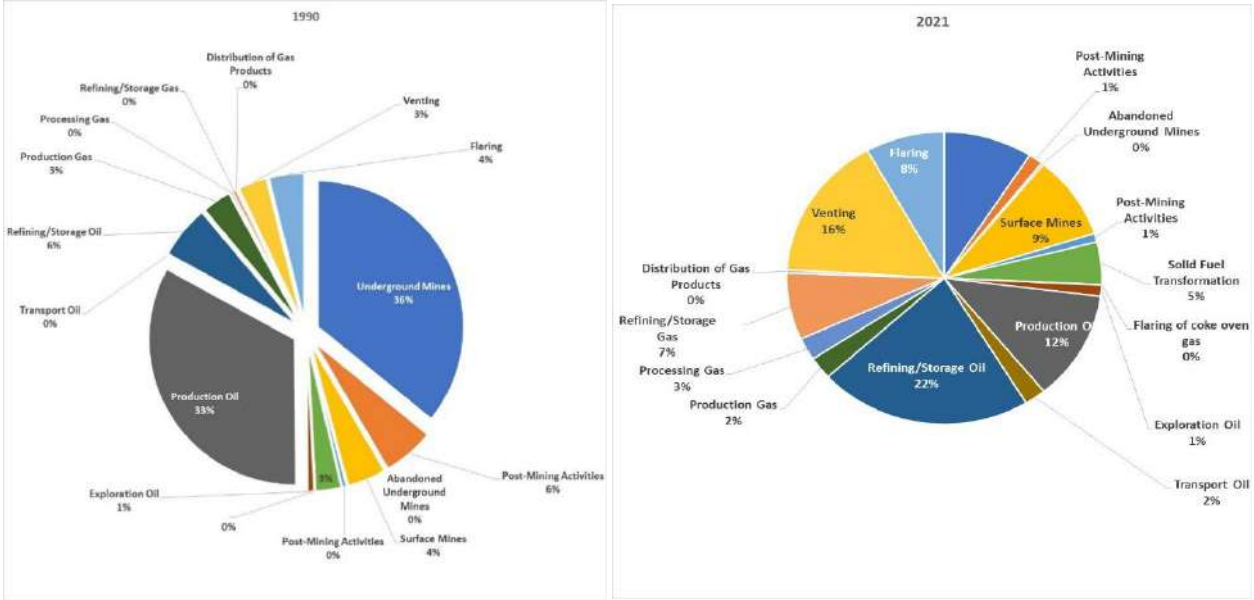


Fig. 3.501. Share of emissions in the Fugitive Emissions category for all major sources, in 1990 and 2021



2.

Fig. 3.50 Share of emissions in the Fugitive emissions category by all sources, in 1990 and 2021

Diagram 3.501 illustrates very well the internal processes that have had a significant impact on the balance of the entire category. A more detailed change in the contribution of each sub-category with the base year and 2021 can be seen in Chart 3.502. Structural changes are significant, as the contribution of underground mining has decreased by more than two, while the share in the distribution of natural gas has increased, the share of open-pit coal mining and gas processing has increased. These changes once again prove that the change in the entire structure could not occur in one day, but was carried out throughout the entire period of years under consideration. More details on internal developments and contributions are provided in the respective sectors below.

However, the main conclusion that can be drawn from the presented data is the overall decrease in emissions, which are observed in almost all sectors of the presented category.

3.5.2 Solid fuels. Development of coal deposits (1.B.1)

3.5.2.1 Subcategory overview

A significant share of coal-fired energy in the total share of the main electricity and heat generation, as well as a large share of it for the domestic needs of the population, significantly determines the volume of coal production, and in fact largely determines the share of fugitive emissions in this category. It should be noted that both open and closed coal mining is carried out in Kazakhstan. The structure of this industry is very developed, it makes it possible for entire regions to develop economically and determines the volume of production at the present time. In addition, due to the energy crisis, there is information about the export of coal to neighboring countries, which supports the demand for it and stimulates production. At the same time, it should be noted that the country is already taking measures to reduce the dependence of the population on coal supplies (gasification), as well as the transfer of part of the city and Republican CHPPs to gas, which has already led to a slight decrease in production for the period under review. , against

the background of growing energy demand in the industrial sector and for the needs of the population, Figure 3.5.1.

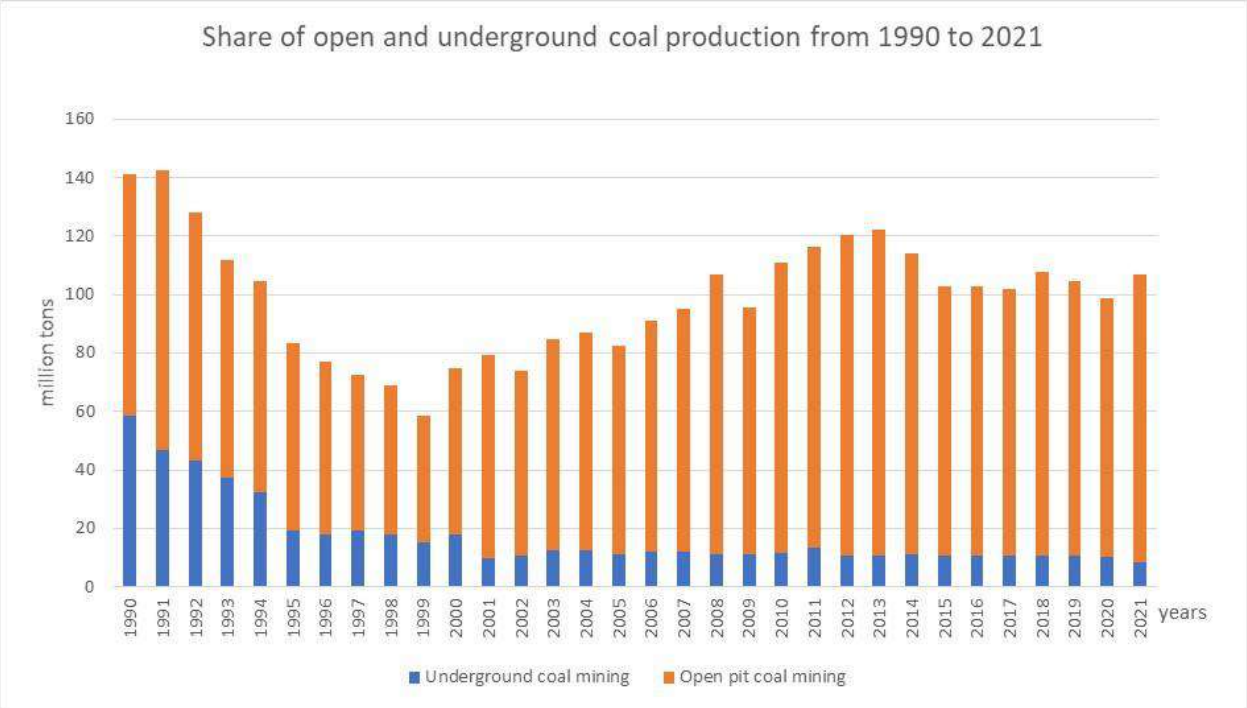


Fig. 3.5.1. Share of coal mining by open and closed methods for the period 1990 to 2021, (million tons of coal).

As can be seen from graph 3.5.1. in 1990, almost half of all coal mined was from underground mining. According to available sources, [42]Kazakhstani mines are classified as deep, since mining is carried out from a horizon of 400 meters and deeper. This significantly affected the volumes of fugitive emissions in this category, since it is known that the most methane-bearing coal, where the methane content can exceed 25 m^3 per ton, increases with the depth of development. In addition, according to the IPCC Guidelines, as well as other sources, it has been established that underground coal mining generates the largest amount of methane at all stages. It is this very fact that in 1990 the largest volume of coal (58.3 million tons) was mined underground, which is the reason for the largest emissions in this category, in the base year. We also note the important point that for the entire period under review, at the beginning of the nineties, the largest volumes of coal production fell - 142.6 million tons (1992), and, as already mentioned, almost half of the mined coal was mine coal. Thus, the volume of fugitive emissions in 1990 amounted to 33561.6 thousand tons of CO_2 equivalent, fig. 3.5.2.

[42]Overview of Kazakhstani coal deposits. https://ru.wikipedia.org/wiki/%D0%9A%D0%B0%D1%80%D0%B0%D0%B3%D0%B0%D0%BD%D0%B4%D0%B8%D0%BD%D1%81%D0%BA%D0%B8%D0%B9_%D1%83%D0%B3%D0%BE%D0%BB%D1%8C%D0%BD%D1%8B%D0%B9_ %D0%B1%D0%B0%D1%81%D1%81%D0%B5%D0%B9%D0%BD

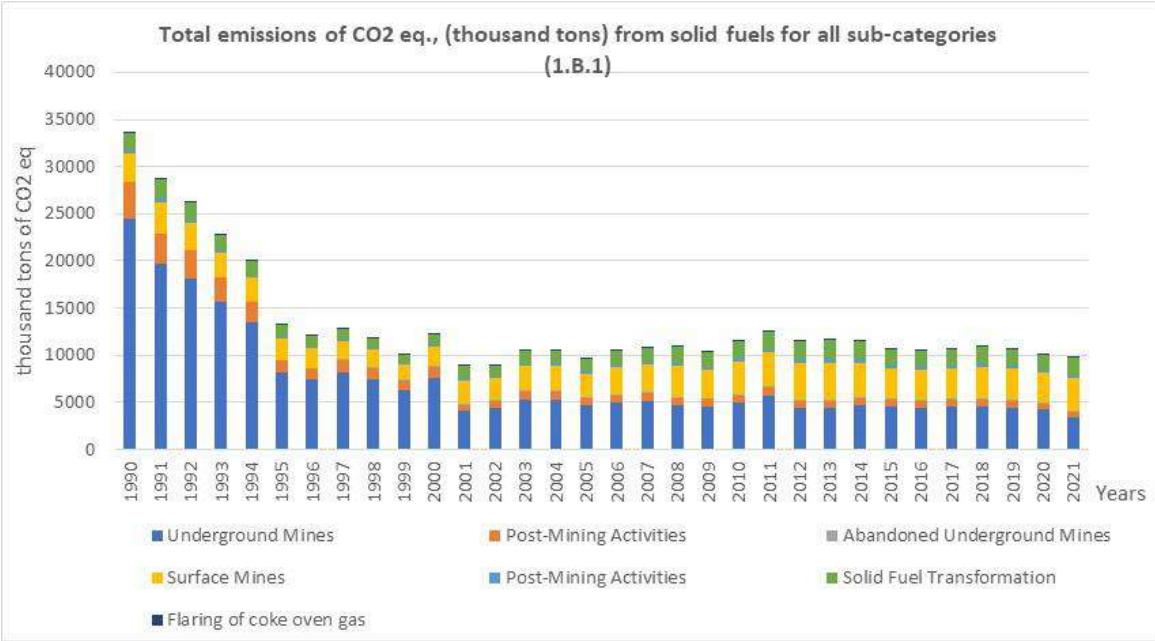


Fig.3.5.2 Total emissions of CO_2 eq., (thousand tons) from solid fuels for all subcategories (1.B.1)

Chart 3.5.2 also shows the contribution of each sub-category to total emissions from coal deposits. A significant reduction in emissions in 2021 to 9688.2 thousand tons of CO_2 equivalent (a decrease of 71.1% compared to the base year) is primarily due to structural changes in the industry (Figure 3.5.1), as well as a decrease in total production volumes –up to 106 million tons, which is 25.6% less than coal produced in the base year. At the same time, we note that against the background of significant changes associated with the economic restructuring of mining enterprises in the period 1990 to 1995, the rejection of high-quality Kazakh coal by some enterprises in Russia and Kazakhstan led to the closure of at least 9 mines in 1997 and another 4 mines by 2000, and their complete conservation.

The current situation with the volumes of coal mining by underground and quarry methods has not actually changed for twenty years. The observed fluctuations of the series in the period from 1995 to 2021 are associated with the recurrence of warm winters, as well as the demand in the world market for Kazakhstani coal. Some role in this process is also played by endogenous fires that occur in mining, Figure 3.5.3.

1990 2021

Fig 3.5.3. Contribution to the total emissions of each process, category fugitive emissions from solid fuels

Diagram 3.5.3. shows the structural redistribution of fugitive emissions from solid fuels between the base year 1990 and the comparable year 2021. It can be seen that the share of underground mining has changed significantly from 73% to 35%, and as a result of post-mining processes from 11 % to 6% (Figure 3.5.4). At the same time, the share of emissions from open-pit mining increased significantly from 9% in 1990 to 36% in 2021. Accordingly, the share of emissions from post-mining processes increased from 1% in 1990 to 4% in 2021, and from endogenous fires - from 6% in 1990 to 18% in 2021. We also add that since 1997, emissions from closed mines have been added to emission sources. Despite the fact that today experts have data on only thirteen closed mines, the share of their emissions in the total balance of solid fuels was 1% (66.6 thousand tons of CO 2 eq) in 2021.

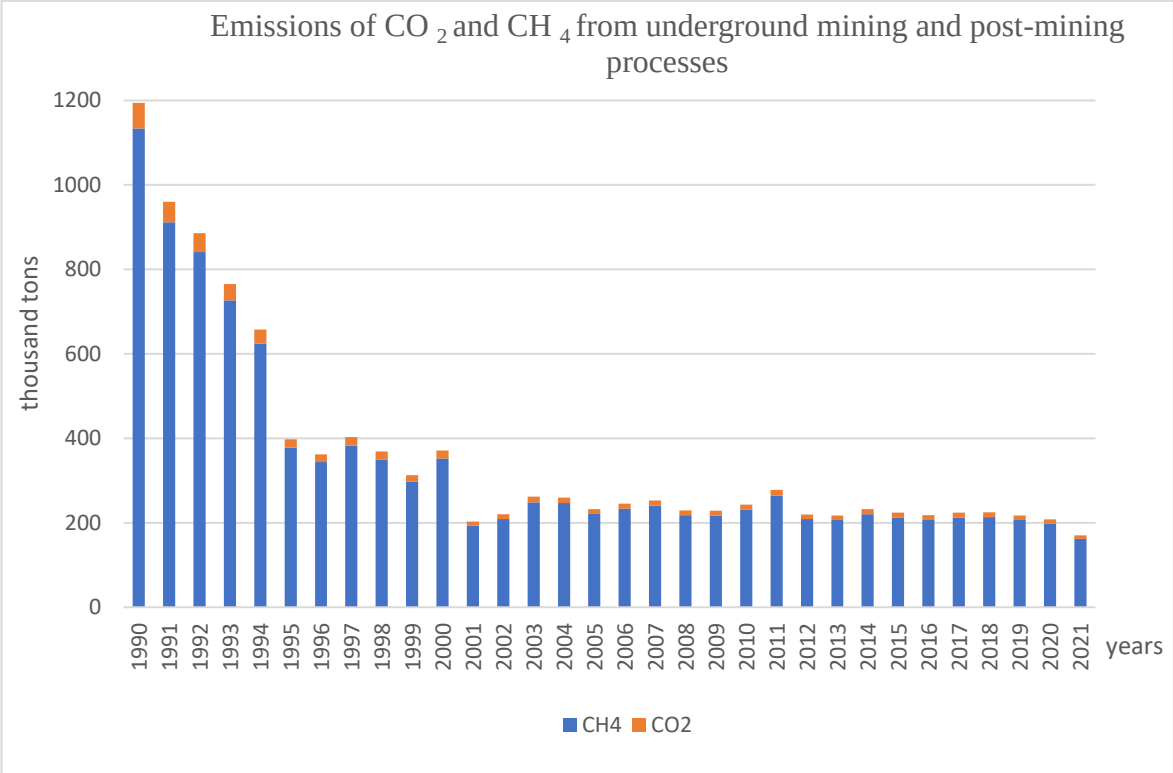


Fig 3.5.4. Emissions of CO_2 and CH_4 (tonnes) from underground mining and post-mining processes

Recorded changes confirm significant structural changes in the category of solid fuels and, as a result, their decrease by 71.2%, in relation to the base year.

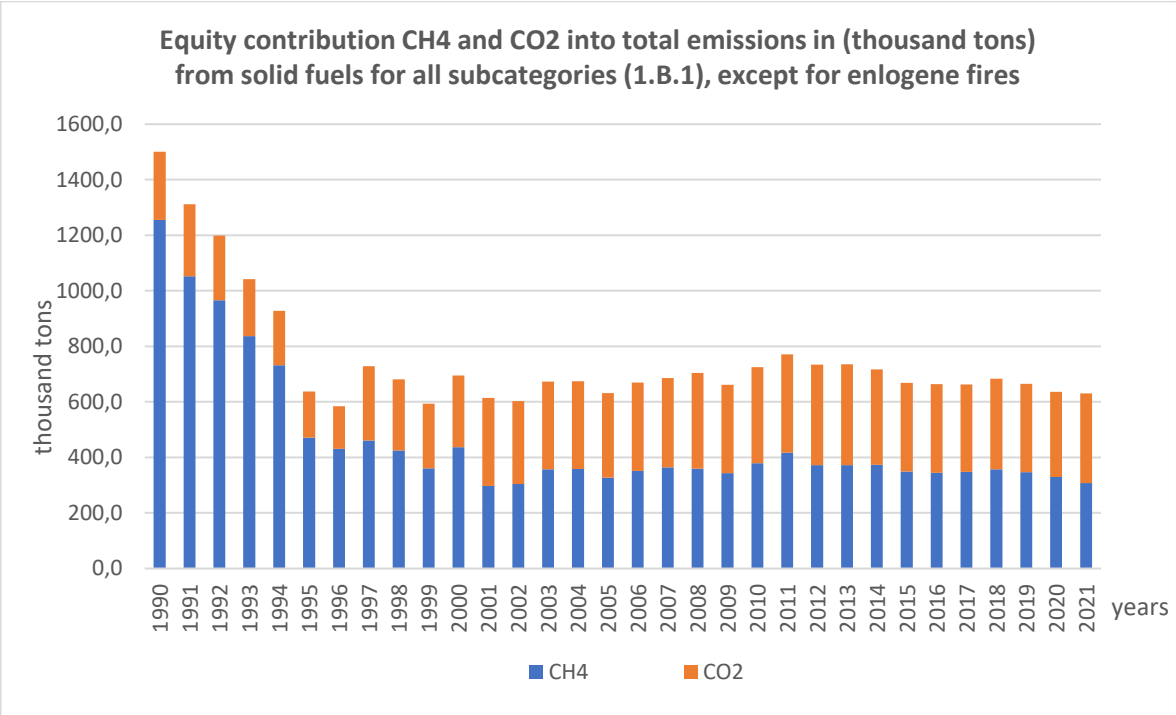


Fig. 3.5.5. Share contribution of CH_4 and CO_2 to total emissions in (thousand tons) from solid fuels for all subcategories (1.B.1), except for endogenous fires.

The change in the share of CO_2 in the total structure of fugitive emissions in the category of solid fuel (Figure 3.5.5.) is due to several reasons. First of all, by the fact that the amount of coal mined by the open method has increased. According to the IPCC Guidelines, as well as scientific sources [43], the content of CO_2 in coal significantly depends on the depth of occurrence. The closer to the surface the coal is mined, the higher the carbon dioxide content. Available measurement results show that the presence of CO_2 in coal mined is fixed at 0.45 m^3/t. While open-cast mining, the average content of carbon dioxide reaches 0.89 m^3/t [44], i.e. almost twice as much (Figure 3.5.6).

The described changes explain the significant transformation of the share of open-pit coal mining in Kazakhstan from 10% in 1990 to 40% in 2021 (Fig. 3.5.3). 14.3% from 82.69 million tons in 1990 to 96.46 million tons in 2021, in total greenhouse gas emissions they play a large role in the presented sub-category, Figure 3.5.6. The diagram clearly shows that the share of CO_2 emissions from quarrying is somewhat higher than that of methane, however, in terms of CO_2 eq. the situation is changing, the reasons for this, as already mentioned above, are in the higher content of CO_2 in coal during open mining than with closed mining.

[43]Carbon dioxide in coal mines / E. M. Sokolov, N. M. Kachurin. - M. : Nedra, 1987. - 141 [1] p. : ill.; 21 see https://search.rsl.ru/ru/record/01001367710
[44]Techniques for open and underground coal mining 2010 RK

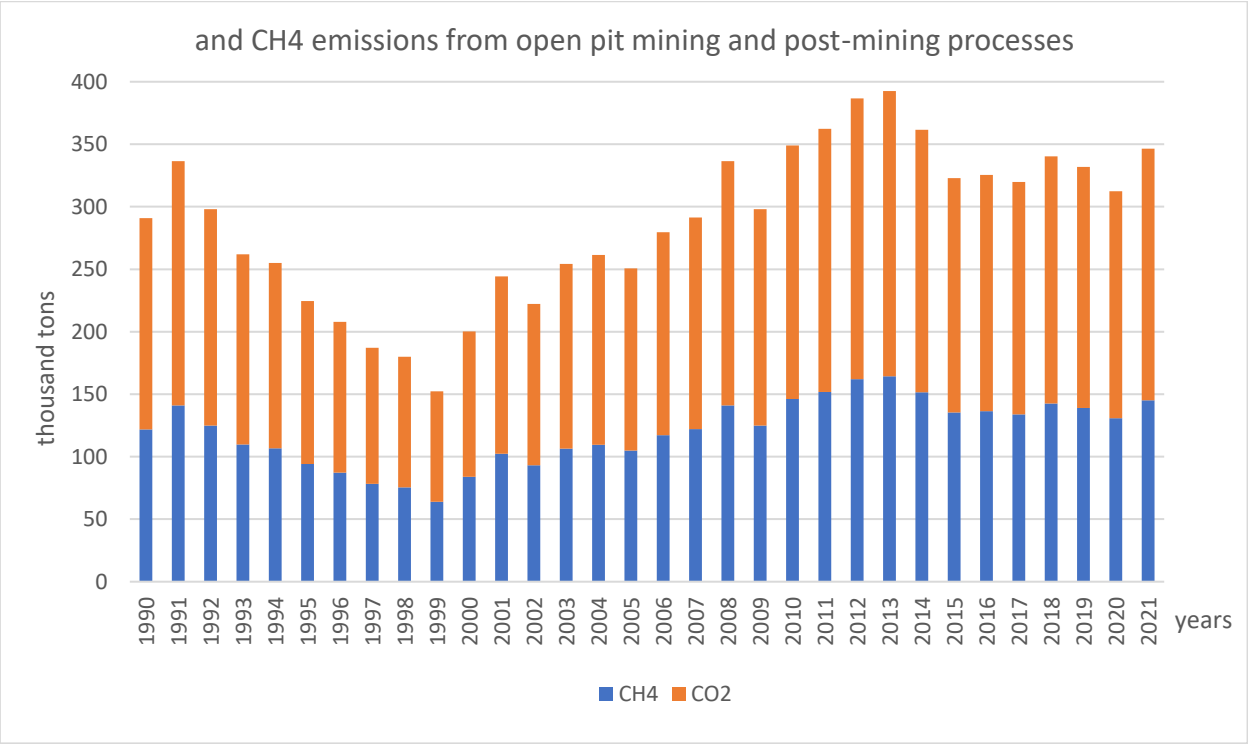


Fig. 3.5.6. Emissions of CO_2 and CH_4 from open pit mining and post-mining processes (thousand tons).

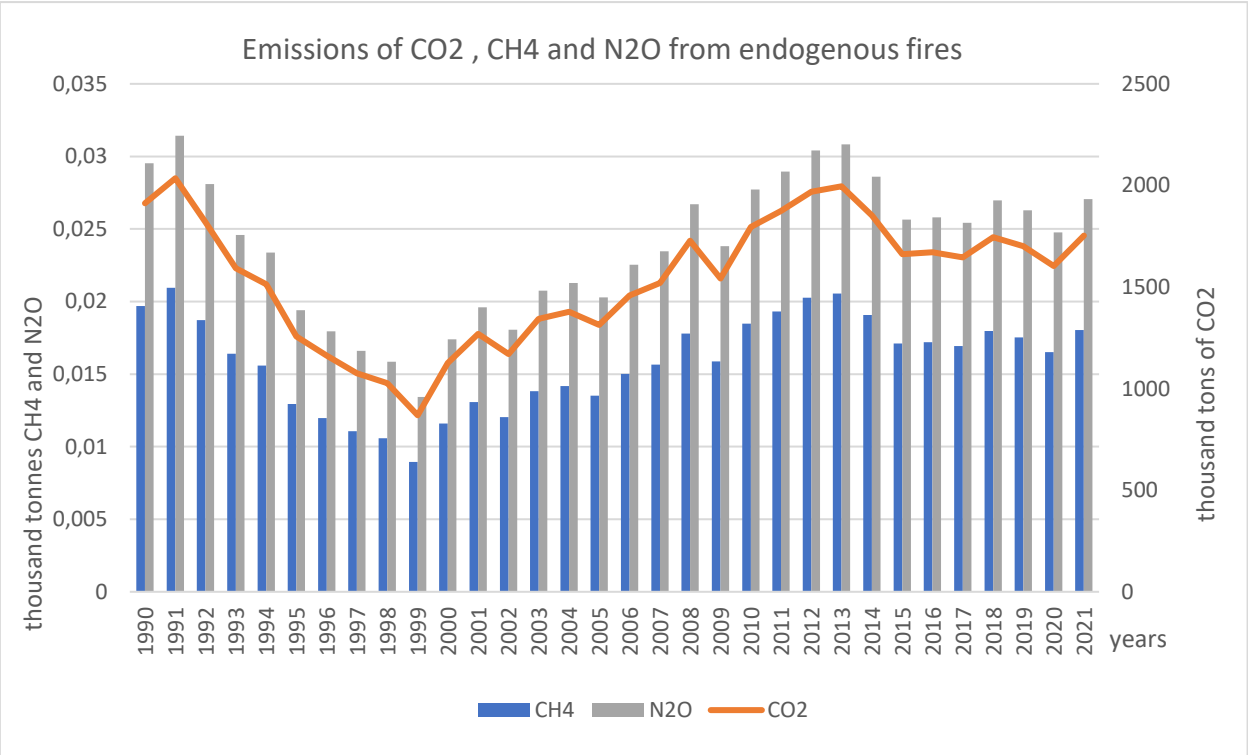


Fig. 3.5.7. Emissions of CO_2, CH_4 and N_2O from endogenous fires

A somewhat different situation develops with endogenous fires when dumps are stored in waste heaps. Since direct combustion is assessed in this case, $CO_{2\ emissions}$ are expected to be more than other gases. Endogenous fires began to play a large role in emissions due to the overall reduction in emissions from mines, despite the fact that overall emissions decreased by 159

thousand tons of CO_2 eq. For this reason, their share has changed from 6% (1920 thousand tons of CO_2 eq) in 1990 to 18% (1761 thousand tons of CO_2 eq) in 2021, Figure 3.5.7.

3.5.2.2 Methodological approaches

When assessing the volume of emissions from the category "Fugitive Emissions", development of coal deposits (1.B.1 Solid fuels), the experts adhered to the Guidelines for National Greenhouse Gas Inventories of the IPCC, 2006, [45]for Tier 1 and 2. Note that there are no coefficients in the Guidelines to calculate CO_2 emissions, this aspect concerns both the presence of carbon dioxide in coal during its extraction from mines and open pit mining, for this reason the experts were forced to use the available national data, in particular the 2010 Guidelines for coal mining enterprises. industry, recommended by the Ministry of Ecology of the Republic of Kazakhstan [46]. Also, scientific data sources, reference books and monographs on the composition of Kazakhstani coals, and the state of the coal industry of the Republic [2,3 were used] .

The calculation of emissions at all stages was made according to equation 4.1.1, Guidelines 2006, for levels 1 and 2:

Greenhouse gas emissions = Raw coal production × Emission factor × × Unit conversion factor

As well as equations 4.1.2., for levels 1 and 2:

$_4$ recovered and burned or used as an energy carrier

In addition, depending on the type of production, Equations 4.1.3, 4.1.4 of the 2006 IPCC Guidelines were applied.

<u>Estimation of emissions for underground coal mining</u>

When estimating methane emissions from underground mining, the following coefficients were used:

for underground mining, the methane concentration is 25 m^3 / t, the gas density is 0.67 kg / m^3 . As already mentioned, a high factor was used due to the depth of development, which starts from 400 meters and below. According to available sources, the deeper the mine, the greater the concentration of methane in the coal. National data show that methane content can be up to 30 m^3 /t and higher. However, on average, the coefficient recommended in the 2006 IPCC Guidelines is used. Upon receipt of more detailed data (when introducing the carbon market in accordance with the articles of the Environmental Code 287, 289), the applied coefficients will be revised.

for processes after mining, for closed mining, the coefficient for methane was used - 4 m^3 /t, gas density 0.67 kg/m^3 . The choice of the coefficient was determined by high concentrations of methane in coal during its extraction by a closed method.

Emissions of CO_2 were estimated using the same approach and equations. At the same time, the following coefficients were used to estimate $CO_{2\ emissions}$ from underground mining:

for underground mining, the concentration of CO_2 is 0.45 m^3 / t, the gas density is 1.98 kg / m^3 . Relatively low concentrations of carbon dioxide are explained by the fact that its presence

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[45] https :// www . ipcc - nggip . iges . or . jp / public / 2019 rf / pdf / 2_Volume 2/19 R_V 2_4_Ch 04_Fugitive_Emissions . _ _ _ _ _ pdf

[46]Currently, Order 280 dated November 5, 2010 is no longer valid, but is valid for the 2021 inventory and it is expected that these coefficients will be included in the current order of the Minister of Ecology and Natural Resources

in coal decreases with the depth of mining. This is supported by both scientific data and field measurements, the results of which were used in the 2010 Surface Mining Methodology.

$_2$ emissions, a coefficient of 0.07 m^3/t, gas density of 1.98 kg/m^3 was used .

It should be noted that at present experts do not have information on the amount of gas burned in flares from well drainage. It is believed that all extracted gas is consumed for own needs and accounted for in the energy sector. For this reason, the NO key is used .

Estimation of emissions for open pit coal mining

To estimate emissions from open pit coal mining, processes directly from mining, post-mining processes and emissions from endogenous fires were evaluated. The following coefficients were used for calculations:

for open-pit coal mining, the concentration of methane is 2 m^3/t, the gas density is 0.67 kg/m^3. Relatively high concentrations of CH_4 are due to geological origin, and are confirmed by occasional measurements by companies.

for calculations of emissions after open-cast coal mining, the coefficient for methane was used - 0.2 m^3/t, gas density 0.67 kg/m^3.

to estimate direct emissions of carbon dioxide from open pit mining, a coefficient of 0.89 m^3/t, gas density of 1.98 kg/m^3 was used. The presented coefficient is an average for Kazakhstan coal pits. It is known that for some developments this value may be somewhat higher, however, on average, the coefficient presented is satisfactory and applicable to the entire industry.

for the calculation of emissions after open-cast coal mining, a coefficient for carbon dioxide of 0.142 was used, at a gas density of 1.98 kg/m^3.

Estimation of emissions from mothballed underground mines

Assessment of emissions from mothballed mines was carried out in accordance with the IPCC Guidelines 2006. To date, experts are aware of thirteen mothballed mines, from the reports of Arcelor Mittal Kazakhstan, and in accordance with the Decree of the Government of the Republic of Kazakhstan dated 01.11.1995 No. 1415 and the order Minister of Energy and Coal Industry No. 99 dated November 09, 1995 for the liquidation of unprofitable mines of the Karaganda coal basin. Due to low profitability and safety risks, nine [47]mines (Severnaya, Maikudukskaya, Dubovskaya, Stepnaya, Toparskaya, Sherubay. Nurinskaya, Dolinskoy, named after the 50th anniversary of the October Revolution) were closed and scuttled in 1997. In 2000, four more mines (No. 1 Kirovskaya, No. 2 named after Gorbachev, No. 3 named after Baizhanov, No. 1 LLP Arman) were mothballed, thus, to date, records are kept of thirteen closed mines. At the same time, about 780 km of mine workings were extinguished, 100 vertical and inclined shafts were filled in, 2057 wells of various diameters and purposes were liquidated, 70 lifting units and 67 main ventilation fans were dismantled, 13 sludge pits were liquidated, more than 3040 hectares of land were reclaimed and handed over to local authorities, disturbed by mining .

Unfortunately, data on direct measurements of methane from mothballed mines are not available to experts, for this reason emissions were estimated taking into account Equation 4.1.9 for Tier 1.

$$CH_{4\ emissions} = Emissions\ from\ abandoned\ mines - recovered\ CH_4\ emissions$$

[47] http://novikovv.ru/rgsp-karagandalikvidshacht/rgsp-karagandalikvidshacht

Emission coefficients were used from the recommended indicators of Table 4.1.6., Gas density was taken into account as 0.67 kg/m ^{3} . It should be noted that until the moment of conservation, the mines were operated. For this reason, experts believe that the total emissions from them are taken into account in the total emissions from underground coal mining for the period from 1990 to 1996 (2000).

Assessment of emissions from endogenous fires

To estimate the volume of emissions from endogenous fires, several methods were studied, proposed both by the companies themselves and existing standards for overburden volumes, during open mining and storage of rock from underground mining. Unfortunately, it is not possible to obtain direct data from companies on the volume of overburden storage. The difficulty also lies in maintaining the homogeneity of the series, which should be maintained for 30 years. For this reason, the experts approached the calculation of emissions through an analysis of scientific and technical sources made for Kazakhstan, which showed that the most optimal is the use of waste rock formation factors in coal mining. Thus, for closed mining, a coefficient of 10% of the production volumes for the entire period was used, and for open pits, 20%. In both cases, the presence of coal in waste heaps is limited to 10% of the stored volume. No more than 20% of the coal residues accumulated during the year are involved in endogenous fires [48].

The formation of GHG emissions was estimated for stationary combustion conditions, with the corresponding coefficients for energy activities.

Assessment of emissions from coke oven gas combustion

This sub-category is calculated from the combustion of coke oven gas, according to the smelter, which provides data on the amount of coke coal used for metal smelting. Currently, the enterprise provides data for the entire series from 1990 to 2021. However, the company does not provide direct measurements and emission factors. For this reason, Tier 1 was applied to estimate CO2 emissions $_{from}$ coke oven gas combustion according to the 2006 IPCC Guidelines.

The general form of the equation for estimating emissions under the Tier 1 methodology based on coke production activities is given by the equation:

Emissions of CO_2 = (Activity of coke oven gas produced ● RCOG) ● Coke oven gas) ● 44/12,

Where:

$_2$ emissions = CO_2 emissions from coke gas combustion (kg CO_2);

Activity of coke oven gas produced - quantity of coke oven gas produced (GJ);

RCOG is the coke oven gas fraction removed from the production stream and then combusted. If this data is not available, you can accept the default value of 0.02;

Coke oven gas = carbon content of coke oven gas (kg carbon per GJ coke oven gas).

Carbon content taken from Table 4.3.7, Volume 2, Chapter 1, of the 2006 IPCC Guidelines, default for coke oven gas. The coefficient used is within the recommended range - 360-518 nm ^{3} - of coke produced per unit of production. The amount of gas removed from the production stream was assumed to be 0.02 (2%) by default.

[48]Research "Bogatyr Komir"

3.5.2.3 Formation of a consistent time series. Uncertainty assessment

The estimated developments did not have any major changes, in terms of changing quarries or changing the leader in coal production. All years are present in the statistical series, that is. data were not extrapolated. The data was formed taking into account the type of development, the coefficients were applied in accordance with each type of development. Thus, the original series is homogeneous and consistent.

The uncertainty assessment for the solid fuel category was based on the two main sources recommended for Tier 1. These are the applicability of the generic emission factors to individual countries, and the specific uncertainties of the factors. Since the coefficients recommended by the Guidelines were used to estimate emissions, the estimation uncertainty assumes a value of at least ±50 percent. However, since the data are partially confirmed by measurements for the purposes of monitoring and scientific activities, the uncertainty estimate can be reduced by half.

The uncertainty associated with the activity data will be within ± 5% as judged by the experts (Expert Report (GEEP, 2000)). Typically, this uncertainty is caused by the moisture content present in the mined coal, which can range between 5-10 percent and cannot be determined with great accuracy.

According to the Guidelines, the proposed approaches are applicable to both surface and underground coal mining, although for open pits the assessment can be somewhat confusing. At present, there is no reason to believe that approaches may differ.

5.2.4 QA/QC procedure

Quality control is based on the use of official data from the Bureau of National Statistics of the ASPIR RK, so the initial data is subject to multiple checks, at the enterprises themselves and in the overall balance at the Republican level.

All source data can be cross-checked through the official publications that are available. Some of the coefficients used to calculate $CO_{2\ emissions}$ have also been published and formed taking into account both measurement error data and confirmed by several independent measurements.

Appropriate methodologies were used to calculate emissions from coal mining, including the use of the most appropriate levels for Kazakhstan, taking into account that this category is one of the key ones for the country. National inventory experts are confident that appropriate emission factors have been used. For all processes and developments, the best available activity data according to the level used is used, in particular the amount of methane recovered and utilized, wherever possible.

The data are consistent with the proposed approaches for other countries. The inventory takes into account all sources of emissions. Graphical and statistical testing revealed no anomalies. Significant fluctuations are consistent with changes in coal production for different years.

Also, the general QA/QC procedures were carried out as described in Section 1.2.3. NDK.

3.5.2.5 Recalculations

At present, for the entire series, for all subcategories, a recalculation has been made to identify errors and eliminate a number of comments. The consultations held with experts from other countries as part of the preparation of this NIR also did not reveal significant errors, both in approaches and in calculations.

3.5.2.6 Planned improvements

Currently, no improvements are planned. However, due to the introduction of new reporting requirements for quotas in the coal industry, experts may get more accurate and real

emission factors from activities, which may differ significantly from those reflected in the Guidelines, in which case the series will be revised taking into account relevant information.

3.5.3 Emissions from development, processing and other processes for oil and natural gas (1.B.2)

3.5.3.1 Oil and gas sub-category overview

Many of the processes presented in the categories - development, processing and other processes for oil and natural gas, are very closely related to each other, and in some cases, the resulting emissions are difficult to separate by emission source. This explains why, despite the fact that each of the oil and gas categories accounts for 20 to 31% of all emissions of total emissions, they are presented together in the description.

At present, both subcategories are quite developed and established. Despite the fact that the history of oil and gas development has a rather long period, over the past thirty years a real breakthrough has been made in this area in quantitative and qualitative terms. Thus, the amount of oil produced from 25,820 thousand tons in the base year increased to 86,228 thousand tons in 2021, thus, production volumes more than tripled.

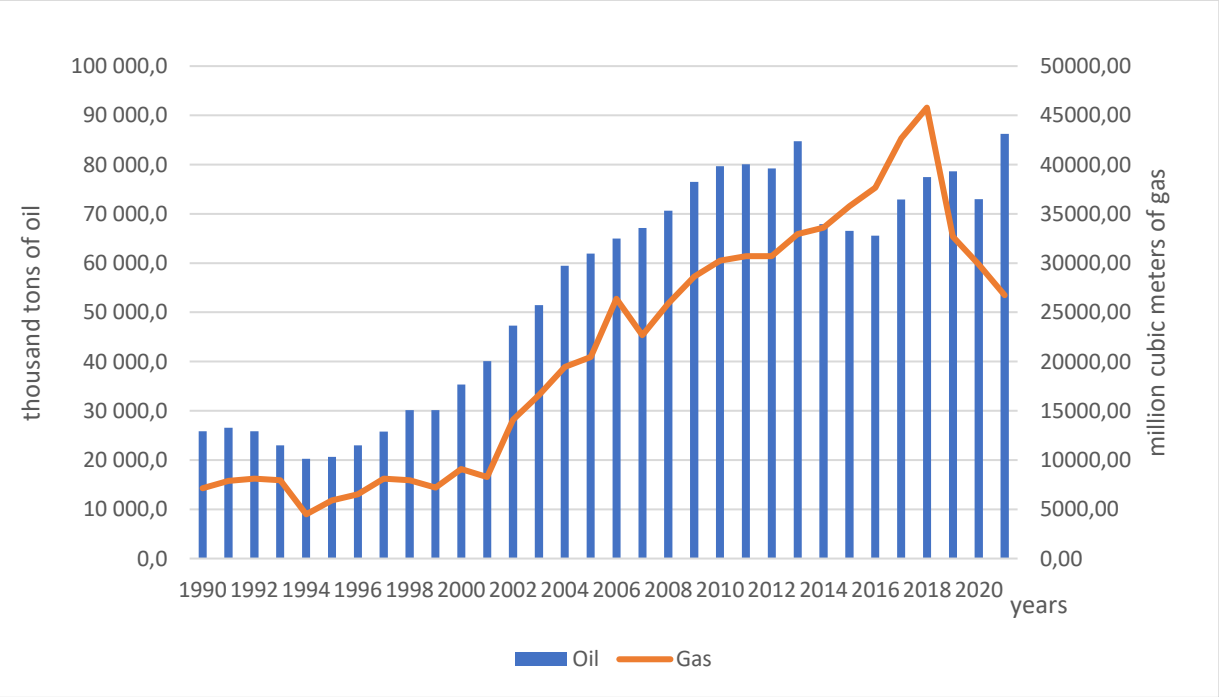


Fig. 3.5.8 Volumes of oil and gas production in Kazakhstan (oil thousand tons, gas million m ^{3}).

Gas production in Kazakhstan is very limited and very little pure gas is produced, in most cases associated oil gas is present, with a high content of sulfur compounds. In 1990 , Kazakhstan produced 7,123 million m a small amount, Figure 3.5.8 .

The significant decline in gas production in 2014 is explained, according to the available analytical materials, by a sharp decrease in the cost of fuel. As you know, the fall in prices hits primarily small and medium-sized oil companies, and they are the majority in the republic [49][50].

[49]https://www.zakon.kz/4681007-proshedshijj-god-dlja-kazakhstanskojj.html
[50]https://www.rogtecmagazine.com/%D0%BD%D0%B5%D1%84%D1%82%D1%8C-%D0%B8-%D0%B3%D0%B0%D0%B7-%D0%BA%D0%B0%D0%B7%D0%B0%D1%85%D1%81%D1%82%D0%B0%D0%BD%D0%B0-

The export of small batches of oil barely covers their costs. And in this case, companies reduce production volumes, but do not stop it completely. This situation persisted for almost two years, and some companies experienced significant difficulties. However, in 2017 the situation with the price changed and the companies were able not only to restore production volumes, but also to increase it, which was facilitated by the improvement of the overall fuel transportation infrastructure.

Oil (1.B.2.a). Currently, out of all possible categories for oil that are possibly estimated, calculations are made for: exploration, production, transportation and processing and storage. At present, emissions from the distribution of petroleum products and other sources have not been estimated, Figure 3.5.9 .

Fig 3.5.9. Distribution of GHG emissions from oil-related processes (1.B.2.a)

The main emissions are expected to come from the category of oil production, about 83% in the base year, and 32% in 2021 (down 51%). The second most important category is oil refining, which accounted for 15% in the base year and 59% in 2021, i.e. this category becomes the leading one in terms of emissions, which is explained by the increase in the volume of processed products (the growth in processing almost doubled). The participation of other processes in the base year was limited to two percent for oil exploration and less than a percent for transportation. Transportation accounted for less than 1% of all emissions. However, in 2021 the situation is changing somewhat, with transportation and exploration accounting for 6% and 3%, respectively. Against the background of a general increase in the amount of oil produced, the share of emissions from oil refining is quite large - 59%, despite the introduction of new technologies in the refining process.

It is important to note that the increase in the share of transport workers to 6% is associated with an increase in the volume of oil transportation in general (due to the growth of its production), as well as with the emergence of a new type of transport - offshore oil tankers. Judging by the pumping processes, the process of loading and unloading give comparable emissions against the background of a decrease in all emissions as such, Figure 3.5.9.

Thus, the maximum emissions of greenhouse gases were observed in 1997 - 1998, against the background of an increase in the total volume of oil and the use of relatively outdated technologies. Subsequently, with the modernization of the entire industry, and the strengthening of state control, the organization of internal trading in quotas in the carbon market, the situation began to change against the background of an increase in oil production by almost 3.5 times, emissions decreased by almost two times.

Total emissions from 27099.28 thousand tons of CO_2 equivalent in 1990 decreased to 14067.5 thousand tons of CO_2 equivalent in 2021, the decrease was 48.1%.

Gas (1.V.2. b). The estimation of emissions for the processes connected with gas development was made for the following categories: extraction, processing, transportation and distribution, fig. 3.5.10 . Note that the emissions associated with the exploration of oil and gas

%D1%80%D0%B5%D0 %B7%D1%83%D0%BB%D1%8C%D1%82%D0%B0%D1%82%D1%8B-2014-%D0%B3%D0%BE/?lang=ru

fields are reflected in category 1.B.2.a - oil, since these processes are unambiguously difficult to separate.

Over the past five years, the volume of emissions that are carried out from processes related to gas exceed the base year by almost one and a half times.

As it was said at the beginning of the descriptive part, this is due to a significant increase in gas production by almost 4 times. Diagram 3.5.10 illustrates the dynamics well, and in the base year the main emissions accounted for gas production - 78% of all emissions, storage, processing and distribution accounted for 11%, 6% and 5%, respectively.

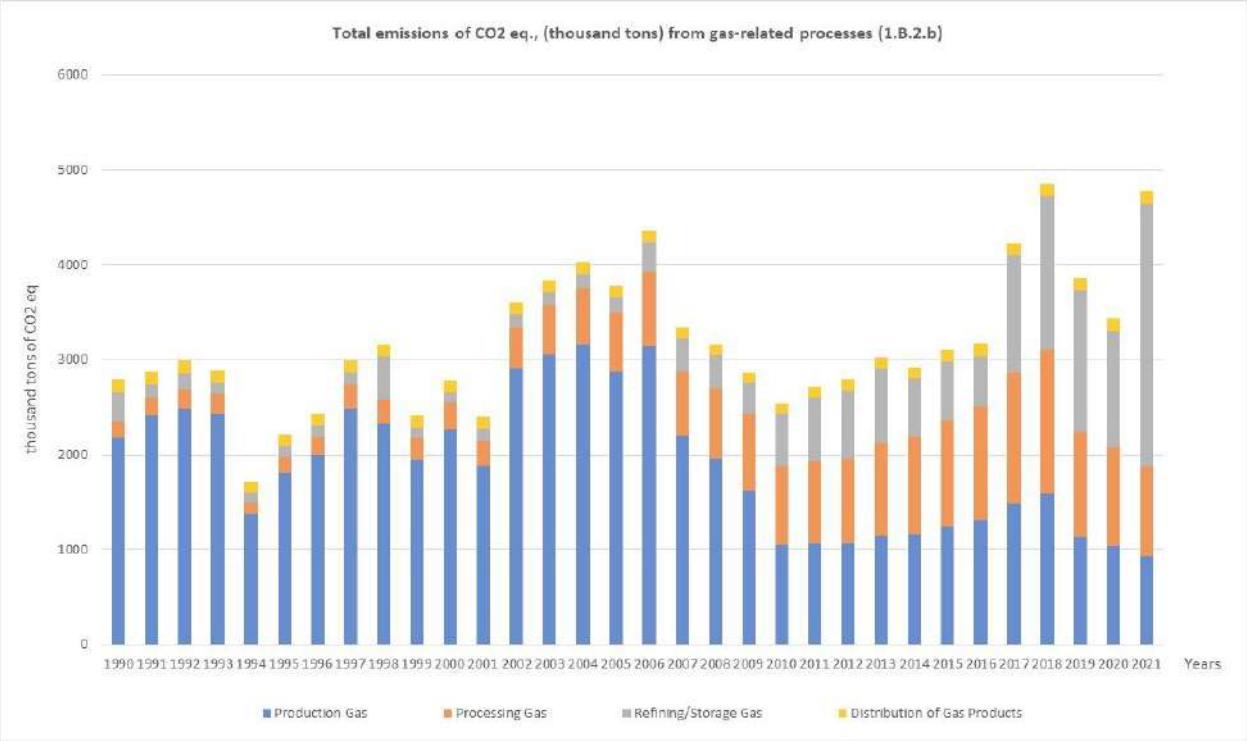


Figure 3.5.10 Distribution of GHG emissions from gas-related processes (1.B.2. b)

To date, the industry has changed significantly technologically and the share of subcategories has also changed significantly, the main source of emissions has become the category of gas transportation 58%. Gas processing accounts for 20% of all emissions, 19% for gas production, and only 3% for gas distribution to end consumers.

The presented changes are due to several reasons, firstly, the share of processed gas within the country has increased, and secondly, the length and throughput capacity of pipelines, the main component of gas transportation, has significantly increased. Moreover, part of the systems is used for gas transit through the territory of the Republic of Kazakhstan from Uzbekistan and Russia. In the future, it is planned to expand this transport infrastructure even more to be able to transfer gas from Russia to Iran and vice versa, as well as to transport our own gas to the south. Therefore, in the foreseeable future, we can expect an even greater increase in the share of emissions from gas transportation. And the last most important factor of fluctuations is the price of gas, which significantly affects the interest of companies to carry out activities in the extraction of fuel. This partly explains the fluctuations in 2017 and 2019 [51].

[51]https://ru.sputnik.kz/20191112/eksport-kazakhstan-gaz-12010760.html

Potentially, the share of emissions from the distribution network will also grow, as the planned connection of the private sector in large cities to gas supply is currently being carried out to improve the environment, as well as improve the living standards of citizens.

Thus, the total number of emissions from gas operations increased from 2,793 thousand tons of CO2 equivalent in 1990 to 4,774 thousand tons of $CO2_{equivalent}$ in 2021. The growth in emissions amounted to 41.5%.

Purging and burning (1.B.2.c). This category is an indicator of the state of the oil and gas industry in Kazakhstan, and generally reflects the processes and trends taking place in the industry. Against the backdrop of growing oil and gas production, an increase in emissions in this subcategory is a natural process. We also note that the largest emissions occurred in 2013 and amounted to 14,657 thousand tons of CO2 equivalent, which exceeds the base year by 3.5 times. However, at present, through the joint efforts of the Government of the Republic of Kazakhstan and specialized companies, the volume of emissions exceeds the baseline only twice. %), Fig. 3.5.11.

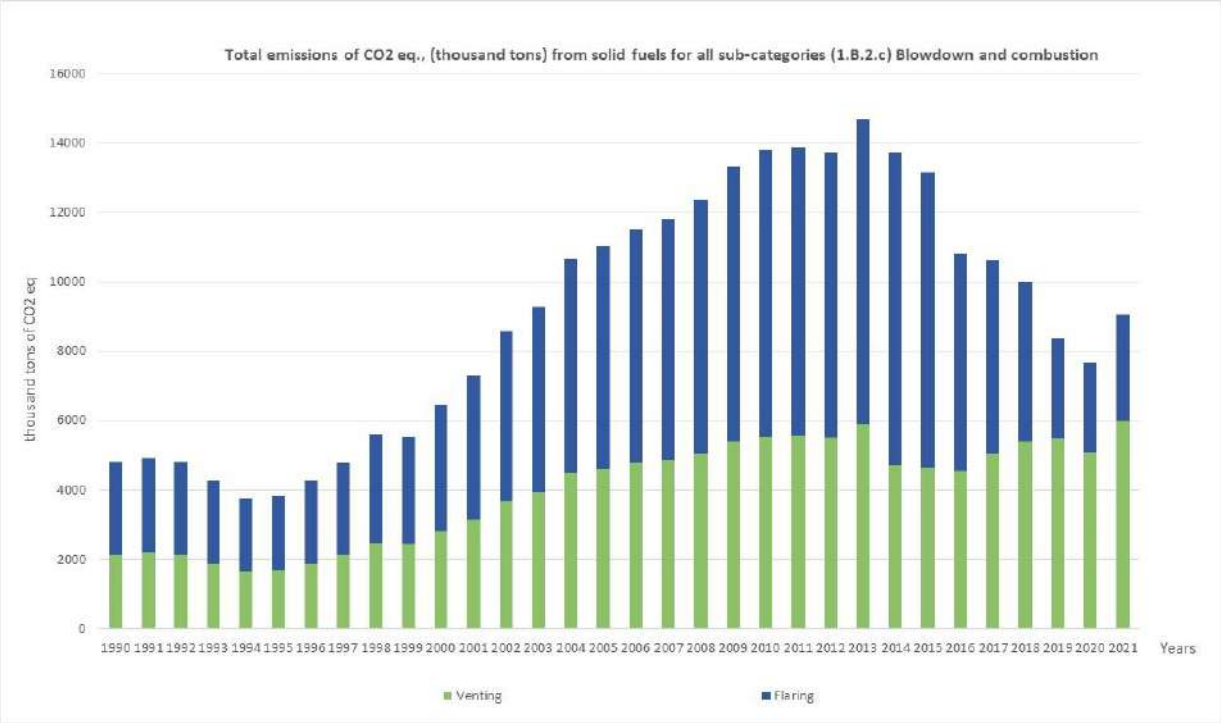


Figure 3.5.11 Distribution of GHG emissions from blowdown and flaring processes (1.B.2.c)

Diagram 3.5.11 illustrates well that the main emissions in 1990 were from gas flaring, their share in this category was 69%, against 31% of blowdown. In the base year, emissions from flaring were the main ones, but by now the situation has changed. The share of blowdown processes increased by 66% versus 34% of flaring.

The change in the share of participation of one process to another occurred at the beginning of the 2000s, as the share of oil and gas production increased and companies began to apply new equipment and technologies. Recall that the total share of this subcategory in fugitive emissions is 31% of all fugitive emissions, that is, it is quite significant. At the same time, there are still quite significant opportunities for reducing emissions in the future.

3.5.3.2 Methodological approaches

Sources of fugitive emissions from gas and oil systems include, but are not limited to, equipment leaks, evaporative losses, ventilation, flaring, incineration, and accidental releases. Once again, we note that at present there are no CO_2 sequestration projects in Kazakhstan , therefore, all relevant positions in the CRF tables are designated by the keys NO .

It should be noted that at present the process of modernization of enterprises continues in Kazakhstan, which is reflected in the decrees of the Government of the Republic of Kazakhstan, under legislative documents and orders. Most of them can be found https://snipkz.online/oil-gas/doc/mun19-10.pdf , as well as [52]:

Decree of the Government of the Republic of Kazakhstan dated July 18, 2022 No. 488

Law No. 20-V (2012, June 22) On the main pipeline: as amended. 2019-04-02

Law No. 202-V (2014, May 16) On Permits and Notifications: amended 2019-07-03

Law No. 532-IV (2012, January 9) On gas and gas supply: amended. 2019-04-02

Law No. 541-IV On Energy Saving and Increasing Energy Efficiency Law No. 210-VI (2018, 28 12 (2012, January 13) : amended 2018-12-28

Code No. 125-VI (2017, December 27) On subsoil and subsoil use: as amended. 2019-04-02

Regulations on the Oil and Gas Advisory Committee

Regulations on the National Operator for the Main Gas Pipeline

Regulations on the Central Commission for Exploration and Development of Deposits Approved: Order No. 214 (2018, May 28) / Minister, Ministry of Energy 15 Hydrocarbons of the Republic of Kazakhstan infrastructure development of the Republic of Kazakhstan

Rules for the acquisition by subsoil users and their contractors of goods, works and services used in the exploration or production of hydrocarbons and uranium mining Approved: Order No. 196 (2018, May 18) / Minister, Ministry of Energy of the Republic of Kazakhstan

Rules for submitting reports in the course of exploration and production of hydrocarbons, operations in the field of production and circulation of oil and (or) raw gas, uranium, coal, pilot production and uranium mining Approved: Order No. 203 (2018, May 23) / Minister, Ministry of Energy of the Republic of Kazakhstan

Issuance of a permit for flaring of raw gas: as amended. 2019-02-01

Order No. 537 (2018, December 27) / Minister, Ministry of Energy of the Republic of Kazakhstan

Issuance of a license for the design (technological) and (or) operation of mining (exploration, mining), petrochemical industries, operation of main gas pipelines, oil pipelines, oil product pipelines in the field of oil and gas: as amended. 2018-02-13 Order No. 48 (2018, February 13) / Minister, Ministry of Energy of the Republic of Kazakhstan

Registration of an agreement on pledge of subsoil use rights for exploration, production of common minerals Order No. 552 (2019, July 25)

As part of the implementation of the order of the Government of the Republic of Kazakhstan, enterprises increased investments from profits and borrowed funds for their equipment and technological support. Such indicators are quite difficult to assess, since enterprises submit their reports individually, however, thanks to the new indicators that have been introduced by the Bureau of National Statistics of the ASPIR RK, it is possible to evaluate the total investment

[52]Decree "On measures to stimulate the reduction of atmospheric air pollution by products of burning associated petroleum gas at flares" http://neftegaz.ru/news/view/101273/

in modernization through target indicators. These data are published annually in Bulletins and Statistical Compilations [53]:

Science and innovation activity of Kazakhstan;

Fixed assets of Kazakhstan;

Investment and construction activities in the Republic of Kazakhstan;

Kazakhstan in numbers;

Kazakhstan today;

Regions of Kazakhstan;

It can be seen that despite the difficulties in the economy and other factors such as COVID 19 and others, enterprises continue the process of renewal.

The presented documents allow the National Experts to state that over a thirty-year period, many productions, developments and conditions for transporting raw materials and final goods to the consumer have changed significantly. That gives grounds to make a qualitative change in the applied coefficients. In particular, for the period of 1990, which is the base year, coefficients for developing countries were applied, which is how Kazakhstan positioned itself as a State. However, today the situation has changed significantly, as well as the technologies and capabilities used. Therefore, since 1998, the weight of new equipment in the Energy sector has been changing and over the course of 12 years, the application of the emission factor for the oil and gas industry has been changing from developing countries to developed ones. Thus, starting from 2011, all applied coefficients refer to developed countries. This somewhat does not change the homogeneity of the series or approaches to the unity of assessment, which is embedded in the concept of the IPCC Guidelines. This is a normal process of renewal and qualitative change in industries, which should manifest itself through a change in the applied coefficients. The next, expected step, which should take place in the near future, is the application of national coefficients that the Companies will receive as a result of the introduction of new standards for assessing activities and conditions for monitoring enterprises in accordance with the Environmental Code of the Republic of Kazakhstan, paragraph 3 of Article 294, as well as Articles 284, 286,289,290, 293 and others.

In the course of improving the National Report, preliminary consultations were held with a number of international experts, and having familiarized themselves with the arguments of the Kazakh side, the experts agreed that such a qualitative transition could well be carried out, and over thirty years of independence, the qualitative composition of the equipment should change due to physical wear and tear. labor safety considerations. It should be noted that with the beginning of the development of new fields, after gaining independence, the share of equipment supplied to Kazakhstan for oil and gas production was foreign-made, namely from those countries that are among the developed ones. And local legislation and state control services monitor the conditions of its operation at the proper level. Thus, changing the coefficients is a reasonable step to apply.

Another important point to be noted is the absence of any projects in the Republic on CO_2 sequestration from enterprises (for this reason, Amount captured is indicated as NO in all categories). Within the framework of the tasks set by the President of the country Kassym-Jomart Kemelevich Tokayev to achieve carbon neutrality of the Republic of Kazakhstan, such projects are expected to be implemented after 2030, when technologies for storing carbon dioxide in world practice will already be developed and the price in terms of one ton will be adequate and achievable. Currently, the National Companies are conducting preliminary consultations and

[53] https://stat.gov.kz/edition/publication/collection

assessments with international experts on the possible implementation of such projects in the future. It should be noted that the main sources that are technically and logistically suitable for such projects have already been identified.

Emissions were estimated by source according to Table 4.2.1 of the IPCC Guidelines for National Greenhouse Gas Inventories, 2006. Calculations were made at Tier 1 using Equations 4.2.1 and 4.2.2 of the IPCC Guidelines.

$$\mathbf{E}_{\text{gas industry segment}} = \mathbf{A}_{\text{industry segment}} \times \mathbf{EF}_{\text{gas industry segment}}$$

$$\mathbf{E}_{\text{gas}} = \sum \mathbf{F}\text{газ, сегмент отрасли}$$

Where:

E gas, industry segment = annual emissions (Gg)

EF gas, industry segment = emission factor (Gg/activity)

A industry segment = activity value (activity units),

The default emission factors for Tier 1 were used from tables 4.2.4 and 4.2.5. Moreover, until 1998, a coefficient was applied for developing countries, then in the period from 1998 to 2012 a transition coefficient was applied, which took into account the share of updating the production fleet of equipment in the industry, an average of 8% per year. After 2012, the coefficient for developed countries was applied. As already mentioned, this approach is justified from the standpoint of equipment upgrades, the introduction of new technologies, the use of new materials, as well as the tightening of environmental standards and requirements that are planned to be implemented in the country.

The presented approach was applied to all sources of emissions without exception, thereby observing the principle of unity of approaches.

The completeness and accuracy of the input data used as initial information is not in doubt, since the official data presented in the Fuel Energy Balance of the Republic of Kazakhstan were used.

Oil.

Intelligence service. When assessing emissions from oil, it was taken into account that some of the volumes could be reflected in other subcategories. In particular, emissions from oil and gas exploration were taken into account only in category 1.B.2.a (oil), since it is not yet possible to single out the share of emissions from exploration of gas fields, with the existing specification of the initial data. In this subsection, all gases were evaluated.

Mining. Calculations from oil production are made taking into account the coefficients of the subcategory (Land), since it is believed that most of all production takes place on the continental part of the Republic, while offshore production is carried out on artificial islands, since in the offshore drilling zone, the depth is relatively small. large up to 3.5-5 meters. The creation of an island infrastructure a short distance from the coast is more economically profitable, from the standpoint of maintenance and supply, in contrast to real offshore platforms in their pure form. In this sub-category, only methane and carbon dioxide were assessed.

Mining emissions from 'Removal' - 1.B.2.ai and 'Flagring' - 1.B.2.a.ii processes are estimated and presented separately in Table 1.B.2.c.1.i . in category 1.B.2.c.

Oil transportation . Currently, oil is transported by all types of transport - oil by road, rail, pipeline and sea transport , Figure 3.5.12 .

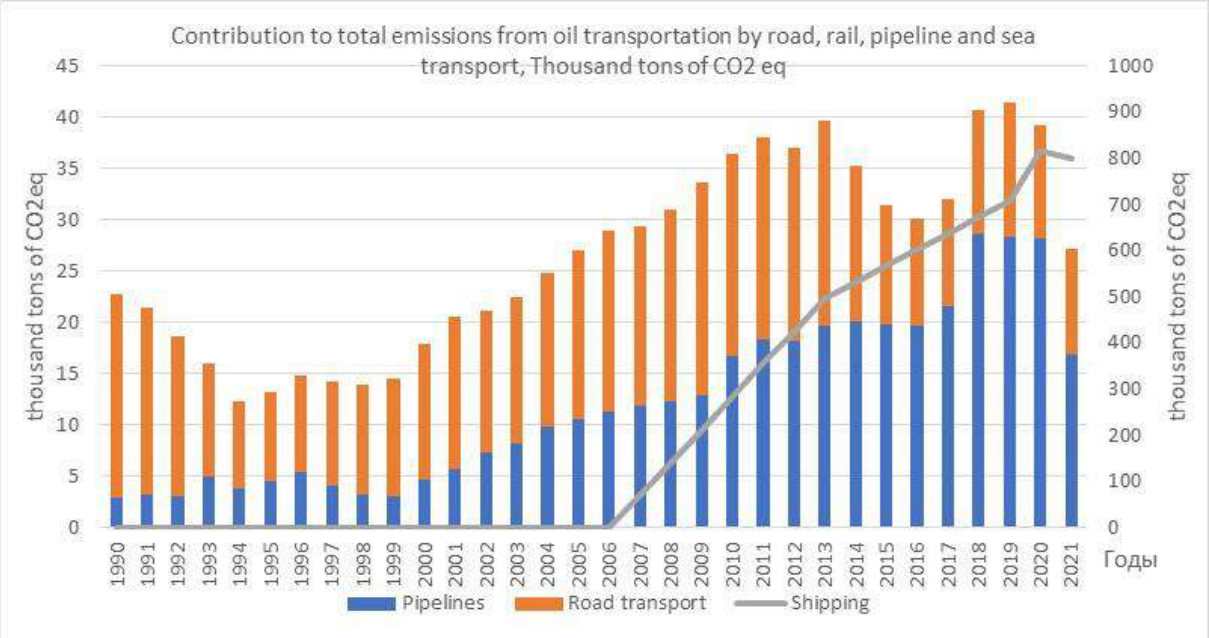


Fig 3.5.12. Contribution to total emissions from oil transportation by road, rail, pipeline and maritime transport.

For the period of 1990, the main part of the transported oil, about 59% of the total transported volume, was carried out by rail and road transport, only 41% of oil was pumped by pipelines. Maritime transportation was not carried out at that time, since the maritime infrastructure of neighboring states on the Caspian Sea was not ready to receive oil barges. In addition, the Republic did not have an appropriate fleet and infrastructure for maritime transport.

It should be noted that, according to analytics [54], a significant decrease in oil shipments in 2017 was due to the tightening of standards by Transneft Public Joint Stock Company, which oversaw the direction from the port of Aktau to Makhachkala. In 2018, the standards were somewhat relaxed, but this was not done immediately. In this connection, Kazakh suppliers agreed to ship about 2 million tons of heavy grades. A slight increase was observed in the Mediterranean Sea and Makhachkala-Baku directions due to the reorientation of tankers. The decrease in the Black Sea is associated with a decrease in the volume of oil supplies from the resources of JSC NC KazMunayGas to refineries in Petromidia.

The creation of the necessary infrastructure and fleet begins in 1998 by the Decree of the Government of the Republic of Kazakhstan No. 1239 dated December 4, 1998 in the form of the National Maritime Shipping Company (NMSC) Kazmortransflot Joint Stock Company. But she really started working in 2006. Further, by the Decree of the Government of the Republic of Kazakhstan, NMSC Kazmortransflot LLP in 2011 was assigned the status of the National Sea Carrier. The sole founder of NMSC Kazmortransflot LLP is National Company KazMunayGas JSC.

[54]http://neft-gas.kz/f/zhd_osmanov.pdf

The main goal of NMSC Kazmortransflot LLP is the development of the national merchant marine fleet of the Republic of Kazakhstan and the organization of international maritime transportation of domestic cargo on its own.

Thus, the official merchant fleet in Kazakhstan was created only in 1998. Until that moment, the operating activity was not carried out significantly by the ships of other countries. The second important point in the operational activity of the merchant fleet of the Republic of Kazakhstan is the appearance of the first own oil tanker only in 2005. Today, a total of 9 oil tankers are in operation.

Thus, emissions from maritime transport are not carried out until 2005, inclusive. Since 2006, such emissions have been taken into account, and coefficients are applied according to the appendix to table 4.2.4, point " h ".

Accordingly, for 2021, there has been a significant redistribution of GHG emissions from the “transportation” category, so the bulk of the product is pumped by pipelines - 79%, rail tanks and vehicles account for 12% of oil, and the remaining 9% are transported by sea. Accordingly, emissions are carried out according to the share of the contribution from the types of oil transportation.

In this sub-category, only methane and carbon dioxide were assessed.

Recycling. Oil refining is one of the main processes where GHG emissions are formed. To estimate this source, the coefficients presented in table 4.2.4, IPCC Guidelines, for the sub-category - 1.B.2.a.iii.4 oil refining, the coefficients are used for sour oil, which correspond to the local oil quality. This subcategory did not take into account emissions for CO_2 and N_2O, respectively, these gases in the CRF tables are designated by the keys NO , since there are no coefficients for them.

Distribution and Other Processes . There are currently no coefficients for both processes in the IPCC Guidelines. There are no such coefficients in the Republic of Kazakhstan either. For this reason, both categories in all positions are represented by the key NO .

Gas.

Intelligence service. Since emissions from oil and gas exploration are currently quite difficult to separate, all emissions that occur here are reflected in the category - Oil. This does not affect the underestimation of emissions, but reduces the overall uncertainty of the estimate and preserves the unity of approaches. Accordingly, all entries in the CRF tables for oil exploration are marked with the key IE , referring to the fact that potential releases are reflected in category 1.B.2.a.1.

Mining. Estimation of emissions from gas production was carried out according to the data provided by the Bureau of National Statistics. The coefficients were used from tables 4.2.4 and 4.2.5. The evaluation was made for all gases.

Recycling. Estimation of emissions from gas processing was carried out according to the data provided by the Bureau of National Statistics of ASPIR RK. The coefficients were used from tables 4.2.4 and 4.2.5. The evaluation was made for all gases.

Transportation. Estimation of emissions from gas transportation was carried out according to the data provided by the Bureau of National Statistics of ASPIR RK. The coefficients were used from tables 4.2.4 and 4.2.5. The evaluation was made for all gases.

Distribution. Estimation of emissions from gas distribution was carried out according to the data provided by the Bureau of National Statistics of ASPIR RK. The coefficients were used from tables 4.2.4 and 4.2.5. The evaluation was made for all gases.

other processes. Emissions estimates for other processes have not been made due to lack of activity data. Accordingly, NO keys were used in the CRF tables .

For all CRF tables without exception, for gas-related processes, in the line " Amount captured " key NO was used .

Ventilation and flaring.

Emissions were assessed based on data on the amount of associated gas from oil production, as well as the calculated amount of flared gas. In both cases, the coefficients from Table 4.2.4 were used.

For this category, all emissions are presented in the CRF tables 1.B.2.c.1.i and 1.B.2.c.2.i.

3.5.3.3 Formation of a consistent time series. Uncertainty assessment

As already mentioned, for estimating emissions from the category fugitive emissions, a homogeneous and consistent set of initial data obtained from official sources was used. Thus, the requirements for the homogeneity of the series are met.

Since this Chapter did not use national measurement data, the uncertainty estimate is determined only by the coefficients presented in the IPCC 2006 Guidelines, which in turn determine the accuracy according to tables 4.2.4 and 4.2.5 presented for each coefficient. The use of the presented coefficients for estimating emissions from sources has a significant uncertainty, but at present there are no other approaches.

The estimate of activity data uncertainties is based on Management's expert judgment and approximates the 95% confidence interval of the main estimate. For gas compositions, the accuracy for individual components is typically ±5 percent.

3.5.3.4 QA/QC procedure

Despite the fact that the state generalized data for analysis is used in the basis, we note that such large enterprises as Kazakh Oil and KazTransGas are involved in the industry, which determine the position of the industry as a whole. For this reason, the original data does not differ much from the companies' data. Thus, it is considered that there are no missing or unaccounted sources.

At present, direct measurements are not yet used to determine country-specific emission factors.

Experts closely monitor the use of IPCC default factors with factors calculated in other countries with similar production characteristics. However, at present, they adhere to the established approaches and recommendations from the 2006 IPCC Guidelines.

Trends in key emission drivers and activity data were carefully examined in the analysis and estimation of category emissions, and anomalies were checked for errors. It should be noted that all abrupt changes usually have technical reasons, which caused a sharp increase or decrease in emissions. In particular, this could be the commissioning of a new pipeline, a plant or new production facilities. In some cases, the reductions were caused by accidents or the failure of existing facilities for the transportation or processing of raw materials.

As part of the preparation of this section, comparisons were made between the results of other experts, for some categories. In general, the estimates coincide, which increases the credibility of the results obtained.

3.5.3.5 Recalculations

For oil and gas, recalculations were made for the entire period from 1990 to 2021. This was due to a significant number of comments on the Fugitive Emissions category since the last review in 2019 by the Expert Group. As part of the preparation of the new chapter, training was conducted with experts from other countries. Consultations were held with GHGMI , which allowed to revise the assessment of some subcategories. In particular, attribute part of emissions from production to flaring, recalculate maritime transport, and include oil and gas processing. Account for associated gas flaring in category 1.B.2.c.

For all categories, the units of measurement in the source data are checked in the CRF tables.

3.5.3.6 Planned improvements

Currently, no improvements are planned. However, in connection with the introduction of new reporting requirements for quota oil and gas enterprises, experts may get more accurate and real emission factors from activities, which may differ significantly from those reflected in the Guidelines, in which case the series will be revised taking into account relevant information

In addition, the reports of other countries are currently being evaluated in order to introduce improvements both in the methodological plan and in the search for more suitable coefficients. It should be noted that today in Kazakhstan, advanced technologies have been implemented, which puts the country among the countries that determine policies and measures in the Central Asian region, and it is not easy to find suitable improvements.

4 INDUSTRIAL PROCESSES AND PRODUCT USE. SECTOR 2 CRF

4.1 Overview of the sector

In 2021, the Republic of Kazakhstan, in terms of economic indicators of industrial development, returned to pre-pandemic levels. Even with the strengthening of restrictive measures due to the COVID-19 epidemic in the first half of 2021, GDP indicators in the second half of the year increased and provided a 4% increase for the year. The overall production growth in 2021 in Kazakhstan amounted to 3.8% [55].

The inventory of greenhouse gas emissions in the sector "Industrial Processes and Use of Products" (IPPU) includes an estimate of emissions from seven sub-sectors: the production of mineral materials (2.A), the chemical industry (2.B), the metallurgical industry (2.C), the use of solvents and non-energy products from fuels (2. D), the electronics industry (2.E), the use of fluorinated ODS substitutes (2. F), and the production and use of other products (2. G). The Kazakhstan GHG inventory includes six categories from the above list, these are: emissions from the production of mineral materials (2.A), the chemical industry (2.B), the metallurgical industry (2.C), the use of solvents and non-energy products from fuel (2. D), the use of fluorinated substitutes for ODS (2. F), and the use of sulfur hexafluoride (2. G .1). This chapter presents all industrial sources of GHG emissions (CO_2, CH_4 and N_2O) available in Kazakhstan.

It should be noted that the Republic of Kazakhstan lacks some production processes, which, according to the methodology of the IPCC WP, 2006, are significant sources of emissions. These are the production of adipic acid, sheet glass, the production of carbon black, the non-metallurgical production of magnesia, the production of caprolactam, glyoxal and glyoxylic acid, and the production of titanium dioxide. There is no pulp production in the Republic of Kazakhstan, but there is a pulp and paper industry that works on the recycling of raw materials. According to the Bureau of National Statistics, there are about 160 pulp and paper and paperboard companies operating in Kazakhstan. In Kazakhstan, 90% of the main raw material of the pulp and paper industry (PPI) is waste paper [56]. In our country, for natural reasons , there is no production of wood pulp, as there are no forests. According to the Ministry of Ecology and Natural Resources of the Republic of Kazakhstan, forested land covers 13 million hectares. The forest cover of the country in 2021 was equal to 4.8% [57].

And cellulose is the main component for the production of paper and cardboard. More than 60% of pulp and paper products are packaging materials. The main part of packaging materials, about 70%, goes to the food industry [58].

There is also no production of HFCs, PFCs and $SF_{6\ \text{in Kazakhstan}}$. The IPPU section includes an assessment of PFC, HFC and $SF_{6\ \text{emissions}}$ from the use of these substances in refrigeration, air

[55]Data from the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, 2022

[56]https://ru.sputnik.kz/economy/20171214/4036484/cellyulozno-bumazhnoj-promyshlennosti-kazahstana-grozit-unichtozhenie.html

[57]https://strategy2050.kz/ru/news/vosstanovlenie-lesov-v-rk-obemy-porody-derevev-i-interaktivnaya-karta-po-kontrolyu-za-sazhentsami/

[58]//atameken.kz/ru/news/32230-uvelichenie-eksporta-i-vozdelyvanie-konopli-chto-zhdet-cellyulozno-bumazhnuyu-otrasl-kazahstana

conditioning, foam and other materials. These substances used on the territory of the republic are imported, mainly from European and Chinese manufacturers.

The main document used to calculate GHG emissions is the IPCC Guidelines, 2006 (IPCC SPM, 2006) [59].

According to the results of the inventory of greenhouse gases in the IPPU sector, the key sources of greenhouse gas emissions, as in previous years, are: cement production (2A.1), limestone and dolomite use (2A.4 d), iron and steel production (2C.1) in including sinter production (2C.1d) and pellet production (2C.1e); further production of ferroalloys (2C.2), aluminum production (2C.3), refrigeration and air conditioning (2.F.1).

The main sources of emissions of indirect greenhouse gases in Kazakhstan is category 2.G "Production and use of other products", which is represented by the following subcategories SNAP 0601 (use of paints), SNAP 0602 (degreasing and dry cleaning), SNAP 0604 (other use of solvents and related activities) . In these sub-categories, only non-methane volatile organic compounds (NMVOC) emissions were estimated, which are not included in total national GHG emissions, as they are not greenhouse gases.

Activities aimed at improving the quality of the National Report in the IPPU sector:

In general, when compiling this National Report in the section of the sector "IPPU" were carried out improvements:

1) supplemented information on the pulp and paper industry in the Republic of Kazakhstan;

2) changes were made to the structure of sectoral chapters, in particular, the description of category 2.E "Electronics industry" was included;

3) description of the use of products of category 2. F as substitutes for ODS and electrical equipment 2. G .1 and 2. G .3 - N_2O emissions from the use of products have been moved from the section on emissions of metallurgical processes to separate sections.

4) Also, in general, the following changes were made to R&D:

- Table 2 (I) of the CRF includes information on activity data;

- in categories 2 B .2 "Production of nitric acid"; 2C.1 b "Iron production"; 2C.1e "Production of pellets"; 2C.1 f "Production of agglomerates"; 2.C.2 "Production of ferroalloys"; 2.C.3 "Aluminum production" recalculations were carried out for the entire time series;

- in CRF tables in category 2.D.3. “Other” the subcategory “Use of urea converters” was included, as according to IPCC RP, 2006. Emissions from this subcategory are accounted for in the IPPU sector, but the description for this subcategory is included in the section on category 1.C transport. sector "Energy";

- in the relevant sections of the National Report, detailed descriptions of the reasons and results of recalculations are provided, as well as comparative tables of the resulting changes in greenhouse gas inventories for 2020 and 2021 are presented.

4.1.1 Trends in Greenhouse Gas Emissions from the Industrial Processes and Product Use Sector

IPPU sector in 2021 amounted to **27,144.677 tons of CO_2-eq.** This is only 0.42% higher than 2020 emissions and 19.4% higher than 1990 GHG emissions for the IPPU sector as a whole (Figure 4.1 and Table 4.1).

[59] 2006 IPCC Guidelines for National Greenhouse Gas Inventories

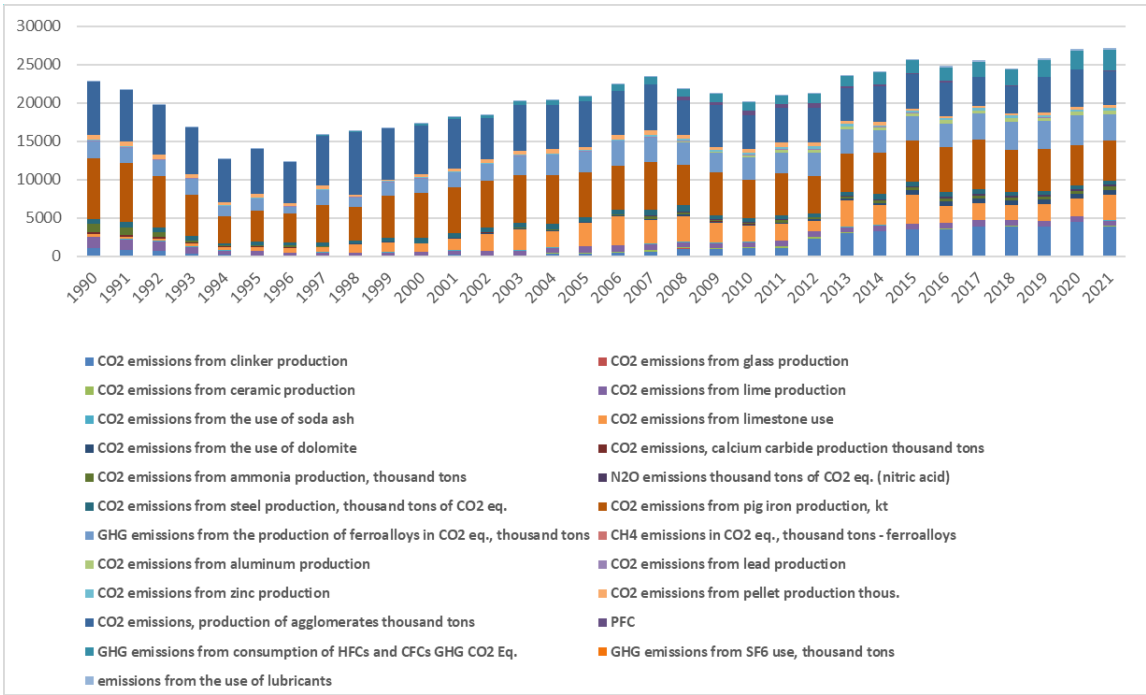


Figure 4.1 - Dynamics of greenhouse gas emissions from the sector "Industrial processes and product use" for 1990-2021

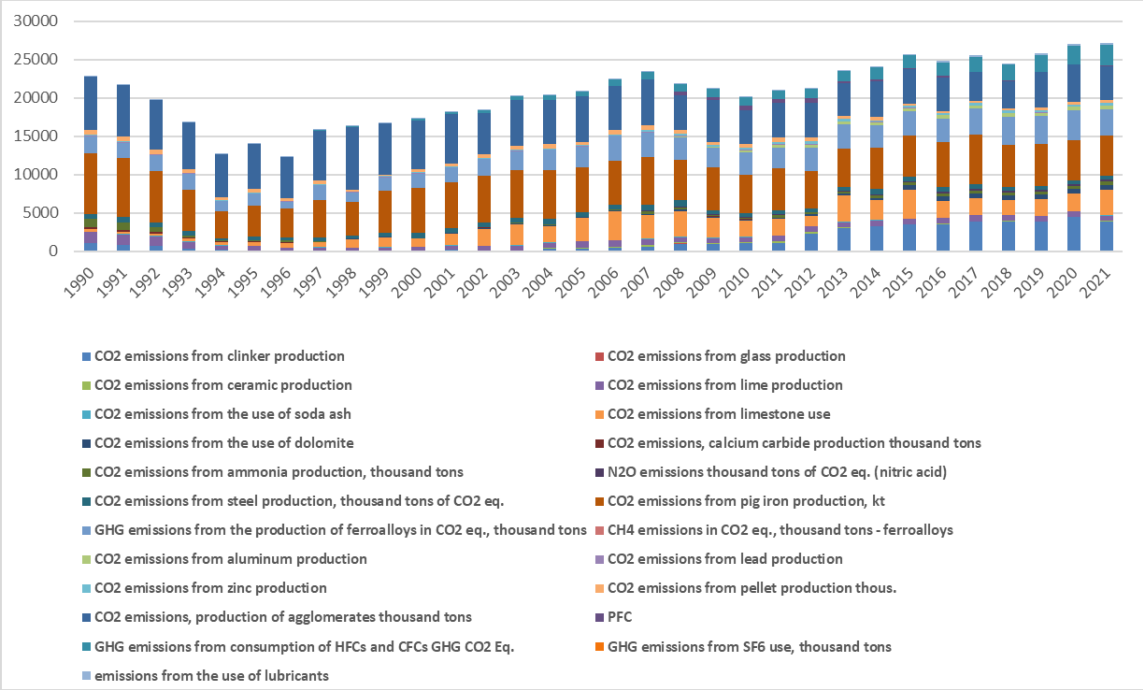
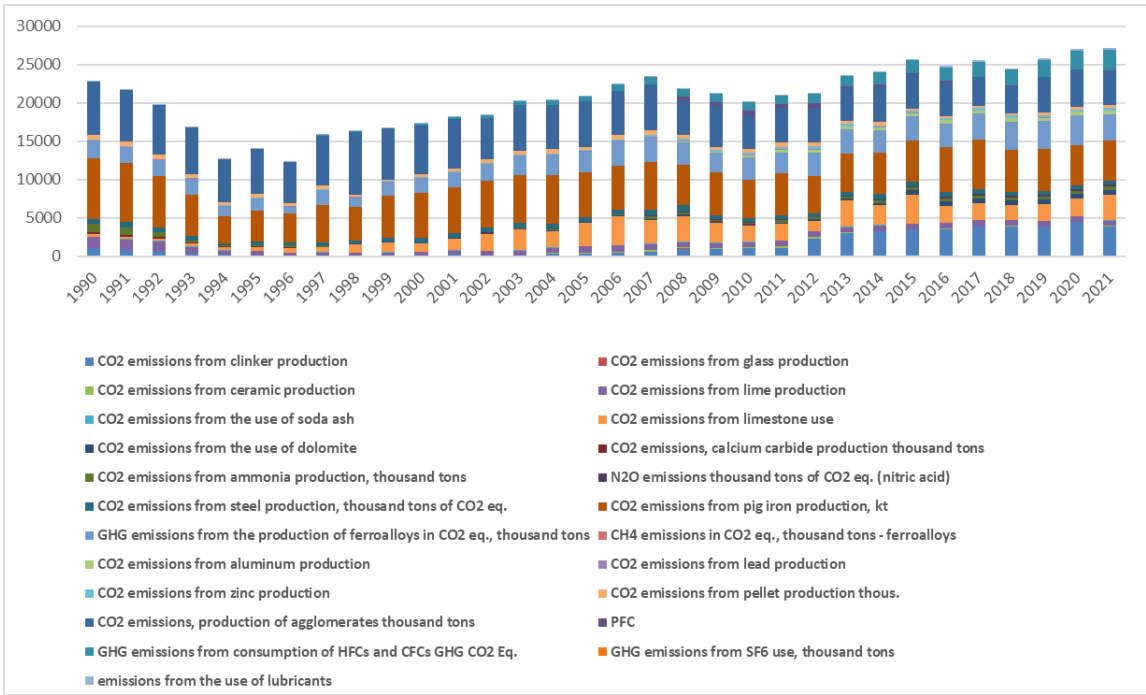


Figure 4.1 - Dynamics of greenhouse gas emissions from the sector "Industrial processes and product use" for 1990-2021



4.1-suret - 1990-2021 zhyldarga arnalgan "Ondiristik processer zhane onimdi paidalanu" sectorinan greenhouse gasdar shygaryndylarynyn dynamics

Table 4.1 - Values of GHG emissions from the IPPU sector for the period 1990-2021, thousand tons of CO_2 eq.

years	GHG emissions in the IPPU sector, thousand tons of CO2 eq.						
	Total emissions by the IPPU sector	Production of mineral materials (2A)	Chemical industry (2B)	Production of metals (2C)	ODS consumption (2F)	Using SF6 (2G.1)	Non-energy fuel products and solvent use (2D)
1990	22737.402	2901.759	1270.418	18562.866	0	0	2.361
1991	21713.797	2525.169	1203.377	17983.009	0	0	2.242
1992	19795.848	2246.26	845.901	16701.561	0	0	2.125
1993	16820.647	1677.112	379.113	14762.042	0.372	0	2.007
1994	12685.166	1194.904	171.004	11316.121	1.248	0	1.888
1995	13990.088	1228.076	228.279	12527.569	4.452	0	1.711
1996	12257.188	1084.965	274.901	10890.041	5.688	0	1.593
1997	15771.28	1117.233	176.902	14466.359	9.312	0	1.475
1998	16338.772	1628.561	28.655	14580.728	99.471	0	1.357
1999	16797.105	1863.478	33.322	14768.429	130.636	0	1.239

2000	17341.32	1689.17	27.558	15350.463	273.008	0	1.121
2001	18159.778	2387.277	51.461	15424.861	295.706	0	0.472
2002	18413.385	3057.763	55.938	14961.359	337.735	0	0.59
2003	20194.539	3622.944	114.651	15993.944	462.588	0	0.413
2004	20326.221	3387.695	117.172	16232.993	587.999	0.007	0.354
2005	20853.668	4458.852	54.948	15694.279	643.64	1.653	0.295
2006	22447.704	5342.589	123.47	16087.191	889.531	1.687	0.236
2007	23434.429	4853.595	416.4101	17168.484	946.838	1.695	47.406
2008	21829.098	5406.298	423.361	14962.642	1019.574	1.715	15.507
2009	21339.742	4506.297	315.286	15289.485	1068.897	1.735	158.041
2010	20224.289	4135.187	358.839	14497.696	1072.993	1.735	157.839
2011	21323.773	4345.026	442.805	15064.649	1144.648	1.749	324.893
2012	21530.106	4789.132	333.482	14814.886	1259.572	1.827	331.207
2013	23716.069	7517.013	361.497	14305.885	1328.219	1.925	201.529
2014	24141.789	6926.702	510.258	14978.253	1619.868	2.009	154.698
2015	25801.093	8579.29	572.565	14771.577	1698.535	2.013	177.112
2016	24870.976	7142.046	602.443	15167.891	1740.315	2.062	216.22
2017	25563.975	7522.897	628.417	15283.214	1968.387	2.097	158.963
2018	24535.745	7254.743	613.843	14383.748	2119.498	2.152	161.759
2019	25792.759	7419.648	569.239	15375.982	2258.361	2.319	167.211
2020	27031.372	8118.531	586.141	15623.479	2529.75	2.304	171.166
2021	27144.677	8626.526	680.221	14889.484	2706.491	2.370	239.585

The data in Figure 4.1 show that in the IPPU sector a significant reduction in greenhouse gas emissions occurred in the first half of the 1990s. On average, over the period from 1994 to 1998, greenhouse gas levels were about 60% below base year emissions. At the same time, in 1996, emissions in this sector fell most significantly from the level of 1990 due to the stagnation of industrial production during this period. Growth in industrial emissions began in 1997 and peaked in 2017, exceeding the base year level.

In Kazakhstan, industrial processes are sources of emissions of gases such as CO_2 and CH_4, as well as the only source of emissions of PFCs, HFCs and SF_6. Also in this National Report, N_2O emissions from the production of weak nitric acid (46%) are calculated. Fluorine gases are emitted from aluminum production (CF_4 and C_2F_6), use of refrigerants (HFCs, PFCs) and insulation in high voltage electrical engineering (SF_6).

According to Figure 4.2., the most significant source of greenhouse gas emissions in the reporting year in the Industrial Sector, as in previous years, is metallurgy. Based on the results of the 2021 greenhouse gas inventory, its contribution to total greenhouse gas emissions from the Industrial Processes and Product Use sector in 2021 amounted to 55.5%, excluding ODS consumption.

The next largest source of GHG emissions is the category “Emissions from the production of mineral materials”, the emission values for this category amounted to 32.0% of greenhouse gas emissions from the IPPU sector.

Emissions from the chemical industry accounted for 2.5% of total greenhouse gas emissions from the Industrial Processes and Product Use sector in 2021.

The share of greenhouse gas emissions from the use of ODS in 2021 increased and amounted to 10.0% (in 2020 - 5.3%) of emissions from the IPPU sector as a whole.

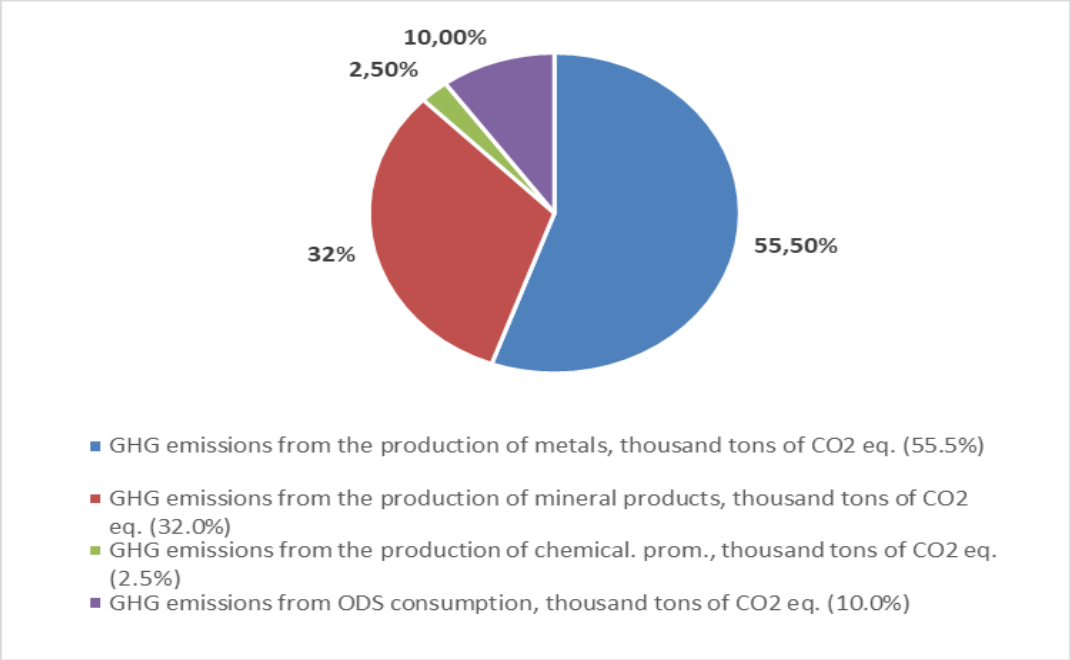
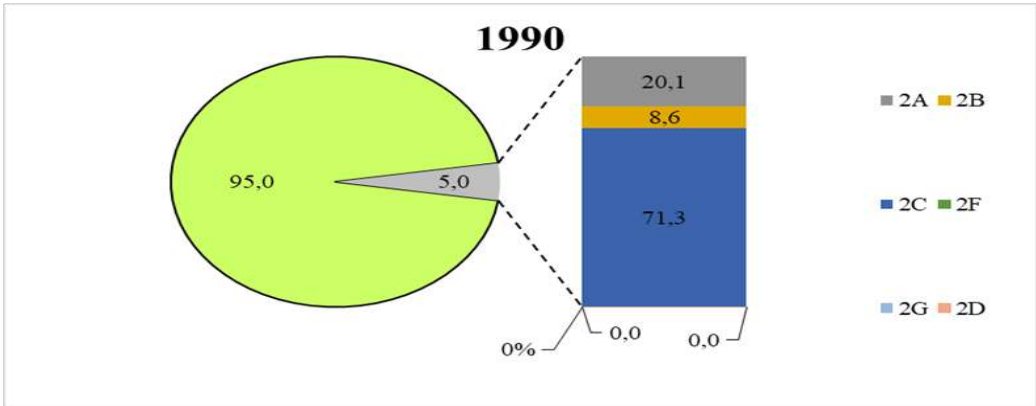


Figure 4.2 - The share of individual categories in total greenhouse gas emissions from the sector "Industrial processes and product use" in 2021

The contribution of the IPPU sector as a whole to total national greenhouse gas emissions in 1990 and in 2021 (% excluding the CFO sector) is shown in Figure 4.3 (a; b).



A)

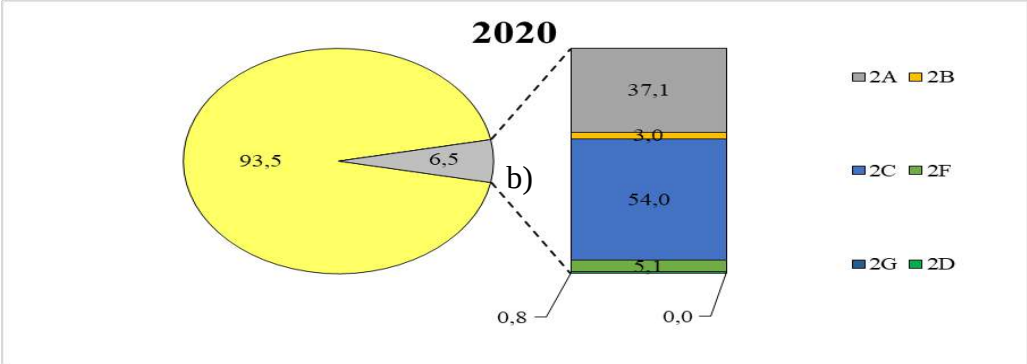


Figure 4.3 - Contribution of the IPPU sector to total national GHG emissions in 1990 (a) and 2021 (b), % (excluding the LULUCF sector)

The share of greenhouse gas emissions from the IPPU sector in total national emissions, excluding the LULUCF sector, in 2021 was 6.5%, while the share of sector emissions in 1990 was 5.0%. In this connection, there is an increase in greenhouse gas emissions from the IPPU sector by 1.5% due to emissions mainly in such categories as: emissions from Cement Production, Limestone and Dolomite Use and Ferroalloys Production.

4.1.2 Source categories

The 2006 IPCC SPM suggests using the most detailed data and national factors, primarily for key emission sources. For sources of greenhouse gas emissions from the production of iron, steel, agglomerates, pellets, ferroalloys, aluminum and the production of zinc from Waelz cakes, calculations were carried out on the basis of the Guidelines (IPCC 2006) using these enterprises. For these source categories, the calculations were mainly carried out for Tier (Tier) 2.

Emission factors for calculating greenhouse gas emissions from key source categories were determined on the basis of information provided by manufacturing plants. For other sources, the default coefficient values from the IPCC Guidelines, 2006 were taken. When calculating emissions from the consumption of fluorocarbons and SF_6, the initial data were the actual and estimated leaks of these substances based on data from KEGOC, the Traffic Police and the Bureau of National Statistics of the Agency for Strategic Planning and reforms of the Republic of Kazakhstan.

4.2 EMISSIONS FROM THE PRODUCTION OF MINERAL MATERIALS (CATEGORY 2A CRF)

This sub-sector estimates $CO_{2\ emissions}$ from cement production (2.A.1), construction and technological lime production (2.A.2), glass production (2.A.3), ceramic products production (2A.4.a), as well as processes for the use of carbonates (2.A.4) are the use of soda ash (2.A.4.b) and other uses of carbonates (in particular limestone and dolomite) (2.A.4.d).

The key source of greenhouse gas emissions in this category is cement production (2.A.1), where emissions are calculated based on clinker production data, emissions from this category in 2021 amounted to 44.5% of the total emissions of the mineral materials production category (2.A.1).

Further $CO_{2\ emissions}$ from lime production (2.A.2) are 8.29%; from the production of glass (2.A.3) - 0.24%; from other uses of carbonates, in particular from the use of limestone - 37.6% and dolomite - 7.8% (2.A.4. d); production of ceramic products (2.A.4.a) - 0.74%; as well as the use of soda ash (2.A.4. b) - 0.75%. In addition, we note that in the Republic of Kazakhstan there is no production of fiberglass and glass wool.

4.2.1 Cement production (category CRF 2.A.1)

4.2.1.1 Category description

$_{2\ )}$ emissions from the use of carbonate raw materials in production and the use of various mineral materials.

Estimated estimate of $CO_{2\ emissions}$ was carried out according to formula 2.2 (IPCC, 2006). The emission factor was calculated taking into account the content of CaO in clinker in accordance with the IPCC methodology (IPCC, 2006). The national clinker CaO content and a default CKD Correction factor (IPCC, 2000) of 1.02 were used.

Clinker production volume in 2021 according to the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, it amounted to 7295.7 thousand tons, which is 13.7% less than the production volume in 2020, there is a decrease in clinker production in the country. National statistics, as well as the State Revenue Committee of the Ministry of Finance of the Republic of Kazakhstan, do not provide data on the share of exports and imports of clinker for the entire time period 1990-2021, since the information is confidential [60].

Calculations of $CO_{2\ emissions}$ in this category are based on an estimate of the raw material consumed or the product produced, as well as emission factors that show the amount of $CO_{2\ emitted}$ per unit mass of the raw material. Greenhouse gas emissions in the category "Cement production" from 1990-2021, as well as the dynamics of GHG emissions for the period 1990-2021 from clinker production in the Republic of Kazakhstan are presented in Table 4.2.

Table 4.2 - Dynamics of greenhouse gas emissions from clinker production for the period 1990-2021

years	Cement production, thousand tons	Clinker production, thousand tons	$_2$ emissions , thousand tons
1990	8300.7	1929.0	1015.078
1991	7575.0	1528.0	804.064
1992	6436.3	1328.7	699.189
1993	3963.3	670.6	352.883
1994	2033.4	320.6	168.706
1995	1772.0	186.1	97.929
1996	1114.9	30.1	15.839
1997	656.5	89.2	46.939
1998	622.4	19.5	10.261

[60]Letter ref. No. KGD-04-2-15 / 40691-KGD, response to the request Entry No. 13036 dated 11.07.2022

1999	837.8	14.2	7.472
2000	1175.0	3.8	1.999
2001	2029.2	300.6	158.182
2002	2128.5	51.2	26.942
2003	2581.1	1.0	0.52
2004	3662.0	657.4	345.937
2005	4181.0	675.0	355.199
2006	4880.2	903.8	475.598
2007	5723.2	1134.3	596.891
2008	5837.3	1870.3	984.189
2009	5694.1	1772.4	932.672
2010	6682.6	1948.3	1025.234
2011	7645.4	2026.4	1066.332
2012	10823.1	4411.3	2321.314
2013	12832.8	5759.1	3030.554
2014	14292.9	6153.2	3237.937
2015	15298.1	6569.1	3456.792
2016	15901.5	6697.9	3524.569
2017	16654.2	7254.1	3819.0
2018	17257.5	7393.8	3892.542
2019	17489.2	7221.6	3801.885
2020	19416.6	8453.0	4450.168
2021	19609.4	7295.7	3840.896

Table 4.2 shows that greenhouse gas emissions in 2021 from this category amounted to 3840.896 thousand tons of $CO_{2.}$ eq. . Since the acquisition of independence by the Republic of Kazakhstan, there has been an increase in the overall volume of industrial production, including clinker production, which increased by 3.8 times compared to 1990, which is shown by greenhouse gas emissions from this category. According to the initial data on activities in the cement industry, provided by the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, greenhouse gas emissions in 2021 in this category showed a decrease in greenhouse gas emissions, which amounted to 13.7% compared to greenhouse gas emissions in 2020 .

4.2.1.2 Methodological approaches

$_2$ emissions occur during the production of clinker, which is an intermediate component in the cement production process. In the production of clinker, limestone, which consists mainly of calcium carbonate ($CaCO_3$), is heated (calcined), producing lime CaO and CO_2 as a by-product. The CaO then reacts with the silicon, aluminum and iron oxides contained in the feed to form the basic clinker minerals, but these reactions do not release additional CO_2. Metallurgical slag (blast-furnace slag) and gypsum are used as an additive in cement grinding, which takes place after clinker firing and does not affect $CO_{2\ emissions}$.

Emissions from the cement production category were estimated using the Tier 2 method (IPCC SPM, 2006) using data on the production of clinker, an intermediate product of cement production that produces $CO\ 2_{\ emissions}$. Estimated estimate of $CO_{2\ emissions}$ was carried out according to formula 2.2 (IPCC, 2006). The emission factor was calculated taking into account the content of CaO in the clinker in accordance with the methodology of the IPCC, 2006. The national value of the content of CaO in the clinker by mass was 65.72% and a correction factor of 1.02 was used.

Improvements

As it is known in previous National Reports, based on the results of the review-2017, work was carried out to determine the national significance of CaO content in clinker produced in Kazakhstan. The content of CaO in the clinker was determined on the basis of data on the content of CaO in the clinker obtained from 9 out of 12 operating cement plants. The average value of the CaO content in the clinker was calculated as a weighted average, taking into account the volume of clinker production at the plants and amounted to 65.72%.

In 2022, following the results of a training field seminar, which was held from September 13-16, 2022 at the IGKE named after. Yu.A.Izrael on the greenhouse gas regulation system within the framework of the UNFCCC, organized by the UN Development Program in Kazakhstan, this parameter was updated taking into account the changes that have taken place in the cement industry of the Republic of Kazakhstan over the past 5 years, from 2017-2021.

In 1990–2009, new production lines and plants using modern high-tech lines were not built in Kazakhstan. New small capacities were introduced at separate enterprises of the wet method of cement production that existed at that time. From 2010 - 2017 Against the backdrop of growing economic activity in the country, 6 new highly efficient dry process production lines with a capacity of 1.0 - 1.5 million tons of cement per year were put into operation.

These significant changes in the industry and its raw material base caused a revision of the value of the national content of CaO in clinker produced in Kazakhstan. The content of CaO in the clinker was determined on the basis of data on the average content of CaO in the clinker obtained from 9 out of 12 operating full-cycle cement plants. The average value of the CaO content in clinker was calculated as a weighted average, taking into account the volume of cement production at the plants, and in 2021 amounted to. 65.75%, which is 0.04% higher than the value obtained for 2017.

According to the comments of the ERT on the results of the review of the National Report 2021 (I .50,2019) (I .6,2017) (I .13,2016) I would like to clarify that more detailed information on clinker production, CaO and CP values by individual cement companies (similar to the one that was presented for 2014 in the 2016 NIR) the Kazakh side cannot provide, since the data on activities received from cement companies, according to the request, [61]were received with the “Confidential” mark.

4.2.1.3 Estimating uncertainty and consistency of time series

Since activity data are provided by the Bureau of National Statistics of the Republic of Kazakhstan and directly by cement production enterprises, they can be regarded as fairly reliable. The main uncertainty factors in cement production are:

• the accuracy of the results of the chemical analysis of the clinker composition, which affects the uncertainty of the emission factor;

• accuracy of determination of clinker production volumes;

• dispersion of results of chemical analysis of clinker composition during the year (CaO and MgO content in clinker).

Each of the first two factors, according to the IPCC Guidelines, 2006, introduces an uncertainty at the level of ±1…2%. The general uncertainty of the CO_2 emission factor in the production of clinker is 1...2%. The uncertainty of the cement dust correction factor can be

[61]Letter of request No. 13-1-13 / 2380-I dated July 26, 2022

neglected (because it differs from unity by a small variable). Assuming the uncertainty of data on clinker production volumes in accordance with the IPCC Guidelines, 2006, at the level of 2%, the total uncertainty in the estimation of $CO_{2\ emissions}$ from cement production in the Republic of Kazakhstan can be estimated at the level of 2.2%.

4.2.1.4 QA/QC procedures

For category 2.A Mineral production, quality control procedures were applied: information on the choice of activity data and emission factors was documented; for subcategory 2.A.1 "Cement production", the correctness of the used formulas and units of measurement was checked for the entire time series; the homogeneity of the input data and the methods used was checked for the entire time series. When calculating greenhouse gas emissions, the value of CaO content in clinker by mass, updated and recalculated over the past five years, was used, equal to 65.75%, which was obtained and calculated from data directly received from cement manufacturing plants, as well as a correction factor equal to 1, 02.

The general QA/QC procedures applicable to the entire National Report 2021 are described in Section 1.2.3.

4.2.1.5 Recalculations and improvements

Despite the fact that the average value of CaO content in clinker was in 2021. 65.75% (previously it was 65.72%) in this category, no recalculations were carried out, because the difference in CaO content values turned out to be only 0.04% higher than the value obtained for 2017. Based on the recommendation of the SER experts, in section 4.2.1.2 “Methodological Approaches” of this NDT, the description of the methodological approach for obtaining the national value of the CaO content in clinker and cement dust has been expanded.

4.2.1.6 Planned improvements

$_2$ emissions to a higher level of calculation. In accordance with the Order of the Minister of Ecology and Natural Resources of the Republic of Kazakhstan dated January 17, 2023 No. 9 [62]and in accordance with paragraph 3 of Article 294 of the Environmental Code of the Republic of Kazakhstan [63], as well as with subparagraph 2) of paragraph 3 of Article 16 of the Law of the Republic of Kazakhstan "On State Statistics" were new Methodologies for calculating greenhouse gas emissions for industrial enterprises were approved with the transition to levels 2 and 3. On this basis, it is supposed to improve the National report on the inventory of greenhouse gas emissions of our country.

4.2.2 Lime production (2.A.2 CRF)

4.2.2.1 Category description

Emissions of CO_2 during lime production result from the calcination of calcium and magnesium carbonates at high temperatures. This category in the national inventory of greenhouse gases of the Republic of Kazakhstan is not a key one. According to the business registers of official statistics, large producers of quicklime are registered in the Republic of Kazakhstan: TEMK JSC, SAS-TobeTechnologies LLP, Maykainsky Lime Plant LLP, NEOCHIM LLP, and KAZKHIMTEHSNAB LLP and LLP operate in the segment of hydrated lime. SH Work. Lime production includes chemical, metallurgical plants (ferroalloys, iron and steel), plants for the production of mineral materials, as well as one plant for the production of sugar.

[62]https://adilet.zan.kz/rus/docs/V2300031735/history
[63]https://kodeksy-kz.com/ka/ekologicheskij_kodeks/294.htm

The market of Kazakhstan is represented mainly by two types of air lime: quicklime and quickly hydrated (slaked lime). Data on the volume of lime production were taken from the Annual Compendium of Statistical Reports of the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan based on the results of the industry for 2021. "Manufacture of industrial products in physical terms".[64]

In accordance with the Instructions for filling out the statistical form of national statistical monitoring "Report of the enterprise on the production and shipment of products (goods, services)" [65](code 151101128, index 1-P, monthly frequency) Appendix 6 to the Order of the Chairman of the Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan dated December 13, 2018 No. 5. Paragraph (4) reads: "... *industrial production in physical terms is the gross output of certain types of products in physical terms, including products spent on the needs of industrial production at this enterprise and produced from dealing raw materials* ". According to the data provided by the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, it is worth noting that the source data on lime production activities include all aggregated data (including non-market lime, i.e. lime used by enterprises for their own consumption) of the country, are complete and reflect all available information on lime production in Kazakhstan.

Default emission factors have been used from the 2006 IPCC SPM for the entire time series. Emissions from the Lime Production category in 2021 amounted to 715.62 thousand CO_2, which is 51.9% less than emissions in 1990. At the same time, compared to greenhouse gas emissions in 2020, there is an increase in emissions, which amounted to 12.4% . This increase in emissions is driven by an increase in lime production in 2021.

Table 4.3 shows lime production data and CO2 emission trends for the period 1990 - 2021.

Table 4.3 - Dynamics of greenhouse gas emissions from lime production in the Republic of Kazakhstan (thousand tons)

Category	years							
	1990	1995	2000	2005	2010	2011	2012	2013
2A2 Lime production	1943.0	721.0	622.9	993.5	886.6	959.8	908.2	869.2
$_2$ emissions from lime production	1489.3	552.6	477.4	761.5	679.5	735.6	696.1	666.2

Table 4.3 continued

Category	years							
	2014	2015	2016	2017	2018	2019	2020	2021
2A2 Lime production	923.3	870.6	927.9	1048.2	886 , 63	874.5	830.9	933.62
$_2$ emissions from lime production	707.7	667.3	711.2	803.5	679.1	670.3	636.8	715.62

[64]https://www.stat.gov.kz/
[65]https://online.zakon.kz/Document/?doc_id=34734851

4.2.2.2 Methodological approaches

As the initial data on lime production in Kazakhstan, data from the Bureau of National Statistics ASPIR of the Republic of Kazakhstan were used. The data in the statistical collections present the total figure for the production of slaked lime, quicklime and hydraulic lime in thousands of tons. There are no detailed data on the production of fat and dolomitic lime in the national statistics of the Republic of Kazakhstan. Greenhouse gas emissions from lime production are calculated according to the IPCC methodology: the total production figure is divided into fat and dolomitic lime in the ratio 85/15. $CO_{2\ emissions}$ from lime production in the Republic of Kazakhstan were estimated using the IPCC Tier 1 methodology (IPCC, 2006). For fatty lime, a default $CO_{2\ emission\ factor\ (IPCC,\ 2006)\ of\ 0.75\ t\ CO_2}$ /t lime produced was used. For dolomitic lime, a $CO_{2\ emission\ factor}$ of 0.86 tCO_2 /t lime produced was used (IPCC, 2006).

4.2.2.3 Estimating uncertainty and consistency of time series

Since activity data are provided by the Bureau of National Statistics of the ASPR of the RK, they can be regarded as fairly reliable. Analysis of all available information, given that this is statistical reporting, allows us to estimate the uncertainty of the initial data on activities within 5 ... 10%.

4.2.2.4 QA/QC procedures

Tier 1 quality control procedures were applied to Category 2.A Mineral Materials Production: information on the choice of activity data and emission factors is documented; for the category "Production of lime" the correctness of the used formulas and units of measurement was checked for the entire time series; the homogeneity of the input data and the methods used was checked for the entire time series.

The general QA/QC procedures applicable to the entire National Report 2021 are described in Section 1.2.3.

4.2.2.5 Recalculations and improvements

In accordance with the recommendations of the GER experts, we are attaching a message to the section of the National Report, which means the following: "Information note on the revision of published official statistical information for statistical purposes":

“In accordance with paragraph 18-1) of Article 12 of the Law of the Republic of Kazakhstan “On State Statistics” dated March 19, 2010 No. 257-IV and the Rules for Revising Published Official Statistical Information for Statistical Purposes in the event of a change in statistical methodology and based on updated, documented information, approved by the Order of the Committee of Statistics of the Republic of Kazakhstan dated December 28, 2018 No. 20, official statistical information [66]can be revised based on changes in indicators of industrial activity in connection with the respondent’s making adjustments to primary statistical data in the form 01-IP (prom) “Report on the production of industrial products (goods , services) by an individual entrepreneur” for the corresponding reporting year.

For questions from ERT experts (I.14 2.A.2 Lime production - CO2 (I.14, 2019) (I.31, 2017) in this NIR, section 4.2.2.1 provides a list of industries in the country that produce lime and which are included in the aggregate data on lime production in the Republic of Kazakhstan.

[66]https://adilet.zan.kz/rus/docs/V1800018136

In this regard, the activity data for 2018 was corrected and amounted to 886.63 thousand tons (previously it was 885.99 thousand tons), the changes amounted to 0.07% and are shown in Table 4.4 below.

Table 4.4 - Comparative data on activities based on the results of inventories for 2018-2021 in the category "Lime production"

years	Lime production, thousand tons		Difference, %
	NDK 20 20g.	NDK 2021	
1990	1943.0	1943.0	-
2018	885.9	886.63	0.07%
2019	874.5	874.5	-
2020	830.9	830.9	-
2021	-	933.62	-

4.2.2.6 Planned improvements

$_2$ emissions to a higher level of calculation. In accordance with the Order of the Minister of Ecology and Natural Resources of the Republic of Kazakhstan dated January 17, 2023 No. 9 [67]and in accordance with paragraph 3 of Article 294 of the Environmental Code of the Republic of Kazakhstan, as well as with subparagraph 2) of paragraph 3 of Article 16 of the Law of the Republic of Kazakhstan "On State Statistics" were new Methodologies for calculating greenhouse gas emissions for industrial enterprises with the transition to levels 2 and 3 were approved.On this basis, it is expected to improve the National report on the inventory of greenhouse gas emissions in our country.

4.2.3 Glass production (CRF 2A.3)

4.2.3.1 Category description

Currently, there is not a single operating plant for the production of flat glass in Kazakhstan, all products are supplied from Russia or Kyrgyzstan. Over the past seven years, the construction of a sheet glass plant in Kazakhstan was planned to be launched in Aktobe, Kyzylorda and Pavlodar.

In the spring of 2015, the construction of the first OrdaGlass glass factory began in Kazakhstan with a production capacity of 197.1 thousand tons / year (or 600 tons per day) of sheet glass, which was planned to be put into operation in 2017 on the territory of the Kyzylorda region . [68]However, the work was suspended. In 2021, as in previous years, the work was not completed due to a number of circumstances.

According to studies by Maxrise Consulting, one of the leading consulting companies in Ukraine in the field of marketing research, the global market for tempered sheet glass will exceed $40 billion by 2024. The main driver of this growth will be the increase in the construction of commercial and residential real estate.

4.2.3.2 Methodological approaches

This category is not a key category in the inventory of greenhouse gases of the Republic of Kazakhstan. The initial data on the production of glass containers in Kazakhstan are based on the

[67]https://adilet.zan.kz/rus/docs/V2300031735/history

[68]Serdyuk, Elena (2015). The construction of a glass factory in Kyzylorda has started. *Okna - tm platform* , May 26. Available at https://okna-tm.kz/news/20150526/startovalo-stroitelstvo-stekolnogo

data of the Bureau of National Statistics of the ASPIR RK. In our country, there is a plant for the production of glass containers "Glass Company SAF", which was founded in April 1998, therefore, data on the production of glass containers in the country provided by the Bureau of National Statistics of ASPIR RK in their statistical collections are presented for the period 1998-2021. National statistics do not provide a detailed distribution of types of glass containers (bottles and jars), but only the volume of manufactured products in thousands of pieces, table 4.5.

Table 4.5 - Dynamics of greenhouse gas emissions from the production of glass containers in the Republic of Kazakhstan from 1990 to 2021 (thousand tons).

years	Production, thousand pieces	Weight, thousand tons	CO2 emissions, thousand tons
1990	0	0	0
1995	0	0	0
1998	10415.5	5.333	0.533
1999	8339.4	4.269	0.427
2000	26263.8	13.447	1.345
2001	129016.9	66.057	6.606
2002	162034.8	82.962	8.296
2003	201817.3	103.331	10.333
2004	197349.9	101.043	10.104
2005	221772.9	113.548	11.355
2006	246196.0	126.052	12.605
2007	238158.0	121.937	12.194
2008	186826.0	95.655	9.565
2009	137591.6	70.447	7.045
2010	148270.5	75.915	7.591
2011	218338.5	111.789	11.179
2012	220153.8	112.719	11.272
2013	200846.0	102.833	10.283
2014	187842.0	96.175	9.618
2015	151358.0	77.495	7.749
2016	209860.0	137.434	13.743
2017	395613.0	202.554	20.255
2018	418827.8	214.439	21.444
2019	382594.1	195.888	19.588
2020	228507.0	116.996	11.699
2021	403134.2	206.405	20.641

$CO_{2\ emissions}$ from glass production in Kazakhstan were estimated using the IPCC Tier 1 methodology (IPCC, 2006) using a default emission factor of 0.1 t CO_2/t glass.

According to the calculation data, GHG emissions from the “Glass production” category in 2021 amounted to 20.641 thousand tons of CO_2 eq., which is 76.4% more than emissions in 2020. Such a significant increase in $CO_{2\ emissions}$ is caused by an increase in the production of glass containers in 2021 compared to 2020.

4.2.3.3 Uncertainties and sequence of time series

Emissions from glass production are estimated from quantities of glass using the Tier 1 default emission factor. Therefore, the emission factor uncertainty in this case is very high and is estimated at ±60%.

4.2.3.4 QA/QC procedures

The general QA/QC procedures in accordance with Section 1.2.3 were applied to the calculation of GHG emissions from glass production. NDK 2021.

To calculate greenhouse gas emissions, data on the production of glass containers in Kazakhstan from the data of the Bureau of National Statistics of ASPIR RK were used.

4.2.3.5 Recalculations and improvements

There were no recalculations in this category. On the recommendation of the ERT experts, improvements were made, in particular, in Section 4.2.3.1 "Category Description" of this NIR, a message is included that there is no production of glass fiber and glass wool in the Republic of Kazakhstan.

4.2.3.6 Planned improvements

In this category, improvements are planned, which will be associated with the commissioning of a plant for the production of sheet glass in the country.

4.2.4 Other processes using carbonates (2.A4 CRF)

4.2.4.1 Ceramic production (2. A.4a CRF)

4.2.4.1.1 Category description

Emissions from the ceramic manufacturing process result from the calcination of clay carbonates as well as additives. Just as in the cement and lime production process, carbonates are heated to high temperatures in a kiln, which produces oxides and CO_2. Most ceramic products are made from one or more types of clay (eg schist, refractory clay and ball clay). Raw materials are combined and finely ground in successive grinding operations. The crushed particles are burned in a furnace and a powder is obtained. Additives are then added, the ceramic product is formed or cast, machined to smooth sharp edges and obtain the desired properties of the ceramic.

In 2010-2014, it was difficult for Kazakh manufacturers of ceramic plates and household products to withstand tough competition with foreign manufacturers such as China, Russia, as well as the countries of the Customs Union.

Many businesses went bankrupt and stopped. However, thanks to the direct support of the Investment Fund of Kazakhstan JSC, which is part of the Baiterek NMH JSC group of companies, the DAMU Fund Support Program, since 2015, a number of production facilities for the manufacture of ceramic tiles and porcelain tiles have been launched, which made it possible to increase the pace of production for the production of ceramic plates in the Republic of Kazakhstan.

CO_2 emissions from the production of ceramic bricks, facade ceramic tiles and ceramic household products. This category is not a key category, GHG emissions were estimated using the Tier 1 methodology using the IPCC default emission factor (IPCC, 2006). The carbonate content of the clay was assumed to be 10%, the amount of clay used to produce ceramics was calculated by multiplying the product weight by a default loss factor of 1.1 (IPCC, 2006).

4.2.4.1.2 Methodological issues

The calculations used the data of the Bureau of National Statistics ASPIR RK on the volume of production of ceramic bricks, facing tiles, ceramic household products. The calculation was carried out in the following sequence:

1) the number of bricks produced (thousand m^3) was multiplied by the density of bricks (t/m^3);

2) the emission factor EFs was multiplied by the mass of carbonates in the clay that was used to make the ceramics.

The mass of carbonates was calculated in accordance with the 2006 IPCC SPM according to the following scheme:

Mass of ceramic products * 1.1 (correction factor for clay) * 0.1 (proportion of carbonates in clay).

Table ***Table 4.6 shows the calculation data for*** CO_2 emissions from the category "Production of ceramics" for the entire time series 1990-2021. In 2021, there is a decrease in the production of ceramic products in the country, therefore, according to the calculations, greenhouse gas emissions in 2021 amounted to 63.76 thousand tons of CO_2 eq., which is 2.3% less than emissions in 2020, and according to In relation to 1990, GHG emissions have grown almost 12 times. Such results are associated with the overall increase in the volume of industrial production of ceramics in Kazakhstan, caused by an increase in demand for these products over the entire time series.

Table 4.6 - Dynamics of greenhouse gas emissions from the production of ceramics in the Republic of Kazakhstan for 1990-2021

years	Production of ceramics, thousand tons	$_2$ emissions , thousand tons
1990	47.667	5.24
1991	26.574	2.92
1992	26.429	2.91
1993	33.314	3.66
1994	12.124	1.33
1995	10.632	1.17
1996	7.044	0.77
1997	7.571	0.83
1998	7.588	0.83
1999	372.155	40.94
2000	453.696	49.91
2001	341.149	37.52
2002	650.258	71.52
2003	657.452	72.32
2004	806.240	88.68
2005	1167.374	128.41
2006	1233.777	135.71
2007	1699.392	186.93
2008	1190.303	130.93
2009	1148.569	126.34
2010	1106.302	121.69
2011	1449.537	159.44
2012	1544.576	169.90

years	Production of ceramics, thousand tons	$_2$ emissions , thousand tons
2013	343.402	37.77
2014	554.824	61.03
2015	485.499	53.41
2016	473.366	52.07
2017	513.844	56.52
2018	587.201	64.59
2019	649.969	71.49
2020	593.467	65.28
2021	579.621	63.76

4.2.4.1.3 Uncertainties and sequence of time series

The uncertainty of ceramic production data is estimated at 10%. The uncertainty of the default $CO_{2\ emission\ factor}$ is estimated at 5%.

4.2.4.1.4 QA/QC procedures

The general QA/QC procedures in accordance with Section 1.2.3 have been applied to the calculation of GHG emissions from ceramic production. NDK 2021.

The calculations used the data of the Bureau of National Statistics ASPIR RK on the volume of production of ceramic bricks, facing tiles, ceramic household products. Standard procedures were used to estimate QA/QC, including control of activity data and comparison of emission estimates from different years.

4.2.4.1.5 Recalculations and improvements

In this category, in connection with the adjustment of the Bureau of National Statistics of ASPIR RK activity data for 2018 and 2019, recalculations were performed. The changes amounted to a decrease of 0.4% in 2018; and for 2019 an increase of 0.7%.

The correction of the data of the Bureau of National Statistics of the ASPIR RK was carried out in accordance with the "Information note on the revision of published official statistical information for statistical purposes" : Rules [69]for the revision of published official statistical information for statistical purposes in the event of a change in statistical methodology and on the basis of updated, documented information, approved by the Order of the Statistics Committee of the Ministry of National Economy of the Republic of Kazakhstan dated December 28, 2018 No. 20, official statistical information may be revised based on changes in indicators of industrial activity in due to the respondent making adjustments to the primary statistical data in the form 01-IP (prom).

4.2.4.1.6 Planned improvements

No improvements are planned for this category.

4.2.4.2 Other uses of soda ash (Subcategory 2. A4b CRF)

Soda ash (sodium carbonate Na_2CO_3) is widely used as a raw material in many industries: glass production, chemical industry, detergent production, pulp and paper production, metal and oil refining and other processes. The raw material for the production of soda ash is carbonate deposits of salt beds and throne. Carbon dioxide (CO_2) is released when soda ash is used. These

[69]https://adilet.zan.kz/rus/docs/Z100000257

emissions are accounted for as a source in the industry where it is used. Carbon dioxide CO_2 is also released during the production of soda ash. The amount of CO_2 depends on the type of industrial process. CO_2 emissions from the production of soda ash vary considerably depending on the production process.

4.2.4.2.1. Category Description

The production and consumption of soda ash (sodium carbonate Na_2CO_3) results in $CO_{2\ emissions}$. Kazakhstan does not have its own production of soda ash, this inventory takes into account $CO_{2\ emissions}$ from the use of soda ash. Emissions from the production of soda ash are accounted for in the Chemical Industry, while emissions from its use are accounted for in the end-use sectors.

The largest consumers of soda ash are glass, chemical, metallurgical and other industries. Today, the need of the Republic of Kazakhstan for soda ash is fully covered by imports from the Russian Federation due to the lack of its own production in the country.

Unfortunately, national statistics and the Customs Committee of the Ministry of National Economy of the Republic of Kazakhstan do not provide data on the volume of soda ash imported into the country, as well as on the amount of its use by sectors of the economy. Therefore, in this inventory, emissions from the use of soda ash in the process of alumina production were calculated according to the data provided by Aluminum of Kazakhstan JSC.

In accordance with the 2006 IPCC Guidelines (Section 2.5.1, Volume 3, page 2.37), emissions for this category are accounted for under CRF 2A.4 b Other Uses of Soda Ash.

Greenhouse gas emissions from the use of soda ash in 2021 amounted to 64.4 thousand tons of CO_2 eq., which in relation to 2020 shows an increase in $CO_{2\ emissions}$ by 5.05%. CO_2 emissions in 2021 were 32.24% higher than in 1990. The time series of greenhouse gas emissions in this category shows a consistent increase in emissions over the entire time period 1990-2021, which is caused by an increase in the use of soda ash in the production of alumina.

Emissions from the use of soda ash were estimated according to the IPCC Tier 1 methodology (IPCC, 2006). A default emission factor of 0.415t CO_2/t soda ash used was applied. Dynamics of greenhouse gas emissions from the use of soda ash from 1990 to 2021 presented in table 4.7.

Table 4.7 - Dynamics of greenhouse gas emissions from the use of soda ash, thousand tons

Index	years								
	1990	1995	2000	2005	2010	2011	2012	2013	2014
2.A.4.b Use of soda ash	117.4	100.9	137.4	148.9	180.1	218.0	222.6	196.1	143.6
Emissions of CO_2 from the use of soda ash, thousand tons of CO2eq.	48.7	41.8	57.0	61.8	74.7	90.4	92.4	81.3	59.5

Continuation of table 4.7

Index	years						
	2015	2016	2017	2018	2019	2020	2021
2.A.4.b Use of soda ash	156.2	163.3	160.4	162.3	153.4	147.7	155.2

Emissions of CO_2 from the use of soda ash, thousand tons of CO2eq.	64.8	67.7	66.5	67.4	63.6	61.3	64.4

4.2.4.2.2 Methodological issues

As noted in the category description section, the Republic of Kazakhstan does not have its own production of soda ash. All the soda used comes from outside the country. This category is not a key category, GHG emissions calculations were performed only from the use of soda using Tier 1, without taking into account technologies and industrial processes using soda.

Estimation of $CO_{2\ emissions}$ from soda use was carried out in accordance with the 2006 IPCC Guidelines for National GHG Inventories using the Tier 1 method using a default $CO_{2\ emission\ factor}$ of 0.415 tCO_2 /t soda ash used. Data on the volume of use of soda ash was provided by the enterprise JSC "Aluminium of Kazakhstan" of the Republic of Kazakhstan.

4.2.4.2.3 Uncertainties and sequence of time series

The uncertainty of soda consumption data is estimated at 10%. The uncertainty of the default $CO_{2\ emission\ factor}$ is estimated at 5%.

4.2.4.2.4 QA/QC procedures

The general QA/QC procedures in accordance with Res. 1.2.3 were applied to the GHG emissions calculations for soda consumption. NDK 2021, including a comparison of data from the enterprise JSC "Aluminium of Kazakhstan" of the Republic of Kazakhstan.

4.2.4.2.5 Recalculations and improvements

General QA/QC procedures were applied to the calculation of greenhouse gas emissions from the use of soda ash. The initial data were taken from the enterprise JSC "Aluminium of Kazakhstan" of the Republic of Kazakhstan, data on the use of soda ash in the production of alumina.

4.2.4.2.6 Planned improvements

In this category, improvements are planned in carrying out calculations of greenhouse gas emissions as more complete information is received on the initial data on the volumes of soda ash use by sectors of the economy in Kazakhstan.

4.2.4.3 Use of limestone and dolomite (Subcategory 2. A.4d CRF)

4.2.4.3.1 Category description

Limestone ($CaCO_3$), dolomite ($CaCO_3$ *$MgCO_3$) and other carbonates are the main materials with commercial applications in various industries. In accordance with the 2006 IPCC RP, the description of emissions from carbonate consumption should be carried out in the source category where these carbonates were consumed and the greenhouse gas $CO_{2\ was\ released}$. The Bureau of National Statistics of the ASPIR RK does not have information on the data on the balance of the use of limestone and dolomite in the sectors of the economy of Kazakhstan for 1990-2021. The BNS ASPIR RK provided data for the specified period only on the volume of products sold in the domestic market without disaggregation by type of activity (for example, construction, food industry, agriculture, etc.).

Previously, in previous inventories of greenhouse gases, the calculation of emissions in this category was carried out according to the data provided by the BNS ASPIR of the Republic of Kazakhstan on the basis of how much was produced, how much was sold, i.e. used in Kazakhstan. But since 2020, we have made changes to the methodology for calculating greenhouse gas emissions from this category of limestone and dolomite use. A more detailed description of the methodology for calculating greenhouse gas emissions from this category is given below.

4.2.4.3.2 Methodological issues

The default method was used to calculate GHG emissions. Emission factors for limestone and dolomite calcination were taken from the 2006 IPCC Guidelines, Table 2.1, page 2.7 Section 2.1 Chapter 2 Volume 3 respectively;

- 0.44t CO_2 /t - for the use of limestone;
- 0.477 t CO_2 /t - for the use of dolomite.

As noted in the previous section 4.2.4.3.1, this NIR has changed the approach to applying input data for calculating greenhouse gas emissions from the Limestone and Dolomite Use category.

To calculate the inventory of greenhouse gas emissions for 1990-2021, a request was made to obtain data on activities for the period 1990-2021 [70]from the Bureau of National Statistics of the ASPIR RK and provide additional information on the data on the balance of use of limestone and dolomite in the sectors of the economy of Kazakhstan since 1990 2021. However, the Bureau of National Statistics does not appear to have this information. At the same time, the BNS ASPIR RK provided data for the specified period only on the volume of products sold in the domestic market without disaggregation by type of activity (for example, construction, food industry, agriculture, etc.).

Previously, in previous inventories of greenhouse gases, the calculation of emissions in this category was carried out according to the activity data provided by the Bureau of National Statistics of the ASPIR of the Republic of Kazakhstan on the basis of how much was produced, how much was sold, i.e. used in Kazakhstan. So, to start calculating greenhouse gas emissions for this category, data were requested on the volume of limestone use from metallurgical plants, from clinker plants, as well as data on the use of limestone for the production of calcium carbide. In accordance with the sections of the NIR of the "Agriculture" sector, it became known that liming of soils in Kazakhstan is not carried out, therefore, the use of limestone in agriculture was excluded. The same procedure was carried out on the use of dolomite.

Improvements:

In order to avoid double counting of emissions in this category, as well as following the results of the training field seminar, which was held from September 13-16, 2022 at the IGKE named after. Yu.A.Izrael on the greenhouse gas regulation system within the framework of the UNFCCC, organized by the UN Development Program in Kazakhstan, we once again revised the consistency and correctness of the approach to the methodology for calculating greenhouse gas emissions from this category. A more thorough analysis of all the information received on the original activity data revealed some gaps in accounting for the use of limestone in the cement industry. Based on the above, the emission values for the entire time series from 1990-2021 were recalculated. According to the request from metallurgical enterprises, information was received on the volume of dolomite use. In the cement industry, dolomite is used as a clinker grinding sludge in the cement production process, i.e. emissions from use in this industry are also excluded. Thus, having collected all the information on the volumes of use of limestone and dolomite, the difference between the amount of use of limestone and dolomite (metallurgy, including the production of calcium carbide, plus the production of clinker) and the total amount of limestone and dolomite sold in the country separately was derived. Calculation data to identify the volumes of use of limestone and dolomite by industry in Kazakhstan are presented in Table 4.8 below.

[70]Letter of request No. 13-1-13 / 2380-I dated 07/26/2022

Table 4.8 - Data on the volume of use of limestone and dolomite by industry of the Republic of Kazakhstan (thousand tons)

Name	years								
	1990	1995	2000	2005	2010	2011	2012	2013	2014
Domestic marketed, limestone (I)	2682.0	1925.7	3480.3	8966.6	9097.9	10533.0	10088.5	15084.4	14324.8
Amount used in metallurgy and clinker production (II)	1905.96	712.3	1138.15	2188.39	4380.95	5665.09	7026.9	7344.42	8485.13
Difference between use in industry and sales in the country (I-II), limestone	776.11	1213.4	2342.1	6778.2	4716.9	4867.91	3061.59	7739.98	5839.6
Implemented in the domestic market, dolomite (III)	693.0	278.7	308.8	1016.6	723.4	774.8	885.7	1082	1193.7
Amount of use in metallurgy and manufacturing clinker (IV)	693.0	278.7	457.3	331.5	316.3	481.2	569.1	484.1	603.8
The difference between using in industry and sales in the country (III - IV), dolomite	0	0	148.5	685.1	407.1	293.5	316.5	597.8	589.8

Continuation of table 4.8

Name	years						
	2015	2016	2017	2018	2019	2020	2021
Domestic marketed, limestone (I)	15182.3	15086.0	15970.7	15931.9	15667.5	16678	17165.8
Amount used in metallurgy and clinker production (II)	6651.4	10086.3	10956.8	11590.4	10789.9	11549.8	9791.3
The difference between using in industry and sales in the country (I-II), limestone	8530.8	4999.7	5013.89	4341.47	4877.5	5128.1	7374.4
Implemented in the domestic market, dolomite (III)	1690.1	1642.8	1669.4	1755.4	1891.9	1895.1	1927.4
The amount of use in metallurgy and production of clinker (IV)	483.4	442.1	514.4	457.8	536.4	560.1	509.2
Difference m / y isp. in industry and sales in the country (III - IV), dolomite	1206.6	1200.7	1154.9	1297.53	1355.4	1334.9	1418.2

The resulting difference in the equations for the volume of use of limestone and dolomite separately was the initial figure for calculating GHG emissions from the category of use of limestone and dolomite, Table 4.9.

Table 4.9 - Dynamics of greenhouse gas emissions from the use of limestone and dolomite (thousand tons)

Index	years									
	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
2A 4.d Use. limestone	776.1	1213.3	2342.1	5461.4	4716.9	4867.9	3061.6	7739.98	5839.6	8530.8
Emissions of CO_2 from isp. limestone	341.5	533.8	1030.5	2403.0	2075.4	2141.9	1347.1	3405.5	2569.4	3753.5
2A 4.d Use. dolomite	0	0	148.5	331.4	316.3	293.5	316.5	597.8	589.8	1206.6
Emissions of CO_2 from isp. dolomite	0	0	70.8	158.1	150.8	140.0	151.0	285.1	281.3	575.5
Total CO_2 Emissions from Spain limestone and dolomite	**341.5**	**533.8**	**1101.4**	**3140.5**	**2226.3**	**2281.9**	**1498.1**	**3690.7**	**2850.7**	**4329.1**

Continuation of table 4.9

Index	years					
	2016	2017	2018	2019	2020	2021
2 A 4.d Use. limestone	4999.7	5013.8	4341.4	4877.5	5128.1	7374.4
Emissions of CO_2 from isp. limestone	2199.8	2206.1	1910.2	2146.1	2256.3	3244.7
2A 4.d Use. dolomite	1200.7	1154.9	1297.5	1355.4	1334.9	1418.1
Emissions of CO_2 from isp. dolomite	572.7	550.9	618.9	646.5	636.8	676.4
Total CO_2 Emissions from Spain limestone and dolomite	**2772.6**	**2757.0**	**2529.1**	**2792.6**	**2893.1**	**3921.2**

Based on the results of the calculations, the following indicators were obtained: total greenhouse gas emissions from the use of limestone and dolomite in 2021 amounted to 3921.2

thousand tons of CO_2 eq., of which from the use of limestone 3244.7 thousand tons of CO_2 eq., and from the use of dolomite 676.4 thousand tons of CO_2 eq. respectively.

Thus, according to the results of the inventory of greenhouse gas emissions in 2021, there is a significant increase compared to 2020, which amounted to 35.5%. In relation to 1990, total GHG emissions from this category in 2021 exceeded 1990 GHG emissions by more than ten times. Such an increase in greenhouse gas emissions compared to 1990 is caused by an increase in the industrial production of limestone and dolomite in the country throughout the entire 1990-2021 time series. Table 4.9 presents CO2 emissions from the limestone and dolomite use category for the entire time series 1990-2021. (category 2. A4d. CRF).

4.2.4.3.3 Uncertainties and sequence of time series

The main factors affecting the uncertainty in the calculation of $CO_{2\ emissions}$ when using limestone and dolomite are:

- accuracy of estimation of volumes of production and use of limestone and dolomite;
- lack of studies to determine the purity of the limestone fraction in $CaCO_3$ per ton of total raw materials and the purity of the dolomite fraction in $CaCO_3$ *$MgCO_3$ per ton of total raw materials.

The uncertainty of activity data when using limestone and dolomite is taken at the level of 10% according to the data provided by the enterprises of the metallurgical complex, and the uncertainty of the $CO_{2\ emission\ factor}$ is taken at the level of 5%. Thus, the overall estimate of the uncertainty of $CO_{2\ emissions}$ when using limestone and dolomite was 12.1%.

4.2.4.3.4 QA/QC procedures

General QA/QC procedures were applied to the calculation of greenhouse gas emissions from the use of limestone and dolomite in accordance with Res. 1.2 .3 of the NIR 2021.

Among the detailed quality control procedures were performed: analysis of the time series of data on activities and $CO_{2\ emissions}$ (assessment of annual changes and determination of the causes of these changes); assessment of the applicability of the IPCC default coefficients for national conditions, comparison of data on the extraction and use of dolomite and limestone obtained from the Bureau of National Statistics of the ASPIR of the Republic of Kazakhstan and enterprises of the metallurgical complex of the Republic of Kazakhstan.

4.2.4.3.5 Recalculations and improvements

In connection with the revision of the sequence and correctness of the approach to the methodology for calculating greenhouse gas emissions for this category, as well as carefully analyzing all the information received on the initial activity data, in order to eliminate gaps in accounting for the use of limestone in the cement industry, the emission values for the entire time series were recalculated . The recalculations led to significant changes in the values of emissions from the use of limestone: in 1990 a decrease of 74.1%, in 2020 a decrease of 5.14%. Comparative data of changes obtained from the results of inventories of two years are presented in Table 4.10.

$_2$ emissions from the use of limestone based on the results of inventories in 2020 and 2021

	$_2$ emissions from the use of limestone, thousand tons	Difference

years	NDK 2020	NDK 2021	
1990	1318.2	341.5	Decrease 74.1%
2020	2413.1	2256.3	Decrease 5.14%
2021	-	3244.7	-

4.2.4.3.6 Planned improvements

In this category, improvements are planned to transfer the methodology for calculating CO2 emissions to a higher level of calculation. In accordance with the Order of the Minister of Ecology and Natural Resources of the Republic of Kazakhstan dated January 17, 2023 No. 9 and in accordance with paragraph 3 of Article 294 of the Environmental Code of the Republic of Kazakhstan, as well as with subparagraph 2) of paragraph 3 of Article 16 of the Law of the Republic of Kazakhstan "On State Statistics" were new Methodologies for calculating greenhouse gas emissions for industrial enterprises with the transition to levels 2 and 3 were approved.On this basis, it is expected to improve the National report on the inventory of greenhouse gas emissions in our country.

4.3 EMISSIONS FROM THE CHEMICAL INDUSTRY (CATEGORY CRF 2B)

For the category “Chemical Industry Emissions”, an assessment of CO_2 emissions from the production of ammonia (2B.1) and calcium carbide (2.B.5.a) was carried out; also in this inventory, N_2O emissions from the production of weak (46%) nitrogen acids (2.B.2). The Republic of Kazakhstan lacks some production processes, which, according to the methodology, are significant sources of emissions. Kazakhstan does not have the following types of chemical production: adipic acid, carbon black, non-metallurgical production of magnesia, caprolactam, glyoxal and glyoxylic acid, titanium dioxide, soda ash.

The share of emissions from the Chemical Industry Emissions category in 2021 amounted to 2.5% (in 2020 - 3.0%) of all emissions from the IPPU sector. At the same time, ammonia production (2B.1) amounted to 62.7%; calcium carbide (2.B.5.a) 3.6%; N_2O emissions from the production of weak (46%) nitric acid (2.B.2) accounted for 33.7% of the share of the “Chemical Industry Emissions” category.

4.3.1 Ammonia production (Subcategory CRF 2B.1)

4.3.1.1 Category description

The main source of greenhouse gases in the chemical industry of the Republic of Kazakhstan are CO_2 emissions from the production of ammonia and N_2O from the production of weak (46%) nitric acid.

Initial data on activities were provided by the Bureau of National Statistics of ASPIR RK. In the Republic of Kazakhstan, ammonia is produced at the only chemical plant of KazAzot JSC, which was established in 2005 on the basis of the chemical complex of the Caspian Mining and Metallurgical Combine (PGMK), which included three plants: Nitrogen-Fukovy (ATZ), Chemical-Hydrometallurgical (KhGMZ) and Sulfuric Acid (SKZ). In July 2006, a decision was made to decommission and mothball the facilities of the Chemical-Hydrometallurgical and Sulfuric Acid Plants. The equipment of the sulfuric acid plant was dismantled.

Based on the above, data on production indicators for 1990-2005. the JSC KazAzot plant does not have, but historical data from 1990 are available in the national statistics. In this regard, the initial activity data for the entire time series 1990-2021. for the calculation of GHG emissions

from the category "Production of ammonia" were used from the data of the Bureau of National Statistics ASPIR RK.

The production site of the KazAzot JSC plant occupies an area of 152.36 hectares and is located 9 km from the city of Aktau, the regional center of the Mangistau region. The production site has 73 buildings, 22 structures, a developed network of engineering communications, access railways and roads with access to the main transport communications of the region and the commercial seaport of Aktau. KazAzot JSC has operating production facilities for ammonia, weak nitric acid and complex mineral fertilizers, which are located on the site of KazAzot JSC. The final commercial products of KazAzot JSC at the moment are granulated ammonium nitrate, liquid ammonia and commercial gas. Gaseous ammonia and weak nitric acid are semi-finished products and are used in technological processes as reagents in the production of ammonium nitrate.

Category 2.B.1 “Ammonia production” is not a key category in the national GHG inventory of Kazakhstan. Upon request for baseline activity data from KazAzot JSC [71], we received data on natural gas consumption for ammonia production from 2006 to 2021.

Table 4.11 - Dynamics of $CO_{2\ emissions}$ from ammonia production (thousand tons)

Category	years							
	1990	1995	2000	2005	2010	2011	2012	2013
2 IN 1. Ammonia production	455.9	59.2	8.7	5.07	91.8	128.1	101.5	116.0
Consumption of natural gas for the production of ammonia, thousand m^3	542521	70448	10367.28	6035.68	126715	153899	114718	131147
$_2$ emissions from ammonia production	989.1	129.2	19.02	11.07	232.5	282.4	210.5	240.6

Continuation of table 4.11

Category	years							
	2014	2015	2016	2017	2018	2019	2020	2021
2 IN 1. Ammonia production	169.1	185.0	209.8	217.9	210.4	217.4	217.9	260.102
Consumption of natural gas for the production of ammonia, thousand m^3	176464	197715	205303	217163	212759	188596	199106	232560
$_2$ emissions from ammonia production	323.7	362.7	376.7	398.4	390.38	346.05	365.3	426.7

Based on the recommendations of the ERT of previous reviews of national inventory reports on the transition to a higher level of calculations of greenhouse gas emissions from this category, data on natural gas consumption for 1990-2005 were obtained by the calculation method in accordance with the IPCC RP, 2006. As mentioned above, despite the difficult economic years of 2020-2021, ammonia production in 2021 increased by 19.3%. According to updated activity data received directly from the ammonia plant, $CO_{2\ emissions}$ in 2021 from ammonia production amounted to 426.7 thousand tons of CO2 eq. Table 4.11, compared to 2020, greenhouse gas emissions increased by 16.8%, which is due with an increase in ammonia production. At the same

[71]Letter of request No. 13-1-13 / 2380-I dated 07/26/2022

time, compared to emissions in 1990, emissions amounted to 42.8%. This is also due to the overall decline in ammonia production over the period 1990–2021.

4.3.1.2 Methodological approaches

This category is not a key category in the national inventory of greenhouse gas emissions of the Republic of Kazakhstan. To calculate the emissions, we used the data obtained from the plant of the ammonia producer JSC KazAzot, as well as the data of the Bureau of National Statistics of the ASPIR RK (annual Statistical Compilation "Key indicators of the industry of the Republic of Kazakhstan") [72]. In connection with the revision of the method for calculating greenhouse gas emissions from this category, a Tier 2 approach was applied. The calculation of greenhouse gas emissions was carried out through the consumption of natural gas for the production of ammonia, using the conversion factor thousand m 3 into mules, and then into TJ, taking into account the content carbon in natural gas 14.8 tons/TJ. The KazAzot JSC plant cannot provide data on the volume of natural gas consumption for ammonia production for 1990-2005, since it was established in 2005. The data on natural gas consumption for 1990-2005 were obtained by the calculation method in accordance with IPCC RP, 2006.

I would also like to note that in the category "Production of ammonia" in the general data format (tables of CFR 2B.1) the values of emissions of indirect gases NO_x, SO_2 and CO are given .

4.3.1.3 Estimating uncertainty and consistency of time series

Since data on ammonia production volumes are provided by the Bureau of National Statistics of the AASPIR RK and directly by the manufacturer, they can be regarded as fairly reliable. Analysis of all available information, given that this is statistical reporting, allows us to estimate the uncertainty within ± 5%.

4.3.1.4 QA/QC procedures

For category 2.B "Manufacture of chemicals", the quality control procedures according to Section 1.2.3 were applied. NDK 2021.

Information on the choice of activity data and emission factors is documented; the correctness of the used formulas and units of measurement for the entire time series was checked; the homogeneity of the input data and the methods used was checked for the entire time series.

4.3.1.5 Recalculations and improvements

In connection with the transition to another level of calculation of greenhouse gas emissions for this category, recalculations were carried out for the entire time series. As a result of the recalculations, changes were obtained - for example, emissions in 1990 increased by 3.1%, while greenhouse gas emissions in 2020 decreased by 20.3%, which are shown in Table 4.12.

Table 4.12 - Comparative data on the results of recalculations of GHG emissions based on the results of inventories for 2020-2021 in the category "Ammonia production"

years	CO2 emissions from ammonia production, thousand tons		Difference, %
	NDK 20 20g.	NDK 2021	
1990	959.21	989.1	3.1% growth
2020	458.57	365.3	decrease by 20.3%

[72]https://www.stat.gov.kz/

2021	-	426.7	-

4.3.1.6 Planned improvements

Improvements were made to move the calculation of GHG emissions from the Tier 1 method to the Tier 2 method.

4.3.2. Production of nitric acid (Subcategory CRF 2B.2)

4.3.2.1 Category description

Nitric acid is used as a raw material mainly in the production of nitrogen fertilizers. In the production of nitric acid (HNO_3), nitrous oxide (N_2O) is produced as an unwanted by-product of the high temperature catalytic oxidation of ammonia (NH_3).

In Kazakhstan, the production of nitric acid is carried out at the KazAzot LLP plant. The final commercial products of KazAzot JSC at the moment are granulated ammonium nitrate, liquid ammonia and commercial gas. Gaseous ammonia and weak nitric acid are semi-finished products and are used in technological processes as reagents in the production of ammonium nitrate. Natural gas is the raw material for the production of ammonia. Potentially, in the presence of demand and provision of transportation conditions, weak nitric acid can also become a final commercial product. The Company's finished products (ammonium nitrate and ammonia) are sold on the territory of the Republic of Kazakhstan and beyond. Sending granulated ammonium nitrate and liquid ammonia to the buyer's address is carried out by rail and sea. In 2021, as well as in previous years, products were exported to Ukraine, Russia, Kyrgyzstan, Uzbekistan, Azerbaijan, Georgia, Turkmenistan. Commercial gas is sold by KazTransGas JSC. KazTransGas JSC is the main gas energy and gas transportation company of the Republic of Kazakhstan, representing the interests of the state both in the domestic and foreign gas markets.

4.3.2.2 Methodological issues

N_2O emissions from nitric acid production were estimated using the IPCC SPM Tier 1 methodology (IPCC, 2006). Baseline activity data and N_2O emissions are given in Table 4.13.

Table 4.13 - Dynamics of N_2O emissions from nitric acid production (thousand tons).

years	Nitric acid production	Ammonium nitrate production[73]	Emissions of N_2O from the production of nitric acid, thousand tons	Emissions of N_2O from the production of nitric acid, thousand tons of CO_2 eq.
1990	0	0	0	0
1995	0	0	0	0
2000	0	0	0	0
2005	0	0	0	0
2006	31.494	37.497	0.072	21.585
2007	175.582	206.113	0.404	120.343
2008	171.724	189.911	0.395	117.699
2009	125.998	176.751	0.289	86.359
2010	137.887	147.752	0.317	94.507
2011	188.204	206.491	0.433	128.994
2012	139.733	148.322	0.321	95.773
2013	149.134	170.828	0.343	102.216
2014	236.546	264.272	0.544	162.128

[73]Data from the Bureau of National Statistics ASPIR RK

2015	261.679	285.882	0.602	179.355
2016	287.222	321.805	0.661	196.862
2017	302.872	337.442	0.697	207.588
2018	294.955	330.874	0.678	202.162
2019	284.303	330.078	0.654	194.861
2020	285.780	329.015	0.657	195.874
2021	334.434	380.709	0.769	229.221
Note Data on the production of ammonium nitrate are provided by BNS RK*				

The production of nitric acid is an intermediate product for the production of ammonium nitrate. The calculation was carried out in accordance with Equation 3.5 (p.3.22 Chapter 3.3.2.1 Volume 3 of IPCC 2006 RP), using a default emission factor selected from the factors given in Table 3.3. p.3.25 Ch.3.3.2.2 Volume 3 IPCC 2006 RP In Kazakhstan, the production of nitric acid takes place at atmospheric (low) pressure (3.5 atm), therefore, for calculations, the N_2O emission factor equal to 5 kg N_2O/ton of nitric acid was chosen . Taking into account conversion to 46% nitric acid, the N_2O emission factor was 2.3 kg. N_2O/ton of nitric acid.

The data in Table 4.13 show that $CO_{2\ emissions}$ in 2021 from the production of nitric acid increased significantly by 17.02% compared to 2020, which is associated with an increase in the production of nitric acid.

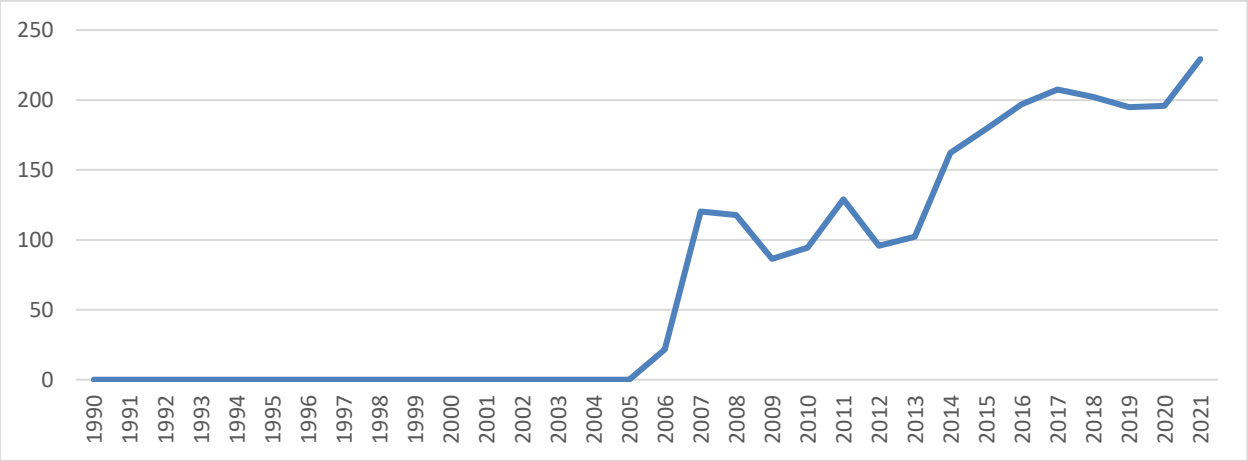


Figure 4.4. – Dynamics of GHG emissions from the production of nitric acid for the period 1990-2021 in the Republic of Kazakhstan

4.4-suret. – Kazakhstan Republicsyndagy 1990-2021 zhyldardagy nitrogen qyshkylyn ondiru kezindegi greenhouse gasdar shygaryndylarynyn dynamics

Data on the activities of KazAzot JSC for the production of nitric acid have been presented since 2006. The production of nitric acid is an intermediate product in the production of nitrogen fertilizers from ammonia. According to the data provided by the Bureau of National Statistics of the Republic of Kazakhstan, in the Republic of Kazakhstan from 1990 to 2005 there was no production of nitrogen fertilizers, respectively, and the production of nitric acid, on this basis, as well as according to numerous literary sources in this inventory of NDK-2023, it was decided to revise calculations of GHG emissions based on the results of the previous NIR-2022 for the category of nitric acid production. As is known, on the recommendation of the GER, in order to restore the entire series in the last year's NIR 2022 report, we applied the splicing method in calculating greenhouse gas emissions from 1990-2005 relative to ammonia production in the

country. However, as described above, after analyzing all the available data and conducting a large analytical review of the literature sources of [74]the Republican Scientific and Technical Library [75](RSTL) of the Republic of Kazakhstan, we came to the conclusion that we will carry out calculations of greenhouse gas emissions for this category based on the initial data on activities provided by JSC " KazAzot" from 2006-2021. So, according to the results of the calculations of emissions, N_2O emissions in 2021 from this category amounted to 229.221 thousand tons of CO_2 eq. 2021, figure 4.4.

4.3.2.3 Uncertainties and sequence of time series

Activity data was provided by the only nitric acid plant in the Republic of Kazakhstan, KazAzot JSC. The value of uncertainty is accepted by default equal to ± 2%.

4.3.2.4 QA/QC procedures

Standard procedures were followed for quality assessment and quality control, including activity data control and emission factor selection as per Section 1.2.3. NDK.

4.3.2.5 Recalculations and improvements

Recalculations have been made in this category. According to the data provided by the Bureau of National Statistics of the ASPIR RK, in the Republic of Kazakhstan from 1990 to 2005 there was no production of nitrogen fertilizers, respectively, and the production of nitric acid, on this basis, as well as according to numerous literary sources in this inventory of NDK-2023, it was decided to revision of GHG emissions calculations based on the results of the previous NIR-2022. According to the recalculation results, there were no GHG emissions in this category from 1990-2005, and from 2006 to 2020, there were no changes in the values of GHG emissions.

4.3.2.6 Planned improvements.

Improvements have been made in this inventory for this category. Table 4.13 includes data on the production of ammonium nitrate in Kazakhstan for 1990-2021.

4.3.3 Calcium carbide production (Subcategory 2.B.5 CRF)

4.3.3.1 Category description

Calcium carbide CaC_2 is produced by heating calcium carbonate (limestone) and then reducing CaO with carbon (eg petroleum coke carbon). Emissions of CO_2 from limestone occur during the production of CaC_2 and also during the reduction of lime and the use of calcium carbide.

In the Republic of Kazakhstan, the production of calcium carbide is carried out at JSC Temirtau Electrometallurgical Plant. In the city of Temirtau there is a plant, the only one in the territory of the Republic of Kazakhstan that produces calcium carbide - a substance from which acetylene gas, calcium cyanamide are obtained, and also used for desulfurization of cast iron. The bulk of the produced calcium carbide goes abroad. They sell it to a greater extent to Russia, Romania, Georgia, Ukraine and the countries of Central Asia. In general, work for export is carried out on the territory of the CIS, as well as some countries of the Far Abroad. In the Republic of Kazakhstan, calcium carbide is mainly used for iron desulfurization, which does not emit CO_2 .

4.3.3.2 Methodological issues

This category is not a key category. Baseline activity data was provided by JSC "Temirtau Electrometallurgical Plant", a plant that is the only producer of calcium carbide in the Republic of Kazakhstan. Calculation of CO_2 emissions from calcium carbide production was done through the amount of reductant used using

[74]Properties, production and use of mineral fertilizers: a textbook for universities / B.A.

[75]Ilyin A.P. Production of nitric acid: textbook for universities / A.P. Ilyin, A.V. Kunin. - St. Petersburg: Lan, 2013. -247p.

Tier 2 and applying a default CO_2 emission factor from reductant use (coke) of 1.7 (tonnes of CO_2 / ton of raw material). Total change in calcium carbide production and derived CO_2 greenhouse gas emissions from 1990 to 2021 are presented in table 4.14.

Table 4.14 - Dynamics of greenhouse gas emissions from the production of calcium carbide (thousand tons)

Category	years								
	1990	1995	2000	2005	2010	2011	2012	2013	2014
2.B.5 Calcium carbide production	306.7	111.0	9.9	48.1	35.6	28.8	27.0	18.1	23.0
$_2$ emissions from calcium carbide production thousand tons CO_2 eq	274.9	99.0	8.5	43.8	26.0	27.8	25.4	17.6	17.4

Table 4.14 continued

Category	years						
	2015	2016	2017	2018	2019	2020	2021
2.B.5 Calcium carbide production kt	27.0	27.3	22.9	22.3	28.3	26.1	29.8
$_2$ emissions from calcium carbide production, thousand tons CO_2 eq	23.0	23.6	22.3	21.2	28.4	24.9	24.28

As can be seen from Table 4.14, GHG emissions in 2021 from the production of calcium carbide amounted to 24.28 thousand tons of CO_2 eq. Their contribution to total emissions from the Chemical Industry Emissions subsector in 2021 is only 3.6%. Compared to 2020, there is a slight decrease in GHG emissions in this category by 2.48%, which is associated with an overall decrease in calcium carbide production in the country in 2021.

4.3.3.3 Uncertainties and sequence of time series

$_2$ emissions, data on the production of calcium carbide at JSC "Temirtau Electrometallurgical Plant" were used. The uncertainty of $CO_{2\ emissions}$ in the production of calcium carbide is assumed to be ±5% by default.

4.3.3.4 QA/QC procedures

General quality control procedures in accordance with Section 1.2.3 have been applied to calculations of greenhouse gas emissions from calcium carbide production. Information on the choice of activity data and emission factors is documented; the correctness of the used formulas and units of measurement for the entire time series was checked; the homogeneity of the input data and the methods used was checked for the entire time series.

4.3.3.5 Recalculations and improvements

No recalculations have been made in this category. Further use of calcium carbide for the production of welding acetylene is not carried out due to the lack of such activities in the country.

4.3.3.6 Planned improvements

No improvements are planned for this category.

4.4 EMISSIONS FROM THE METALLURGICAL INDUSTRY (CATEGORY CRF 2.C.)

The mining and metallurgical complex (MMC) is the most important sector of the economy of the Republic of Kazakhstan after the oil industry. Its share in the country's GDP at the end of 2021 amounted to 9.3% (in 2020 - 8.1%) [76].

In the national inventory of the Republic of Kazakhstan for the category "GHG emissions from the metallurgical industry" (2.C.), the following gases were assessed: CO_2 from the production of iron, steel, iron ore pellets, sinter, ferroalloys, primary aluminum, CO_2 from the combustion of volatile substances and combustion of the furnace feed material (coke) in the production of aluminum, lead and zinc; CH_4 from the production of ferroalloys (ferrosilicon) and from the production of agglomerates; perfluorocarbons, CF_4 and C_2F_6 from the production of primary aluminum.

CO_2 emissions from magnesium production in the country; carnallite is used as a raw material for its production. There are also no SF_6 and HFC emissions from magnesium castings. In the Republic of Kazakhstan, there is no production of direct reduced iron [77](DRI) (2019 KAZQA 115, I .44, 2017), therefore, in the CRF (CRF 2.C.1.c) - tables in the category "2.C.1.c" is the designation key is “ NO ” , which means there is no such activity in the country.

Direct reduced iron (DRI) is either metallized pellets (DRI) or hot briquetted iron (HBI). The use of technologies for the production of direct reduced iron (DRI), mainly in the form of metallized pellets (DRI) or hot briquetted iron (HBI), is still, as it was several decades ago, considered in the metallurgical literature to be one of the most promising areas for the effective development of world metallurgy. Theoretically, iron production is possible, but access to coke is needed, which is not available in Kazakhstan [78].

Analysis of industrial production for the period 1991-1998. in the metallurgical industry shows a noticeable decrease in greenhouse gas emissions associated with a decline in production and the economic crisis in the Republic of Kazakhstan as a whole. This is the period of gaining independence, the development of a young sovereign state, the period when all the former Soviet republics were rebuilding their production within the framework of the acquired independence of states, including Kazakhstan.

At the end of 2021, the weight of metallurgy in the manufacturing industry amounted to 45.7%, in the total volume of industrial production - 20.7%. The mining and metallurgical complex of the Republic of Kazakhstan provided about 30% of the total industrial production in the country, or 11 trillion tenge in value terms [79].

The main source of greenhouse gases in the metallurgical industry of the Republic of Kazakhstan, as in previous years, is the integrated production of iron and steel smelting (2.C.1), whose emissions in 2021 amounted to 38.5% of the total greenhouse gas emissions in the category "Emissions from the metallurgical industry". The next largest sources of greenhouse gases in the industry are: production of agglomerates (2.C.1. d) 29.9%; production of ferroalloys (2.C.2) in 2021 amounted to 23.7%; the sum of CO_2 emissions from aluminum production and PFCs is 2.89%

[76]https://kz.kursiv.media/2022-09-08/kazahstanskij-gmk-v-2021-godu-pokazal-rost-po-vsem-pokazatelyam/
[77] https://www.urm-company.ru/production/dri/
[78]https://metallplace.ru/about/stati-o-chernoy-metalurgii/zhelezo-pryamogo-vosstanovleniya/
[79] https://forbes.kz/news/2022/02/21/newsid_270026

(2.C.3) of total greenhouse gas emissions from the Metallurgical Industry Emissions category. Next come GHG emissions from pellet production 2.5% (2.C.1.e). Emissions from ODS consumption in 2021 accounted for 10.0% of emissions from the IPPU sector. GHG emissions from lead and zinc production accounted for 0.39% (2.C.5) and 2.0% (2.C.6), respectively, of the total greenhouse gas emissions in the Metallurgical Industry Emissions category.

tended to decrease by 4.7% compared to 2020 emissions .

4.4.1 Iron and steel production (category 2.C.1 CRF)

4.4.1.1 Category description

In this inventory, the assessment of greenhouse gas emissions in the category of iron and steel production (2.C.1 CRF) was carried out in accordance with the methodology of the IPCC (IPCC) , 2006. To calculate greenhouse gas emissions, the IPCC Tier 2 method (IPCC , 2006) was used, which provides for a separate assessment of $CO_{2\ emissions}$ for blast-furnace pig iron production and for steel smelting.

When calculating greenhouse gas emissions in this category, data from enterprises are used, namely the Steel Plant JSC Arcelor Mittal Steel for the production of iron and steel, which includes the following components - this is the amount of reducing agent used in the production of a particular metal, as well as the balance of carbon content in the production of iron and steel. In preparing this NIR, data were used on the production of electric steel from the metallurgical enterprises of the Republic of Kazakhstan, in particular, the Steel Plant of Arcelor Mittal Steel JSC and data from the National Bureau of Statistics ASPIR of the Republic of Kazakhstan.

JSC "Arcelor Mittal Steel" presented data on the production of coke, its characteristics, and the amount that was used directly in the production process.

4.4.1.2 Methodological approaches

Pig iron production is associated with the reduction of iron ore, mainly in blast furnaces. The carbon contained in the coke is used both as a fuel and as a reducing agent. In this NIR, all CO2 emissions $_{from}$ the use of coke in the production of iron are referred to industrial $_{CO2\ emissions.}$

Estimation of $CO_{2\ emissions}$ from iron and steel production was carried out in accordance with the IPCC methodology (IPCC , 2006). For the calculation, the IPCC Tier 2 method was used, which provides for a separate assessment of $CO_{2\ emissions}$ for blast-furnace pig iron production and for steel smelting (categories 2.C.1. a , 2.C.1. b), as well as emissions from sinter production (category 2 .C.1. d) and pellets (category 2.C.1. e) taking into account the consumed fuel for production (natural gas).

In this NIR, the calculation of greenhouse gas emissions using the IPCC Tier 1 method (IPCC , 2006) in the Iron and Steel Production category was used to calculate methane (CH_4) emissions. from the production of sinter (2.C.1.d) .

4.4.1.2.1 Pig iron production (subcategory 2.C.1.b CRF)

$_{CO2}$ emissions from iron and steel production are key categories of greenhouse gas sources in Kazakhstan. The main and only producer of pig iron in the Republic of Kazakhstan is the plant of Arcelor Mittal Temirtau JSC, which is an integrated production including the production of pig iron, steel, as well as the production of coke and agglomerates.

When calculating greenhouse gas emissions in this category, the Tier 2 method was used, which is practically equivalent to Tier 3, since all data from the only iron producer in Kazakhstan, JSC Arcelor Mittal Temirtau, were used. As a reducing agent in the production of iron in Kazakhstan, coal coke is used, which, as noted above, is produced directly at the same enterprise

where iron, steel and other metal products are produced. Data on activities, as well as greenhouse gas emissions from iron production for 1990-2021 are presented in Table 4.15.

Table 4.15 – Production and GHG emissions from iron production, thousand tons of CO_2 eq.

years	Pig iron production, thousand tons	Use of coke for the production of pig iron, thousand tons	Emissions from the use of coke, thousand tons of CO_2 eq.	Emissions from the use of limestone, thousand tons of CO_2 eq.	Total $_2$ emissions from pig iron production, thousand tons CO_2 eq.
1990	5226.414	2785.678	7653.717	265.413	7919.131
1991	4953.175	2699.480	7434.468	251.537	7686.005
1992	4666.275	2379.800	6506.809	236.967	6743.777
1993	3552.134	1896.839	5212.662	180.388	5393.050
1994	2138.875	1229.688	3405.752	108.415	3514.167
1995	2529.381	1426.571	3942.732	128.449	4071.181
1996	2535.53	1333.689	3659.091	128.762	3787.853
1997	3089.35	1730.038	4777.993	156.887	4934.880
1998	2594.169	1533.154	4256.884	131.739	4388.624
1999	3438.082	1925.326	5317.338	174.596	5491.934
2000	4010.261	2085.336	5714.087	203.653	5917.740
2001	3905.698	2105.171	5790.939	198.343	5989.282
2002	4007.995	2128.245	5845.033	203.538	6048.571
2003	4137.07	2180.236	5982.906	210.093	6192.999
2004	4283.142	2252.933	6181.116	217.511	6398.627
2005	3582.198	2049.017	5671.049	181.915	5852.964
2006	3369.217	1987.838	5518.440	171.099	5689.539
2007	3795.352	2170.941	6008.498	192.739	6201.237
2008	3105.547	1869.539	5199.990	157.709	5357.699
2009	2995.948	1965.342	5508.829	152.143	5660.973
2010	2893.883	1756.587	4889.611	146.960	5036.571
2011	3141.17	1925.537	5364.794	159.518	5524.312
2012	2707.009	1708.123	4771.582	137.470	4909.052
2013	2622.744	1754.616	4926.361	133.190	5059.552
2014	3184.78	1894.944	5264.813	161.733	5426.545
2015	3233.671	1901.399	5276.74	164.215	5440.963
2016	3595.089	2063.581	5713.339	182.569	5895.909
2017	3766.322	2237.195	6214.707	191.265	6405.973
2018	3153.569	1907.909	5309.191	160.147	5469.339
2019	3165.135	1902.246	5290.133	160.735	5450.868
2020	3101.633	1860.979	5174.558	157.510	5332.068
2021	3195.305	1834.105	5078,000	162.267	5240.267

Emissions of CO_2 and CH_4 from coke production in the national inventory of the Republic of Kazakhstan are taken into account in the sector "Energy" (1.A 1.c) in the CRF tables this is indicated in the NIR category 2. C.1 f " Other " in the cells stands with the key designation “ IE ”, which means that CO_2 and $CH_{4\ emissions}$ from coke production are accounted for in the “Energy” sector (RF 1.A 1. c). Calculations of $CO_{2\ emissions}$ from iron production include $CO_{2\ emissions}$ from the use of coke. The calculation formula uses the data provided by Arcelor Mittal Temirtau JSC on the volume of pig iron production, as well as the values of the carbon content balance in the

production of pig iron. The carbon content in coke (83%) and in ore (0%) was taken as default (IPCC , 2000). The carbon content in cast iron according to Arcelor Mittal Temirtau JSC is 4.3%.

Improvements

To calculate $CO_{2\ emissions}$, the specific coke consumption was taken into account, which was submitted by the enterprise according to the request [80]from Arcelor Mittal Temirtau JSC; earlier, in previous inventories, the specific coke consumption was taken into account by the calculation method. The specific consumption of limestone for the production of pig iron, taking into account agglomeration, according to the request, amounted to 0.12 t/ton of pig iron.

Upon request for activity data, ArcelorMittal Temirtau JSC provided us with a wider range of data (specific consumption of coke for iron production; specific consumption of steel scrap for steel production; specific consumption of iron scrap for steel production; specific consumption of electrodes for electric steel production; amount of used limestone and dolomite for the production of converter steel). Based on the data obtained, we revised the methodology for calculating $CO_{2\ emissions}$ from the production of pig iron with the transition practically to Tier 3 of the IPCC (IPCC , 2006), volume 3 section 4.2. obtained from the recalculation results are shown in Table 4.16. Also, according to the request for activities for 1990-2021. JSC "Arcelor Mittal Temirtau" noted that coal and natural gas are not used in the production of pig iron in the steel department of JSC "Arcelor Mittal Temirtau". According to the results of the calculations, the total $CO_{2\ emissions}$ from the production of pig iron in 2021 amounted to 5240.267 thousand tons eq. CO_2 and this is 66.17% of 1990 emissions, compared to 2020, greenhouse gas emissions decreased by 1.72%, while pig iron production increased by 3.02%. The decrease in emissions in 2021 is due to a decrease in the specific consumption of coke used for the production of pig iron in 2021 compared to 2020.

Table 4.16 - Comparative data on the results of recalculations of greenhouse gas emissions based on the results of inventories for 2020 and 2021 in the category "Iron production"

years	$_2$ emissions from pig iron production, thousand tons		Difference, %
	NDK 202 0	NDK 202 1 g	
1990	8571.26	7919.13	Decrease by 7.6%
2020	5332.068	5332.068	-
2021	-	4460.6	-

4.4.1.2.2 Steel production (Subcategory 2.C.1.a CRF)

In the Republic of Kazakhstan, steel is produced both by primary and secondary methods. The main production of steel in the country, by the primary method from iron ore, is carried out at the integrated production of Arcelor Mittal Temirtau JSC. Secondary steel production is carried out both at Arcelor Mittal Temirtau JSC and at small metallurgical enterprises from secondary steel scrap, data on which is provided by the Bureau of National Statistics ASPIR of the Republic of Kazakhstan.

$_2$ emissions from steel production are based on changes in the carbon content of products from iron, metallized pellets and scrap steel production. In addition, for steel produced in electric

[80]Letter of request No. 13-1-13 / 2380-I dated 07/26/2022

arc furnaces, the carbon released during the combustion of electrodes in the production of electric steel is also added (formula 4.9, (IPCC , 2006).

Steel production volumes were used from the data of the Bureau of National Statistics of ASPIR RK and Arcelor Mittal Temirtau JSC. When assessing CO_2 emissions, data were used on the amount of pig iron (used for steel production) at Arcelor Mittal Temirtau JSC, taking into account the amount of reducing agent used in the production of steel (0.043 t/t) and the carbon content in steel (0.04%). Separately, CO_2 emissions from electric steel production were estimated according to the IPCC Tier 3 method based on enterprise data on steel production by Arcelor Mittal Temirtau JSC, consumption of metallized pellets, steel scrap and carbon electrodes, carbon content in raw materials and final products.

When calculating CO_2 emissions from steel production, the following parameters were taken into account: specific consumption of steel scrap, specific consumption of iron scrap for steel production, specific consumption of electrodes for electric steel production, consumption of electrodes for steel production, carbon content in pig iron (%); carbon content in steel (%); carbon content in electrodes (%), carbon content in cast iron, scrap and electrodes, and carbon content in steel. As a result of calculations, $CO_{2\ emissions}$ from the steel production category were obtained , which are presented in Table 4.17. Greenhouse gas emissions from steel in 2021 amounted to 492.8 thousand tons of CO_2 , which is 68.7% of 1990 emissions. In relation to greenhouse gas emissions in 2020, there is a slight increase in greenhouse gas emissions, which amounted to 2.3%, and this is due to an increase in steel production in 2021 in the country

Table 4.17 - Production and GHG emissions from steel production, thousand tons of CO_2 eq.

years	1990	1995	2000	2005	2010	2011	2012	2013
2.C1a. Steel production	675 3.4 _	3026.5	4799.2	4477.0	3338.0	4794.0	3758.1	3503.4
Emissions of CO_2 from steel production, thousand tons of CO_2 eq.	717.1	398.3	625.8	515.1	468.2	503.08	366.4	415.8

Continuation of table 4.17

years	2014	2015	2016	2017	2018	2019	2020	2021
2.C1a. Steel production	4014.9	3902.6	4264.1	4657.0	3972.7	4130.6	4003.7	4521.9
Emissions of CO_2 from steel production, thousand tons of CO_2 eq.	506.1	508.3	564.8	587.7 _	484.4	492.2 _	481.8	492.8

4.4.1.2.3 Sinter production (Subcategory 2.C.1.d CRF)

Iron ore and other iron-bearing materials are sintered in sinter plants within integrated smelters before being loaded into a blast furnace. Sinter plant feedstocks may include powdered iron ores, additives (eg lime, olivine) and iron-bearing materials from downstream iron and steel production processes (eg dust from blast furnace gas cleaning). Coke breeze (fine coke with a particle size of <5 mm) is the most common material in sinter plants. Coke breeze can be obtained from local coke ovens within the Integrated Smelter or purchased from a third party coke producer.

In the Republic of Kazakhstan, agglomerate is produced at Arcelor Mittal Temirtau JSC, and in accordance with the data provided by the manufacturer, we calculated carbon dioxide and

methane emissions. In this NIR, accounting for CO 2 emissions from $_{sinter}$ production was carried out using the IPCC Tier 2 method (IPCC , 2006) which is practically close to the Tier 3 method. [81]. Based on the initial data obtained in this inventory, we revised the approach for calculating greenhouse gas emissions for this category and recalculated the entire time series from 1990-2021. CO_2 emissions from sinter production were made up of emissions from the use of coke breeze used in sinter production and emissions from gas combustion, which included the amount of coke oven gas consumed by the sinter furnace and the amount of blast furnace gas consumed for sinter production. Tier $_1$ method was applied to calculate CH4 emissions, emission factor for methane of 0.07 kg CH4 per ton of sinter product was used from Table 4.2 page 4.28, Section 4.2.2.3, Chapter 4, Volume 3 of 2006 IPCC SPM .

The results of calculations of greenhouse gas emissions from the production of sinter in Kazakhstan from 1990-2021 are presented in Table 4.18. The total emissions in the "Sinter production" category in 2021 amounted to 4,460.6 thousand tons of CO_2 eq., which is 64.5% of GHG emissions in 1990; in 2021, the total greenhouse gas emissions in this category compared to 2020 year decreased by 7.9%. The decrease in greenhouse gas emissions in 2021 is due to a decrease in sinter production in 2021 compared to 2020.

Improvements

In this NIR, we have revised the table that presents the dynamics of greenhouse gas emissions from the production of agglomerates, and provides more extensive information on greenhouse gas emissions that occur as a result of the production of agglomerates.

Table 4.18 - Dynamics of GHG emissions from the production of sinter 1990-2021, thousand tons

years	1990	1995	2000	2005	2010	2011	2012	2013
Sinter production	9716.0	4080.0	5895.0	6064.0	5257.0	5856.0	5092.0	4596.0
Emissions from the use of coke breeze in sinter production	1989.3	788.1	956.2	1297.2	1081.6	958.5	867.5	822.5
Emissions from gas combustion for sinter production	4908.3	5057.9	5414.7	4614.2	3248.2	3553.1	3704.9	3419.7
Total $CO_{2\ emissions}$ from sinter production, thousand tons CO_2 eq.	6897.6	5846.1	6371.0	5911.5	4329.9	4511.6	4572.5	4242.3
$_4$ emissions	0.68	0.28	0.41	0.42	0.36	0.40	0.35	0.32
Emissions of CH_4 in eq. CO_2	17.03	7.14	10.31	10.61	9.19	10.24	8.91	8.04
Total GHG emissions from the production of agglomerates, thousand tons of CO_2 eq.	**6914.6**	**5853.2**	**6381.3**	**5922.2**	**4339.1**	**4521.9**	**4581.4**	**4250.3**

Continuation of table 4.18

years	2014	2015	2016	2017	2018	2019	2020	2021

[81]Letter of request No. 13-1-13 / 2380-I dated 07/26/2022

Sinter production	5562.0	4711.8 *	5270.1 *	5151.3 *	4741.4 *	5304.1 *	5507.5 *	5396.4
Emissions from the use of coke breeze in sinter production	991.6	858.3	948.2	904.04	761.9	956.5	927.2	598.9
Emissions from gas combustion for sinter production	3738.4	3678.4	3488.7	2839.5	2695.2	3649.1	3907.2	3852.2
Total $CO_{2\ emissions}$ from sinter production, thousand tons CO_2 eq.	4730.1	4536.7	4436.9	3743.6	3457.1	4605.6	4834.4	4451.2
$_4$ emissions	0.38	0.33	0.37	0.36	0.33	0.37	0.38	0.37
Emissions of CH_4 in eq. CO_2	9.73	8.24	9.22	9.01	8.29	9.28	9.63	9.44
Total GHG emissions from the production of agglomerates, thousand tons of CO_2 eq.	**4739.8**	**4545.02**	**4446.2**	**3752.6**	**3465.5**	**4614.9**	**4844.1**	**4460.6**
Note: *- data of Arcelor Mittal Temirtau JSC upon request Letter No. 13-1-13 / 2380-I dated 07.26.2022 activity data for the inventory of NDK-2023								

Dynamics of greenhouse gas emissions and sinter production volumes for the entire time series 1990-2021 also shown in Figure 4.5.

To avoid double counting of emissions, as well as on the recommendations of the ERT of previous reviews (I .29 2. C .1 Iron and steel production – CO_2 (I .33, 2019) (I .45, 2017) Accuracy) the volumes of gases used (coke oven and blast-furnace gases), as well as coke breeze used for the production of sinter, were excluded from the reporting section of the Sector "Energy" section "Production of iron and steel" (OFO 1.A.2.a) NDK 2023

Significant changes were obtained as a result of recalculations. So emissions in 1990 increased by 321.3%, greenhouse gas emissions in 2020 also increased by 398.6%, which are shown in Table 4.19

Table 4.19 - Comparative data on the results of recalculations of GHG emissions based on the results of inventories for 2020 and 2021 in the category "Production of sinter"

years	CO_2 emissions from sinter production, thousand tons		Difference, %
	NDK 202 0	NDK 202 1 g	
1990	1641.3	6914.6	growth by 321.3%
2020	971.5	4844.1	growth by 398.6%
2021	-	4460.6	-

4.4.1.2.4 Production of iron ore pellets (Subcategory 2.C.1.e CRF)

Kazakhstan is in the TOP-15 largest iron ore miners and producers of iron ore raw materials (IOR) in the world. The leading enterprise of the industry in the Republic of Kazakhstan is Sokolovsko-Sarbay Mining and Processing Production Association JSC (SSGPO), which is located in the Kostanay region and provides about 2/3 of the total concentrate output in the country and is the only pellet producer. The role of exports for Kazakh iron ore producers is difficult to

overestimate - deliveries to the domestic market traditionally do not exceed 5–10% of the total volume of commercial shipments of concentrate, sinter ore and pellets, while the rest is sent to the metallurgical enterprises of Russia and China.

To calculate greenhouse gas emissions from the Pellet Production category, activity data from the statistical collections of the Bureau of National Statistics of the ASPIR of the Republic of Kazakhstan and data provided by Sokolov-Sarbay Mining and Processing Production Association (SSGPO) JSC at the request of Zhasyl Damu JSC were used [82].

Accounting for greenhouse gas emissions of the category " Production of iron ore pellets" in the tables of the general data format is carried out in the category "2.C.1.e CRF". According to the IPCC RP (IPCC , 2006) greenhouse gas emissions are calculated from the pellet production process. In accordance with the request of Zhasyl Damu JSC, SSGPO JSC provided complete data on the volume of pellet production, taking into account the volume of natural gas used for pellet production for the entire time series. To calculate GHG emissions for this category, the Tier 2 method was applied. Also, according to the enterprise, there were changes in the volumes of pellet production and natural gas consumption in 2020, therefore, emissions were recalculated for 2020 alone.

To calculate $CO_{2\ emissions}$ for this category in the 2021 inventory, the calculation approach was changed, that is, we applied the following sequence of calculations:

- the volume of the total consumption of natural gas for the production of pellets from (thousand m^3) was converted to (toe), and then to (TJ).

- further the obtained value was multiplied by the carbon content in natural gas (14.836 tons/TJ) which gave us the amount of emissions from pellet production in thousand tons of CO_2 eq.

Due to the change in the methodology for calculating $CO_{2\ emissions}$ for this category, the entire time series for 1990-2021 was recalculated. The obtained data on pellet production and GHG emissions are shown in Table 4.20.

Table 4.20 - Dynamics of greenhouse gas emissions from pellet production 1990-2021, thousand tons of CO_2 eq

years	1990	1995	2000	2005	2010	2011	2012	2013
Pellets production, thousand tons	8871.1	7211.5	6640.0	7494.0	8150.0	7803.2	7360.4	6919.7
Consumption of natural gas for the production of pellets, thousand m3	317410.9	265830.5	211737.2	258078.9	280431.3	290947.5	268949.7	249437.9
Emissions from the use of natural gas for production pellets, thousand tons of CO_2 eq.	583.8	488.9	389.4	474.6	515.8	535.1	494.6	458.8

[82]Letter of request No. 13-1-13 / 2380-I dated 07/26/2022

Table 4.20 continued

years	2014	2015	2016	2017	2018	2019	2020	2021
Pellets production, thousand tons	6250.5	3283.6	3387.0	3488.5	3837.3	4528.1	4809.137	5788.51
Consumption of natural gas for the production of pellets, thousand m3	206176.7	117505.7	120252.1	138870.7	161468.0	181500.0	16649.0	203670.0
Emissions from the use of natural gas for the production of pellets, thousand tCO_2 eq.	379.2	216.1	221.1	255.4	296.9	333.8	306.2	374.6

Table 4.20 shows that greenhouse gas emissions in 2021 from the Pellet Production category amounted to 374.6 thousand tons of CO_2 eq, which is 64.16% of GHG emissions in 1990. CO_2 emissions in 2021 compared to 2020 show an increase in emissions by 22.3%, which is caused by an increase in pellet production and, accordingly, an increase in natural gas consumption for pellet production.

As a result of the recalculations, changes were obtained, which are presented in Table 4.21.

Table 4.21 - Comparative data on CO_2 emissions based on the results of inventories in 2020 and 2021 in the category "Pellet production"

years	$_2$ emissions from pellet production, thousand tons		Difference, %
	NDK 202 0 g	NDK 202 1 g	
1990	583.8	583.826	-
2020	294.846	306.2	3.86% growth
2021	-	374.6	-

To eliminate double counting of emissions, as well as on the recommendations of the ERT of previous reviews, the volume of natural gas used for the production of pellets was excluded from the reporting section of the Energy Sector section 1A.1 of this NIR.

4.4.1.3 Estimating uncertainty and consistency of time series

$_2$ emission factor from the use of electrodes in steelmaking in electric arc furnaces is assumed by default and is 5%. It should be noted that CO_2 emissions from the use of electrodes in the production of electric steel are disproportionately lower than emissions from other sources in this category. As a result, the value of the uncertainty in estimating CO_2 emissions from the use of electrodes has practically no effect on the value of the overall uncertainty in estimating CO_2 emissions, which is 10%. The uncertainty of the methane emission factor for pig iron production is assumed to be 20%. Taking into account the uncertainty of activity data (at the level of 5%), the total uncertainty in estimating methane emissions from iron production is 20.6%.

Having considered the time series of the specific consumption of coke for the production of pig iron, we note the sufficient constancy of this indicator from 1990 to 2004. with an increase in subsequent years. In addition, the total production of products changed in accordance with the

demand in the world markets and the general economic situation in the country. Such dynamics is explained by the decline in production (from 1991 to 1998), when it was necessary to keep blast furnaces in working condition without production, which was accompanied by an increased consumption of coke to maintain a high temperature in the blast furnace. With the increase in pig iron production and the adaptation of the industry to work in new conditions, the specific consumption of coke gradually changed.

CO_2 emission factor for pig iron production, equal to the ratio of CO2 emissions to pig iron production, changed over the entire reporting period from 1.48 in 1990, with a subsequent increase to 1.9 in 2020.

The heterogeneity of this indicator is connected, firstly, with a change in the carbon content in the used coke and cast iron, and also with the fact that until 1999 the enterprise had open-hearth metal production. For comparison, we note that the default value of this indicator (table 4.1 p.4.2.2.3 v.3 of the IPCC Guidelines, 2006) is 1.35 t CO_2 per 1 t of pig iron produced.

4.4.1.4 QA/QC procedures

to the calculation of CO2 emissions from iron and steel production. Among the detailed quality control procedures, the following were performed:

- time series analysis of activity data (production of pig iron, steel, agglomerates and pellets), assessment of annual changes in CO_2 emission factors and determination of the reasons for these changes;
- $_2$ emission factors with default IPCC factors and determination of the specifics of national conditions that led to the difference between them;
- $_2$ emissions from the production of pig iron, steel, agglomerates and pellets calculated using different methods;
- comparison of data on the production of iron, steel and agglomerates provided by ArcelorMittal Temirtau JSC, as well as the production of pellets and the consumption of natural gas for its production from SSGPO for the entire reporting period;
- analysis of the balance of coke during production processes at the enterprise of ArcelorMittal Temirtau JSC.

4.4.1.5 Recalculations and improvements

In the general category "Production of iron and steel (category 2.C.1 CFR)", recalculations were made that affected the categories "Production of pig iron" (category 2C.1 b CRF), "Production of sinter" (category 2C.1 d CFR) and “Pellet production (Category 2C.1 e CRF)”. Also in this inventory, the format for presenting tables by categories of production of iron, steel, agglomerates and pellets was revised. Changes that have occurred in these categories as a result of recalculations are given in the relevant sections of this NIR.

In general, I would like to note that the production of iron ore in Kazakhstan is export-oriented. For Kazakh iron ore producers, deliveries to the domestic market traditionally do not exceed 5–10% of the total volume of commercial shipments of concentrate, sinter ore and pellets, while the rest is sent to the metallurgical enterprises of Russia and China.

In accordance with the recommendation of the ERT (2021KAZQA121 -ARR2019-ID#I.28), Table 4.22 provides a comparative analysis of the ratio of production volumes (“sinter + pellets” to “pig iron + steel”).

Table 4.22 - Dynamics of the ratio of production volumes ("sinter + pellets" to "pig iron + steel") for 1990-2021

years	pellets + agglomerates	cast iron + steel	Amount (100%)	Ratio (pellets + agglomerates%)	Ratio (cast iron + steel %)
1990	18587	11979.903	30566.903	60.8	39.2
1991	17827.9	11330.311	29158.211	61.1	38.8
1992	16022.3	10729.403	26751.703	59.9	40.1
1993	12131.4	8109.649	20241.049	59.9	40.1
1994	12131.4	5103.419	17234.819	70.4	29.6
1995	11291.5	5555.976	16847.476	67.0	33.0
1996	9139.6	5752.126	14891.726	61.4	38.6
1997	11155.4	6969.601	18125.001	61.5	38.5
1998	7622.8	5710.669	13333.469	57.2	42.8
1999	8405.4	7543.182	15948.582	52.7	47.3
2000	12534.9	8809.261	21344.161	58.7	41.3
2001	12163.6	8596.698	20760.298	58.6	41.4
2002	13312.9	8873.995	22186.895	60.0	40.0
2003	15226.6	9206.47	24433.07	62.3	37.7
2004	15942.1	9654.842	25596.942	62.3	37.7
2005	13563.9	8059.198	21623.098	62.7	37.3
2006	14437.6	7614.217	22051.817	65.5	34.5
2007	15152.3	8579.352	23731.652	63.8	36.2
2008	12084.8	7349.547	19434.347	62.2	37.8
2009	11931.4	6320.248	18251.648	65.4	34.6
2010	13274.3	6231.883	19506.183	68.0	32.0
2011	13503.8	7935.253	21439.053	63.0	37.0
2012	12235.75	6465.194	18700.944	65.4	34.6
2013	11294.9	6126.144	17421.044	64.8	35.2
2014	11324.3	7199.68	18523.98	61.1	38.9
2015	7945.083	7136.271	15081.354	52.7	47.3
2016	8611.349	7859.203	16470.552	52.3	47.7
2017	9121.724	8423.322	17545.046	52.0	48.0
2018	9310.097	7126.269	16436.366	56.6	43.4
2019	10683.305	7295.736	17979.041	59.4	40.6
2020	10316.66	7105.418	17422.078	59.2	40.8
2021	11184.923	7717.219	18902.142	60.9	39.1

The analysis showed that the sum of the production volume "pellets + agglomerates" for the entire time period is on average 60.9%, and the sum of the production volume "pig iron + steel" on average for all years is 39.1% of the total production volume (" sinter + pellets” to “cast iron + steel”).

4.4.1.6 Planned improvements

Significant improvements have been made to this inventory by revising the format of the presentation of the tables for iron, steel, sinter and pellet production categories. Changes that have occurred in these categories as a result of recalculations are reflected in the relevant sections of this inventory.

4.4.2 Manufacture of ferroalloys (Subcategory 2.C.2 CRF)

4.4.2.1 Category description

One of the world's largest producers of chromium ore and ferroalloys with a unique resource base and the lowest unit costs in the Republic of Kazakhstan is TNK Kazchrome JSC, which ranks second in the world in terms of production and supply of chromium alloys and first in terms of quality of chrome ore. The main place in the company's ferroalloy products is occupied by high-quality high-carbon ferrochrome. The company also produces silicon and manganese alloys and refined ferrochromium.

The main use of ferrochromium is in the production of stainless steel. According to the annual report of TNC Kazchrome JSC, analysts predict an increase in demand for stainless steel due to the ongoing urbanization and economic development of China, India and other developing countries. Demand for stainless steel is expected to grow by 3.6% per annum until the end of 2030, leading to higher demand for ferrochromium and chromium ore.

Despite the difficulties faced by the market due to the ongoing COVID-19 pandemic, Kazchrome has maintained all established supply chains and once again confirmed its long-term status as a reliable ferroalloys producer for the markets of Europe, Japan, the USA and other countries of the world. Production indicators in 2021 turned out to be slightly lower than in 2020 due to a reduction in production at the 40 Let KazSSR-Molodezhnoye deposit, a decrease in the supply of chromium raw materials from the Donskoy GOK, caused, among other things, by the impact of COVID-19 on the increase in the incidence of production personnel . This year was favorable for the company in terms of financial indicators: thanks to external trends in the global market, the Company's revenue increased by 59.5%, net profit grew by 231.9%. In addition, in 2021 the Company increased the volume of investments in strategic areas [83].

4.4.2.2 Methodological approaches

This section discusses methods for estimating carbon dioxide (CO_2) and methane (CH_4) emissions. The main producer of ferroalloys in Kazakhstan is Transnational Company KazKhrom JSC, which includes the Aktobe Plant and the Aksu Ferroalloy Plant. The main products of the enterprises are ferrochromium, ferrosilicon, ferrosilicochromium and ferrosilicomanganese.

In order to reduce the uncertainty in estimating CO2 emissions from ferroalloy production, this inventory used data on ferroalloy production, the Bureau of National Statistics of the ASPIR RK, and Kazchrome JSC data using the Tier 2 method.

Improvements

To calculate CO_2 emissions, the emission factor of the reducing agent (coke) was used equal to 3.3 t CO_2 / ton of reducing agent for the data of Kazchrome JSC, the difference in production volumes between the data of the enterprise and the Bureau of National Statistics of the ASPIR RK was considered as "Other". In this inventory, the estimate of emissions from the “Other” category has been revised, i.e. if earlier in the previous inventories for this category the default CO_2 emission factor EF 1.6 t CO2 / t of ferroalloys was used , then in this NIR we derived the average value of the reducing agent consumption per 1 t of all ferroalloys production (thousand tons), then it was determined the average value of the reducing agent consumption per 1 ton of “Other” (thousand tons), which amounted to 0.56 tons .). Thus, greenhouse gas emissions from the category "Production of ferroalloys" are calculated using a reducing agent emission factor equal to 3.3t CO_2 /tonne of reducing agent.

[83]https://www.kazchrome.com/files/pdf/Kazchrom_ARA_2021_EN_updated.pdf

In connection with the updated statistics, according to the results of coordination with government agencies, the values of ferroalloy production volumes were recalculated for the entire time series. Data on the production of ferroalloys in Kazakhstan and greenhouse gas emissions from them are presented in Table 4.23 below. In this NIR, CH_4 emissions from ferroalloys were also calculated , in particular, according to the IPCC RP, 2006, the calculation of methane emissions comes from the production of ferrosilicon. The default emission factor for methane is 1.0 kg CO_2 /tonne produced.

Analysis of the data in Table 4.23, which shows the values of CO_2 and $CH_{4\ emissions}$ from the production of ferroalloys for the period 1990-2021. showed that the total emissions from the category of production of ferroalloys in 2021 amounted to 3523.337 thousand tons in CO_2 eq. There is a decrease in greenhouse gas emissions in 2021, which amounted to 8.6% compared to emissions in 2020, and compared to 1990, greenhouse gas emissions increased by 63.0%. Such changes are generally caused by: an increase in the volume of production of ferroalloys and, accordingly, an increase in the consumption of the amount of a reducing agent in the production of these ferroalloys.

Table 4.23 - Production volume and GHG emissions from ferroalloys for 1990-2021

years	Total production volume, thousand tons	Total $CO_{2\ emissions}$, thousand tons	Emissions of CH_4 in CO_2 eq., thousand tons	Emissions of CO_2 +CH_4 , thousand tons of CO_2 eq.
1990	1322.9	2145.949	15.35	2161.301
1991	1191.8	2044.888	13.15	2058.0411
1992	1063.3	1985.769	10.39	1996.164
1993	905	2018.579	7.62	2026.20
1994	647.4	1283.194	4.002	1287.197
1995	808.7	1593.743	5.01	1598.759
1996	534.4	942.452	1.93	944.390
1997	843.4	1916.803	2.04	1918.843
1998	726.3	1208.448	1.37	1209.825
1999	999.6	1673.826	2.09	1675.9245
2000	1092.0	1841.129	1.98	1843.1095
2001	1130.05	1877.182	2.16	1879.346
2002	1235.4	2197.087	1.88	2198.968
2003	1401.1	2455.063	1.87	2456.942
2004	1447.3	2650.578	1.51	2652.093
2005	1530.1	2733.124	1.53	2734.658
2006	1614.3	3252.052	1.26	3253.314
2007	1702.8	3237.950	0.88	3238.832
2008	1590.5	2859.038	0.81	2859.849
2009	1468.7	2473.860	0.52	2474.387
2010	1702.0	2823.394	0.10	2823.494
2011	1669.0	2696.729	0.05	2696.781
2012	1724.1	3081.916	0.03	3081.953
2013	1706.9	3101.683	0.03	3101.719
2014	1715.1	2985.447	0.02	2985.473
2015	1741.9	3166.411	1.32	3167.739
2016	1826.3	3097.129	1.00	3098.131
2017	1934.7	3386.608	0.77	3387.379

years	Total production volume, thousand tons	Total $CO_{2\ emissions}$, thousand tons	Emissions of CH_4 in CO_2 eq., thousand tons	Emissions of CO_2+CH_4, thousand tons of CO_2 eq.
2018	2088.1	3713.012	0.79	3713.802
2019	2175.7	3610.043	0.78	3610.826
2020	2214.6	3855.291	1.36	3856.649
2021	2070.04	3522.446	0.89	3523.337

4.4.2.3 Estimating uncertainty and consistency of time series

The main factors that determine the uncertainty of inventory results in this category are the uncertainty of data on the production of ferroalloys and data on the mass of the used reducing agent, slag-forming materials and waste, as well as their carbon content; due to the use of data obtained from not all enterprises that produce ferroalloys. Since the Tier 2 method was used, ferroalloy production data are obtained from the producer, the uncertainty of activity data is assumed to be less than 10%. The uncertainty of data on the mass of the used reducing agent, slag-forming materials and waste, as well as the carbon content in them, can be estimated at the level of 5%

Using production data from plants that produce between 88 and 96% of ferroalloys to estimate a weighted average CO2 emission factor $_{for}$ all plants in the industry can be estimated at 5%. Thus, the estimate of the uncertainty of $CO_{2\ emissions}$ is 7.1%.

4.4.2.4 QA/QC procedures

When performing calculations of $CO_{2\ emissions}$ from the production of ferroalloys, general and detailed QA/QC procedures were applied in accordance with Section 1.2.3 of the NIR2023. Among the detailed control procedures according to the statistics of the Republic of Kazakhstan and JSC “Transnational Company “KazKhrom”.

4.4.2.5 Recalculations and improvements

Recalculations have been made in this category. According to the recommendations (ARR 2019- ID # I .36 - I .37) in the category "Production of ferroalloys", the estimate of emissions from the category "Others" was revised, i.e. if earlier in the previous inventories the default $CO_{2\ emission\ factor}$ EF 1.6 t CO2 / t of ferroalloys was used , then in this NIR we derived the average value of the reducing agent consumption per 1 t of all ferroalloys production, thousand tons, then the average value of the reducing agent consumption was determined per 1 ton "Other" (0.56) thousand tons. Further, using the emission factor of the reducing agent equal to 3.3 t $CO_{2\ /\ ton\ of\ reducing\ agent,\ CO\ 2\ emissions}$ from "Other", thousand tons, were calculated . Thus, emissions from the category "Production of ferroalloys" are calculated using a reducing agent emission factor equal to 3.3t CO_2 /tonne of reducing agent.

Also, in connection with the updated statistics, based on the results of coordination with government agencies, the values of ferroalloy production volumes, the entire time series was recalculated. As a result of the recalculations, the changes were obtained, which are presented in table 4.24 below.

Table 4.24 - Comparative data on GHG emissions based on inventory results for 2020 and 2021 in the category "Production of ferroalloys"

years	GHG emissions from ferroalloy production, thousand tons		Difference, %
	NDK 202 0 g	NDK 202 1 g	
1990	1974.08	2161.301	growth by 6.7

2020	3796.34	3856.649	growth by 1.6
2021	-	3523.337	-

In general, according to the recalculation results, the changes affected 1990, which showed an increase of 6.7% in greenhouse gas emissions, while for 20210 and 2021. no changes. Also, in accordance with the recommendations of the ERT, Table 4.25 shows the values of production volumes by type of ferroalloys.

Table 4.25 - Production volumes by type of ferroalloys for 1990-2021, thousand tons

years	Ferrochrome production	Production of ferrosilicomanganese	Ferrosilicon production	Production of ferrosilicochromium	Other ferroalloys
1	2	3	4	5	6
1990	372.932	0	614.065	129.784	206.119
1991	357.42	0	526.142	60.554	247.684
1992	332.145	0	415.783	46.255	269.116
1993	274.02	0	304.815	29.751	296.413
1994	276.134	44,900	160.097	21.489	144.78
1995	428.076	21,800	200.688	17.014	141.122
996	292.436	60.100	77.533	54.332	49.999
1997	514.478	56,300	81.607	27.634	163.381
1998	470.254	57,600	55.071	26.453	116.922
1999	642.223	74.195	83.951	39.408	159.823
2000	691.222	98.076	79.233	44.807	178.662
2001	683.467	130.192	86.554	46.728	183.109
2002	660.544	145.890	75.237	65.422	288.307
2003	819.177	160.428	75.17	67.844	278.481
2004	901.054	137.078	60.62	91.108	257.44
2005	964.548	155.410	61.342	84.885	263.915
2006	969.372	202.874	50.473	103.0	288.581
2007	1086.68	159.790	35.29	126.24	293.8
2008	1097.157	159.988	32.449	117.905	183.02
2009	943.464	174.409	21.067	51.676	278.178
2010	1108.8	185.501	4.034	137.749	265.916
2011	1098.96	210.537	2.114	124.717	232.6726
2012	984.099	230.793	1.481	142.409	365.318
2013	1010.868	178.314	1.417	141.21	375.122
2014	1069.151	178.739	1.036	136.24	329.971
2015	1109.854	140.496	53.140	64.068	374.361
2016	1309.637	107.093	40.061	80.2	289.348
2017	1409.204	80.204	30.829	95.5	319.036
2018	1526.609	116.353	31.614	95.5	318.561
2019	1626.45	97.372	31.31	97.2	323.435
2020	1539.671	112.186	54.32	59.8	448.675
2021	1498.239	124.493	35.63	71.9	339.775

4.4.2.6 Planned improvements

No improvements are planned for this category.

4.4.3 Aluminum production (Subcategory 2C.3 CRF)

4.4.3.1 Category description

This section deals with emissions from primary aluminum production processes. JSC "Kazakhstan Electrolysis Plant" (KEP) is a Kazakhstani aluminum company. The only aluminum producer in Kazakhstan , located in the city of Pavlodar. Kazakhstan Aluminum Smelter JSC is part of ERG's alumina and aluminum division, which is the world's ninth largest supplier of traded alumina by volume (source: CRU, 2008).

This division consists of two separate enterprises: Pavlodar Aluminum Smelter (PAZ) and Kazakhstan Aluminum Smelter (KAZ), and includes two bauxite mines, a limestone mine, a thermal power plant, an alumina refinery and an aluminum smelter.

Recall that in the year of the launch of the first stage by the end of 2007, the Kazakhstan Aluminum Smelting Plant produced 11,000 tons of primary aluminum. In 2010, the First President of the Republic of Kazakhstan, Nursultan Nazarbayev, launched the second stage of production, which brought the enterprise to a design capacity of 250,000 tons.

All over the world, primary aluminum is produced by the electrolytic decomposition of alumina from a cryolithic-alumina melt using the Héroult-Hall method. In the aluminum industry, electrolyzers of various designs and capacities are used. The most modern technology for the production of primary aluminum, based on the achievements of the world's leading companies and the practical experience of recent years, includes the technology of electrolytic decomposition of aluminum oxide in a cryolite-alumina melt in electrolyzers with pre-baked anodes, equipped with highly efficient gas removal systems, central loading and point feeding of alumina (PFPB), this technology is used in the production of aluminum in the Republic of Kazakhstan.

The most significant emissions from aluminum production are: carbon dioxide (CO_2) as a result of the reaction of carbon anode carbon with aluminum oxide to form aluminum metal and perfluorocarbons (PFCs) - emissions of CF_4 and C_2F_6 as a result of the anode effects of CF_4 and C_2F6 . _ To a lesser extent, CO, SO 2 and NMVOCs are emitted from industrial processes.

SF_6 is not released in the electrolytic process and is generally very rarely used in the aluminum production process - only small amounts of SF_6 are released when fluxing aluminum alloys with a high magnesium content. In addition, we note that the value of the collected tar waste during the production of baked anodes is zero, since they are not formed. In the technological process of aluminum production in the Republic of Kazakhstan, electrode coal pitch is used, which is a product of coal tar processing, formed in the process of coal coking [84].

As noted above, the first complex of electrolysis production in the Republic of Kazakhstan JSC "Kazakhstan Aluminum Smelter" was put into operation in December 2007, therefore, data from aluminum production are provided for the period from 2007-2021. The share of CO_2 emissions from the production of aluminum and PFCs for 2021 for this category amounted to 3.0% of the total greenhouse gas emissions of the Metallurgical Industry Emissions category.

Table 4.26 shows the values of aluminum production volumes, as well as CO_2, CF_4 and C_2F_6 (PFC) emissions from aluminum production for the period 2007-2021.

Table 4.26 - Dynamics of greenhouse gas emissions from aluminum production for the period 2007-2021, thousand tons

[84]Letter ref. No. 1.16-0970 dated March 15, 2022, signed by the chief ecologist of KEP JSC, response to a request from Zhasyl JSC for data on activities

years	2007	2010	2011	2012	2014	2015	2016	2017	2018	2019	2020	2021
2.C.3 Aluminum production	11.74	227.30	248.76	248.94	209.51	221.59	235.56	254.99	258.41	263.58	265.10	262.36
$_2$ emissions from aluminum production	17.49	338.48	370.58	370.86	373.42	312.12	351.63	395.85	401.23	429.31	449.44	450.21
$_2$ emissions from tar volatile combustion	0	0	0	0	0	18.77	40.65	25.67	22.97	35.59	36.65	31.50
$_2$ emissions from kiln feed material	0	0	0	0	0	4.78	7.36	7.96	7.74	8.09	8.17	8.25
Emissions of CF_4 and C_2F_6 in CO_2 equivalent from aluminum production	29.79	622.51	529.87	530.26	236.45	199.76	196.66	209.06	84.05	127.78	12.67	10.75
Total emissions in CO_2 eq,	**47.292**	**961.13**	**900.46**	**901.12**	**609.88**	**511.88**	**548.30**	**604.91**	**485.28**	**557.09**	**462.12**	**460.96**

Improvements

An analysis of the data in Table 4.26 showed that greenhouse gas emissions in general for the Aluminum Production category (2C.3 CRF) for 2021 decreased by 4.5% compared to emissions for 2020. This is due to a slight decrease of 1.02% in aluminum production in 2021 compared to 2020. Emissions from the combustion of fossil fuels used in the production of baked anodes are covered in the Energy sector. According to recommendations I.39, based on the results of the annual review of the NIR (Review 2019) in the category "Aluminum production", we calculated two other sources of $CO_{2\ emissions}$ associated with anode roasting furnaces - combustion of volatile substances released during roasting and combustion of furnace feed material (coke). Equations 4.22 and 4.23, Section 4.4.2, Volume 3, IPCC RP, 2006, were used to calculate these emissions.

At the request of Zhasyl Damu JSC [85]for data on the activities of KEZ JSC for the preparation of the national inventory for 2021, more expanded information was obtained, including the volumes of aluminum production and the use of reducing agents for 2007-2021, which allowed us to move to a higher level of calculations, almost close to the level 3. In this regard, the entire series from 2007-2021 was recalculated. The results of the recalculations are given below in Table 4.27 in Section 4.4.3.5 "Recalculations and Improvements" of this inventory.

[85]Letter of request No. 13-1-13 / 2380-I dated 07/26/2022

PFC

During electrolysis, alumina (Al_2O_3) is dissolved in the fluoride melt, which is approximately 80% cryolite (Na_3AlF_6). Perfluorocarbons (the term PFC here means CF_4 and C_2F_6 substances) are formed in the reaction of anode carbon with a cryolite melt in violation of the technological process parameters, known as the "anode effect".

The slope method was used to calculate emissions from PFCs in this GHG inventory. The slope is equal to the number of kg of CF_4 per ton of aluminum production, divided by the number of minutes of anode effect per bath-day.

JSC "Kazakhstan Smelter" provided at the request of JSC "Zhasyl Damu" the values of minutes of anode effect per bath-day in detail for all years, while in previous inventories minutes of anode effect for Kazakhstan were calculated as an average value equal to 1.19. Since PFC emissions are measured in relation to a tonne of aluminum production, the equation includes the effect of current on the bath and the efficiency of the current, two main factors that determine the amount of aluminum produced in the bath. Equation 4.26 from 2006 IPCC SPM Volume 3 p.4.4.2.3 p.4.55 was used, which describes the slope method for CF_4 and C_2F_6 emissions. Values of slope coefficients for calculation of PFC emissions were used from Table 4.16 T.3 p.4.4.2.3 p. 4. 59 IPCC 2006 RP. and respectively amounted to values for CF_4 (0.143) and C_2F_6 (0.121).

4.4.3.2 Methodological approaches

The production of aluminum at the Kazakhstan Electrolysis Plant is based on the electrolytic decomposition of aluminum oxide in a cryolite-alumina melt and is carried out in electrolyzers. The consumption of prebaked anodes is the main source of carbon dioxide emissions from primary aluminum production. Other sources of industrial carbon dioxide emissions associated with anode prebaking account for less than 10% of total non-energy CO_2 emissions and are not accounted for. To calculate greenhouse gas emissions (CO_2 and PFCs) from the production of aluminum by electrolysis at the plants of the Republic of Kazakhstan, a calculation method is used using data on consumables and raw materials, their composition, specific consumption indicators, and the volume of products produced. All calculations use plant-level data (Tier 3 method). CO_2 emissions for pre-calcined cells are calculated using Equation 4.21 from IPCC SPM, 2006. (vol. 3, chapter 4, p. 4.45). The coefficients for calculating CO_2 emissions were used on the basis of data obtained from the results of laboratory studies of JSC KEP, provided in accordance with the letter ref. No. 1.16-0970 dated 15.03.2022 signed by the chief ecologist of KEZ JSC, for pre-baked electrolyzers, in which the sulfur content in the baked anodes is 1.84%; ash content in baked anodes 0.3%.

4.3.3 Estimating uncertainty and consistency of time series

$_2$ emission factors from anode carbon or anode mass are less than 5%. Reactions leading to CO_2 emissions are well understood; emissions are directly related to aluminum production volumes through the fundamental electrochemical equations for aluminum reduction at a carbon anode and oxidation in thermal processes. All calculations use plant-level data (Tier 3 method). While there may be variability in the minor components of the anode materials, this variability does not contribute significantly to the overall calculation of CO_2 emissions .

Indicators of annual aluminum production are characterized by very low uncertainty - less than 1%. The uncertainty of carbon consumption in the form of baked anodes or coke and in the form of anode mass is only slightly higher than the uncertainty for aluminum production - less than 2%. The other component of the Tier 3 factory emission calculation is activity data for the

anode effect, i.e. minutes of anode effect per bath-day or overvoltage of the anode effect. These parameters are recorded in the memory of an automated process control system, so the uncertainty of such data is low.

4.4.3.4 QA/QC procedures

When performing calculations of $CO_{2\ emissions}$ from aluminum production, general and detailed QA/QC procedures were applied in accordance with section 1.2.3.

4.4.3.5 Recalculations and improvements

In connection with the received more complete and expanded data on activities from KEZ JSC, the entire series from 2007-2021 was recalculated. As a result of the recalculations, there is a significant change in the total greenhouse gas emissions from the category "Aluminum production"; in 2007, an increase in emissions by 27.9%; in 2020 there is a decrease of 49.5%, table 4.27.

Table 4.27 - Comparative data on GHG emissions based on the results of inventories in 2020 and 2021 in the category "Aluminum production"

years	Total GHG emissions from aluminum production, thousand tons		Difference, %
	NDK 202 0 g	NDK 202 1 g	
2007	36.97	47.292	growth by 27.9%
2020	853.09	462.12	Decrease 49.5%
2021	-	460.96	0

4.4.3.6 Planned improvements

No improvements are planned for this category.

4.4.4 Magnesium production (Category 2C.4 CRF)

4.4.4.1 Subcategory description

The amount and type of emissions from the magnesium industry depends on the raw materials used to produce primary magnesium and/or the type of shielding gas mixture used to protect molten magnesium from oxidation in foundries and secondary metal smelters.

Primary magnesium is metallic magnesium obtained from mineral sources. Primary magnesium can be obtained either by electrolysis or by a thermal reduction process. Raw materials used for the production of primary magnesium include dolomite, carnalite, serpentite, mineralized water or sea water. The processing of carbonate raw materials (magnesite and dolomite) is accompanied by the release of CO_2. Carbon dioxide CO_2 is released during the calcination of carbonate ores (dolomite/magnesite), which precedes the electrolytic/thermal reduction stage.

The secondary production of magnesium involves the recovery and recycling of metallic magnesium from various magnesium-containing wastes, such as used parts, mechanical cutting waste, foundry scrap, furnace residues. Magnesium can be cast from primary and secondary magnesium. Magnesium casting processes involve working with a pure magnesium melt and/or a high magnesium alloy melt. In secondary magnesium production (recycling), processing, smelting and casting, the molten metal is protected from oxidation throughout the entire process by protective systems such as protective mixtures containing a carrier gas or in some cases a flux.

In the Republic of Kazakhstan, magnesium production is carried out at the country's only magnesium production enterprise, Ust-Kamenogorsk Titanium Magnesium Plant JSC (UKTMC JSC). For the production of magnesium at this enterprise, the method of electrolysis of molten

salts of magnesium chloride $MgCl_2$ and anhydrous carnallite $KCl_2 * MgCl_2$ is used . To protect liquid magnesium during casting , ground technical sulfur is used in production, which, when burned, forms a protective atmosphere of sulfur dioxide. No other methods were used to protect liquid magnesium during casting.

Thus, with this technology of magnesium production in the Republic of Kazakhstan, greenhouse gas emissions are not observed, which, accordingly, is not reflected in this NIR.

4.4.5 . Lead production (Category 2C.5 CRF)

4.4.5.1 Subcategory description

Lead has a number of unique properties: high ductility, malleability, density, low melting point, fluidity, lack of solubility of iron, as well as extreme resistance to corrosion and protection against the penetration of various types of radiation, which determines the wide demand for it in various industries, both in the form metal of acceptable purity, and a component of alloys.

For the processing of sulfide lead concentrates, both pyrometallurgical and hydrometallurgical technologies are applicable. However, due to technological imperfections, hydrometallurgical methods for extracting lead are uncompetitive with respect to pyrometallurgical methods and have not yet found application in industry.

There are two primary production methods for lead from lead concentrates. The first is sintering/smelting, which consists of sequential sintering and smelting and accounts for about 78% of primary lead production. The second method - direct smelting, without the sintering stage - accounts for 22% of primary lead production in developed countries. In the sintering/smelting process, the first stage of sintering involves mixing lead concentrates with recycled sinter, limestone and silica, oxygen and high lead slag in order to remove sulfur and volatile metals by incineration. Lead is smelted either in a traditional blast furnace or in the so-called Imperial Smelting furnace. The lead smelting process is a reduction reaction of lead oxide with the formation of CO_2 emissions . The product of the sintering process is a raw lead melt.

In the direct smelting process, there is no sintering step and lead concentrates and other materials are charged directly into the furnace where they are smelted and oxidized.

The secondary production of lead is equal to the volume of processing of recycled lead in order to prepare for reuse. The vast majority of this recycled lead comes from used lead batteries.

Estimation of CO_2 emissions from lead production was carried out in accordance with the methodology of the IPCC Guidelines for National Greenhouse Gas Inventories, 2006. In the national inventory of GHG emissions of the Republic of Kazakhstan, this category is not a key category.

4.4.5.2 Methodological approaches

In the Republic of Kazakhstan, the main lead production is carried out: according to the primary method - sintering / smelting of lead production, which is carried out at the lead plant of the Ust-Kamenogorsk metallurgical complex, the process of secondary lead production also takes place in the Republic of Kazakhstan. The share of greenhouse gas emissions from the “Lead Production 2.C.5 CRF” category in total emissions from the category “Emissions of the metallurgical industry” in 2021 amounted to 0.39%.

Speck obtained during agglomeration is melted in shaft furnaces. The purpose of mine smelting is to obtain crude lead by reducing its oxides from the charge and sinter. The reducing

agent and heat for melting are obtained by burning the coke loaded into the furnace. Also in shaft furnaces, scrap and crumbs of cut lead batteries are processed.

The secondary production of purified lead is equal to the volume of processing of recycled lead in order to prepare for reuse. The vast majority of this recycled lead comes from lead batteries. Lead batteries are either broken up in a hammer mill and smelted with or without desulfurization, or smelted whole without prior crushing. Traditional Imperial Smelting furnaces can be used to melt batteries and other secondary lead scrap.

In preparing this NIR, in order to reduce the uncertainty in the estimation of CO_2 emissions from lead production, data on lead production provided by the ASPIR Bureau of National Statistics of the Republic of Kazakhstan were used.

Category “Lead production 2.C.5 CRF” does not belong to the key category of emissions of the Republic of Kazakhstan, activity data provided by the Bureau of National Statistics of the ASPIR of the Republic of Kazakhstan was used, a Tier 1 method was used to calculate greenhouse gas emissions, which consists of multiplying default emission factors 0.52 tons/ton of lead produced. The coefficient value was used from Table 4.21 Volume 3 Section 4.6.2.2 p.4.81, 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Lead production volumes and GHG emissions from the Lead Production category for the entire time series are presented in Table 4.28.

Table 4.28 - Dynamics of greenhouse gas emissions from "Lead production" for 1990-2021, thousand tons of CO_2 eq.

	years								
	1990	1995	2000	2005	2010	2011	2012	2013	2014
2.C.5 Lead production	290.3	88.5	185.8	135.4	103.4	115.5	88.1	91.1	127.06
$_2$ emissions from lead production	150.9	46.02	96.6	70.4	53.7	60.0	45.8	47.3	66.1

Table 4.28 continued

years	2015	2016	2017	2018	2019	2020	2021
2.C.5 Lead production	120.1	134.1	149.1*	152.7*	132.6*	123.3*	111.3
$_2$ emissions from lead production	62.4	69.7	77.5	79.4	68.9	64.1	57.9

*Note - * Changes in source data according to the Bureau of National Statistics*

Due to changes in the baseline activity data for 2020, according to the Bureau of National Statistics , CO_2 emissions[86] for 2020 have been revised . According to the inventory calculations for 2021, CO_2 emissions from this category "Lead production" in 2021 amounted to 57.907 thousand tons of CO_2 eq., and this amounted to 38.36% of the 1990 level. Over the entire time series, we observe a decrease in greenhouse gas emissions, which is associated with a drop in lead production in the country. When comparing CO2 emissions in 2021 with 2020, there is also a slight decrease in emissions by 9.7%, which is also caused by the overall decrease in lead production in Kazakhstan.

[86] https :// stat . gov . kz /

4.4.5.3 Estimating uncertainty and consistency of time series

The estimation of uncertainties for lead production results mainly from the uncertainties associated with the activity data and, to a lesser extent, from the uncertainties associated with the emission factor.

As the data on lead production are obtained from the Bureau of National Statistics of the AASPIR RK, the uncertainty of the activity data was assumed to be ±10%. The default emission factor used in Tier 1 calculations has an uncertainty of ±50%, Table 4.23 Volume 3 Section 4.6.3.2 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

4.4.5.4 QA/QC procedures

When calculating $CO_{2\ emissions}$ from lead production, general QA/QC procedures were applied in accordance with Section 1.2.3 of the NIR. The detailed quality control procedures included:

– time series analysis of activity data (lead production volumes) and $CO_{2\ emissions}$ (assessment of annual changes and determination of the causes of these changes);

– assessment of the applicability of the default IPCC coefficients for national conditions.

4.4.5.5 Recalculations and improvements

Due to changes in the initial data on activities for 2020, according to the Bureau of National Statistics of the ASPIR RK, $CO_{2\ emissions}$ for the above year were revised. Table 4.29 shows the changes that have occurred after recalculations based on the results of inventories for 2020 and 2021.

According to the results of the annual review of the NIR (Review 2019, 2021), there were no comments and recommendations from the ERT in this category.

Table 4.29 - Comparative data on GHG emissions based on the results of inventories in 2020 and 2021 in the Lead Production category

years	GHG emissions from lead production, thousand tons		Difference, %
	NDK 202 0 g	NDK 202 1 g	
1990	150.9	150.9	-
2020	66.5	64.1	decrease by 3.6%
2021	-	57.9	-

4.4.5.6 Planned improvements

No improvements are planned for this category.

4.4.6 . Zinc production (Subcategory 2C.6 CFR)

4.4.6.1 Category description

In the national inventory of greenhouse gas emissions of the Republic of Kazakhstan, this category is not a key category. The share of emissions from the Zinc Production 2.C.6 CRF category in total emissions from the Metallurgical Industry Emissions category in 2021 was 2.01%.

Historically, the main environmental issue associated with the production of zinc from virgin materials has been sulfur dioxide emissions from the roasting and smelting of sulfide concentrates.

This problem has been effectively solved by the EU metallurgical enterprises, but in Kazakhstan it still remains relevant. When leaching cinder and other materials, solutions with a high iron content are formed. The precipitation of iron from solutions leads to the production of significant volumes of solid waste, which contain various impurities. Disposal of these wastes requires the use of special methods and technologies. Fugitive emissions from the sintering and roasting process are also significant and must be taken into account at all stages of the process. A typical example of this type of emissions are emissions of acid fumes in zinc electrolysis shops .

Estimates of CO2 emissions from $_{zinc}$ production were carried out in accordance with the methodology of the IPCC Guidelines for National Greenhouse Gas Inventories, 2006.

In the Republic of Kazakhstan, the primary production of zinc is carried out by a hydrometallurgical method, which does not produce non-energy emissions of $CO_{2.}$ In this method, zinc sulfide is calcined and zinc oxide is obtained. The zinc oxide is then treated with sulfuric acid and purified to remove iron impurities, copper and cadmium. The zinc is then recovered from the solution by electrolysis. The electrolytic process produces no non-energy CO2 emissions .

However, in Kazakhstan there is also a secondary method for the production of zinc from Waelz cakes in Waelz furnaces, which emits greenhouse gases CO_2 . This NIR considers greenhouse gas emissions from the secondary method of zinc production from Waelz cakes in Waelz furnaces produced by Kazzinc LLP. When implementing the hydrometallurgical method of zinc production, intermediate products are formed - zinc cake and copper-cadmium cake. In Kazakhstan, zinc cakes are processed to extract zinc and lead in Waelz furnaces (abroad, zinc cakes are mainly processed in the hydrometallurgical cycle).

4.4.6.2 Methodological approaches

In the Republic of Kazakhstan, metal zinc is produced by 3 zinc plants, 2 of which are part of the Kazzinc company (Ust-Kamenogorsk and Ridder), and Balkhash - part of the Kazakhmys company. At the same time, Kazzinc JSC accounts for about 87% of metal zinc production in Kazakhstan.

GHG emissions from zinc production, as noted above, do not belong to the key category of national greenhouse gas emissions of the Republic of Kazakhstan.

In section 4.4.6.1 “Category description”, it was indicated that in Kazakhstan the main production of zinc is carried out by the hydrometallurgical method, which does not give non-energy $CO_{2\ emissions}$. emissions of greenhouse gases CO_2 occur . Therefore, in this NIR, to calculate emissions from the zinc production category, Kazzinc LLP data on the volume of zinc production from weltz cakes were used.

Data on the volume of production of zinc from weltz cakes are not provided by the Bureau of National Statistics of ASPIR RK in the annual statistical collections.

Indicators for the volume of production of zinc from weltz cakes of Kazzinc LLP are included in the total amount of zinc production from the enterprise, i.e. they are already included in the total zinc production in the country, data on which are provided by the Bureau of National Statistics in their annual statistical collections. To calculate GHG emissions, we used the Tier 1 method (IPCC SPM, 2006), which consists of multiplying the default emission factors of 3.66 t/t of welz cake zinc produced.

Data on the production of zinc from Waelz cakes in Waelz furnaces from 1990-2021 are presented by Kazzinc LLP, Table 4.30.

Table 4.30 – Dynamics of GHG emissions from the secondary production of zinc from Waelz cakes in Waelz furnaces from 1990-2021, thousand tons of CO_2 eq.

years	1990	1995	2000	2005	2010	2011	2012	2013
2.C.6 Total zinc production in the Republic of Kazakhstan, thousand tons	314.9	169.2	262.6	357.09	318.85	319.84	319.84	320.15
Of these, zinc production in Waelz furnaces, thousand tons	31.74	19.44	26.32	28.18	78.01	81.98	106.05	84.73
$_2$ emissions from zinc production from Waelz - cakes, thousand tons CO2eq.	116.19	71.17	96.33	103.16	285.51	300.04	388.13	310.11

Table 4.30 continued

years	2014	2015	2016	2017	2018	2019	2020	2021
2.C.6 Total zinc production in the Republic of Kazakhstan, thousand tons	324.94	323.84	325.82	331.01	317.96	318.39	311.32	310.88
Of these, zinc production in Waelz furnaces, thousand tons	63.11	69.1	62.79	79.78	82.10	78.93	75.81	81.86
Emissions of CO2 $_{from}$ the production of zinc from Waelz-cakes, thousand tons of CO2eq.	231.01	252.90	229.83	291.99	300.48	288.88	277.49	299.61

Greenhouse gas emissions of CO_2 from the Zinc Production category from Waelz cakes in 2021 amounted to 299.61 thousand tons of CO_2 eq., which is more by 157.8% of greenhouse gas emissions in 1990. Thus, $CO_{2\ emissions}$ from the production of zinc from Waelz cakes in 2021 exceeded emissions in relation to 1990 by more than two times. Compared to emissions in 2020, emissions in 2021 showed an increase of 7.97%. This is due to the fact that in 2021 there is an increase in zinc production from weltz cakes compared to the previous year.

4.4.6.3 Estimating uncertainty and consistency of time series

The estimation of uncertainties for zinc production results mainly from the uncertainties associated with activity data and, to a lesser extent, from the uncertainties associated with the emission factor.

Since data on production of zinc from Waelz cakes are obtained directly from the manufacturer Kazzinc LLP, the uncertainty of activity data was assumed to be ±10%. The emission factor for individual production methods used in Tier 1 calculations has an uncertainty of ±20% (Table 4.25, Volume 3, Section 4.7.3, page 4.90 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories).

4.4.6.4 QA/QC procedures

in the calculation of $CO_{2\ emissions}$ from zinc production. The detailed quality control procedures included:

– time series analysis of activity data (zinc production from waelz cake) and $CO_{2\ emissions}$ (assessment of annual changes and determination of the causes of these changes);

– assessment of the applicability of the IPCC coefficients for individual modes of production in the country.

4.4.6.5 Recalculations and improvements

Based on the results of the annual review of the NIR (Review 2019, 2021) of the comments and recommendations of the ERT (I .41), section 4.4.6.2 describes in more detail that this category takes into account greenhouse gas emissions only from the production of zinc in Waelz furnaces, other zinc production technologies in the Republic of Kazakhstan do not lead to CO_2 emission . Table 4.30 also contains data on the total production of zinc in the country.

4.4.6.6 Planned improvements

In this category, improvements are planned to move the calculation of GHG emissions to a higher level.

4.6 EMISSIONS FROM THE ELECTRONICS INDUSTRY (CATEGORY CRF 2.E)

The electronics industry is one of the most knowledge-intensive industries, up to 2/3 of the entire production of which is the most complex technology. The global state of not only such high-tech industries as aerospace, defense, nuclear industry, medicine and automotive industry, but also traditional agriculture depends on the development of the industry along with information technology. Historically, there was practically no production of electronic components and modules in the Republic of Kazakhstan. In the Soviet Union, the electronics industry was located mainly in the European part of Russia, Belarus and Ukraine. At the same time, only separate enterprises were created on the territory of Kazakhstan, such as the State Union Plant (now the Kirov Plant), APTP "Granit" (SKTB "Granit"), Gidropribor, instrument-making plant "Omega", which specialized in the development, production, installation and tuning of radio-electronic complexes and devices [87]. To date, activities in the field of the electronic industry of Kazakhstan are aimed at import substitution of electronic products, which are needed for the implementation of projects within the framework of the state program "Digital Kazakhstan" for the digitalization of industry, energy, transport, agriculture and the creation of "smart" cities. Today Kazakhstan is in the stage of formation and development of the electronic industry. So far, this circumstance does not allow us to fully compete with the leading players in the global electronics market.

Based on the above, no greenhouse gas emissions are observed in this category, which, accordingly, is not reflected in this NIR.

[87] https :// www . inform . kz / ru / est - li - buduschee - u - otechestvennoy - elektronnoy - promyshlennosti - kazahstana

5. AGRICULTURE (SECTOR 3 CRF)

5.1 Overview by sector

This chapter presents the results of calculations of greenhouse gas emissions for 1990... 2021 . in the "Agriculture" sector for the following categories of activity:

– methane emissions (CH_4) from internal fermentation of farm animals (Category 3 A CRF);

– emissions of methane (CH_4) and nitrous oxide (N_2O) from manure collection, storage and use systems (category 3 B CRF);

CH_4) emissions from rice cultivation (category 3 C CRF);

N_2O) emissions from cultivated soils (category 3 D CRF);

CO_2) emissions from urea fertilization (Category 3 H CRF).

Since savannahs are not geographically distinguished on the territory of the Republic, the burning of crop residues on agricultural fields is prohibited by law (links are indicated in the relevant section) and there is no practice of liming the soil, the calculation of emissions for categories 3E (Controlled burning of savannahs), 3F (Burning of plant residues on fields) and 3 G (Liming) was not performed (detailed in sections 5.6-5.9). For other categories of activity, emissions were assessed in accordance with IPCC RP, 2006: v. 4. “Agriculture, forestry and other land uses” using methods corresponding to levels 1 and 2 [88]. The Agriculture sector is the second largest emitter of greenhouse gases after the Energy sector. The share of greenhouse gas emissions in the sector in total national emissions increased from 11.5% in 1990 to 11.8% in 2021 (Figure 5.1). The most significant sources of greenhouse gas emissions in the Agriculture sector are methane (CH4) emissions from internal fermentation of farm animals (53.7% in 2021), nitrous oxide (N2O) emissions from cultivated soils (36. 2% in 2021) and methane (CH4) and nitrous oxide (N2O) emissions from manure collection, storage and management systems (8.8% in 2021) .

To recalculate emissions into CO_2 equivalent , the global warming potentials (GWP) recommended by the IPCC were used: CH_4 - 25, N_2O - 298.

[88] Guidelines for National Greenhouse Gas Inventories.-IPCC.-2006. http://www.ipcc-ngip.iges.or.jp/public/2006gl/index.html

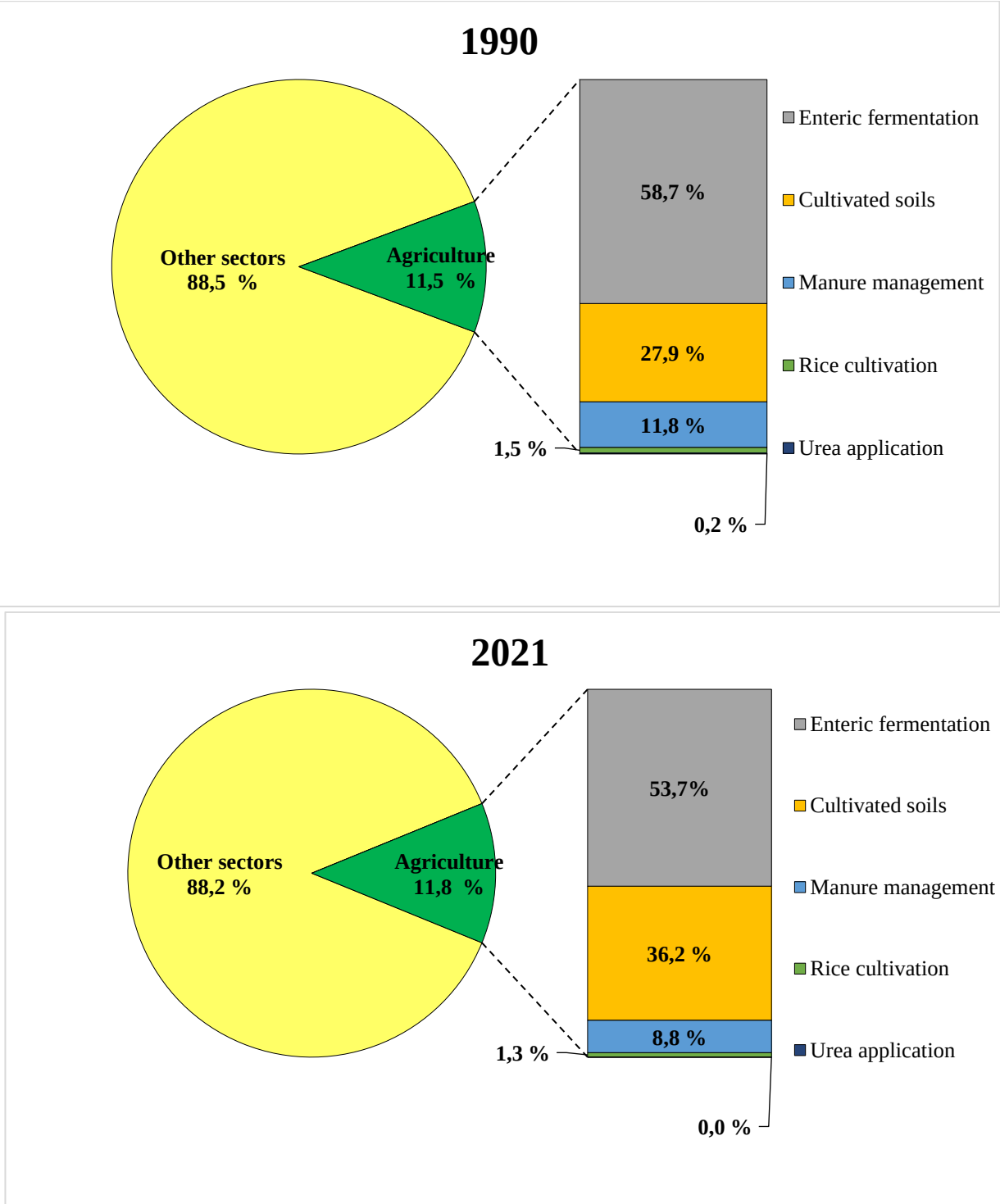
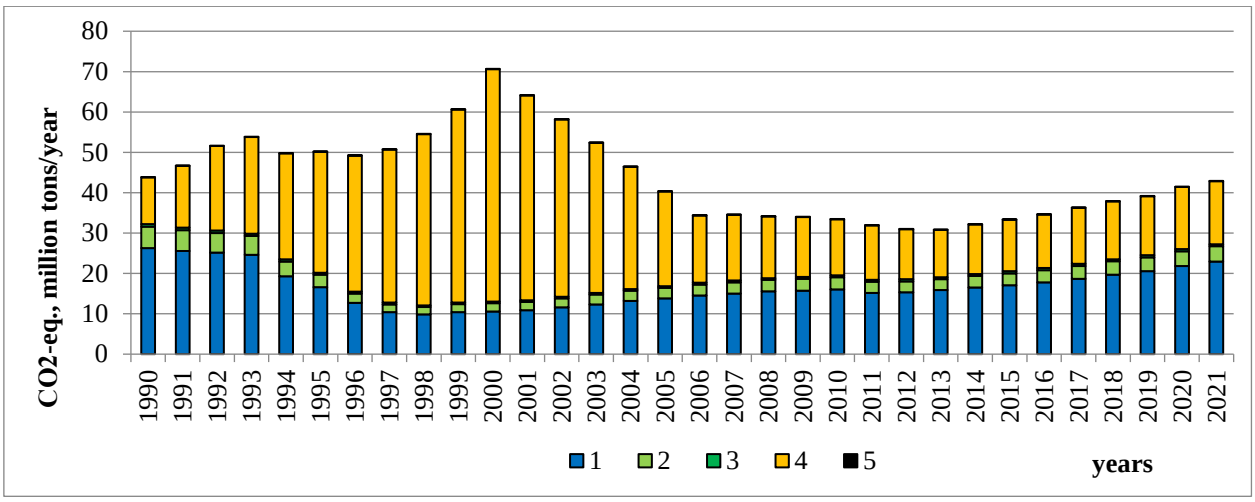


Figure 5.1 - Contribution of the "Agriculture" sector to total national greenhouse gas emissions in 1990 and 2021, % (excluding the LULUCF sector)

On fig. 5.2 and in table. Table 5.1 presents the results of calculations of greenhouse gas emissions from the "Agriculture" sector by activity category in accordance with the IPCC classification. The total greenhouse gas emissions in 2021 amounted to 42.845 million tons of CO_2 eq. and compared with 1990 decreased by 1.016 million tons (6%). Compared to 2020, emissions in 2021 increased by 1.426 million tons (2%). The minimum emission values were observed in 2013 (30.774 million tons).



1 - internal fermentation; 2 - manure management; 3 - rice cultivation; 4 - cultivated soils; 5 - the use of urea.

the "Agriculture" sector for 1990... 2021

The overall increase in emissions observed from 1990 to 2000 primarily associated with the dynamics of nitrous oxide emissions as a result of the mineralization of organic matter in the soil. The dramatic reduction in soil carbon has led to significant emissions from cropland, against which the reduction in emissions from livestock that occurred in the 1990s does not look so significant. In the 2000s, due to the improvement of the economic situation in the republic, the number of animals and sown areas show stable growth, and already due to this, there is a gradual increase in the total greenhouse gas emissions in the sector.

Table 5.1 - Greenhouse gas emissions from activities in the "Agriculture" sector for 1990 ... 2021, thousand tons of CO_2 eq .

years	internal fermentation	manure management	Rice cultivation	Cultivated soils	The use of urea	Total
	3A	3B	3C	3D	3H	3
1990	26245.50	5345.33	651.00	11514.72	104.40	43860.95
1991	25592.75	5138.21	624.75	15263.56	91.36	46710.63
1992	25167.00	4835.23	603.75	20961.32	78.31	51645.61
1993	24613.50	4695.69	567.00	23887.68	65.27	53829.14
1994	19261.00	3689.59	535.50	26262.74	52.23	49801.06
1995	16616.75	3099.92	441.50	29946.02	39.19	50143.38
1996	12717.50	2301.20	472.50	33679.96	26.14	49197.30
1997	10420.50	1922.24	435.75	37932.42	13.10	50724.01
1998	9834.50	1845.20	385.25	42441.16	0.06	54506.17
1999	10416.50	1969.91	372.75	47837.94	0.17	60597.27
2000	10601.25	2043.11	378.50	57597.44	0.08	70620.38
2001	10853.25	2103.60	363.25	50791.12	0.07	64111.29
2002	11564.50	2255.01	357.00	43978.84	0.06	58155.41
2003	12325.75	2436.42	439.00	37148.68	0.06	52349.91
2004	13169.00	2518.31	423.75	30273.82	0.24	46385.12
2005	13811.75	2608.82	445.75	23446.64	0.25	40313.21
2006	14497.50	2715.37	460.00	16705.88	0.13	34378.88
2007	15005.75	2815.58	458.75	16246.96	0.15	34527.19
2008	15533.00	2874.56	396.50	15317.20	0.56	34121.82
2009	15748.25	2917.45	456.25	14852.32	0.23	33974.50
2010	16077.50	2966.10	493.50	13848.06	0.68	33385.84
2011	15146.50	2781.59	489.75	13469.60	2.47	31889.91

years	internal fermentation	manure management	Rice cultivation	Cultivated soils	The use of urea	Total
	3A	3B	3C	3D	3H	3
2012	15322.00	2736.04	488.25	12426.60	0.72	30973.61
2013	15841.25	2769.53	472.00	11690.54	0.20	30773.52
2014	16514.75	2850.54	500.25	12238.86	0.55	32104.95
2015	17085.00	2931.54	518.75	12769.30	0.27	33304.86
2016	17808.00	3016.52	495.00	13246.10	0.59	34566.21
2017	18652.00	3148.02	548.75	13877.86	1.97	36228.60
2018	19682.50	3316.51	532.75	14321.88	2.54	37856.18
2019	20545.50	3443.94	546.00	14563.26	3.22	39101.92
2020	21853.00	3611.36	537.00	15412.56	5.60	41419.52
2021	22947.50	3771.36	507.25	15615.20	4.12	42845.43

The main share of greenhouse gas emissions for 2021 in the sector falls on methane (CH_4) - 24.336 million tons of CO_2 eq. (57%). The emission of nitrous oxide (N_2O) is 18.505 million tons of CO_2 eq. (43%), the amount of CO_2 emission from the use of urea is negligible (about 0.01%) (Figure 5.3).

In addition to emissions of gases with a direct greenhouse effect, additional calculations were made of emissions of indirect greenhouse gases , such as nitrogen oxides (NO_x) and non-methane volatile organic compounds (NMVOC)[89] . The results of these calculations are presented in Table 5.2.

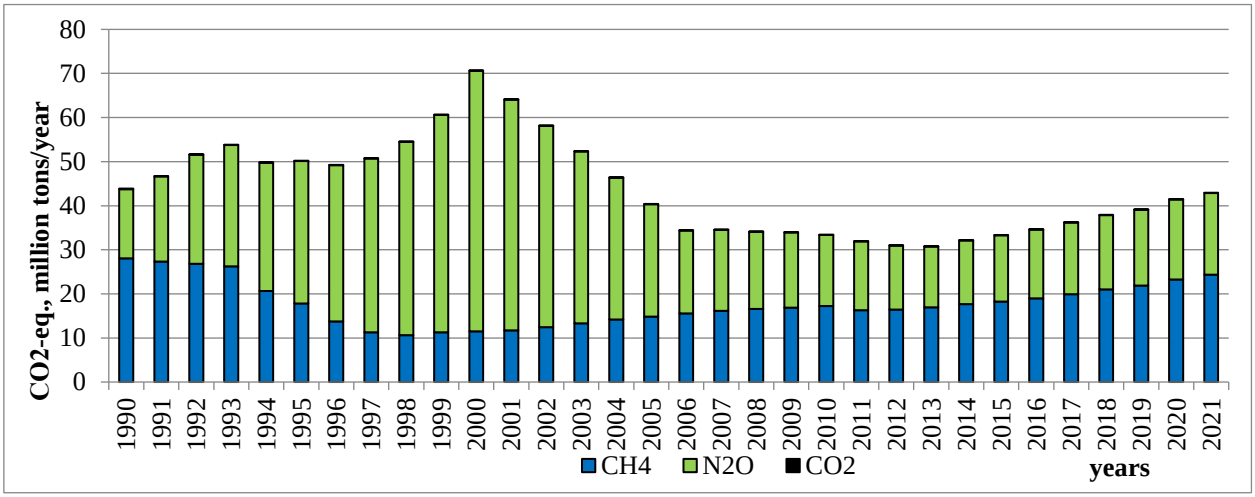


Figure 5.3 - Greenhouse gas emissions from activities in the "Agriculture" sector by types of gases for 1990 ... 2021

Table 5.2 - Emissions of greenhouse gases and pollutants from activities in the "Agriculture" sector by types of gases for 1990 ... 2021, thousand tons

years	Greenhouse gases, in CO_2 eq.			Pollutants	
	CH_4	N2O _ _	CO2 _	NOx	NMVOC
1990	28041.41	15715.14	104.40	57.76	149.07
1991	27326.33	19292.94	91.36	55.67	148.05

[89] . https://www.eea.europa.eu/publications/emep-eea-guidebook-2019

years	Greenhouse gases, in CO_2 eq.			Pollutants	
	CH_4	N2O _ _	CO2 _	NOx	NMVOC
1992	26819.65	24747.65	78.31	56.32	147.28
1993	26211.59	27552.28	65.27	44.73	141.46
1994	20655.27	29093.56	52.23	31.04	126.02
1995	17791.90	32312.29	39.19	26.17	108.71
1996	13741.37	35429.78	26.14	19.36	88.97
1997	11312.47	39398.44	13.10	15.96	73.22
1998	10659.49	43846.62	0.06	15.30	66.55
1999	11251.25	49345.85	0.17	15.93	64.29
2000	11464.03	59156.27	0.08	16.09	66.64
2001	11715.81	52395.41	0.07	16.53	69.45
2002	12454.86	45700.49	0.06	17.90	73.71
2003	13339.34	39010.52	0.06	19.32	77.13
2004	14182.81	32202.06	0.24	20.84	81.42
2005	14864.19	25448.77	0.25	21.63	84.60
2006	15591.66	18787.08	0.13	23.03	87.71
2007	16117.41	18409.63	0.15	24.28	90.44
2008	16598.14	17523.13	0.56	24.34	93.55
2009	16880.65	17093.62	0.23	25.22	96.52
2010	17259.15	16126.01	0.68	26.25	97.86
2011	16273.16	15614.28	2.47	25.74	92.89
2012	16434.66	14538.23	0.72	28.10	93.44
2013	16947.66	13825.66	0.20	26.47	95.97
2014	17664.67	14439.74	0.55	28.52	98.70
2015	18279.91	15024.68	0.27	29.54	101.22
2016	19002.93	15562.69	0.59	29.87	105.49
2017	19928.70	16297.93	1.97	31.79	110.46
2018	20981.71	16871.93	2.54	32.14	116.41
2019	21891.70	17207.00	3.22	32.19	120.89
2020	23235.21	18178.71	5.60	34.92	126.85
2021	24336.45	18504.86	4.12	36.75	133.36

5.2. Methane emissions from internal fermentation of farm animals (category 3A CRF)

5.2.1 Category description

Methane (CH_4) emissions from internal fermentation have been estimated for the main livestock species present in the Republic, including cattle (cows and non-dairy cattle), sheep, goats, horses, camels, pigs, donkeys and buffaloes. Emissions from poultry and rabbits have not been estimated.

Data on the number of livestock and poultry are mainly obtained from the materials of the Bureau of National Statistics of the ASPIR RK (Table 5.3). [90]Data on the number of donkeys and buffaloes are obtained from the materials of the FAO statistical unit [91].

For those species of animals that are seasonally slaughtered, the average annual number of animals was calculated (Table 5.4). For these purposes , statistical data on the intra-annual dynamics of the average monthly livestock in farms of all categories were used .

[90]http://www.stat.gov.kz/
[91] http :// www . fao . org / faostat

Correction factors were established by calculating the ratio of the average of the livestock values for each month to the livestock at the end of the year. They have the following values: non-dairy cattle - 1.213, sheep - 1.152, goats - 1.193, pigs - 1.250.

For other animal species, the coefficients turned out to be close to 1, and for them the average annual livestock was taken equal to the livestock at the end of the year. Then the resulting correction factors were applied to the entire series.

Table 5.3 - Number of livestock and poultry in the Republic of Kazakhstan for 1990 ... 2021, at the end of the year, thousand heads

years	Cows*	Non-dairy cattle**	Sheep*	Goats*	Camels*	Horses*	Pigs*	Bird*	Donkeys***	Buffalo***	Rabbits*
1990	3368,000	6389.200	34674.100	986.400	143,000	1626.300	3223.800	59898.8	45,000	12,000	205.700
1991	3490,000	6102.400	33558.800	996.900	145.100	1666.400	2976.100	59932.2	45,000	12,000	166.600
1992	3623.400	5952.900	33375.700	1044.100	148.800	1703.500	2591.000	52733.4	45,000	11,000	136.700
1993	3687.200	5659.400	33113.300	1094.800	154.800	1776.600	2445.200	49838.4	40,000	10,500	130,900
1994	3396.700	4676.200	24235.300	896.800	141.200	1636.000	1982.700	32715.9	40,000	10,500	99.700
1995	3045,000	3814.900	18724.500	859.400	130,500	1556.900	1622.700	20809.8	40,000	10,000	76,600
1996	2546.600	2878,000	12872,000	807.400	111.200	1310,000	1036.500	15377.9	35,000	10,000	62,400
1997	2109.600	2197.500	9636.900	747.400	97.100	1082.700	879,000	15982.2	29,000	9,000	49.200
1998	1952.800	2005.100	8691.300	835.200	95,800	986.300	891.800	16985.2	29,000	9,000	56.250
1999	1962.300	2035.900	8725.400	931.300	96.100	969.600	984.200	18022.4	30,000	9,000	63,300
2000	2014,700	2091.900	8939.400	1041.700	98.200	976,000	1076,000	19705.7	30,000	9,000	78,400
2001	2077.200	2216.300	9207.500	1271.100	103,800	989.500	1123.800	21130.2	30,000	9,000	92.400
2002	2171.400	2388.100	9787.500	1485.500	107,500	1019.300	1229.800	23790.6	30,000	9,000	115.300
2003	2267.300	2603.700	10420.100	1827.000	114,900	1064.300	1368.800	24823.1	30,000	9,000	105.200
2004	2376.200	2827.700	11286.700	2122.400	125.700	1120.400	1292.100	25606.1	31,000	9,000	92,800
2005	2442.600	3014,800	12005.500	2329.000	130,500	1163.500	1281.900	26215.5	30,000	10,000	92.600
2006	2569.000	3091.400	12813.700	2536.600	138.600	1235.600	1304.900	28239.3	30,000	10,000	82.100
2007	2605.600	3235.300	13470.100	2609.900	143.200	1291.100	1352.700	29506.8	30,000	10,000	79,700
2008	2675.400	3316.200	14126.100	2644.300	148.300	1370.500	1347.300	30148.4	30,000	10,000	68,500
2009	2717.300	3377.900	14660.820	2708.901	155,500	1438.700	1326.300	32686.5	30,000	10,000	75,200
2010	2751.300	3424,000	15313.101	2675.018	169.600	1528.300	1344,000	32780.6	30,000	10,000	75,200
2011	2502.800	3199.600	15439.438	2652.464	173.200	1607.400	1204.200	32870.1	30,000	10,000	82.100
2012	2580.100	3109.900	15137.217	2496.057	164.800	1686.200	1031.600	33474.0	30,000	10,000	78,600
2013	2734.800	3116.400	15197.780	2362.824	160,900	1784.500	922.300	34173.1	30,000	10,000	77,900
2014	2835.200	3197.500	15535.302	2379.266	165.888	1937.921	884.738	35020.0	30,000	10,000	84,400
2015	2999.347	3184.505	15688.315	2327.193	170.513	2070.273	887.627	35632.9	29.379	10,000	80.100
2016	3209.945	3203.260	15884.814	2299.424	180.077	2259.218	834.230	36910.021	29.174	10.067	89.561
2017	3362.435	3401.777	16049.807	2279.165	193.124	2415.654	815.121	39913.459	29.519	10.228	98.354
2018	3576.535	3574.385	16416.177	2282.948	207.566	2646.535	798.732	44337.924	29.689	10.293	102.980
2019	3769.765	3666.642	16912.945	2242.725	216.358	2852.256	813.269	45041.416	29.626	10.343	100.550
2020	4008.270	3841.775	17749.598	2307.969	227.703	3139.831	816.736	43334.963	29.562	10.392	103.608

years	Cows*	Non-dairy cattle**	Sheep*	Goats*	Camels*	Horses*	Pigs*	Bird*	Donkeys***	Buffalo***	Rabbits*
2021	4235.659	3956.756	18595.263	2281.513	243.365	3489.777	776.117	47884.731	29.562	10.392	103.608

* - the number of cows, sheep, goats, camels, horses, pigs, poultry and rabbits is given according to the Bureau of National Statistics ASPIR RK

** – number of non-dairy cattle obtained by subtracting the number of cows from the total number of cattle;

*** - the number of donkeys and buffaloes is given according to FAO data ;

Table 5.4 - The average annual number of livestock and poultry in the Republic of Kazakhstan for 1990 ... 2021, thousand heads *

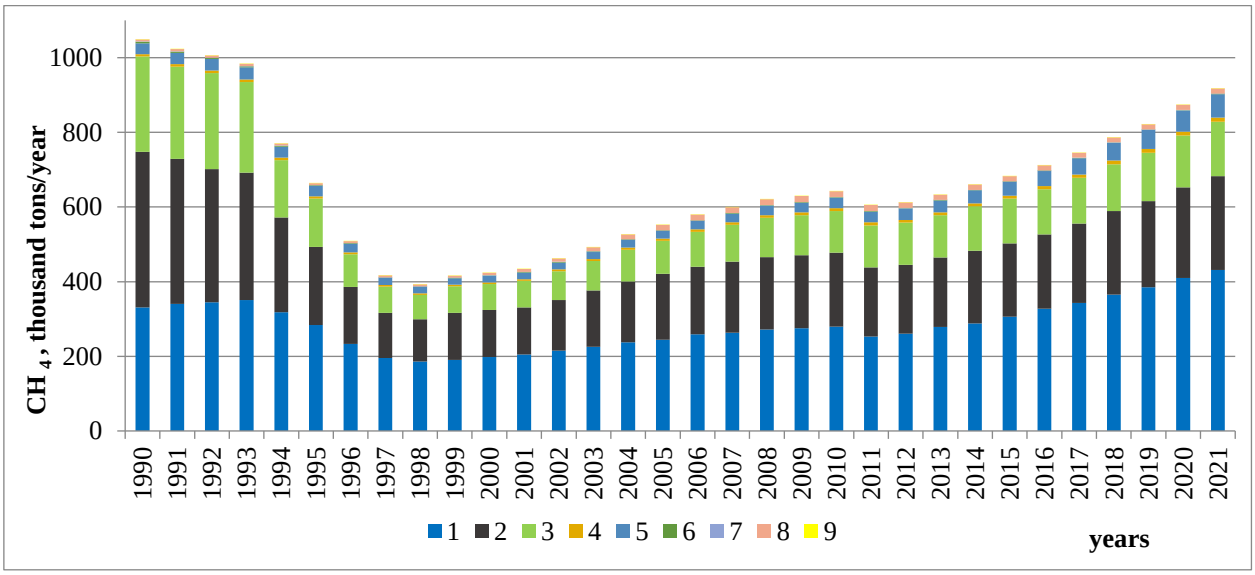
years	cows	Non-dairy cattle	Sheep	goats	camels	Horses	Pigs	Bird	donkeys	buffaloes	rabbits
1990	3368,000	7750.100	39944.563	1176.775	143,000	1626.300	4029.750	59898.8	45,000	12,000	205.700
1991	3490,000	7402.211	38659.738	1189.302	145.100	1666.400	3720.125	59932.2	45,000	12,000	166.600
1992	3623.400	7220.868	38448.806	1245.611	148.800	1703.500	3238.750	52733.4	45,000	11,000	136.700
1993	3687.200	6864.852	38146.522	1306.096	154.800	1776.600	3056.500	49838.4	40,000	10,500	130,900
1994	3396.700	5672.231	27919.066	1069.882	141.200	1636.000	2478.375	32715.9	40,000	10,500	99.700
1995	3045,000	4627.474	21570.624	1025.264	130,500	1556.900	2028.375	20809.8	40,000	10,000	76,600
1996	2546.600	3491.014	14828.544	963.228	111.200	1310,000	1295.625	15377.9	35,000	10,000	62,400
1997	2109.600	2665.568	11101.709	891.648	97.100	1082.700	1098.750	15982.2	29,000	9,000	49.200
1998	1952.800	2432.186	10012.378	996.394	95,800	986.300	1114.750	16985.2	29,000	9,000	56.250
1999	1962.300	2469.547	10051.661	1111.041	96.100	969.600	1230.250	18022.4	30,000	9,000	63,300
2000	2014,700	2537.475	10298.189	1242.748	98.200	976,000	1345,000	19705.7	30,000	9,000	78,400
2001	2077.200	2688.372	10607.040	1516.422	103,800	989.500	1404.750	21130.2	30,000	9,000	92.400
2002	2171.400	2896.765	11275.200	1772.202	107,500	1019.300	1537.250	23790.6	30,000	9,000	115.300
2003	2267.300	3158.288	12003.955	2179.611	114,900	1064.300	1711,000	24823.1	30,000	9,000	105.200
2004	2376.200	3430,000	13002.278	2532.023	125.700	1120.400	1615.125	25606.1	31,000	9,000	92,800
2005	2442.600	3656.952	13830.336	2778.497	130,500	1163.500	1602.375	26215.5	30,000	10,000	92.600
2006	2569.000	3749.868	14761.382	3026.164	138.600	1235.600	1631.125	28239.3	30,000	10,000	82.100
2007	2605.600	3924.419	15517.555	3113.611	143.200	1291.100	1690.875	29506.8	30,000	10,000	79,700
2008	2675.400	4022.551	16273.267	3154.650	148.300	1370.500	1684.125	30148.4	30,000	10,000	68,500
2009	2717.300	4097.393	16889.265	3231.719	155,500	1438.700	1657.875	32686.5	30,000	10,000	75,200
2010	2751.300	4153.312	17640.692	3191.296	169.600	1528.300	1680,000	32780.6	30,000	10,000	75,200
2011	2502.800	3881.115	17786.233	3164.390	173.200	1607.400	1505.250	32870.1	30,000	10,000	82.100

years	cows	Non-dairy cattle	Sheep	goats	camels	Horses	Pigs	Bird	donkeys	buffaloes	rabbits
2012	2580.100	3772.309	17438.074	2977.796	164.800	1686.200	1289.500	33474.0	30,000	10,000	78,600
2013	2734.800	3780.193	17507.843	2818.849	160,900	1784.500	1152.875	34173.1	30,000	10,000	77,900
2014	2835.200	3878.568	17896.668	2838.464	165.888	1937.921	1105.923	35020.0	30,000	10,000	84,400
2015	2999.347	3862.805	18072.939	2776.341	170.513	2070.273	1109.534	35632.9	29.379	10,000	80.100
2016	3209.945	3885.554	18299.306	2743.213	180.077	2259.218	1042.788	36910.021	29.174	10.067	89.561
2017	3362.435	4126.356	18489.378	2719.044	193.124	2415.654	1018.901	39913.459	29.519	10.228	98.354
2018	3576.535	4335.729	18911.436	2723.557	207.566	2646.535	998.415	44337.924	29.689	10.293	102.980
2019	3769.765	4447.637	19483.713	2675.571	216.358	2852.256	1016.586	45041.416	29.626	10.343	100.550
2020	4008.270	4660.073	20447.537	2753.407	227.703	3139.831	1020.920	43335.0	29.562	10.392	103.608
2021	4235.659	4799.545	21421.743	2721.845	243.365	3489.777	970.146	47884.7	29.562	10.392	103.608

* - calculated data

In 2021, the emission of methane (CH_4) during internal fermentation amounted to 917.06 thousand tons (Figure 5.4), which is 132.76 thousand tons (13 %) less than in 1990 (1049.82 thousand tons). Compared to 2020, emissions increased by 42.91 thousand tons (5 %). The lowest emission values were observed in 1998 (393.38 thousand tons).

Table 5.5 provides detailed information on methane (CH_4) emissions from internal fermentation by animal species. The largest contribution to the total emission in 2021 is made by such ruminant species as cows (47.06 %), non-dairy cattle (27.38%) and sheep (15.91%).



1 - cows; 2 - non-dairy cattle ; 3 - sheep; 4 - goats; 5 - camels; 6 - horses; 7 - pigs; 8 - donkeys; 9 - buffaloes

Figure 5.4 - Emission of methane (CH_4) during internal fermentation by types of farm animals for 1990 ... 2021

5.2.2 Methodological approaches

For farm animals that are the main contributors to methane emissions (cows, non-dairy cattle and sheep), a Tier 2 method was applied. like growth, lactation and pregnancy according to IPCC RP, 2006.

Table 5.5 - Emission of methane (CH_4) during internal fermentation of farm animals, thousand tons

years	Types of animals									
	cows	Non-dairy cattle	Sheep	goats	camels	Horses	Pigs	donkeys	buffaloes	Total
1990	330.74	416.96	255.25	5.88	6.58	29.27	4.03	0.45	0.66	1049.82
1991	340.31	388.91	247.04	5.95	6.67	30.00	3.72	0.45	0.66	1023.71
1992	344.40	356.64	257.61	6.23	6.84	30.66	3.24	0.45	0.61	1006.68
1993	350.80	341.46	242.61	6.53	7.12	31.98	3.06	0.40	0.58	984.54
1994	318.24	253.61	153.83	5.35	6.50	29.45	2.48	0.40	0.58	770.44
1995	284.07	208.61	129.86	5.13	6.00	28.02	2.03	0.40	0.55	664.67
1996	233.42	152.66	86.90	4.82	5.12	23.58	1.30	0.35	0.55	508.70
1997	195.33	120.80	70.38	4.46	4.47	19.49	1.10	0.29	0.50	416.82
1998	186.18	112.88	65.28	4.98	4.41	17.75	1.11	0.29	0.50	393.38
1999	190.72	125.72	70.76	5.56	4.42	17.45	1.23	0.30	0.50	416.66
2000	197.68	126.82	69.10	6.21	4.52	17.57	1.35	0.30	0.50	424.05
2001	204.54	126.06	71.17	7.58	4.77	17.81	1.40	0.30	0.50	434.13
2002	215.25	135.48	77.35	8.86	4.95	18.35	1.54	0.30	0.50	462.58
2003	225.57	151.09	78.51	10.90	5.29	19.16	1.71	0.30	0.50	493.03
2004	237.52	163.30	84.90	12.66	5.78	20.17	1.62	0.31	0.50	526.76
2005	244.53	176.70	87.96	13.89	6.00	20.94	1.60	0.30	0.55	552.47
2006	258.90	180.74	94.03	15.13	6.38	22.24	1.63	0.30	0.55	579.90
2007	263.50	190.10	98.69	15.57	6.59	23.240	1.69	0.30	0.55	600.23
2008	272.03	193.40	106.10	15.77	6.82	24.67	1.68	0.30	0.55	621.32
2009	275.56	195.57	107.08	16.16	7.15	25.90	1.66	0.30	0.55	629.93
2010	279.72	197.74	111.84	15.96	7.80	27.51	1.68	0.30	0.55	643.10
2011	252.88	185.67	112.23	15.82	7.97	28.93	1.51	0.30	0.55	605.86
2012	260.77	184.50	112.65	14.89	7.58	30.35	1.29	0.30	0.55	612.88
2013	278.24	186.70	113.10	14.09	7.40	32.12	1.15	0.30	0.55	633.65
2014	287.89	195.21	118.83	14.19	7.63	34.88	1.11	0.30	0.55	660.59
2015	306.05	196.23	120.19	13.88	7.84	37.26	1.11	0.29	0.55	683.40
2016	327.51	198.75	121.51	13.72	8.28	40.67	1.04	0.29	0.55	712.32
2017	343.30	212.01	122.95	13.60	8.88	43.48	1.02	0.30	0.56	746.10
2018	365.31	223.77	125.57	13.62	9.55	47.64	1.00	0.30	0.57	787.33

years	Types of animals									
	cows	**Non-dairy cattle**	**Sheep**	**goats**	**camels**	**Horses**	**Pigs**	**donkeys**	**buffaloes**	**Total**
2019	384.82	231.10	129.37	13.38	9.95	51.34	1.02	0.30	0.57	821.85
2020	409.44	243.21	138.84	13.77	10.47	56.52	1.02	0.30	0.57	874.14
2021	431.53	251.06	145.88	13.61	11.19	62.82	0.97	0.00	0.00	917.06
% of total emission in 2021	***47.06***	***27.38***	***15.91***	***1.48***	***1.22***	***6.85***	***0.11***	***0.00***	***0.00***	***100***

When deriving emission factors, data on the live weight of animals were used (Table 5.6). Cow weights are derived from scientific literature and peer review [92], [93]while non-dairy and sheep weights are from national statistical reporting. The average live weight of non-dairy cattle is significantly less than the mass of dairy cattle due to the fact that non-dairy cattle do not have time to reach their maximum possible weight before slaughter, which is usually done at 2-3 years of animal life.

Table 5.6 - Average live weight of one head of cattle, sheep and goats, kg

years	Cows*	Non-dairy cattle**	Sheep and goats***
1990	475	352	37
1991	475	341	37
1992	475	314	39
1993	475	317	37
1994	475	275	32
1995	475	278	35
1996	475	267	34
1997	475	280	37
1998	475	289	38
1999	475	327	41
2000	475	319	39
2001	475	293	39
2002	475	292	40
2003	475	301	38
2004	475	299	38
2005	475	305	37
2006	475	304	37
2007	475	306	37
2008	475	303	38
2009	475	300	37
2010	475	299	37
2011	475	301	37
2012	475	310	38
2013	475	314	38
2014	475	322	39
2015	475	326	39
2016	475	329	39
2017	475	331	39
2018	475	333	39
2019	475	336	39
2020	475	338	40
2021	475	339	40

*- data obtained by experts.

**- it is assumed that the data on the live weight of non-dairy cattle correspond to the data of the Bureau of National Statistics of the ASPIR RK on the “average live weight of cattle slaughtered on the farm or sold for slaughter”, since it is non-dairy cattle that are slaughtered.

[92] . Feed and feeding of dairy and beef cattle. ON THE. Zhazylbekov. I.I. Alimaev. A.A. Torehanov and others - Almaty. - 2011. - 143 p.

[93]A short guide to feeding beef and dairy cattle. ON THE. Zhazylbekov. A.A. Torekhanov. T.M. Kuliev and others - Almaty. -2011. - 154 p.

*** - data of the Bureau of National Statistics ASPIR RK .

Table 5.7 shows the main factors and parameters that were used to estimate gross energy consumption.

Table 5.7 - Coefficients and parameters for estimating the gross energy consumption of farm animals

Coefficient or parameter name	Meaning
C_{fi}, MJ/day x kg, Cows	0.386
C_{fi}, MJ/day x kg; Non-dairy cattle	0.370
C_{fi}, Sheep	0.217
C_a, Cows	0.234
C_a, Non-dairy cattle	0.234
C_a, Sheep	0.01051
Fat content of milk, %, Cows	3.7
$C_{pregnancy}$ (pregnancy rate), Cows	0.1
$C_{pregnancy}$ (pregnancy rate), Sheep	0.077
Y_m (CH_4 conversion factor), Cows, non-dairy cattle, sheep	0.065
k_e (feed digestibility coefficient), Cows, non-dairy cattle, sheep	60%

Where:

C_{fi} is a coefficient that varies depending on the type of animal;

C_a is the coefficient of physical activity, calculated taking into account the proportion of cattle and sheep that are in the stall and graze on the pasture;

C_a, cows = 0 · 0.35+0.36 · 0.65=0.234;

C_a, non-dairy cattle = 0 · 0.35+0.36 · 0.65=0.234;

C_a, sheep \u003d 0.009 · 0.11 + 0.0107 · 0.89 \ u003d 0.01051

Physical activity coefficients (C_a) corresponding to the conditions of animal feeding are obtained from Table 10.5 of the IPCC 2006 PM.

The default feed digestibility values (60%) from Table 10A.1 of IPCC SPM, 2006 for Eastern Europe were used as the most appropriate for Kazakhstan conditions.

The percentage of cattle content by various methods was obtained by analyzing the meteorological conditions in the regions of the Republic (in particular, this is the number of days with stable snow cover, the time required to start the growing season after the snow melts (10 days)[94] and distribution of livestock by regions in 2015 (Table 5.8). These values are applied for the entire time series due to the lack of data on livestock by regions in the 1990s and due to the fact that such distribution of animals does not change much from year to year. The meteorological stations used in the calculations most characteristically describe the climate of the corresponding region.

Table 5.8 - Calculation of the share of stall keeping of cattle

[94]Agrometeorological support of sheep breeding in Kazakhstan. Kazakh Research Institute for Environmental and Climate Monitoring. Chief editor A.M. Shamen. -Almaty.–1998.
–424 s.

Region	weather station	Number of days with stable snow cover	Duration of the stall period, days	Livestock of cattle, at the end of 2015	Share of the total livestock	Duration of the stall period, multiplied by the proportion of the population
Kazakhstan				6183 852	1.00	
Akmola	Astana	157	167	383 562	0.06	10.36
Aktobe	Aktobe	134	144	384 905	0.06	8.96
Almaty	Almaty	111	121	899 743	0.15	17.61
Atyrau	Atyrau	68	78	150 454	0.02	1.90
West Kazakhstan	Jambeyts	118	128	470 480	0.08	9.74
Zhambyl	Taraz	67	77	315 554	0.05	3.93
Karaganda	Karaganda	148	158	472 484	0.08	12.07
Kostanay	Kostanay	150	160	420 747	0.07	10.89
Kyzylorda	Kyzylorda	61	71	268 963	0.04	3.09
Mangistau	Tushchibek	32	42	13 566	0.00	0.09
Turkestan	Turkestan	50	60	847 957	0.14	8.23
Pavlodar	Pavlodar	141	151	385 481	0.06	9.41
North Kazakhstan	Blagoveshchenka	160	170	327 293	0.05	9.00
East Kazakhstan	Ust-Kamenogorsk	150	160	839 410	0.14	21.72
Astana	Astana	157	167	562	0.00	0.02
Almaty city	Almaty city	111	121	2691	0.00	0.05
					Average number of days in the stall	127.06
					% stall time	34.81≈35%

The percentage of sheep, goats and horses kept by various methods was obtained by analyzing the Kazakh scientific literature on pasture animal husbandry (for sheep, goats and horses, data on the duration of the stall period from sources 7 and the distribution of livestock by regions for 2015 were used. These values are also applied [95]for of the entire time series due to the lack of data on livestock in the context of regions in the 90s and due to the fact that such distribution of animals does not change much from year to year (Tables 5.9, 5.10, 5.11).

Table 5.9 - Calculation of the share of stalled sheep

[95]Reference book on the climate of Kazakhstan. Multi-year data. Republican State Enterprise "Kazgidromet". - Almaty. –2003

Region	Duration of the stall period, days	Sheep population, end of 2015	Share of total livestock	Duration of the stall period, multiplied by the proportion of the population
Kazakhstan		15 688 315	1.00	
Akmola	130.0	469 232	0.03	3.89
Aktobe	85	906 903	0.06	4.91
Almaty	0	2 852 083	0.18	0.00
Atyrau	78	433 188	0.03	2.15
West Kazakhstan	106	936 918	0.06	6.33
Zhambyl	0	2 152 569	0.14	0.00
Karaganda	120	843 462	0.05	6.45
Kostanay	128	337 922	0.02	2.76
Kyzylorda	0	399 094	0.03	0.00
Mangistau	0	257 808	0.02	0.00
South Kazakhstan	0	3 503 095	0.22	0.00
Pavlodar	130	496 794	0.03	4.12
North Kazakhstan	120	350 687	0.02	2.68
East Kazakhstan	51	1 746 522	0.11	5.68
Astana	0	882	0.00	0.00
Almaty	130	1 156	0.00	0.01
			Average number of days in the stall	38.98
			% stall time	10.68≈11%

Table 5.10 - Calculation of the proportion of stall keeping goats

Region	Duration of the stall period, days	Goat population, end of 2015	Share of total livestock	The duration of the stall period, multiplied by the proportion of the population
Kazakhstan		2 327 193	1.00	
Akmola	130.0	40 314	0.02	2.25
Aktobe	85	123 420	0.05	4.51
Almaty	0	411 923	0.18	0.00
Atyrau	78	98 742	0.04	3.31
West Kazakhstan	106	192 431	0.08	8.76
Zhambyl	0	260 626	0.11	0.00
Karaganda	120	205 764	0.09	10.61
Kostanay	128	78 904	0.03	4.34
Kyzylorda	0	171 309	0.07	0.00
Mangistau	0	77 508	0.03	0.00
South Kazakhstan	0	313 355	0.13	0.00
Pavlodar	130	68 907	0.03	3.85
North Kazakhstan	120	14 456	0.01	0.75
East Kazakhstan	51	269 156	0.12	5.90
Astana	0	60	0.00	0.00
Almaty	130	318	0.00	0.02
			Average number of days in the stall	44.30
			% stall time	12.14≈12%

Table 5.11 - Calculation of the share of stall keeping of horses

Region	Duration of the stall period, days	Number of horses, end of 2015	Share of total livestock	The duration of the stall period, multiplied by the proportion of the population
Kazakhstan		2070273	1.00	
Akmola	130.0	152 156	0.07	9.55
Aktobe	85	96 128	0.05	3.95
Almaty	0	273 008	0.13	0.00
Atyrau	78	59 107	0.03	2.23
West Kazakhstan	106	131 456	0.06	6.73
Zhambyl	0	103 353	0.05	0.00
Karaganda	120	245 289	0.12	14.22
Kostanay	128	99 044	0.05	6.12
Kyzylorda	0	97 485	0.05	0.00
Mangistau	0	57 861	0.03	0.00
South Kazakhstan	0	225 316	0.11	0.00
Pavlodar region	130	134 493	0.06	8.45
North Kazakhstan	120	109 372	0.05	6.34
East Kazakhstan	51	285 584	0.14	7.04
Astana	0	219	0.00	0.00
Almaty	130	402	0.00	0.03
			Average number of days in the stall	64.65
			% stall time	17.71≈18%

Local horses, sheep (for example, edilbaevskaya breed of sheep) and goats are able to graze even in severe frosts, digging snow with their hooves and eating grass left under the snow. In the past, on the territory of Kazakhstan, nomads did not harvest hay at all, which sometimes led to a large loss of livestock, the so-called jute . Now stall keeping for horses, sheep and goats is used mainly in the northern part of the Republic with high snow cover. And in the southern regions, where the main livestock of sheep and goats is concentrated, year-round grazing is traditionally common (Table 5.12).

Table 5.12 - Shares of keeping animals by different methods

Animal species	stall content	grazing
cows	0.35	0.65
Non-dairy cattle	0.35	0.65
Sheep	0.11	0.89
goats	0.12	0.88
camels	0	1
Horses	0.18	0.82
Pigs	1	0
donkeys	1	0
buffaloes	1	0

The camel population is concentrated in the south of Kazakhstan and, due to the endurance of this animal species, they are subjected to year-round grazing. The practice of keeping pigs shows that they are not grazing. Donkeys and buffaloes in the country have a very small number of livestock and are kept in a stall.

The calculations used data on the share of ewes in the livestock, as well as the weight of lambs at weaning, which was set at 28 kg [96]. The average daily milk yield was calculated from statistical data on the average annual milk production of cows (Table 5.13). Since 1992, milk production has generally increased and the emission factor correlates quite well with the amount of milk yield.

Table 5.13 - Average daily cow's milk yield and average daily wool shear from one sheep, kg

years	Average daily milk yield per dairy cow per day*	Output of calves per 100 queens**	Average wool shear per sheep**	Percentage of ewes in the livestock**
1990	5.45	81	3.0	62.3
1991	5.30	80	3.0	63.6
1992	4.82	73	2.8	62.6
1993	4.84	73	2.8	61.5
1994	4.58	67	2.3	65.1
1995	4.50	66	2.5	65.6
1996	4.12	66	2.5	65.2
1997	4.27	71	2.6	61.8
1998	4.86	75	2.8	59.0
1999	5.24	79	3.0	58.0
2000	5.39	84	3.0	59.4
2001	5.46	85	3.0	58.9
2002	5.60	86	3.0	55.5
2003	5.67	87	3.0	58.9
2004	5.78	87	2.9	58.1
2005	5.83	86	2.9	57.3
2006	5.96	88	2.9	61.4
2007	6.04	88	2.9	56.6
2008	6.17	88	2.9	55.7
2009	6.12	87	2.8	55.8
2010	6.18	87	2.8	54.7
2011	6.06	85	2.5	55.3
2012	6.08	84	2.4	55.3
2013	6.25	83	2.4	56.6
2014	6.23	81	2.5	57.4
2015	6.36	80	2.5	58.6
2016	6.37	79	2.4	60.2
2017	6.40	78	2.5	59.9
2018	6.41	78	2.4	60.1
2019	6.45	74	2.4	59.9
2020	6.48	73	2.2	60.7
2021	6.43	72	2.4	60.4

*- data obtained by dividing the annual average milk yield per dairy cow (data from the Bureau of National Statistics of ASPIR RK) by the number of days in a year.

**- data of the Bureau of National Statistics ASPIR RK

[96] Kasymov K.M., Ospanov S.R., Musabaev B.I., Khamzin K.P., Zhumadillaev N.K. Scientific and practical bases for increasing the meat productivity of sheep. –Almaty - 2012. -151 p.

The calculation of emission factors for cattle and sheep was carried out in accordance with Equation 10.21 of IPCC RP, 2006 using data on gross energy consumption (Table 5.14).

Table 5.14 - Gross energy consumption E_g, MJ/day

years	cows	Non-dairy cattle	Sheep
1990	230.3507	126.2051	21.6493
1991	228.7119	123.2354	21.6656
1992	222.9605	115.8425	22.6986
1993	223.1612	116.6714	21.5604
1994	219.7510	104.8745	18.6818
1995	218.8146	105.7313	20.3884
1996	215.0017	102.5776	19.8378
1997	217.1748	106.3010	21.4866
1998	223.6293	108.8534	22.0855
1999	227.9765	119.4211	23.8491
2000	230.1493	117.2228	22.7316
2001	230.9854	109.9816	22.7248
2002	232.5238	109.7000	23.2409
2003	233.3599	112.2265	22.1624
2004	234.4636	111.6667	22.1128
2005	234.8316	113.3429	21.5463
2006	236.4031	113.0643	21.5986
2007	237.2058	113.6218	21.5376
2008	238.5102	112.7850	22.0804
2009	237.8752	111.9466	21.4879
2010	238.4772	111.6667	21.4742
2011	237.0058	112.2265	21.3645
2012	237.0728	114.7333	21.8793
2013	238.6452	115.8425	21.8965
2014	238.1772	118.0490	22.5074
2015	239.3480	119.1469	22.5245
2016	239.3150	119.9684	22.5078
2017	239.4823	120.5146	22.5432
2018	239.5827	121.0605	22.5062
2019	239.4497	121.8776	22.5039
2020	239.6170	122.4211	23.0051
2021	238.9816	122.6929	23.0786

The results of emission factor calculations are given in Table 5.15.

Table 5.15 - Methane emission factors (CH_4) during internal fermentation of farm animals

years	Cows, kg/head per year	Non-dairy cattle, kg/head per year	Sheep, kg/head per year
1990	98.20	53.80	6.39
1991	97.51	52.54	6.39
1992	95.05	49.39	6.70
1993	95.14	49.74	6.36
1994	93.69	44.71	5.51
1995	93.29	45.08	6.02
1996	91.66	43.73	5.86
1997	92.59	45.32	6.34

years	Cows, kg/head per year	Non-dairy cattle, kg/head per year	Sheep, kg/head per year
1998	95.34	46.41	6.52
1999	97.19	50.91	7.04
2000	98.12	49.98	6.71
2001	98.47	46.89	6.71
2002	99.13	46.77	6.86
2003	99.49	47.84	6.54
2004	99.96	47.61	6.53
2005	100.11	48.32	6.36
2006	100.78	48.20	6.37
2007	101.13	48.44	6.36
2008	101.68	48.08	6.52
2009	101.41	47.73	6.34
2010	101.67	47.61	6.34
2011	101.04	47.84	6.31
2012	101.07	48.91	6.46
2013	101.74	49.39	6.46
2014	101.54	50.33	6.64
2015	102.04	50.80	6.65
2016	102.03	51.15	6.64
2017	102.10	51.38	6.65
2018	102.14	51.61	6.64
2019	102.08	51.96	6.64
2020	102.15	52.19	6.79
2021	101.88	52.31	6.81

When calculating emissions from goats, camels, horses, pigs, donkeys and buffaloes, default factors were used that are most appropriate for local conditions and animal characteristics (Table 5.16).

Table 5.16 Methane (CH_4) emission factors for internal fermentation of farm animals

Types of animals	$_4$ emission factor , kg/head per year
goats	5
camels	46
Horses	18
Pigs	1
donkeys	10
buffaloes	55

5.2.3 Uncertainty estimation and time series consistency

The initial statistical information has a high degree of reliability (±5%).

When calculating methane (CH_4) emissions from cows, non-dairy cattle and sheep, the emission factor uncertainty was ±20% (calculation level 2). For the rest of the animal species, emission calculations were performed using default factors, but using country-specific data (calculation level 1). Because the emission factors for the Tier 1 method are not based on extended country data, their accuracy was ±30%.

5.2.4 Quality assurance and control

Data on the number of farm animals obtained from the website of the Bureau of National Statistics of the ASPIR RK were compared with the data of the FAO statistical unit , as a result of which no differences were found. In addition, annually specialists of the Bureau of National Statistics of the ASPIR RK control the initial data used. The quality control of the calculations was

carried out by the specialists of JSC "Zhasyl Damu". In addition, as a result of the meeting of the interdepartmental working group, an assessment was made of the quality of the initial data and parameters, as well as the assessment of greenhouse gas emissions itself.

The general QA/QC procedures were carried out in accordance with Section 1.2.1 of the NIR.

5.2.5 Recalculations and planned improvements

Recalculations in this category were not carried out. No improvements are planned.

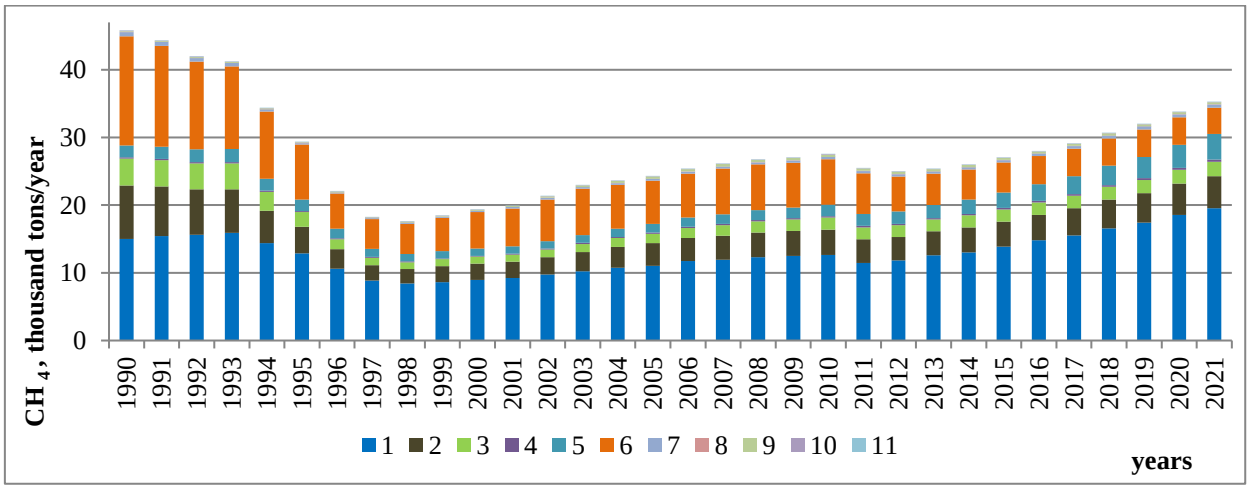
5.3 Methane and nitrous oxide emissions from manure collection, storage and use systems (category 3B CRF)

5.3.1 Emissions of methane (CH4)

5.3.1.1 Category description

Emissions of methane (CH_4) and nitrous oxide (N_2O) from manure collection, storage and use systems have been estimated for livestock species such as cattle (cows and non-dairy cattle), sheep, goats, horses, camels, pigs , donkeys, buffaloes, poultry and rabbits.

In 2021, methane (CH4) emissions from manure collection, storage and use systems amounted to 35.27 thousand tons, which is 10.53 thousand tons (23%) less than in 1990 (45.80 thousand . tons) (Figure 5.5). Compared to 2019, emissions increased by 1.80 thousand tons (6%). The smallest emissions were observed in 1998 (17.59 thousand tons).



1 - cows; 2 - non-dairy cattle ; 3 - sheep; 4 - goats; 5 - camels; 6 - horses; 7 - pigs; 8 - bird; 9 - donkeys; 10 - buffaloes; 11 - rabbits

Figure 5.5 - Emission of methane (CH_4) from manure collection, storage and use systems by types of farm animals

More detailed data on greenhouse gas emissions from manure collection, storage and use systems by animal species are presented in Table 5.17. The largest emissions in 2021 are observed from such types of farm animals as cows (54.89%), non-dairy cattle (13.63%) and pigs (12.07%).

Table 5.17 - Emissions of methane (CH_4) from systems for the collection, storage and use of manure by animal species, thousand tons.

years	Types of animals											
	cows	**Non-dairy cattle**	**Sheep**	**goats**	**camels**	**Horses**	**Pigs**	**Bird**	**donkeys**	**buffaloes**	**rabbits**	**Total**
1990	14.99	7.91	3.99	0.13	0.18	1.77	16.12	0.60	0.03	0.060	0.01646	45.80
1991	15.43	7.33	3.87	0.13	0.19	1.82	14.88	0.60	0.03	0.060	0.01333	44.35
1992	15.62	6.72	3.84	0.14	0.19	1.86	12.96	0.53	0.03	0.055	0.01094	41.96
1993	15.89	6.45	3.81	0.14	0.20	1.94	12.23	0.50	0.02	0.053	0.01047	41.24
1994	14.40	4.76	2.79	0.12	0.18	1.78	9.91	0.33	0.02	0.053	0.00798	34.35
1995	12.88	3.93	2.16	0.11	0.17	1.70	8.11	0.21	0.02	0.050	0.00613	29.35
1996	10.59	2.90	1.48	0.11	0.14	1.43	5.18	0.15	0.02	0.050	0.00499	22.05
1997	8.84	2.27	1.11	0.10	0.12	1.18	4.40	0.16	0.02	0.045	0.00394	18.25
1998	8.44	2.14	1.00	0.11	0.12	1.08	4.46	0.17	0.02	0.045	0.00450	17.59
1999	8.63	2.37	1.01	0.12	0.12	1.06	4.92	0.18	0.02	0.045	0.00506	18.48
2000	8.97	2.39	1.03	0.14	0.13	1.06	5.38	0.20	0.02	0.045	0.00627	19.37
2001	9.26	2.37	1.06	0.17	0.13	1.08	5.62	0.21	0.02	0.045	0.00739	19.97
2002	9.75	2.55	1.13	0.19	0.14	1.11	6.15	0.24	0.02	0.045	0.00922	21.33
2003	10.23	2.84	1.20	0.24	0.15	1.16	6.84	0.25	0.02	0.045	0.00842	22.98
2004	10.76	3.09	1.30	0.28	0.16	1.22	6.46	0.26	0.02	0.045	0.00742	23.60
2005	11.06	3.33	1.38	0.31	0.17	1.27	6.41	0.26	0.02	0.050	0.00741	24.27
2006	11.74	3.41	1.48	0.33	0.18	1.35	6.52	0.28	0.02	0.050	0.00657	25.37
2007	11.93	3.57	1.55	0.34	0.18	1.41	6.76	0.30	0.02	0.050	0.00638	26.12
2008	12.31	3.66	1.63	0.35	0.19	1.49	6.74	0.30	0.02	0.050	0.00548	26.75
2009	12.50	3.69	1.69	0.36	0.20	1.57	6.63	0.33	0.02	0.050	0.00602	27.05
2010	12.66	3.74	1.76	0.35	0.22	1.67	6.72	0.33	0.02	0.050	0.00602	27.53
2011	11.46	3.49	1.78	0.35	0.22	1.75	6.02	0.33	0.02	0.050	0.00657	25.48
2012	11.82	3.47	1.74	0.33	0.21	1.84	5.16	0.33	0.02	0.050	0.00629	24.98
2013	12.61	3.52	1.75	0.31	0.21	1.95	4.61	0.34	0.02	0.050	0.00623	25.38
2014	13.04	3.68	1.79	0.31	0.21	2.11	4.42	0.35	0.02	0.050	0.00675	25.99
2015	13.86	3.71	1.81	0.31	0.22	2.26	4.44	0.36	0.02	0.050	0.00641	27.05
2016	14.83	3.73	1.83	0.30	0.23	2.46	4.17	0.37	0.02	0.050	0.00716	28.00
2017	15.53	4.00	1.85	0.30	0.25	2.63	4.08	0.40	0.02	0.051	0.00787	29.12
2018	16.56	4.25	1.89	0.30	0.27	2.88	3.99	0.44	0.02	0.051	0.00824	30.66

years	Types of animals											
	cows	**Non-dairy cattle**	**Sheep**	**goats**	**camels**	**Horses**	**Pigs**	**Bird**	**donkeys**	**buffaloes**	**rabbits**	**Total**
2019	17.42	4.36	1.95	0.29	0.28	3.11	4.07	0.45	0.02	0.052	0.00804	32.01
2020	18.56	4.61	2.04	0.30	0.29	3.42	4.08	0.43	0.02	0.052	0.00829	33.81
2021	19.53	4.75	2.14	0.30	0.31	3.80	3.88	0.48	0.02	0.050	0.00812	35.2 7

5.3.1.2 Methodological approaches

(CH_4) emissions from manure and bird droppings collection, storage and use systems were calculated using the livestock numbers presented in section 6.1 of the NIR.

Emission factors for methane (CH_4) from cattle manure collection, storage and use systems are calculated at calculation methodological level 2. Volatile matter (VS) emissions were estimated using Equation 10.24 of the IPCC SPM, 2006, with a default ash content of manure of 8% .

In the process of deriving emission factors, the weighted average of the methane conversion factor (MCF) in each manure management system within the climatic region was determined, multiplied by the volatile matter emission rate (VS) and the maximum methane-producing capacity of manure (B_o) by animal species (Table 1). 5.18). The coefficients were derived using equation 10.23 of IPCC RP, 2006.

Table 5.18 – Methane conversion factor (MCF) for manure collection, storage and use systems, %

Manure collection, storage and use system	Methane Conversion Factor (MCF), %
Pasture	1
Dry matter storage	2

To estimate the maximum methane-producing capacity of manure (B_o), default values from tables 10A-4, 10A-5 of IPCC RP, 2006 were used. For cows, the value was 0.24 m^3 CH_4/kg, for non-dairy cattle - 0, 1. The results of emission factor calculations are presented in Table 5.19.

Table 5.19 - Volatile substance emissions (VS) and emission factors (EF) of methane (CH_4) from cattle manure collection, storage and use systems

years	Cows, VS	Non-dairy cattle , VS	Cows, EF	Non-dairy cattle , EF
1990	5.05	2.77	4.45	1.02
1991	5.02	2.70	4.42	0.99
1992	4.89	2.54	4.31	0.93
1993	4.90	2.56	4.31	0.94
1994	4.82	2.30	4.24	0.84
1995	4.80	2.32	4.23	0.85
1996	4.72	2.25	4.16	0.83
1997	4.76	2.33	4.19	0.85
1998	4.91	2.39	4.32	0.88
1999	5.00	2.62	4.40	0.96
2000	5.05	2.57	4.45	0.94
2001	5.07	2.41	4.46	0.88
2002	5.10	2.41	4.49	0.88
2003	5.12	2.46	4.51	0.90
2004	5.14	2.45	4.53	0.90
2005	5.15	2.49	4.53	0.91
2006	5.19	2.48	4.57	0.91
2007	5.20	2.49	4.58	0.91
2008	5.23	2.47	4.60	0.91
2009	5.22	2.46	4.60	0.90
2010	5.23	2.45	4.60	0.90
2011	5.20	2.46	4.58	0.90

years	Cows, VS	Non-dairy cattle , VS	Cows, EF	Non-dairy cattle , EF
2012	5.20	2.52	4.58	0.92
2013	5.24	2.54	4.61	0.93
2014	5.23	2.59	4.60	0.95
2015	5.25	2.61	4.62	0.96
2016	5.25	2.63	4.62	0.96
2017	5.25	2.64	4.62	0.97
2018	5.26	2.66	4.63	0.98
2019	5.25	2.67	4.62	0.98
2020	5.26	2.69	4.63	0.99
2021	5.24 _	2.69	4.61	0.99

For other animal species, default coefficients were applied in accordance with IPCC RP, 2006 (Table 5.20).

Table 5.20 Methane (CH_4) emission factors from manure collection, storage and use systems

Animal species	Methane emission factor (CH_4) , kg/head per year
Sheep	0.1
goats	0.11
camels	1.28
Horses	1.09
Pigs	4
Bird	0.01
donkeys	0.6
buffaloes	5
rabbits	0.08

5.3.1.3 Uncertainty estimation and time series consistency

The initial statistical information has a high degree of reliability (±5%).

In the calculation of methane (CH_4) emissions from cows and non-dairy cattle, the emission factor uncertainty was ±20% (calculation level 2). For the rest of the animal species, emission calculations were performed using default factors, but using country-specific data (calculation level 1). Because the emission factors for the Tier 1 method are not based on extended country data, their accuracy was ±30%.

5.3.1.4 Quality assurance and control

Data on the number of farm animals obtained from the website of the Bureau of National Statistics of the ASPIR RK were compared with the data of the FAO statistical unit , as a result of which no differences were found. In addition, annually specialists of the Bureau of National Statistics of the ASPIR RK control the initial data used. The quality control of the calculations was carried out by the specialists of JSC "Zhasyl Damu". In addition, as a result of the meeting of the interdepartmental working group, an assessment was made of the quality of the initial data and parameters, as well as the assessment of greenhouse gas emissions itself.

General QA/QC procedures were carried out in accordance with Section 1.2.1. NDK

5.3.1.5 Recalculations and planned improvements

The number of donkeys and buffaloes for 2015-2021 has been specified. according to FAO data , as well as unrounded values of methane emissions from buffalo are shown, however, these

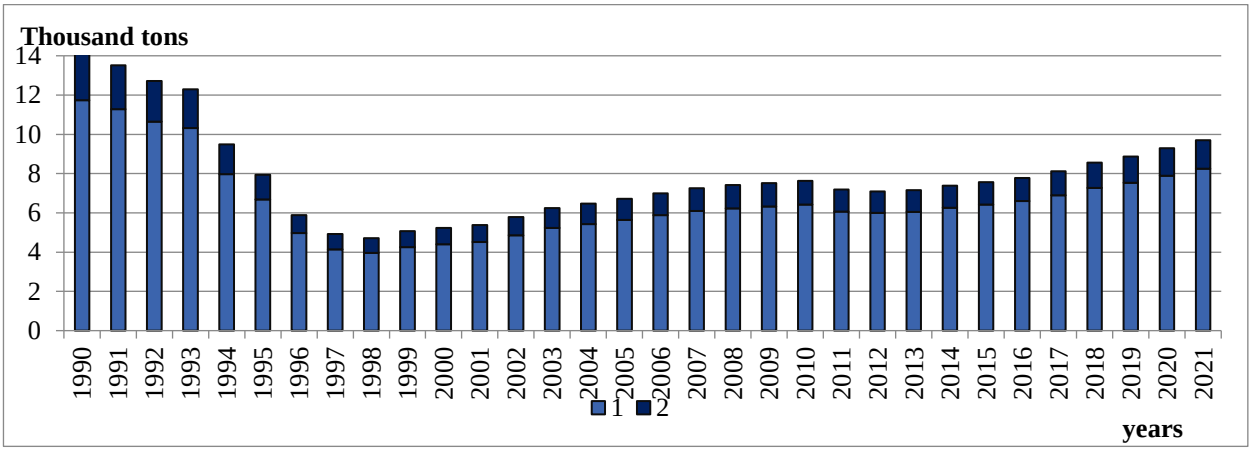
adjustments, due to small values, had almost no effect on the value of methane emissions. There are no upgrades in this category.

5.3.2 Emissions of nitrous oxide (N2O)

5.3.2.1 Category description

Livestock production in Kazakhstan is dominated by dry storage of pet and poultry waste. Manure is stored for a long time directly on the territory of farms and farmsteads. In this regard, the main contribution to emissions is made by direct emissions from dry systems for the collection, storage and use of manure. In addition, indirect emissions of nitrous oxide occur as a result of the volatilization of nitrogen in the form of NH_3 and NO_x.

In 2021, direct and indirect emissions of nitrous oxide (N_2O) from systems for the collection, storage and use of manure amounted to 9.70 thousand tons, which is 31% less than the emission in 1990 (14.10 thousand tons) (Figure 5.6). Compared to 2020, emissions increased by 0.36 thousand tons (4%). The smallest emissions were observed in 1998 (4.72 thousand tons) (table 5.21). The main reason for the decrease in emissions is also a significant reduction in the number of animals in the republic, which was observed from 1990 to 1998.



1 - direct emission; 2 - indirect emission

Figure 5.6 - Emission of nitrous oxide (N_2O) from systems for the collection, storage and use of manure

The largest contributors to nitrous oxide emissions from domestic animals are cows (34.29%), non-dairy cattle (27.75%), sheep (11.75%) and poultry (9.81%). Nitrous oxide emissions from animal manure from pastures are shown in section 5.5 Nitrous oxide emissions from cultivated soils.

Table 5.21 - Direct and indirect emissions of nitrous oxide (N_2O) from systems for the collection, storage and use of manure, thousand tons

years	Direct issue											Indirect emission	Sum of direct and indirect emission
	cows	Non-dairy cattle	Sheep	goats	Horses	Pigs	Bird	donkeys	Buivo-ly	rabbits	Total		
1990	2.25	3.83	1.72	0.08	0.24	2.55	1.02	0.020	0.017	0.05237	11.73937	2.356	14.09537
1991	2.33	3.55	1.67	0.08	0.25	2.35	1.02	0.020	0.017	0.04241	11.27941	2.242	13.52141
1992	2.42	3.19	1.66	0.08	0.25	2.05	0.89	0.020	0.015	0.03480	10.64980	2.056	12.70580
1993	2.46	3.06	1.65	0.09	0.26	1.93	0.85	0.018	0.015	0.03332	10.31632	1.981	12.29732
1994	2.27	2.19	1.20	0.07	0.24	1.57	0.56	0.018	0.015	0.02538	7.96838	1.531	9.49938
1995	2.03	1.81	0.93	0.07	0.23	1.28	0.35	0.018	0.014	0.01950	6.68150	1.259	7.94050
1996	1.70	1.31	0.64	0.06	0.19	0.82	0.26	0.016	0.014	0.01589	4.95589	0.916	5.87189
1997	1.41	1.05	0.48	0.06	0.16	0.69	0.27	0.013	0.013	0.01252	4.14852	0.771	4.91952
1998	1.30	0.99	0.43	0.07	0.15	0.70	0.29	0.013	0.013	0.01432	3.97032	0.746	4.71632
1999	1.31	1.13	0.43	0.07	0.14	0.78	0.31	0.013	0.013	0.01611	4.25211	0.808	5.06011
2000	1.34	1.14	0.44	0.08	0.14	0.85	0.33	0.013	0.013	0.01996	4.38596	0.845	5.23096
2001	1.39	1.11	0.46	0.10	0.15	0.89	0.36	0.013	0.013	0.02352	4.51952	0.864	5.38352
2002	1.45	1.19	0.49	0.12	0.15	0.97	0.40	0.013	0.013	0.02935	4.84535	0.932	5.77735
2003	1.51	1.34	0.52	0.15	0.16	1.08	0.42	0.013	0.013	0.02678	5.23278	1.015	6.24778
2004	1.59	1.44	0.56	0.17	0.17	1.02	0.43	0.014	0.013	0.02362	5.43062	1.040	6.47062
2005	1.63	1.57	0.60	0.19	0.17	1.01	0.44	0.013	0.014	0.02357	5.64057	1.078	6.71857
2006	1.71	1.60	0.64	0.20	0.18	1.03	0.48	0.013	0.014	0.02090	5.86790	1.116	6.98390
2007	1.74	1.69	0.67	0.21	0.19	1.07	0.50	0.013	0.014	0.02029	6.09729	1.160	7.25729
2008	1.79	1.71	0.70	0.21	0.20	1.06	0.51	0.013	0.014	0.01744	6.22444	1.178	7.40244
2009	1.81	1.73	0.73	0.22	0.21	1.05	0.55	0.013	0.014	0.01914	6.32614	1.195	7.52114
2010	1.84	1.75	0.76	0.21	0.23	1.06	0.56	0.013	0.014	0.01914	6.43614	1.208	7.64414
2011	1.67	1.64	0.77	0.21	0.24	0.95	0.56	0.013	0.014	0.02090	6.06790	1.129	7.19690
2012	1.72	1.64	0.75	0.20	0.25	0.81	0.57	0.013	0.014	0.02001	5.98701	1.099	7.08601
2013	1.83	1.67	0.76	0.19	0.26	0.73	0.58	0.013	0.014	0.01983	6.06683	1.098	7.16483
2014	1.89	1.76	0.77	0.19	0.29	0.70	0.59	0.013	0.014	0.02149	6.25849	1.127	7.38549
2015	2.00	1.77	0.78	0.19	0.31	0.70	0.60	0.013	0.014	0.02039	6.41739	1.151	7.56839
2016	2.14	1.80	0.79	0.18	0.33	0.66	0.63	0.013	0.014	0.02280	6.59980	1.174	7.77380
2017	2.24	1.92	0.80	0.18	0.36	0.64	0.68	0.013	0.014	0.02504	6.89204	1.229	8.12104
2018	2.39	2.03	0.82	0.18	0.39	0.63	0.75	0.013	0.014	0.02622	7.26322	1.294	8.55722

years	Direct issue											Indirect emission	Sum of direct and indirect emission
	cows	Non-dairy cattle	Sheep	goats	Horses	Pigs	Bird	donkeys	Buivo-ly	rabbits	Total		
2019	2.52	2.10	0.84	0.18	0.42	0.64	0.76	0.013	0.014	0.02560	7.53260	1.339	8.87160
2020	2.68	2.21	0.88	0.18	0.46	0.64	0.74	0.013	0.014	0.02638	7.89338	1.389	9.28238
2021	2.83	2.29	0.97	0.18	0.51	0.61	0.81	0.013	0.014	0.02583	8.25283	1.444	9.69683

5.3.2.2 Methodological approaches

To estimate nitrous oxide (N_2O) emissions from manure collection , storage and management systems, the total nitrogen (N) excreted by all animal species in each type of manure collection , storage and management system was multiplied by the emission factor for that type of system . After that, nitrogen (N) was recalculated into nitrous oxide (N_2O) and emissions were summed for all systems . Table 5.22 shows the emission factors used to calculate nitrous oxide (N_2O) emissions from manure. When calculating the emission of nitrous oxide (N_2O) on pastures, a coefficient of 0.02 for cattle and 0.01 for other animals was used.

Table 5.22 - Nitrous oxide (N_2O) emission factors for various manure collection, storage and use systems

System	**Nitrous oxide emission factor, kg N_2ON/kg**
Pasture	cattle - 0.02
	Other animal species - 0.01
Pen for feeding	0.02
liquid manure/slurry	0.005

In this category, all emissions of nitrous oxide (N_2O) were estimated before manure was applied to the soil. Emission factors are obtained in accordance with the IPCC RP, 2006 and are given in Table 5.23.

Table 5.23 - Nitrogen emission factors (N) from manure collection systems, storage and use

Animal species	**Nitrogen release rate from manure, kg N/head per year**
cows	60.68
Non-dairy cattle	34.11…44.97
Sheep	10.51…13.47
goats	12.48
camels	30.10
Horses	26.06
Pigs	25.93
Bird	0.54
donkeys	14.24
buffaloes	44.38
rabbits	8.1

$_2O$) emission factors were calculated using averaged animal weights and default nitrogen emission rates from the IPCC SPM, 2006 (Table 5.24).

Table 5.24 - Typical animal weight and nitrogen excretion rates (N)

Animal species	Typical animal weight for a given type of livestock T, kg/animal	$N_{rate(T)}$ = default nitrogen excretion rates, kg N / 1000 kg animal weight x day
cows	475	0.35
Non-dairy cattle	267…352	0.35
Sheep	32…41	1.28
goats	38	0.90
camels	217	0.38
Horses	238	0.30
Pigs	96	0.74
Bird	1.8	0.82
donkeys	130	0.30
buffaloes	380	0.32

Information on the distribution of manure by systems of its collection, storage and use is presented on the basis of an analysis of scientific literature, local meteorological conditions and the distribution of livestock by regions (Table 5.25) and directly depends on the proportion of animals kept by various methods. A detailed explanation is shown in section 5.2.2. For pigs, the default value for Eastern Europe was used.

Table 5.25 - Shares of different systems of collection, storage and use of manure in livestock in Kazakhstan

Animal species	Liquid manure storage systems, in fractions of a unit	Dry manure storage systems, in fractions of a unit	Manure that remains on pastures and pastures, in fractions of a unit
cows	0	0.35	0.65
Non-dairy cattle	0	0.35	0.65
Sheep	0	0.11	0.89
goats	0	0.12	0.88
camels	0	0	1
Horses	0	0.18	0.82
Pigs	0.3	0.7	0
Bird	0	1	0
donkeys	0	1	0
buffaloes	0	1	0
rabbits	0	1	0

Indirect N_2O emissions from volatilization of nitrogen in the form of NH_3 and NO_x were estimated using Equation 10.27 of IPCC SPM, 2006.

5.3.2.3 Uncertainty estimation and time series consistency

The initial statistical information has a high degree of reliability (± 5%).

Emissions calculations were performed at methodological level 1 using country specific data. The range of uncertainty in the calculation of nitrous oxide emissions was ±50%.

5.3.2.4 Quality assurance and control

Data on the number of farm animals obtained from the website of the Bureau of National Statistics of the ASPIR RK were compared with the data of the FAO statistical unit , as a result of which no differences were found. In addition, annually specialists of the Bureau of National Statistics of the ASPIR RK control the initial data used. The quality control of the calculations was carried out by the specialists of JSC "Zhasyl Damu". In addition, as a result of the meeting of the

interdepartmental working group, an assessment was made of the quality of the initial data and parameters, as well as the assessment of greenhouse gas emissions itself.

General QA/QC procedures were carried out in accordance with the procedures described in Section 1.2.1 of the NIR.

5.3.2.5 Recalculations and planned improvements

The number of donkeys and buffaloes for 2015-2021 has been specified. according to the FAO , however, these adjustments, due to small values, had almost no effect on the amount of nitrous oxide emissions.

A technical error in the calculation of nitrous oxide emissions from pigs was corrected (the coefficient for liquid manure management systems was not applied correctly), which resulted in a slight reduction in emissions over the entire time series.

A time series with sheep live weight values was used instead of a fixed value, as a result, greenhouse gas emissions did not change significantly over the entire time series.

For the most numerous animal species, it is planned to obtain baseline data for calculating nitrous oxide (N_2O) emissions from manure collection, storage and use systems at a higher methodological level.

5.4 Methane emissions from rice cultivation (category 3C CRF)

5.4.1 Category description

In Kazakhstan, rice fields occupy a small area of arable land. In 2021, the area sown with rice amounted to 96.634 thousand hectares. The main rice-growing region is the Kyzylorda region, where about 86% of the sown area of rice is concentrated, the rest is in Almaty (11%) and Turkestan regions (3%).

Rice is grown under irrigation conditions in areas provided with heat on the ancient deltaic plains adjacent to the channels of large rivers on gray-brown and takyr-like soils, relatively poor in humus content. In national practice, rice is cultivated with a shortened period of flooding with the application of mineral nitrogen and organic fertilizers, in accordance with agricultural technology [97]. The contribution of rice fields to total greenhouse gas emissions from the Agriculture sector is insignificant. In 2021, methane (CH_4) emissions amounted to 20.29 thousand tons, which is 5.75 thousand tons (22%) less than in 1990 (Fig. 5.7, Table 5.26). Compared to 2020, emissions decreased by 1.19 thousand tons (6%) due to a decrease in the sown area. The minimum emission values were observed in 2002 (14.28 thousand tons).

Table 5.26 - Emission of methane (CH_4) from rice fields for 1990...2020

years	removed area, thousand ha	CH_4 emission , thousand tons
1990	124.00	26.04
1991	119.00	24.99
1992	115.00	24.15

[97] Aleshin E.P., Konokhova V.P. The rice grower's short guide. Moscow: Agropromizdat, 1986.; The system of agricultural production of the Kyzylorda region: Recommendations. Almaty: Bastau Publishing House LLP, 2002; Ramazanova S.B. Nitrogen nutrition and productivity of rice. / Abstract of a doctoral dissertation. M., 2003; Agriculture system of the Almaty region: Recommendations. Almaty: Nurly Alem LLP. 2005. 296 p.

years	removed area, thousand ha	CH_4 emission , thousand tons
1993	108.00	22.68
1994	102.00	21.42
1995	84.10	17.66
1996	90.00	18.90
1997	83.00	17.43
1998	73.40	15.41
1999	71.00	14.91
2000	72.10	15.14
2001	69.20	14.53
2002	68.00	14.28
2003	83.60	17.56
2004	80.70	16.95
2005	84.90	17.83
2006	87.60	18.40
2007	87.40	18.35
2008	75.50	15.86
2009	86.90	18.25
2010	94.00	19.74
2011	93.30	19.59
2012	93.00	19.53
2013	89.90	18.88
2014	95.30	20.01
2015	98.80	20.75
2016	94.30	19.80
2017	104.50	21.95
2018	101.48	21.31
2019	103.98	21.84
2020	102.278	21.48
2021	96.634	20.29

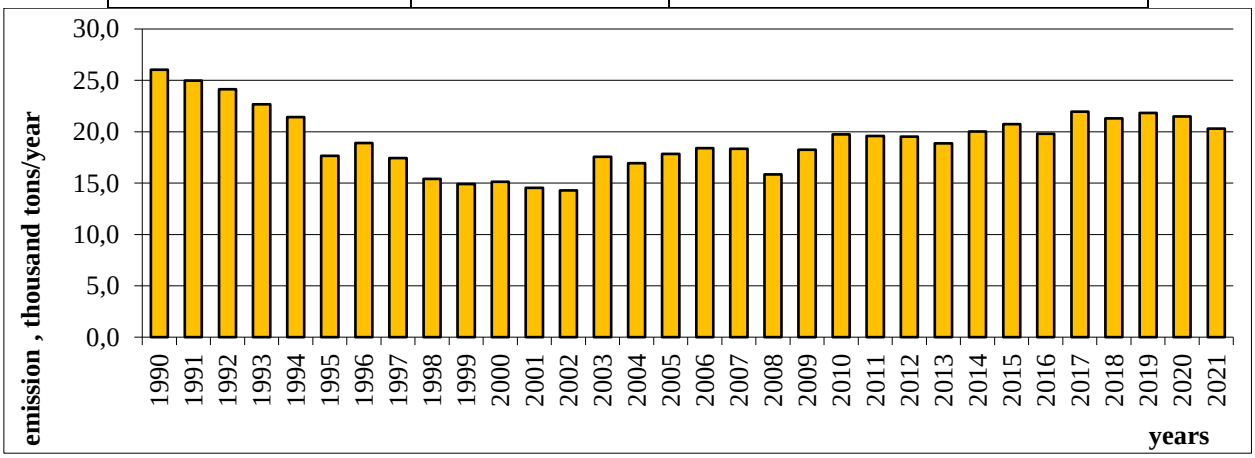


Figure 5.7 Emission of methane (CH_4) from rice fields for 1990…2021

5.4.2 Methodological approaches

In accordance with the IPCC RP, 2006, the daily emission factor was calculated, which is dimensionless and amounted to 2.10.

The daily emission factor includes the following components:

– base emission factor for permanently flooded fields without organic fertilizers (1.30);

– scaling factor to take into account differences in water regimes during the growing period (0.52);

- scaling factor to take into account differences in the water regime before the season before the growing period, (not taken into account due to the technology of growing rice in Kazakhstan with flooding less than 30 days);

- scaling factor for types, and for the amount of applied organic fertilizer (3.10) (from Equation 5.3 and Table 5.14 IPCC RP, 2006, vol. 4, ch. 5);

– scaling factor for soil type, rice variety, etc., if available (not taken into account).

In addition, the duration of the average growing season of rice cultivation was used - 100 days (from germination to harvest).

5.4.3 Uncertainty estimation and time series consistency

The total uncertainty of methane (CH_4) emissions from flooded rice fields is ±25...30%, including ±20% of the emission factor uncertainty and ±5...10% of statistical error.

5.4.4 Quality assurance and control

The control of the initial information used is carried out by specialists of the Bureau of National Statistics of the ASPIR RK . The quality control of the calculations was carried out by the specialists of JSC "Zhasyl Damu". In addition, as a result of the meeting of the interdepartmental working group, an assessment was made of the quality of the initial data and parameters, as well as the assessment of greenhouse gas emissions itself.

General QA/QC procedures are described in Section 1.2.1 of the NIR.

5.4.5 Recalculations and planned improvements

No recalculations were made in this category. In the future, additional refinements of methane (CH_4) emission factors from rice fields are planned, taking into account modern rice cultivation technologies.

5.5. Nitrous oxide emissions from cultivated soils (Category 3D CRF)

5.5.1 Category description

The section presents the results of calculations of nitrous oxide (N_2O) emissions from mineral soils of cultivated and pasture lands. For cultivated lands, direct and indirect emissions of nitrogen compounds were calculated from the additional input of nitrogen into the soil:

- with synthetic (mineral) nitrogen fertilizers;
- with organic fertilizers;
- with stubble and root residues of agricultural crops;
– in the process of mineralization of soil organic matter.

For grazing lands, emissions were calculated from nitrogen supplied with urine and manure left by grazing animals.

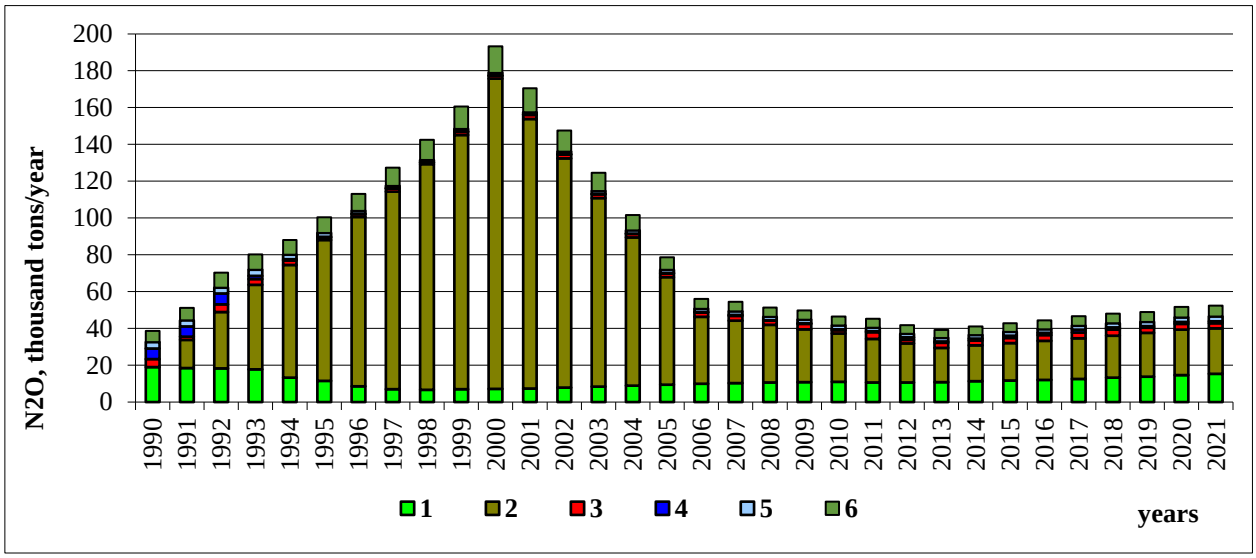
Total atmospheric emissions of nitrous oxide (N_2O) from cultivated land and pastures in Kazakhstan in 2021 amounted to 52.40 thousand tons. Compared to 2020, N_2O emissions increased by 0.68 thousand tons (1%), and compared to 1990 they increased by 13.76 thousand tons (26%). The minimum emission values were observed in 1990 (38.64 thousand tons). The overall dynamics of emissions from the category is mainly determined by the loss of nitrogen as a result of the mineralization of organic matter in the soil. The maximum zaota losses were observed in 2000, which resulted in 169 thousand tons of nitrous oxide emissions. Further, there was a tendency to reduce the emission of N_2O . More detailed information is shown in the LULUCF sector.

Emission of nitrous oxide (N_2O) from mineral nitrogen fertilizers in 2021 amounted to 1.15 thousand tons; from organic fertilizers - 2.52 thousand tons; N_2O emissions from plant residues of agricultural crops amounted to 2.81 thousand tons. Significant volumes of N_2O emissions were obtained from the mineralization of organic matter in the soil - 24.61 thousand tons. From the waste of farm animals grazing on pastures, 15.39 thousand tons of nitrous oxide (N_2O) were released into the atmosphere . Indirect emissions from nitrogen deposition and from leaching and runoff amounted to 2.76 and 3.16 thousand tons, respectively (Table 5.27, Figure 5.8).

Table 5.27 - Annual values of nitrogen input to the soil and nitrous oxide (N_2O) emissions from cultivated soils and pastures in the Republic of Kazakhstan

Years	Nitrogen (N) input to the soil, thousand tons					Direct emissions of nitrous oxide (N_2O) from soil, thousand tons					$_2O$ emissions in as a result of nitrogen deposition, thousand tons	$_2O$ emissions in result washout and runoff, thousand tons	Total emissions of N_2O from cultivated land and pastures, thousand tons
	stubble leftovers harvest	Mineral fertilizers	Organic fertilizer	Mineralization organic substances	Waste of grazing animals	stubble leftovers harvest	Mineral fertilizers	Organic fertilizer	Mineralization organic substances	Waste of grazing animals			
1990	277.29	369.00	226.33	0.00	848.76	4.32	5.79	3.55	0.00	18.99	3.96	2.03	38.64
1991	118.14	350.00	217.99	976.30	823.84	1.82	5.50	3.42	15.33	18.40	3.82	2.93	51.22
1992	271.32	370.00	208.22	1952.50	829.86	4.23	5.81	3.27	30.65	18.25	3.84	4.29	70.34
1993	202.08	115.00	201.52	2928.80	801.67	3.15	1.81	3.16	45.98	17.72	3.33	5.01	80.16
1994	155.37	40.00	155.40	3905.10	580.57	2.43	0.63	2.44	61.31	13.26	2.37	5.69	88.13
1995	87.30	22.00	131.35	4881.30	500.90	1.36	0.35	2.06	76.64	11.44	2.02	6.62	100.49
1996	100.06	15.00	97.28	5857.60	371.65	1.56	0.24	1.53	91.96	8.64	1.50	7.59	113.02
1997	105.26	12.64	81.10	6833.80	305.22	1.64	0.14	1.27	107.29	7.08	1.23	8.64	127.29
1998	58.37	18.92	77.46	7810.10	286.12	0.91	0.16	1.22	122.62	6.62	1.17	9.72	142.42
1999	122.30	9.44	82.82	8786.40	305.92	1.90	0.10	1.30	137.95	7.08	1.24	10.96	160.53
2000	102.57	9.47	85.38	10738.90	307.31	1.60	0.11	1.34	168.60	7.14	1.25	13.24	193.28
2001	140.08	9.36	87.74	9336.20	316.22	2.18	0.10	1.38	146.58	7.29	1.28	11.63	170.44
2002	141.41	12.78	94.36	7933.40	340.43	2.20	0.12	1.48	124.55	7.80	1.39	10.04	147.58
2003	135.86	19.65	101.52	6530.70	361.94	2.12	0.18	1.59	102.53	8.33	1.49	8.42	124.66
2004	116.45	24.77	105.56	5128.00	390.58	1.82	0.26	1.66	80.51	8.95	1.60	6.79	101.59
2005	127.98	20.49	109.57	3725.30	410.70	2.00	0.21	1.72	58.49	9.42	1.67	5.17	78.68
2006	148.82	27.82	114.40	2322.60	433.46	2.32	0.25	1.80	36.46	9.89	1.76	3.58	56.06
2007	175.05	37.53	118.56	2159.60	450.82	2.73	0.44	1.86	33.91	10.27	1.85	3.46	54.52
2008	141.49	16.27	121.67	1996.70	470.51	2.21	0.18	1.91	31.35	10.64	1.88	3.23	51.40
2009	187.49	29.47	123.32	1833.80	477.80	2.93	0.33	1.94	28.79	10.80	1.93	3.12	49.84
2010	118.02	40.74	125.48	1670.90	490.01	1.83	0.52	1.97	26.23	11.03	2.00	2.89	46.47
2011	236.40	47.52	118.83	1508.00	477.04	3.69	0.62	1.87	23.68	10.57	1.95	2.82	45.20
2012	128.07	105.26	117.28	1345.10	480.06	1.99	1.48	1.84	21.12	10.67	2.04	2.56	41.70
2013	177.17	55.70	118.20	1182.20	487.89	2.76	0.77	1.86	18.56	10.91	1.99	2.38	39.23

2014	169.13	80.60	122.11	1237.30	510.32	2.63	1.08	1.92	19.43	11.41	2.11	2.49	41.07
2015	180.94	91.53	125.25	1292.30	521.66	2.82	1.29	1.97	20.29	11.70	2.18	2.60	42.85
2016	203.43	80.00	128.76	1347.40	537.93	3.17	1.10	2.02	21.15	12.11	2.22	2.68	44.45
2017	207.46	104.22	133.88	1402.50	556.75	3.23	1.46	2.10	22.02	12.62	2.33	2.81	46.57
2018	209.76	81.00	140.59	1457.60	581.90	3.26	1.16	2.21	22.88	13.25	2.40	2.90	48.06
2019	188.60	54.54	146.01	1512.60	604.15	2.92	0.75	2.29	23.75	13.78	2.44	2.94	48.87
2020	210.25	74.40	153.57	1567.70	645.00	3.26	1.04	2.41	24.61	14.68	2.62	3.10	51.72
2021	180.75	81.02	160.60	1567.70	677.11	2.81	1.15	2.52	24.61	15.39	2.76	3.16	52.40



1 - waste of animals grazing on pastures; 2 - release of nitrogen from the mineralization of organic matter in the soil, 3 - plant residues of agricultural crops; 4 - mineral fertilizers; 5 - organic fertilizers; 6 - sum of indirect emissions

Figure 5.8 - Emission of nitrous oxide (N_2O) from cultivated and pasture lands of Kazakhstan for 1990 ... 2021

5.5.2. Methodological approaches

In accordance with the IPCC RP, 2006, the assessment of nitrogen input to soil and emissions of its compounds from soil was carried out at the First and Second methodological levels using default and national coefficients (Table 5.29).

Direct emissions

Equation 11.1 of the IPCC, 2006. T 4 was used to calculate the cumulative mass of direct emission of nitrous oxide (N_2O) into the atmosphere from the soil of cultivated lands.

Mineral fertilizers

The amount of nitrogen entering the soil with synthetic fertilizers was obtained by converting them to the active substance using data on the physical mass of complex nitrogen fertilizers applied to the soil. The data were obtained from the Bureau of National Statistics ASPIR RK (Table 5.28).

Table 5.28 - The amount of mineral nitrogen fertilizers applied to the soil for 1990 ... 2021

years	Mineral nitrogen fertilizers applied to the soil in rice fields, thousand tons	Mineral nitrogen fertilizers applied to the rest of the soil, thousand tons	The total amount of mineral nitrogen fertilizers applied to the soil, thousand tons
1990	0.00	369.00	369.00
1991	0.00	350.00	350.00
1992	0.00	370.00	370.00
1993	0.00	115.00	115.00
1994	0.00	40.00	40.00
1995	0.00	22.00	22.00
1996	0.00	15.00	15.00
1997	5.82	6.82	12.64
1998	12.47	6.45	18.92
1999	4.56	4.88	9.44
2000	3.78	5.69	9.47

years	Mineral nitrogen fertilizers applied to the soil in rice fields, thousand tons	Mineral nitrogen fertilizers applied to the rest of the soil, thousand tons	The total amount of mineral nitrogen fertilizers applied to the soil, thousand tons
2001	4.53	4.83	9.36
2002	6.73	6.05	12.78
2003	12.19	7.46	19.65
2004	11.29	13.48	24.77
2005	10.52	9.97	20.49
2006	16.72	11.10	27.82
2007	13.24	24.29	37.53
2008	6.79	9.48	16.27
2009	12.49	16.98	29.47
2010	11.12	29.62	40.74
2011	12.00	35.52	47.52
2012	15.21	90.05	105.26
2013	8.99	46.71	55.70
2014	16.83	63.77	80.60
2015	13.32	78.21	91.53
2016	13.56	66.44	80.00
2017	16.06	88.16	104.22
2018	9.53	71.48	81.00
2019	10.03 _	44.51	54.54
2020	11.65	62.75	74.40
2021	10.92	70.10	81.02

organic fertilizers

In accordance with Equation 11.3 of Volume 4, Chapter 11 (IPCC SPM, 2006), the amount of nitrogen applied with organic fertilizers includes nitrogen from manure coming from collection and storage systems for application to soils; sewage nitrogen; nitrogen in compost (excluding manure/dung compost) and nitrogen from other organic additives.

Manure nitrogen in this NIR includes manure nitrogen supplied for application to cultivated soils from manure management systems. It is assumed that almost all manure is applied to the soil. The nitrogen fraction of manure used as fuel, for construction or for feeding was assumed to be zero, as these manure/manure uses do not exist in Kazakhstan [98].

Dung left by animals on pastures

The calculation of nitrous oxide (N_2O) emissions from farm animals kept on pastures and in fenced pastures was made on the basis of data on the total mass of nitrogen produced by animals during grazing during the year.

Regarding category 3 D . a.2 . c “Introduction of other organic fertilizers into the soil”, there is no information that composting is carried out in agriculture in Kazakhstan . The lack of composting practices and the low level of waste recycling in Kazakhstan is confirmed by various sources. The Government of the Republic of Kazakhstan approved the “Program for the modernization of the solid waste management system for 2014-2050” No. 634 dated June 9, 2014 in order to improve the quality of services provided in the field of solid waste management, increase the amount of collected and processed secondary material resources, maximize the use of energy potential of municipal solid waste and minimize the negative impact on the environment.

[98]Organic fertilizers from animal waste. Agrochemistry in agriculture. wwwagrohimja . ru . 2013

However, it was soon canceled in 2016. The program states that “in Kazakhstan there are no facilities for waste processing (sorting stations) where it would be possible to carry out deep separation of waste in order to extract secondary material resources, as well as biodegradable cracks for recycling and production of green energy and compost” (from “Seventh National Communication and Third Biennial Report of the Republic of Kazakhstan to the UN Framework Convention on Climate Change”). In the Concept of the transition of the Republic of Kazakhstan to a green economy in 2013, an insignificant level of processing of organic waste is also noted. As a consequence, emissions in this category are shown as ' NO '.

plant residues

The cumulative mass of nitrogen M_{CR}, additionally entering the soil with crop residues, was calculated using the equation:

$$M_{CR} = \Sigma [M (p_1) \cdot A_1 \cdot B_1 \cdot D_1] + [M (p_2) \cdot A_2 \cdot B_2 \cdot D_2] + ... [M(pn) \cdot An \cdot Bn \cdot Dn], (5.1)$$

Where:

$M(p_1)$, $(M(p_2)$,... (M(pn) – mass of the crop harvested from the fields (economically valuable part) by crops p_1, p_2,... pn respectively, thousand tons ;

A_1, A_2 ... An - nitrogen content in crop and root residues of plants (aboveground and underground parts), % per air-dry mass or absolutely dry matter;

B_1,B_2,....Bn is the share of stubble and root residues of plants in the fields, % of the economically valuable part of the crop;

D_1, D_2, Dn - correction factor for water content in the economically valuable part of the crop, dimensionless value.

The coefficients A, B and C , designed to calculate the mass of nitrogen additionally entering the soil with crop residues (Table 5.30), are derived by analyzing and summarizing the results obtained in the course of field and laboratory studies by various authors [99].

To calculate the nitrogen content in plant residues, data on the gross harvest of major agricultural crops (Table 5.31) were used ; nitrogen in the residues of perennial fodder crops was taken into account during periodic updating, i.e. not every year, as is the case with annual crops. Periodicity averaged 8 years.

In accordance with footnote 2 of Chapter 11 of Volume 4 of the IPCC SPM, 2006, nitrous oxide (N_2O) emissions from atmospheric nitrogen fixation by nodule bacteria of cultivated plants (nitrogen fixers) are not considered a direct source of N_2O due to the lack of evidence of significant emissions occurring as a result of the fixation itself . Therefore, this source of emissions was not considered in this NIR.

A small proportion of crop residues used as feed, bedding for livestock and for fuel was not taken into account in the emission calculations due to the lack of accounting for these data for the country.

[99] Tureshev O.T. Biologization of irrigated agriculture in the south-east of Kazakhstan. Scientific advice. Almaty, Almalybak Publishing House, 2001. Eleshev R.E. Preservation of soil fertility and increasing the productivity of agricultural crops in farms. Recommendations. Almaty, 2005. Yagodin B.A. Agrochemistry. M., 1989. Ponomareva A.T. Handbook on the use of fertilizers. Almaty, 1981.– 311 p.

Table 5.29 - Coefficients for estimating the direct input of nitrous oxide (N_2O) from the soil into the atmosphere for cultivated land (IPCC RP, 2006).

Emission factor	average value	Range uncertainty
F_1 - for nitrogen additionally supplied to the soil of arable land from mineral and organic fertilizers, plant residues and for nitrogen released during the mineralization of organic matter, kg N_2ON / kg N	0.01	0.003-0.03
F_{1FR} - for flooded rice fields, kg N_2ON/kg N	0.003	0.000-0.006
F_2 - for nitrogen on pastures additionally supplied with manure from cattle, kg N_2ON / kg N	0.020	0.007-0.06
F_3 - for nitrogen on pastures additionally supplied with manure from sheep, goats, camels and horses, kg N_2ON / kg N	0.01	0.003-0.03

Table 5.30 - Coefficients for calculating the amount of nitrogen entering the soil with biological residues of agricultural crops after harvesting[100]

culture	Harvest residues	The share of crop residues from the economically valuable part of the crop, % (a)	Correction factor for maintenance water, rel. units (b)	Nitrogen content in crop residues, % (With)
Winter wheat	High stubble, roots	126	1	0.59*
winter rye	High stubble, roots	160	1	0.45*
Spring wheat	High stubble, roots	130	1	0.59*
spring barley	High stubble, roots	100	1	0.90*
oats	High stubble, roots	120	1	0.80*
Millet	High stubble, roots	160	1	0.57*
Buckwheat	Stems, roots, fruits	100	1	0.80*
Corn for grain	Stems, leaves, roots	180	1	1.20*
Corn for silage	Stubble, roots	20	0.60	0.55*
Rice	High stubble, roots	140	1	0.38*
Legumes	Stems, roots, beans	54	1	1.40*
Soya	Stems, roots	150	1	0.90*
Sunflower	Stems, baskets, roots	520	0.80	0.45*
Cotton	Stems, leaves, buds, flowers, roots	100	0.70	0.25*
Tobacco	Stems, buds, flowers, roots	100	1	0.64*
Sugar beet	Tops, roots	thirty	0.30	0.33*
Potato	Tops, roots	10	0.35	0.90*
Feed root crops	Tops, roots	100	0.16	1.60**
Vegetables	Stems, leaves, buds, flowers, roots, fruit remains	100	0.15	1.50**
melons	Tops, roots, fruit remains	100	0.15	1.50**
Perennial sowing leguminous grasses	Stubble, roots, aftermath before the next plowing	40	1	1.49*

[100]Lebed L.V., Yeserkepova I.B., Iorgansky A.I., Koshen B.M., Ramazanova S.B., Tsareva E.G. Greenhouse gas dynamics for arable land in Kazakhstan. Scientific and technical journal "Soil Science and Agrochemistry" No. 1, 2015, p. 28-42.

culture	Harvest residues	The share of crop residues from the economically valuable part of the crop, % (a)	Correction factor for maintenance water, rel. units (b)	Nitrogen content in crop residues, % (With)
Perennial seeded cereal grasses	Stubble, roots, aftermath before the next plowing	thirty	1	1.06*
annual seeded herbs	High stubble, roots	25	1	1.06*

Note: N is given: per substance in the air-dry state*; for absolutely dry matter**

Mineralization/immobilization of nitrogen associated with loss/accumulation of soil organic matter

In accordance with the IPCC SPM, 2006, the amount of nitrogen released during the mineralization of soil organic matter was calculated using data on changes in soil organic carbon stocks in arable land.

For arable soils of the Republic of Kazakhstan, the weighted average C:N was calculated as 10:1.01. The C:N ratio in the zonal soils of the Republic of Kazakhstan varies within: forest-steppe zone 9-10; steppe - 10-13; desert - 6-9; foothills and mountains 7-15.

The methodology for calculating the change in soil carbon stocks during the mineralization of organic matter is described in Section 6 of the NIR.

organic soils

The 2006 IPCC SPM recommends using national statistics when collecting data on organic soils, and if not, then FAO data . Agricultural lands of the Republic of Kazakhstan do not meet the WRB (FAO 1998) criteria for organic soils in terms of humus content. Therefore, FAO and the Bureau of National Statistics ASPIR RK do not give the area of organic soils in Kazakhstan.

The most fertile soils in Kazakhstan are some types of chernozems with a maximum humus content of 6-8%, i.e. significantly less than the values typical for organic soils (>12% organic carbon). There is no practice of draining land for use in agriculture, since Kazakhstan belongs to regions with insufficient moisture [101],.[102]

ERT recommendation - A 19, potential emissions from the category “3 D . a.2 . b Emissions from sewage sludge applied to soil” to confirm whether they are below or above the threshold specified in paragraph 37(b) of the annex to decision 24/CP.19, using a default factor of 0.05 kg sewage sludge N applied on soils per capita per year, obtained from the EMEP/EEA Guidelines for Inventory of Pollutant Emissions, 2016, and the population of Kazakhstan for 2018, obtained from the Bureau of National Statistics of ASPIR RK . The calculation using the IPCC default factor (0.01) resulted in an equivalent of 4.30 thousand tons of CO_2 . The final estimate of emissions is significantly below the threshold of 188.9 thousand t eq. CO2 (0.05% of the national total) and is therefore not included in this NIR .

[101]Soils of the Republic of Kazakhstan / Faizov K.Sh., Urazaliev R.A. - Almaty. Aleiron LLP, 2001. - 338s.
[102]Uspanov U.U., Borovsky V.M., Storozhenko D.M., Matyshuk I.V. Ecological-geographical and ameliorative soil research in Kazakhstan

Table 5.32 - Gross harvest of main agricultural crops for 1990 ... 2021, thousand tons

years	Wheat	Rye	Barley	oats	Millet	Buckwheat Ha	Rice	Corn for grain	Sundry-nechnik	Cotton	Potato, vegetables open-th soil	Bahce-you	Soya	Cook-ruza for silage	One year old herbs	Perennial herbs
1990	16197.00	839.0	8500.00	610.60	939.30	173.90	579.00	442.00	126.30	324.00	3460.00	301.50	33.00	44104.00	1586.00	4436.00
1991	6889.00	480.0	3085.00	203.90	234.30	136.20	521.00	330.00	93.40	291.10	3098.00	302.70	95.00	14238.00	996.00	3114.00
1992	18249.00	525.0	8511.00	727.30	447.50	230.10	467.00	368.00	98.50	252.30	3555.00	288.30	12.00	24748.00	1304.00	4844.00
1993	11526.00	835.0	7149.00	801.50	231.40	129.60	403.00	355.00	85.50	200.10	3104.00	182.30	3.00	19202.00	1141.00	5549.00
1994	9052.00	264.0	5497.00	821.70	129.50	83.60	283.00	233.00	96.80	207.90	2821.00	146.10	5.50	15837.00	698.00	3532.00
1995	6490.00	84.40	2208.00	249.80	39.20	53.00	184.00	136.00	98.70	223.00	2499.00	162.30	13.00	4404.00	370.00	2917.00
1996	7678.00	28.50	2696.00	358.80	29.70	29.40	226.00	122.00	64.30	182.80	2434.00	181.80	6.90	5077.00	247.00	2712.00
1997	8955.00	51.00	2583.00	286.20	63.70	18.20	255.00	111.00	54.50	197.80	2352.00	181.10	6.90	1728.00	116.00	2069.00
1998	4746.30	13.60	1093.28	73.40	19.70	11.90	236.00	166.84	83.23	161.65	2342.08	305.60	3.90	1077.90	72.51	1528.52
1999	11241.80	16.60	2264.90	194.20	43.80	16.10	199.00	197.60	104.30	249.40	2981.80	369.60	3.90	965.01	69.00	2004.20
2000	9073.46	48.34	1663.65	181.77	62.28	28.70	214.32	248.79	104.63	287.14	3236.18	421.58	3.97	880.01	66.99	1854.56
2001	12706.81	43.36	2243.77	220.20	65.27	44.86	198.70	320.39	149.12	417.45	3966.83	519.20	8.68	1012.61	151.60	1940.34
2002	12617.00	106.0	2058.00	183.20	39.20	29.60	199.10	435.00	189.80	360.70	4083.00	628.80	25.10	766.00	142.00	2623.89
2003	11537.42	42.08	2153.93	170.90	48.84	48.42	273.34	437.55	292.56	402.66	4201.34	603.77	37.87	831.51	91.97	2481.47
2004	9936.97	20.11	1387.93	130.24	50.74	52.39	275.85	457.79	265.61	467.12	4268.69	666.97	46.67	714.04	98.99	2180.52
2005	11198.33	23.55	1527.50	160.02	27.15	43.69	284.57	432.08	267.36	465.02	4689.47	683.80	62.63	1038.20	122.21	2472.74
2006	13460.48	30.47	1952.88	183.33	33.42	58.93	288.78	413.60	267.95	435.42	4418.15	697.41	76.92	844.74	109.02	2241.80
2007	16466.87	68.49	2241.19	229.65	31.00	81.40	294.35	421.20	205.82	441.73	4608.19	661.79	83.27	827.96	149.21	2509.77
2008	12538.20	39.90	2058.60	137.80	27.40	16.60	254.70	420.20	185.80	317.50	4634.30	869.70	88.70	442.00	112.00	2320.00
2009	17052.02	75.09	2518.61	203.96	31.27	61.58	306.96	471.20	367.89	270.01	5196.80	852.35	94.33	967.57	144.74	2868.30
2010	9638.40	42.15	1312.81	133.81	16.48	26.96	373.15	462.04	328.90	239.85	5113.46	1118.19	113.89	592.22	133.24	2604.30
2011	22732.07	28.38	2593.11	258.29	43.36	37.43	346.76	481.96	409.12	336.05	5926.13	1248.00	133.17	1053.34	271.35	3108.34
2012	9841.13	28.57	1490.70	147.16	22.63	48.04	350.83	520.43	400.27	379.66	6127.79	1649.92	169.76	823.41	210.70	3657.04
2013	13940.81	43.40	2539.03	304.80	54.45	83.57	344.30	569.26	572.69	396.73	6495.02	1712.95	203.29	1163.27	503.51	3600.88
2014	12996.90	60.60	2411.80	225.90	27.30	46.50	377.00	663.90	512.76	320.70	6727.69	1927.98	217.91	833.27	526.09	3646.39
2015	13747.59	37.10	2675.37	243.77	34.67	45.41	422.22	734.09	534.05	273.90	6938.34	2087.58	220.35	954.70	742.88	4039.63
2016	14985.38	41.28	3231.27	335.38	61.16	89.62	447.83	762.36	754.86	286.70	7181.38	2070.87	231.17	1177.05	684.10	4224.35
2017	14802.86	38.84	3305.22	284.59	37.93	120.38	489.49	784.69	902.89	330.49	7166.84	2094.01	252.3	1065.95	656.73	4091.73
2018	13944.11	22.50	3971.27	336.13	40.24	82.70	482.95	862.09	936.75	343.62	7712.75	2142.52	255.44	1138.80	632.37	3939.55

2019	11451.65	23.21	3830.07	267.01	42.62	45.00	560.67	895.98	917.85	344.36	8050.40	2382.15	282.16	1240.01	513.16	4080.22
2020	14257.95	29.81	3659.26	240.16	39.85	40.09	556.77	958.11	923.28	326.58	8347.51	2425.09	260.64	1481.05	496.24	4315.08
2021	11814.12	39.78	2366.80	182.28	35.83	78.05	503.77	1129.51	1031.75	290.38	8543.58	2778.64	-	1538.11	228.15	4101.93

Indirect emissions

Indirect emissions of nitrous oxide (N_2O) from atmospheric deposition of nitrogen volatilized from cultivated soils and indirect emissions associated with leaching/runoff of nitrogen from cropland were calculated in accordance with the IPCC SPM, 2006, (v.4 ch. .11) using default emission factors (Table 5.31).

Table 5.31 - Factors (default) used to calculate indirect emissions of nitrous oxide (N_2O) from soil

Coefficient	**Average value**	**Range uncertainty**
F_4 [nitrogen volatilization and reprecipitation], kg N_2ON/ (kg volatilized NH_3 - N + NOx - N)	0.010	0.002-0.005
F_5 - [wash out/runoff nitrogen] N_2ON (kg N for runoff/runoff)	0.0075	0.0005-0.025
$Frac_{GASF}$ [volatilization from artificial fertilizer], (kg NH_3 - N + NOx - N)/kg N applied	0.10	0.03-0.30
$Frac_{GASM}$ [volatilization from all organic nitrogen fertilizers and waste left by ruminants], (kg NH_3 - N + NOx - N)/kg N applied or left	0.20	0.05-0.50
$Frac_{LEACH-(H)}$ - [nitrogen loss through leaching/runoff for regions where total rainfall is greater than soil water-holding capacity or irrigation] kg N/(kg nitrogen added or left by ruminants)	0.3*	0.1-0.8

* - for the conditions of the Republic of Kazakhstan, the coefficient is changed to 0.1.

Annual data on agricultural activities from national statistical compilations and bulletins were used as input data for nitrogen flux calculations.

In accordance with the IPCC SPM, 2006, indirect emissions due to nitrogen leaching/runoff were calculated for croplands if the difference between rainfall and evapotranspiration during the rainy season (ΣR-PE) exceeded the soil water-holding capacity or in the case of irrigated lands. At the same time, a period with a sum of precipitation of at least half of the amount of evaporation from the soil, i.e., physical evaporation, was taken as a rainy one. In Kazakhstan, such conditions for arable land are observed on 10% of the area they occupy, including irrigated land with an area of about 1500 thousand hectares and sloping land in the foothills and low mountains with an area of about 700 thousand hectares. For pasture lands, similar conditions are observed on an area of less than 3%. Hence, the coefficient $Frac_{LEACH-(H)}$ - the proportion of nitrogen losses with leaching / runoff, with its additional introduction into the soil of arable land, was equated to 0.1 with an uncertainty range of 0.1 ... 0.8.

5.5.3 Uncertainty estimation and time series consistency

The total uncertainty of nitrous oxide (N_2O) emissions from cultivated soils is ± 30...35%, including ± 25% due to the uncertainty of the emission factor and ±5...10% due to the error of statistical information.

5.5.4 Quality assurance and control

General QA/QC procedures were carried out in accordance with Section 1.2.1 of the NIR.

The quality control of the calculations was carried out by the specialists of JSC "Zhasyl Damu". In addition, as a result of the meeting of the interdepartmental working group, an assessment was made of the quality of the initial data and parameters, as well as the assessment of greenhouse gas emissions itself.

5.5.5 Recalculations and planned improvements

The number of donkeys and buffaloes for 2015-2019 has been specified. according to the FAO , however, these adjustments, due to small values, had almost no effect on the amount of nitrous oxide emissions during the application of organic fertilizers.

5.6 Savannah burning (Category 3E CRF)

Since there are no savannahs on the territory of the republic, emissions in this category were not calculated.

5.7 Controlled burning of crop residues (Category 3F CRF)

Controlled burning of plant residues on agricultural lands is prohibited by a number of legislative acts of the Republic of Kazakhstan: Law of the Republic of Kazakhstan "On Environmental Protection", dated 15.07.1997 N 160-1, Article 47. Environmental requirements for the use of natural resources; Law of the Republic of Kazakhstan "On the Protection of Atmospheric Air" dated March 11, 2002 N 302-2. Article 16 Land Code of the Republic of Kazakhstan dated June 20, 2003 No. 442, Article 65 and other governing documents[103]

5.8 CO_2 emissions from liming (Category 3G CRF)

Liming is usually done for acidic soils. It is known that acidic soils are characteristic of regions with high humidity. Frequent rains lead to leaching of lime, as well as salts of other alkali metals, from the soil. However, the territory of Kazakhstan is located in the steppe, semi-desert and desert zones and belongs to the zone of insufficient moisture, the annual amount of precipitation in the agricultural zone here is 300-500 mm. In dry climates, the components of dolomite and limestone are practically insoluble. In this case, dolomite flour will not act as a fertilizer, but as a ballast. These conclusions are confirmed by the Associate Professor of the Department of Agronomy of the Kostanay State University. A. Baitursynov, Candidate of Agricultural Sciences Mikhail Shilov, that “on the chernozems and chestnut soils of Northern Kazakhstan, dolomite flour cannot be considered an effective fertilizer due to the above and a number of other reasons. He believes that the introduction of dolomite and limestone necessarily gives a negative effect when used on solonetsous chernozems and chestnut soils, solonets, as well as solonetz complexes as a result of the formation of normal soda Na 2 CO 3 in the soil solution . As a result of this process, the whole complex of physical, physicochemical, biological and agrochemical properties of zonal soils will deteriorate, accompanied by a decrease in the yield of field crops.[104]

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[103]“On Environmental Protection”, Law of the Republic of Kazakhstan dated 15.07.1997 N 160-1; "On the Protection of Atmospheric Air" Law of the Republic of Kazakhstan dated March 11, 2002 N 302-2.

Land Code of the Republic of Kazakhstan dated June 20, 2003 No. 442.

Fire safety rules in the Republic of Kazakhstan. Primary requirements. PPB RK 08-97.

Rules for extinguishing steppe fires, as well as fires in settlements in which state fire extinguishing institutions have not been established dated June 27, 2007 N 542.

On Approval of the Fire Safety Rules” Decree of the Government of the Republic of Kazakhstan dated December 29, 2017 No. 919.

[104] http://agroinfo.kz/est-li-perspektivy-u-dolomitovoj-muki

Based on the information provided, and also due to the fact that there is no information on the introduction of limestone and dolomite into the soil in Kazakhstan, we can conclude that liming is not practiced for the soils of Kazakhstan and in CRF this category will be designated as “NO » (ERT recommendation - A 12).

$_2$ emissions from urea fertilization (Category 3H CRF)

5.9.1 Category description

Annual statistical information on the application of certain types of fertilizers to soils, including urea, is not collected in the country. In accordance with the IPCC recommendations, data on its import/export were used to obtain a rough estimate of the annual amount of urea applied to the soil. The expert opinion showed that about 90% of imported urea in the country is sent for export or other uses (industrial or chemical production). The application to agricultural soils does not exceed 10%, and this estimate is rather conservative. This assumption was used in the calculations.

In 2021, carbon dioxide (CO_2) emissions from the use of urea amounted to 4.12 thousand tons (Table 5.34).

Table 5.34 - $CO_{2\ emissions}$ from the use of urea in agriculture

years	Emissions, CO2, thousand tons
1990	104.40
1991	91.36
1992	78.31
1993	65.27
1994	52.23
1995	39.19
1996	26.14
1997	13.10
1998	0.06
1999	0.17
2000	0.08
2001	0.07
2002	0.06
2003	0.06
2004	0.24
2005	0.25
2006	0.13
2007	0.15
2008	0.56
2009	0.23
2010	0.68
2011	2.47
2012	0.72
2013	0.20
2014	0.55

years	Emissions, CO2, thousand tons
2015	0.27
2016	0.59
2017	1.97
2018	2.54
2019	3.22
2020	5.60
2021	4.12

5.9.2 Methodological approaches

For the calculation of CO_2 emissions from urea, a Tier 1 default factor of 0.20 is applied (SPM, IPCC, 2006). Calculations were made using Equation 11.13 (RP, IPCC, 2006).

5.9.3 Uncertainty estimation and time series consistency

The uncertainty of the emission factor was 50%, activity data - 15%.

5.9.4 Quality assurance and control

General QA/QC procedures were carried out in accordance with Section 1.2.1 of the NIR.

The quality control of the calculations was carried out by the specialists of JSC "Zhasyl Damu". In addition, as a result of the meeting of the interdepartmental working group, an assessment was made of the quality of the initial data and parameters, as well as the assessment of greenhouse gas emissions itself.

5.9.5 Recalculations and planned improvements

Improvements in this category are not planned.

5.10 Generalized values of greenhouse gas emissions from categories of animals recognized as insignificant and not included in this inventory

Here are summarized estimates of releases from categories of animals that, according to paragraph 37(b) of the annex to decision 24/CP.19, the category can be considered insignificant and not included in the inventory. These scores were submitted in response to Saturday Paper 2017 (2015 estimate) and are duplicated in this chapter (ERT recommendation - A 2).

Marals (deer)

Emissions of CH4 for marals (deer) from internal fermentation and from manure management systems were estimated for 2015 using default coefficients from the IPCC SPM , 2006 . IPCC RP, 2006 (Table 5.35).

Table 5.35 - Total greenhouse gas emissions from marals

Year	Maral livestock, heads*	Emission of CH_4 during internal fermentation, thousand tons	$_4$ emissions from manure management systems, thousand tons	Total emission, thousand tons of CO_2 eq.
2015 _	9880	0, 1976	0.0022 _	4.995

*- data of the Bureau of National Statistics ASPIR RK

According to paragraph 37(b) of the annex to decision 24/CP.19, a category can be considered insignificant if it is likely to emit less than 0.05 percent of total national greenhouse gas emissions (314,914 ktCO2e in 2015), and at the same time, it does not exceed 500 thousand tons of CO2eq . Due to the fact that the calculated emissions are much less than this level and due to the lack of data for most years, we consider it inappropriate to further calculate greenhouse gas emissions for marals (deer).

ostriches

CH_4 emissions from manure management systems for ostriches were estimated for 2015 using the default EFs from the IPCC SPM, 2006. N_2O emissions from manure management systems and CH_4 from internal fermentation were not estimated due to the lack of appropriate factors in the IPCC SPM, 2006 (table 5.36).

Table 5.36 - Total greenhouse gas emissions from ostriches

Year	**Livestock of ostriches, heads***	**$_4$ emissions from manure management systems, thousand tons**	**Total emission, thousand tons of $CO_{2\ eq.}$**
2015	54	0.0003	0.00765

*- data of the Bureau of National Statistics ASPIR RK.

According to paragraph 37(b) of the annex to decision 24/CP.19, a category can be considered insignificant if its likely emission level is less than 0.05 per cent of total national greenhouse gas emissions and does not exceed 500 kt CO2eq . Due to the fact that the calculated emissions are much lower than this level and due to the lack of data for most years, we consider it inappropriate to further calculate greenhouse gas emissions for ostriches.

fur animals

Emissions of CH_4 and N_2O from manure management systems for fur animals were estimated for 2015 using default factors from the IPCC SPM, 2006. Emissions from internal fermentation were not estimated due to the lack of appropriate factors in the IPCC SPM, 2006 (Table 5.37) .

Table 5.37 - Total greenhouse gas emissions from fur animals

Year	**Livestock of fur-bearing animals, heads***	**Direct and indirect N_2O emissions from manure management systems, including emissions after application to soil thous. tons**	**$_4$ emissions from manure management systems, thousand tons**	**Total emission, thousand tons of $CO_{2\ eq.}$**
2015	411	0.0000948471	0.00027948	0.035251436

*- data of the Bureau of National Statistics ASPIR RK.

According to paragraph 37(b) of the annex to decision 24/CP.19, a category can be considered insignificant if its likely emission level is less than 0.05 percent of total national greenhouse gas emissions and does not exceed 500 kt CO2eq . Due to the fact that the calculated

emissions are much less than this level and due to the lack of data for most years, we consider it inappropriate to further calculate greenhouse gas emissions for fur-bearing animals.

5.10 Sector quality assurance/quality control procedures

Quality assurance/quality control procedures have been strengthened in this NIR. A cross-check of the calculations and the procedure for filling out the CRF by an expert from the LULUCF sector was implemented , as well as a check by various departments - data providers. The quality control of the calculations was carried out by the specialists of JSC "Zhasyl Damu". In addition, as a result of the meeting of the interdepartmental working group, an assessment was made of the quality of the initial data and parameters, as well as the assessment of greenhouse gas emissions itself. Recommendations from the ERT presented during the 2021 NIR Review have been adopted.

General QA/QC procedures were carried out in accordance with Section 1.2.1 of the NIR.

CHAPTER 6 FORESTRY AND OTHER LAND USE (CATEGORY 4 IN THE TABLES CRF **(** CRF)

6.1 Overview by sector: methodological features of greenhouse gas assessment, land use categorization, land classification systems in Kazakhstan, general trends

The chapter contains the results of the assessment of the absorption / emission of greenhouse gases (GHG) for forestry and other types of land use (LHDL) for 1990 ... 2021, obtained for reporting purposes in accordance with the obligations of the Republic of Kazakhstan under the UNFCCC Convention.

Estimation of the intensity and dynamics of GHG flows is carried out using the IPCC Guidelines for National Greenhouse Gas Inventories, 2006, Volume 4 [1]. Greenhouse gas fluxes in the sector are estimated in two ways: the first is as net changes in carbon stocks over time (used mainly to estimate the absorption and emissions of carbon dioxide (CO_2); the second is as the intensity of fluxes of methane (CH_4), nitrous oxide (N_2O) and other types of GHGs. Estimates of carbon dioxide emissions and removals are based on the fact that changes in carbon stock in ecosystems occur mainly through the exchange of CO_2 between the earth's surface and the atmosphere, while other processes of carbon transport, such as leaching, are considered insignificant. Hence, the increase in total carbon stocks over time is equated to the net absorption of CO_2 from the atmosphere, and the decrease in carbon stocks over time (minus transfer to other reservoirs) is equated to the net emission of CO_2 into the atmosphere. mainly products of microbiological processes in the soil, the digestive tract of animals x, manure and combustion of organic matter, one-way flow directed into the atmosphere is estimated as emissions. Greenhouse gas fluxes in the sector are defined by origin as anthropogenic, associated with human activities on managed lands, i.e. lands on which a person performs production, environmental and social functions.

Consistent with the categorization of land by land use and management systems, as well as their stratification by natural conditions and climate, six land use categories are used in the practice of GHG calculations: *Forest land* (*F*), *Cropland* (*C*), *Pasture land* (*G*), *B one - Wetlands* (*W*), *Settlements* (*E*), *Other Lands* (*Other*) *and Harvested Timber* (*HLWP).*

According to the 2006 IPCC IP Activity Category definitions, *Forest Land* includes all land with woody vegetation that meets the thresholds used to define forest area in the national GHG inventory and has the potential to meet these criteria. National forest definitions should cover all forests subject to human intervention, including management practices for their protection, afforestation, restoration activities, commercial and non-commercial timber production, and other activities. *Cultivated land* includes arable and arable land, rice fields, land under annual, perennial crops, including fodder crops, land temporarily under fallow, as well as agro-and forest reclamation systems in which the indicators of plant structure are below the criteria used to determine forest areas. *Grassland* represents land suitable for grazing with mostly herbaceous vegetation, woody and other non-grass vegetation that is not considered cropland, as well as agricultural and forest-pastoral systems with threshold criteria lower than those for forest land, *water- Wetlands* include lands that are covered or saturated with water during all or part of the year, including reservoirs as managed facilities. *Settlements* represent all developed land, including transportation infrastructure and settlements of any size, unless they are allocated to other land categories as nationally defined. To *Others* includes land with bare soil, rock, ice, and all other

land not included in any of the above categories. Natural rivers and lakes within *the Wetlands* and *Other Lands* are unmanaged lands .

Also, during the GHG inventory in accordance with the requirements of the IPCC WP, 2006, an assessment of land-use conversions is carried out, which includes: *Forest Land Remaining Forest (FF), Land Converted to Forest Land (LF), Cropland Remaining Cropland (CC), Land Converted to Cropland (LC), Grassland Remaining Grassland (GG), Land Converted to Grassland (LG).* More precise definitions and classifications of land are established at the national level.

Ecosystem emissions and removals are ordered by the components of large ecosystems as carbon sinks, including biomass (above and below ground), dead organic matter and soil. Plant biomass is the main conduit for the uptake of CO_2 from the atmosphere, primarily through the interrelated processes of synthesis and respiration, which provide a net change in the carbon stock of an ecosystem, defined as the net productivity of the ecosystem. Aboveground biomass includes a mass of stump trunks, bark, twigs, seeds, leaves of woody vegetation and a mass of stems, twigs, generative organs, leaves for herbaceous vegetation. Underground biomass - all biomass of living roots, *Dead organic matter* is represented as: *Dead wood* - non-living woody biomass standing or lying on the ground; *Litter* - dead biomass lying on the ground at various stages of decomposition or *litter* - non-living remains of predominantly herbaceous forms of vegetation lying on the ground, as well as lignified parts of plants in case of participation of shrubs and semi-shrubs in cenoses. *Soil* as a reservoir of carbon includes organic carbon in mineral soils up to a certain depth (according to the IPCC SPM, 2006, assumed to be 0–0.30 m), living and dead thin roots, and DOM less than 2 mm in size. Inorganic carbon can also be estimated in soil if Tier 3 calculation method is used.

Anthropogenic activities related to land use are aimed at ensuring economic, environmental and social functions and are carried out in the Republic of Kazakhstan in accordance with legal documents: the Land Code of the Republic of Kazakhstan, 2003, with subsequent amendments and additions in 2013, 2015, 2020, and 2021, Forest Code of the Republic of Kazakhstan, 2003, as amended 2018, 2021, Environmental Code of the Republic of Kazakhstan, 2007, as amended 2021, Law of the Republic of Kazakhstan on pastures, 2017, Strategy "Kazakhstan - 2050" and other documents.

Classification systems territories and lands in the Republic of Kazakhstan . According to the Law of the Republic of Kazakhstan “On the administrative-territorial structure of the Republic of Kazakhstan”, the system of the territorial structure of the country includes administrative-territorial units: village, town, rural district, district in the city, city, district, region (table 6.1.1, figure 6.1.1). The largest regions in terms of the area of land assigned to them are Karaganda (42.8 million hectares), Aktobe (30.1 million hectares) and East Kazakhstan (28.3 million hectares) regions, in which 37.1% the territory of the republic from its total area, which is 272,490.2 million hectares.

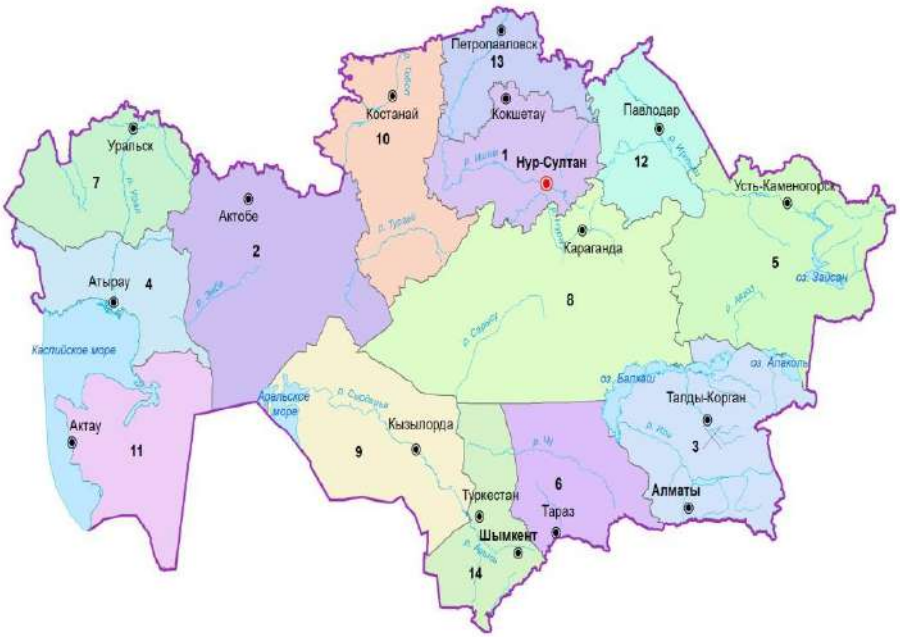
The regions with the smallest areas of fixed land are the North Kazakhstan (9.8 million hectares), Turkestan (11.6 million hectares) and Atyrau (11.9 million hectares) regions.

Table 6.1.1 - Land area and number of administrative-territorial units by regions of the Republic of Kazakhstan as of November 1, 2021

Name regions	Square lands,	Number of administrative-territorial units			
		areas			

	thousand ha		cities and towns	rural settlements	aul (rural) districts
Akmola	14,613.2	17	25	580	226
Aktobe	30,062.9	12	8	316	134
Almaty	22,354.9	17	eleven	730	246
Atyrau	11,863.1	7	6	150	68
V-Kazakhstan	28,322.6	15	34	685	239
Zhambyl	14,427.5	10	4	386	153
W-Kazakhstan	15,133.9	12	5	428	147
Karaganda	42,798.2	9	47	384	191
Kyzylorda	22,601.9	7	5	220	142
Kostanay	19600.1	16	13	516	194
Mangistau	16,564.2	5	3	58	45
Pavlodar	12,475.5	10	8	352	123
S-Kazakhstan	9,799.3	13	5	634	186
Turkestan	11,608.6	13	15	826	177
city, Shymkent	116.3	-	1	-	-
Almaty city	68.3	-	1	-	-
city, Nur-Sultan	79.7	-	1	-	-
Total (territory)	**272 490.2**	**163**	**192**	**6265**	**2271**

according to the Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan



Rice. 6.1.1- Administrative and territorial structure of the Republic of Kazakhstan

1, Akmola region	7, West Kazakhstan	13, North Kazakhstan
2, Aktobe	8, Karaganda	14, Turkestan
3, Almaty	9, Kyzylorda	15, Shymkent
4, Atyrau	10, Kostanay	16, Almaty
5, East Kazakhstan	11, Mangistauskaya	17, city, Nur-Sultan
6, Zhambyl	12, Pavlodar	

According to the Land Code of the Republic of Kazakhstan [2], the category of land is defined as part of the country's land fund, which has an appropriate legal regime and is classified according to the intended use and types of land. According to the intended purpose **,** as part of the land fund of the Republic of Kazakhstan, lands are allocated : agricultural; settlements (cities, towns and rural settlements); industry, transport, communications, for the needs of space activities, defense, national security and other purposes ; lands of specially protected natural territories, health-improving, recreational and historical and cultural purposes; forest fund; water fund; reserve land (table 6.1.2).

Table 6.1.2 - Distribution of the land fund of the Republic of Kazakhstan by purpose for 1991 ... 2020 thousand ha

Purpose of lands	1991	2002	2010	2019	2020
Agricultural land	218 375.8	86218.8	93,387.6	106,432.6	108.562.7
Lands of settlements	3747.2	20505.2	23217.0	24,077.2	24192.2
Lands of industry, transport, communications, for the needs of space activities, defense, national security and other non-agricultural purposes	18796.8	2334.9	2663.8	2877.2	2209.0
Lands of specially protected natural territories, health-improving, recreational and historical and cultural purposes	775.1	1378.1	5651.6	7696.7	7,705.7
Lands of the Forest Fund (LF)	10179.2	22432.4	23048.4	22808.8	22,398.3
Water fund lands (WF)	819.9	3603.9	4096.1	4140.0	4208.4
reserve lands	18,952.3	124696.5	109109.3	97037.3	93,642.1
Lands used outside the country	149.8	0.9	0.9	0.9	0.9
Lands used by other states	993.7	11321.3	-	9630.5	9,572.7
Territory of the Republic of Kazakhstan	**272 490.2**	**272490.2**	**272490.2**	**272490.2**	**272490.2**

* according to information received from the Committee for Land Management of the Ministry of Agriculture of the Republic of Kazakhstan and NJSC "State Corporation "Government for Citizens" of the ICRIAP RK

As can be seen from the table, the largest areas in the structure of the land fund accounted for in 1991 ... 2020, on agricultural land. During the period of reforming agricultural enterprises in 1991-2005, the area of agricultural land in the republic decreased by 136.2 million hectares. Subsequently, since 2005, the area of land in this category has increased annually and in 2020 amounted to 108.56 million hectares. In the category of agricultural land there are the most agriculturally valuable lands of the republic, including 98.0% of arable land, including 91.1% irrigated, 42.2% - perennial plantations, 48.2% - deposits, 45.4% hayfields and pastures

In accordance with the Land Code of the Republic of Kazakhstan, land lands are divided into arable land, perennial plantations, fallow land, hayfields and pastures according to the type of cultivation and mode of use in agriculture, and forest areas according to use in forestry. Lands occupied by water and swamps, lands under parks, squares, boulevards, buildings, streets, roads, in accordance with Table 6.1.2 are classified as other lands.

Arable land is a land plot systematically cultivated and used for crops, including crops of perennial grasses, as well as pure fallows. Arable land does not include land occupied by crops of preliminary crops plowed up for the purpose of radical improvement.

Fallow land - a piece of land that was previously part of arable land and for more than one year, starting from autumn, is not used for sowing crops and is not prepared for fallow.

Perennial plantations - land plots used for artificially created tree, shrub perennial plantations intended for harvesting fruit and berry, technical and medicinal products.

Natural hayfields are land plots that are systematically used for haymaking.

Pastures are land plots provided and used for year-round and seasonal grazing of farm animals. When grazing animals on pastures, haymaking is allowed for the purpose of harvesting fodder in cases where their productivity exceeds the need for fodder for grazing animals, subject to the norms of load on the total area of pastures.

Hayfields for radical improvement are land plots on which a new herbage has been created by grassing.

Grasslands of radical improvement - areas of pastures on which a new herbage has been created by sowing perennial grasses.

The distribution of areas by main types of land in the Republic of Kazakhstan for 1980 ... 2020 is presented in table 6.1.3.

Table 6.1.3 - Dynamics of the land fund of the Republic of Kazakhstan by land for 1980 ... 2020, thousand ha

land	1980	1990	1991	2000	2010	2013	2018	2020 _
1	2	3	4	5	6	7	8	9
arable land, *in t, h, irrigated*	35526.8 *1661.6*	35607.2 *1969.7*	35412.9 *1969.7*	21399.9 *1371.3*	24169.2 -	25015.9 *1535.5*	*25813.3* *1634.4*	*26,324.5*
perennial plantations	137.0	164.8	163.2	135.8	116.3	131.5	*147.5*	147.7
deposit	1 84.8	184.8	277.9	8759.4	4514.6	4378.8	*4067.1*	3,848.0
hayfields *in , t, h, improved*	6063.3 *250.4*	5173.2 *177.3*	5106.3 *164.3*	5015.5 *63.2*	5174.2 -	5148.4 *52.3*	*5134.8* *43.1*	*5,117.4* *41.6*
1	2	3	4	5	6	7	*8*	*9*
pastures, *v, t, h, improved*	182717.3 *5689.1*	182069.7 *5908.8*	182 126.1 *5908.8*	18 70 8 1 , 8 *5999.6*	188361.6 -	187467.9 *5871.0*	*186156.1* *5835.9*	*184 318.0* -
Forest areas: *including forested and tree and shrub plantations, including protective ones;* *unforested;* *open forest crops* and *nurseries*	10221.5 *8889.5* 1069.0 263.0	14290.3 *8852.1* *4008.0* *330.2*	14290.3 *8852.1* *4008.0* *330.2*	14326.0 *9977.9* *4208.7* *139.4 _*	14333.3 9878.0 4283.7 171.6	14572.8 *10109.2* *4292.1* *171.5*	*14736.7* *10338.5* *4519.5* *153.5*	 *15340.8* - *4122.0* *143.8*
Occupied by water, including swamps and artificial reservoirs (WBU)	9297.3	9663.7	9672.2	8816.5	8825.0	8800.5	*8786.8*	*7654.7*
Parks, squares, boulevards	20.4	20.4	20.4	20.4	20.4	21.2	*20.4*	*21.1*
Buildings, streets, roads	1953.8	20 62.9	2062.9	20 58 , 6	2130.8	2141.2	*2254.7*	***2285 0 _***
Other lands, including inconveniences,	*26316.6*	*23418.0*	*23358.0*	*24876.9*	*24844.5*	*24812.0*	*26098.0 _ _*	24,938.0

disturbed lands, vegetable gardens, allotments, lands under reclamation buildings								
Territory of the Republic of Kazakhstan	**272490.2**	**272490.2**	**272490.2**	**272490 .2**	**272490.2**	**272490.2**	**272 490.2**	**272 490.2**

*according to the information of the Committee for Land Management of the Ministry of Agriculture of the Republic of Kazakhstan and NAO "SC "Government for Citizens" of the ICRAC of the Republic of Kazakhstan

Forest areas. In accordance with the Forest Code of the Republic of Kazakhstan [3], a forest is defined as “a natural complex that is formed in a certain area, based on a combination of tree and shrub vegetation and other components of wildlife, interacting with the environment and having important environmental, economic and social significance” .

This definition does not contain quantitative forest criteria, therefore, in the practice of forest accounting in the Republic of Kazakhstan, in accordance with the Instructions for conducting forest management, paragraph 90, 2012, KLKHZhM MEGNR RK, the following definitions are adopted:

Forest land - plots of land on an area of more than 0.05 hectares, covered with trees and shrubs, including: tree and shrub plantations; areas with non-closed forest cultures; clearings and clearings on the lands of the state and private Forest Fund (LF) and on lands of other departmental affiliation, primarily on forest lands of specially protected natural areas: LF lands temporarily not covered with forest as a result of human intervention (cutting, burning, dead plantations) , nurseries and plantations with forest crops.

Forested lands include: lands occupied by trees and shrubs with a density of 0.3 or more; young animals of 1 and 2 age classes with a fullness of 0.4 and above; areas occupied by shrubs of medium density, on which tree species do not grow or a shrub economy is organized; areas of forest plantations created by planting or sowing tree species; plots of forest areas transferred in accordance with the established procedure to forested lands upon reaching the normative forest inventory indicators.

In accordance with the Forest Code of the Republic of Kazakhstan, 2003, as part of forest areas stand out: sparse forests - a natural forest stand, except for young growth of the 1st and 2nd age classes, with a tree cover of 10–20%; *clearings* - forest areas devoid of trees, but retaining elements of forest vegetation.

National forest definitions are quantitatively close to those adopted for forests by FAO, 2003 (plots of land in an area of at least 0.05 ha with at least 10% forest tree cover).

The Forest Fund of the Republic of Kazakhstan by categories and lands was distributed for 2020 in the following order:

1. Specially protected forest areas with a total area of 2,8356 thousand hectares. including forested 2,231.6 thousand ha;

2. Forest lands of the State Forest Fund with a total area of 16,185.5 thousand hectares, in tons, hours, forested 10,846.2 thousand hectares, of which the following are allocated: plots where felling of the main use is allowed; of scientific importance, including genetic reserves; especially valuable forests; forest fruit plantations; state protective forest belts; urban forests; green zones of settlements and health-improving institutions; anti-erosion forests; forbidden strips of forests

along the banks of rivers, lakes, and other water bodies; protective forest belts along railways and highways of international and national importance; field and soil protection forests with a total area of 13,970.5 thous. hectares and forested 9,260.5 thousand hectares.

3. Protective plantings on the right of way of railways and highways of international and republican significance, main pipelines of other linear structures.

4. Private forest fund.

5. Total land of the state and private Forest Fund of the Republic of Kazakhstan with a total area of forest lands 19,085.9 thousand hectares and forested 13,121.8 thousand hectares.

The distribution of the forest fund of the Republic of Kazakhstan by types of land in dynamics for 1988 ... 2020 can be judged from the data presented in Table 6.1.4, which shows that the total area of forest land has increased over the years from 15,388.7 thousand ha to 19 044.3 thousand hectares, in tons, hours, forested from 9309 thousand hectares to 13121.7 thousand hectares. The total area of forest and non-forest lands of the state LF increased from 20,760.5 thousand ha to 30,058.1 thousand ha. According to the information published in the Consolidated Analytical Report on the Condition and Use of Lands of the Republic of Kazakhstan for 2020 (KLZR of the Ministry of Agriculture of the Republic of Kazakhstan), the areas of the LF increased due to the return of about 13.5 million hectares of lands of forestry enterprises to its composition, transferred in earlier years during temporary use by agricultural economic entities.

The distribution of land on the territory of the Republic of Kazakhstan is clearly presented on the map (Figure 6.1.2).

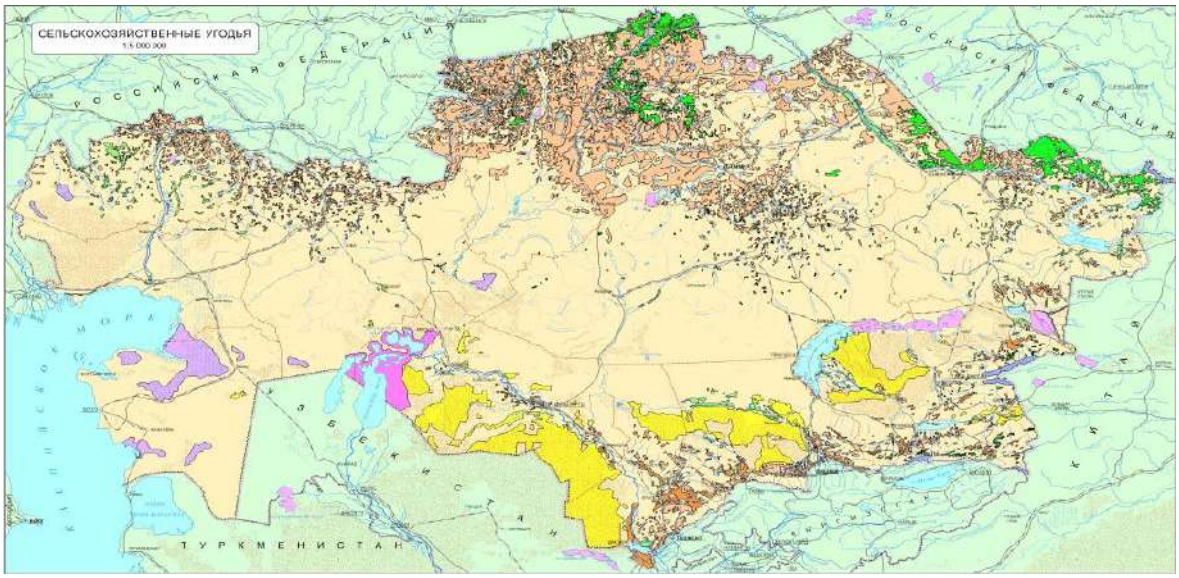


Figure 6.1.2 Distribution of agricultural, forest and other lands on the territory of the Republic of Kazakhstan (NA RK, 2003)

In the process of calculating carbon dynamics, volumes of absorption / release of CO2 and other types of GHGs associated with land use activities, to represent the lands of the Republic of Kazakhstan in accordance with the requirements of the IPCC RP, 2006, the performers of the section built a simplified land transformation matrix (Table 6.1.5) . At the same time, such indicators as the intended purpose of the land, types of cultivation, real economic and natural conditions of land use, and other significant factors were taken into account.

The results of the assessment of absorption / release of CO2 for the LHDVZ sector in the Republic of Kazakhstan for 1990 ... 2020, obtained in the context of land use categories of the IPCC, 2006, are summarized in Table 6.1.6.

Calculations of carbon stocks and volumes of absorption / release of CO2 were carried out by categories of activities represented in the sector and by components of ecosystems, taking into account the redistribution of carbon into its accumulation reservoirs, including biomass, dead matter and soil. As shown by the analysis of GHG flux calculations for the key category of land use in the Republic of Kazakhstan Cropland (C), they are estimated as CO2 release over the past ten years, which ultimately determines GHG emissions in the LHDVZ sector over the time series. At the same time, as can be seen from Table 6.1.6, the calculations for 2020 confirm the conservation of $CO_{2\ absorption}$ for other main categories of land use Forest lands (F), Pastures ((G) and Settlements (E). For 2020, the total GHG emissions for the sector are estimated at the level of 8288.6 thousand tons of CO2 equivalent , which exceeds the total emissions for the sector by 3332.19 thousand tons of CO2 in 2019. In relation to the base year, the total value of GHG flows for 2020 exceeds its 1990 12196.6 per thousand tons of CO2, taking into account the opposite sign of the direction of the final CO2 flow for 1990, characterizing it as absorption.

Table 6.1.4 - Distribution of forest lands of the State and private forest fund of the Republic of Kazakhstan, for 1988 ... 2020, thousand ha

Accounting years	wooded		Unclosed crops, nurseries, plantations tions	Not wooded					Total Forest Land	Non-forest land				Total area of forest and non-forest land
	Total	V, t, h, forest crops		clearing ki	Gary, dead nsaz - denia	lina program	sparse	Total not covered		agricultural lands	Roads, clearings, fire preventio n breaks	Other non-forest land	Total non-forest land	
1961	10479.7	61.7	134.8	(210.5)	48.0	1690.2	5579.8	9159.4	19773.9	2179.0		2381.9		25337.6
1988	9309.9	917.2	282.8	261.8	129.1	1890.6	3805.9	5787.0	15388.7	3452.6	67.4	1390.0	6371.8	20760.5
1993	10273.7	1029.3	273.0	333.7	86.1	1890.6	3858.8	6169.2	16705.9	4958.4	66.8	2463.5	7268.1	23974.0
1998	11427.1	1056.1	174.0	435.8	180.8	2202.0	3935.0	6751.8	18362.9	5346.1	71.7	1630.1	7686.3	26444.7
2003	12427.8	909.1	77.4	205.9	244.9	2017.3	3665.6	6902.6	19631.1	4871.1	73.0	1741.3	7686.3	26216.4
2008	12274.2	913.0	128.1	158.4	466.7	2184.5	3654.7	6464.3	18869.3	6829.0	82.4	2119.1	8918.2	27775.5
2013	12548.6	923.1	194.0	158.3	445.2	2067.2	3687.2	6248.3	18991.0	6285.2	86.5	2464.3	9797.1	28778.1
2018	12903.5	896.3	*315.2*	*117.6*	513.8	1872.0	3542.5	6798.11	*19053.3*	77100	91.7	2556.7	10826.8	29843.3
2019	12933.1	899.2	327.3	118.6	557.8	1850.3	3257.8	6784.6	19044.9	7158.7	92.8	3661.9	10011.8	29056.7
2020	13121.7	939.1	315.9	118.2	577.8	1837.4	3109.0	5642.4	19086.0	7025.4	95.6	2791.1	10972.1	30058.1

information of RSE "Kazakh forest management enterprise" KLKHZhM MEGPR RK

Table 6.1.5 - Simplified matrix of distribution of lands of the Republic of Kazakhstan by land for 1990 ... 2020, using information from the State land cadastre of the KLZR of the Ministry of Agriculture of the Republic of Kazakhstan and the cadastre of forest lands of the State Forest Fund of the KLKHZhM MEGNR RK thousand, ha

years	Forest land remaining forest	Cultivated Land Remaining Cultivated	Grassland Remaining Grassland	Pastures developed for settlements	Pastures bred for artificial reservoirs	Wetlands (rivers, streams, lakes and swamps)	Settlements that remain settlements	Other lands (not managed)	Territory of the Republic of Kazakhstan
1990	15915.7	35960	187344	109.3	784.74	8285.2	1974	22116.83	272490.2
1991	16178.7	35958	187320	113	785.3	8285.2	1974	21875.85	272490.2
1992	16441.7	35956	187295	116.7	785.6	8285.2	1974	21636	272490.2
1993	16705.9	35955	187271	120.4	785.49	8285.2	1974	21393.2	272490.2
1994	17037.5	35953	187246	124.1	785.6	8285.2	1974	21084.8	272490.2
1995	17369.1	35952	187222	127.5	786	8176	1974	20883.6	272690.2
1996	17700.7	35951	187198	130.4	786	8176	1974	20574.1	272490.2
1997	18032.3	35950	187173	134.7	786	8176	1974	20264.2	272490.2
1998	18363.9	35949	187149	138.3	786	8176	1974	19954	272490.2
1999	17995	35947	187124	142	786	8171	1974	20351.2	272490.2
2000	18381.7	35946	187100	146	786	8058	1974	20098.5	272490.2
2001	18765.5	35946	187071	149.8	786	8058	1974	19739.9	272490.2
2002	18454.6	35946	187041	153.6	786	8058	1974	20077	272490.2
2003	18631	35946	187012	157.4	786	8058	1974	19925.8	272490.2
2004	18737	35946	186982	161.2	786	8058	1974	19846	272490.2
2005	18842.8	35946	186953	165	816.6	7996.4	1974	19796.4	272490.2
2006	18870.5	35946	186924	168.8	816.6	7996.4	1974	19793.9	272490.2
2007	18782.2	35946	186894	172.6	816.6	7996.4	1974	19908.4	272490.2
2008	18859.3	35948	186865	175.8	816.6	7996.4	1974	19855.1	272490.2
2009	18857.9	35948	186835	180.8	816.6	7996.4	1974	19881.5	272490.2
2010	18553.6	35946	186806	184.6	782.05	7964.8	1974	20244.6	272490.2
2011	18876.9	35949	186788	188.8	805.77	7964.8	1974	19932.1	272490.2
2012	18945	35950	186769	192	813.66	7964.8	1974	19878.8	272490.2
2013	18991	35946	186751	199	816.6	7964.8	1974	19847.8	272490.2
2014	19004.5	35946	186732	206.1	816.6	7964.8	1974	19846.2	272490.2
2015	19027	35945	186714	231	799.38	7964.8	1974	19824.3	272490.2
2016	19042.3	35945	186696	268.9	808.58	8038.6	1974	19716.8	272490.2

2017	19063.3	35944	186677	301.2	869.3	8039.2	1974	19620.7	272490.2
2018	19016.8	35944	186659	305.2	870.8	8115	1974	19605.4	272490.2
2019	19044.3	35943	186640	332.4	870.8	7983.4	1974	19702.3	272490.2
2020	19086.9	35943	186622	332.7	800.9	7990.2	1974	19740.5	272490.2

Table 6.1.6 - Annual values of net absorption (-) / emission (+) of CO_2 and other types of GHG, calculated for forestry and other types of land use in the Republic of Kazakhstan for 1990 ... 2020,

years	Total absorption/emissions for the LHDVZ sector, taking into account emissions from forest fires, thousand tons / year in eq, CO_2	Forest areas and tree and shrub plantations, with taking into account emissions from fires, thousand tons / year in eq, CO_2	Cultivated land, including arable land in crop rotation, taken to fallow land, pastures and perennial crops plantings, CO_2 thousand, tons / year	Pastures and hayfields natural, taking into account emissions from fires, thousand tons / year in eq, CO_2,	Settlements (additional telno equipped-lands), CO_2 thousand, tons / year	In one-wetlands (art-natural water bodies), CO_2 thousand, tons / year
1990	-3908.0	-1445.03	5599	-6911.67	- 1166.00	4.25
1991	1536.04	-2182.03	13566.66	-8666.90	-1202.66	1.46
1992	7016.43	-2638.16	21307.00	-10422.13	- 1241.90	0.00
1993	11142.77	-3823.2	28413.00	-12177.37	-1281.13	1.10
1994	17027.60	-3509.36	35753.66	-13932.60	-1321.83	0.00
1995	23344.86	-3194.76	43424.33	-15701.03	-1362.17	0.00
1996	2950.61	-2880.9	51153.66	-17432.07	-1401.40	0.00
1997	36207.00	-2567.03	58736.33	-19187.30	-1441.00	0.00
1998	28569.18	-2957.9	66407.00	-20942.53	-1481.33	0.00
1999	49143.22	-864.6	74048.33	-22697.78	-1521.66	0.00
2000	56572.04	1229.06	81246.00	-24453.00	-1560.90	0.00
2001	53750.75	3322.7	76277.66	-24412.67	-1598.66	0.00
2002	52268.75	5418.23	72735.66	-24372.33	-1639.73	0.00
2003	47827.73	4865.66	68680.33	-24332.00	-1682.26	0.00
2004	42729.91	3145.2	65420.66	-24291.67	-1722.60	0.00
2005	37441.04	1425.23	61926.33	-24258.67	-1762.93	0.00
2006	33017.93	-295.4	59150.66	-24233.00	-1802.53	0.00
2007	26874.11	-2015.56	54699.33	-24181.67	-1842.86	0.00
2008	23599.55	-1470.33	51062.00	-24145	-1881.00	0.00
2009	20201.23	-2523.76	48726.33	-24099.53	-1921.33	0.00
2010	14940.42	-3576.46	44887.33	-25527.33	- 1228.33	342.79
2011	11680.64	-4629.16	41367.33	-23184.33	-2001.26	107.47
2012	7730.0	-5681.86	37719.00	-22311.66	-2041.60	29.19
2013	3205.42	-7482.2	34232.00	-21431.67	-2116.03	0.00
2014	4320.74	-6458.8	33498.66	-20555.33	-2191.56	0.00
2015	5337.15	-5435.83	32739.66	-19682.66	-2456.66	106.37
2016	5874.23	-4412.83	31735.00	-18810.00	-2645.50	0.18
2017	6409.21	-3389.83	30411.33	-17941.00	-2859.27	14.89
2018	8907.00	-2865.86	30560.1	-1,577 5.66 _	- 3202.83	0.00
2019	5051.91	-6461.03	28372.66	-13768.33	-3245.27	0.00
2020	8375.47	-10056.93	31905.13	-10120.00	-3540.90	0.00

Figure 6.1.3 clearly shows the dynamics of greenhouse gas flows in the context of key categories of land use for 1990 ... 2020.

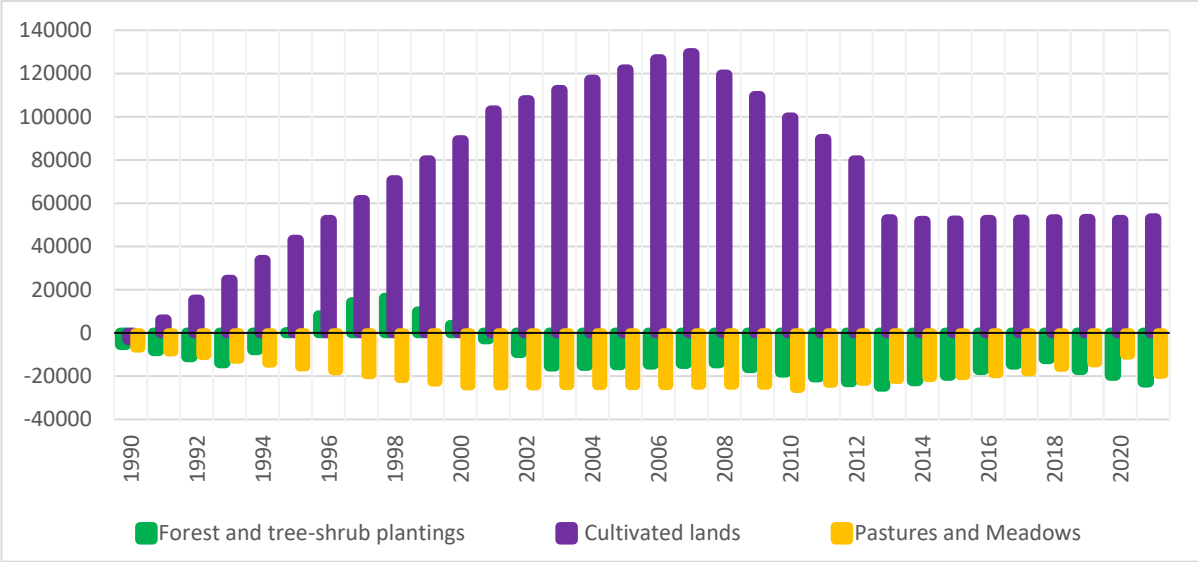


Figure 6.1.3 - Annual absorption (-) / emission (+) CO2 values for the main categories of land use in the Republic of Kazakhstan according to calculations for 1990 ... 2020

More detailed results on the dynamics of carbon stock and GHG absorption/emission in ecosystems, including those calculated at the national level, as well as at the level of individual administrative regions for key categories (Forest lands (F), Crop lands *(C)) are presented* in ND in subsequent subsections 6.2, ……6.8 of Chapter 6.

As initial information for the calculation and control of carbon stock, CO_2 fluxes and other types of GHGs, regarding the LHDVZ sector, mainly data from subordinate organizations of the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan, the Ministry of Agriculture of the Republic of Kazakhstan, the Ministry of Digital Development of Information and aerospace industry of the Republic of Kazakhstan, which on a regular basis carry out in the country accounting of lands, their quantity and quality condition, as well as carry out systematic monitoring of plant, soil and water resources,

General methodological approaches. Anthropogenic emissions/removals of GHGs for the LHDBR sector were estimated at the national level, as well as at the level of individual administrative regions for the categories *Forest land* (*F), Crop land (C)* , in accordance with the Guidelines for National Greenhouse Gas Inventories of the IPCC, 2006, Volume 4, Agriculture, forestry and other land uses. Calculations were made for managed lands, since it was assumed that in the Republic of Kazakhstan all forest areas and agricultural lands, as well as lands under settlements, artificial reservoirs from the " *Wetlands" category,* belonged to managed lands, lakes, rivers, rivers, swamps and other areas.

When preparing the LHDVZ section , in the process of calculating the dynamics of carbon accumulated by ecosystems and the volumes of absorption and emissions, the performers used statistical data on land areas in the territory of the Republic of Kazakhstan obtained from various land cadastres. Including, data from the State Land Cadastre of the Committee for Land Management of the Ministry of Agriculture of the Republic of Kazakhstan was used, which combines information from the state registration of all lands and balances of lands, which are submitted by authorized bodies for land relations at all administrative levels in the territory of the

Republic of Kazakhstan (tables 6.1.2 and 6.1.3). We also used data from the cadastre of forest lands of the State Forest Fund, which is maintained by the Committee for Forestry and Wildlife of the MEGNR RK (Tables 6.1.4 and 6.1.5).

Implementation of the UNFCCC Secretariat IA recommendations received during the October 2021 NDP Review process, online .

The recommendations dealt with the issues of further development of the national inventory system, including improvement of land representation, aggregation of GHG flow calculations, development of the information block and consistency of information obtained in land use (KAZ 171,169,167, etc.). As part of the ND-2020, it was not possible to fully resolve the issue of consistency of data on the areas of forest land received from various departments, which was decisive when choosing a method for constructing a land conversion matrix for various land use categories.

For a consistent presentation of land use areas in accordance with the requirements of the IPCC RP, 2006 Volume 4, Chapter 3 , the implementers used approach 2 in combination with approach 1. In this case , a simplified land use transformation matrix was built (Table 6.1.5), for which forest areas lands were used from the cadastre of the State Forest Fund, and information about the areas of non-forest lands, including agricultural and other lands, was entered into the land use matrix from the State cadastre of the KLM of the Ministry of Agriculture of the Republic of Kazakhstan. Consistency of the balance of areas of all types of land at the national level was carried out by the RD executors at the expense of areas of the Other land category.

In order to control possible transformations in land use, in accordance with the recommendations of the IPCC RP, 2006, the main categories of land in the process of calculating carbon dynamics were divided into separate strata (subcategories), by analogy with tables 3.3 and 3.4, from Chapter 3 of the IPCC, 2006. Using this methodological technique ND executors ensured the division of land into “remaining in the previous category of use” and “converted” into a new category.

To ensure completeness of the reporting on the LHDVZ sector, and carbon stock changes for land-use categories and their strata were estimated taking into account the carbon cycling processes between carbon pools: above ground biomass (AB); underground biomass (BB); dead wood (DW); forest floor or litter for non-forest ecosystems (LI *);* mineral soil (SO). CO2 fluxes were calculated for each category of land and allocated strata by changes in carbon stock, fluxes of CH4 , N2O and other types of GHGs were calculated by changes in flux intensity based on the equations presented in the summaries of equations A, B, C , D and G (Annex 3 Volume 4 (AFOLU) IPCC RP, 2006. Including, annual carbon stock changes for each of the land use categories and their strata (subdivisions) were determined from the difference in stocks measured repeatedly or calculated using national stock standards and influence coefficients activity intensity from Table 5.5 of IPCC WP, 2006.

Based on the results of assessing the dynamics of carbon and the volumes of absorption / release of CO2 associated with land use in the Republic of Kazakhstan at the regional level, articles were prepared for publication in scientific and technical journals: Potential for absorption of CO2 by the forests of the Republic of Kazakhstan with an assessment *at the regional level (in press) . Comprehensive assessment of absorption / emission of CO2 and other types of GHGs associated with land use (agricultural land), carried out for individual regions (in press).*

6.2 Forestry (category 4A. in the CRF table **)**

6.2.1. Description of category calculation results

The main areas of highly productive coniferous and deciduous forests are concentrated in areas relatively provided with moisture: forest-steppe and steppe plain landscapes in the north and northeast and mountain landscapes of the Altai and Zhytysu Alatau ranges in the east, Zailiysky Alatau in the southeast and Tien Shan in the southeast. west (Figure 6.1.2). In the desert zone in the ancient deltas of the large rivers Ile, Karatal, Syrdarya, Shu and on vast sandy massifs, saxaul forests are common, and in modern river valleys floodplain and tugai forests are found. Shrubs are common in almost all natural areas, interspersed with woody and herbaceous vegetation.

According to the results of a one-time accounting (taxation) of forests in the territory of the Republic of Kazakhstan, carried out by the State Enterprise "Kazakh Forest Inventory Enterprise" KLKHZhM MEGPR RK with an interval of five years, the total area of forested land and the total stock of wood in the forests of the Republic of Kazakhstan increased steadily over the reporting period (tables 6.2.1 and 6.2.2). In 2020, forested areas amounted to 13,121.7 thousand hectares with a timber reserve of 456.81 million $m^{3.}$ The increase in the area covered with forests and timber reserves was mainly ensured by: their natural renewal and overgrowing, increasing the area of artificially created forest crops through sowing and planting, as well as through measures taken to protect them, prevent forest fires and regulate the areas of industrial forest felling.

It should be noted that the full cycle of forest inventory (taxation) in the Republic of Kazakhstan takes 5 years. The materials of the full forest inventory of the Republic of Kazakhstan were completed in 2018. Full data on the next taxation cycle will be available in 2023. Until that time, preliminary data are used, which will be revised after receiving the final data on forest inventory. With the receipt of additional information by the RD executors from the Committee for Land Resources Management of the Ministry of Agriculture of the Republic of Kazakhstan, they found that a stable increase in the area of forest land in the Forest Fund was provided at the expense of the lands of forestry enterprises that were previously (until 1990) included in the composition of lands of agricultural enterprises from subsequent return to the Forest Fund in 1991 (mainly to Reserve Land). Based on this, the performers considered it right to classify Forest Lands as Lands remaining in the same category for the entire time series (1990 ... 2020).

Calculation results. In ND 2020, carbon stocks for forest land and forest and shrub plantations were calculated for the first time and presented for 1988…2020 in a time-aggregated form by administrative regions (Table 6.2.3). Also, for the first time, the assessment of carbon stocks was carried out separately: for mixed coniferous-deciduous forests, common in the high-mountain zone of the south-eastern and southern regions and in the low-mountain conditions of the northern regions; for deciduous forests predominantly common in the floodplains of large rivers; for saxaul forests of the desert. Calculations of changes in carbon stocks and volumes of absorption / emission of CO_2 for forest areas and forest and shrub plantations are presented for 1988 ... 2020 in an aggregated form in Table 6.2.4 with subsequent generalization at the national level (Table 6.2. 5).

the CO_2 flux for all categories of forest lands of the Republic of Kazakhstan over the past two decades remained mainly as absorption. Including, for 2020, the total absorption of CO_2 by forests obtained from their regional values was 10056.93 thousand tons / year, which is more than the absorption value for 2019 by 3594.97 thousand tons due to an increase in the forested area of LF forest lands in particularly under highly productive coniferous and deciduous species, as well as improved forest care. By correcting the calculations of annual changes in soil carbon stock in

LF forests, the volume of $CO_{2\ absorption}$ for the base year 1990 decreased compared to the value presented in the 2020 ND, and amounted to -1445.63 thousand tons/year at the national level. Within regions, CO2 fluxes for forests have been estimated over the last five years as sinks in most cases. The most stable absorption values were noted for the forests of the East Kazakhstan , Karaganda , Kostanay , West Kazakhstan and Atyrau regions .

Table 6.2.1 - Results of a one-time accounting of the Forest Fund of the Republic of Kazakhstan, including forest areas of specially protected natural areas, for 1988 ... 2020, summarized at the national level. *

Main breeds	Accounting indicators	1988	1993	1998	2003	2008	2013	2018	2019 _	2020
Conifers	Area, thousand ha	1737.5	1742.5	1687.3	1650.8	1605.8	1691.0	1765.3	1784.4	1792.5
	Growing stock, million, m^3	221.10	230.04	230.85	228.59	235.35	255.23	266.06	271.15	274.50
soft-leaved	Area, thousand ha	1303.3	1324.0	1371.0	1372.6	1376.1	1516.5	1537.8	1544.5	1552.8
	Standing timber stock, mln, m3	115.60	117.88	122.12	128.96	127.23	138.76	137.51	138.23	140.96
hardwood	Area, thousand ha	100.90	95.20	98.00	100.30	98.90	99.8	93.7	95.3	104.7
	Standing timber stock, mln, m3	2.30	2.84	2.99	3.11	3.23	3.37	3.44	3.53	4113.9
Saxaulniki	Area, thousand ha	4714.3	4994.7	5305.5	6136.9	6088.0	6132.4	6320.1	6354.4	6492.2
	Growing timber stock, mln.3	9.73	10.63	10.14	11.00	14.93	14.89	14.86	15.53	16.75
Other trees	Area, thousand ha	43.9	45.41	82.5	137.4	140.1	158.7	137.2	121.4	111.0
	Standing timber stock, mln, m3	1.00	1.40	2.52	2.60	2.70	3.06	2.65	2.34	4 , 8
shrubs	Area, thousand ha	1410.0	2071.9	2523.6	2942.7	2963.2	2949.6	3048.8	3032.9	3068.5
	Standing timber stock, mln, m3	6.50	7.00	8.53	11.00	10.90	10.85	11.22	11.6	17 , 2
All breeds	Area, thousand ha	9391.4	10273.7	11427.1	12427.8	12274.2	12548.6	12903.4	12933.1	13121.7
	Standing timber stock, mln, m3	354.03	369.60	366.10	386.80	394.36	426.16	435.74	441.94	456.81

* - according to the State Enterprise "Kazakh Forest Inventory Enterprise" KLHZhM MEGPR RK

Table 6.2.2 - Distribution of forest land by area and stock of standing timber in the Forest Fund of the Republic of Kazakhstan by administrative regions for 1988-2020

years	Area, thousand ha						stock of timber											
							Conifers		soft-leaved		hardwood		Saxaulniki		Other		shrubs	
	Total Forest Land	wooded	Non-Closed Cultures	Clearings	Gary	Clearings and sills	thousand hectares	million m3	thousand ha	million m3	thousand hectares	million m3	thousand hectares	million m3	thousand hectares	million m3	thousand hectares	million m3
1	2	3	4	5	6	7	8	9	10	eleven	12	13	14	15	16	17	18	19
1. Akmola region																		
1988	335	304.7	11.2	0.4			104	15319	192.5	17370	3.3	50			0.1	0.2	4.8	thirty
1993	386.6	320	11.2	1.5			217.4	29600	277.5	24950	43.2	610			8.1	60	13.2	70
1998	380.7	376	9.5	2.6			115.8	21774	188.6	18128	7.6	70			1.1	70	14.3	82
2003	401.7	379.2	4.2	9			190.2	28786	154.6	14035	6.3	92			12.4	92	15.7	83
2008	427.7	375.1	30.6	13.7			177.6	28578	162.4	14030	4.8	83			9.8	73	20.5	108
2013	440.2	378	44.8	16.1			184.5	31339	168.5	14004	2.5	62			8.9	70	15.5	84
2018	456.6	382.1	59.5	11.3			186.7	30981	166.6	13548	2.9	61			8.9	100	15.6	72
2020	466.7	384.2	70.8	8.6			188.5	31855	168.7	14111	9.5	474			1.9	70	15.6	73
2. Aktobe region																		
1988	46.3	38.8	6.3	0														
1993	46.3	38.8	6.3	0			0.5	50	4.8	470	20.8	530	1.8	3.9	0	0	10.9	60
1998	48.8	40.3	6.4	0			0.46	53	4.83	475	21.6	540	2.3	5.6	0.5	5.05	10.6	58.1

2003	56.3	47.7	6.4	0.04	1.2		0.5	53.3	4.81	471.7	20.6	519.5	2.7	6.2	5.9	51.5	12.2	67
2008	53.8	47.5	5.1	0	1.3		0.5	53.3	4.78	462.7	27.2	1018	4.6	8.3	4.7	45.4	10.9	60
2013	56.4	47.8	6.2	1	1.4		0.46	53.6	4.8	472	21.8	532	5.2	10.3	4.7	47.2	10.8	54
2018	71.7	51.9	5.4	0.2	13.1		1.4	182.8	5.2	468	19.4	467	5.2	14.1	2.1	20.2	18.6	93.4
2020	69.6	56.3	5.7	0.2	13.1		1.4	182.8	5.2	468	25.2	1116	5	14.3	1.6	18.4	15	20
3. Almaty region																		
1988	1679.8	1546.4	59.1	57	16.8		159.3	29220	36	17270	3.3	250	940.5	-	13.7	2.4	380	-
1993	1642.8	1663	37.5	31.6	10.5		159.5	30340	38.8	2740	5.5	270	883.4	1600	1.3	2400	338	1740
1998	1806.1	1779.7	15.9	6.3	4.2		170.9	31634	35	2540	5.9	426	1474	3147	35.5	868	393	2322
2003	1865.1	1835.8	19.2	5.4	4.7		169.4	32582	37.6	2819	5.8	305	1135	2976	48.4	1377	400.5	2087
2008	1828.9	1801.8	12.1	10	5		169.9	32652	39.7	3034	5.5	301	1130	2854	42.4	1377	408	2172
2013	1885.3	1851.7	12.2	1	10.4		171.9	32794	41.9	4724	5.6	321	1135	2841	68.3	1481	429	1948
2018	1948	1928.7	8.4	1.2	10		201.9	41164	41.6	4862	5.4	408	1180.2	2969	68.9	1497	431	1954
2020	2142.5	2104.2	15.4	1.1	31.8		213.7	43716	45.3	3442	7.4	501	1231.4	3631	47.7	1010	430.5	1954
4. Atyrau region																		
1993		13.2							5.7	thirty	0.1	3	0	0	7.8	36.8		
1998		14.5		14.4					6.6	37.8	0.25	7.4	0.18	3.01	7.38	35.2		
2003		16.5		16.4					6.7	38.6	0.3	7.6	1.6	27.5	7	37.9		

2008		16.4		15.5	0.4				593	444.8	0.2	9.8	1.2	21	9.7	46.6		
2013		15.7			0.4				5.4	450.5	0.173	9.8	1.87	32.2	9.09	43.7		
2018		16.65			0.4				5.62	452.2	0.173	9.8	1.667	28.7	9.09	43.07		
2020		18.7			4.2				4.8	400	0.39	16.5	0.35	3.3	12.9	6.2		

Continuation of table 6.2.2

1	2	3	4	5	6	7	8	9	10	eleven	12	13	14	15	16	17	18	19
5. East Kazakhstan region																		
1988	1920.5	1812.3	41.5	32.2			1065	134450	364	27410	2.1	3.6	364	27410	6.2	80		
1993	398	1843	31.4	33.5			10744	14060	375	28180	2.3	thirty	39.1	1090	0.6	1.5		
1998	386.6	1823.8	23.4	34.7			1023	138329	414	33360	2.3	49.4,	374.4	206.6	0.74	1.62		
2003	387.6	1766.1	15.7	39			974.3	132988	417	34014	3.8	127	362.7	1799	4.8	9.7		
2008	374.8	1799.2	12.2	24.5			981	140482	428	34014	5.2	183	377.1		8.4	20.9		
2013	2164	1874.1	19.3	19.2			1046.1	150120	547	47344	5.3	134	367		5.8	11.3		
2018	2185.4	2015.3	30.9	17.5			1061	1581074	557	4793	9.5	328	384		4.6	9.2		
2020	2188.1	2029.1	34.7	15.4			1070	167937	560	50004	9.5	347	380		4.5	9		
6. Zhambyl region																		
1988																		
1993		1229.2																
1998	770.3	1229.2	19.6	72	7.2		3.5	32	0.7	20	3.9	50	1027.7	4440	3.7	thirty	190	320
2003	900.6	2020.4	2.1	63.7	15.2		4.92	56	0.7	15.6	4.86	110.7	1173.6	3053.8	4.8	82.9	831.4	1988
2008	897.4	2305.6	9	55.8	116.9		4.9	55.8	0.7	19.1	6.9	124.6	1157.7	3997	9.1	163.9	1128.4	163.9
2013	884.5	2209.1	16.1	50.5	115.2		4.9	55.8	0.7	19.1	6.9	124.6	1112.9	3229	9.7	206	1074.7	2362
2018	619	2222.3	13	23.5	215.9		4.9	70.1	0.7	23.7	7	123.9	1126.4	3234.1	9.6	164.2	1073.4	5152.3
2020		2364.3																
7. West Kazakhstan region																		
1988																		
1993		93.5																
1998		93.5		1	0.6	49.8	0.6	40	53.5	6850	25.7	1280			2.1	10	11.6	80

2003		94.16		0.9	0.7	48.6	0.68	60.7	53.7	6791	26.1	1282			2.16	eleven	11.5	80
2008		97.5		0.5	0.6	48.6	0.6	61	54.7	6738	26.3	1285			2.3	19.4	14.5	88
2013		98.6		0.4	0.7	49.7	0.6	60.9	54.8	6685	26.3	1287			2.3	19.4	14.9	88
2018		106		0.6	16.8		0.62	60.9	58.5	6831	29.6	1444			2.3	19.4	16	86
2020		91.16					0.72	81.9	53.2	6676	21.4	963			2.2	18	15.6	89.8
8. Karaganda region																		
1988																		
1993		99.8				106.3												
1998		99.8	0.3	0.2	4.1		27.3	31.2	24	1520	7.2	240			0	0	42.4	290
2003		98	1.1	0.7	3.8		25.37	30.54	22.73	1455.4	7.42	140.8			0.08	0.45	42.39	290
2008		104	1.3	0.7	5.5		25.4	3015	21	1376.1	7.6	144.2			3.4	19.4	46.6	192
2013		145.1	1.3	0.6	6.4		25.3	3018.1	23	1472.4	6.8	431.5			5.5	22.7	84.5	460
2018		155.67	1.8	0.1	6		25.51	3012.5	23.26	1476.2	6.77	130.2			5.33	31.68	94.8	510
2020		153.35					30.5	3475	28.23	1798.3	7.44	268.4			0.32	1.94	86.4	464

Continuation of table 6.2.2

1	2	3	4	5	6	7	8	9	10	eleven	12	13	14	15	16	17	18	19
9. Kostanay region																		
1988	366.8	212.9	2	11.6	6.4	44.7	72.3	7550	125.8	10470	2.9	60			-		11.9	80
1993	366.8	210.6					73.4	6900	125.4	9900	3.1	50			-		8.7	70
1998	366.8	226.4	7.2	5.3	7.3	48.3	76.49	6584	127.62	9037	3.04	56.9			3.2	13.3	16.08	128.8
2003	366.8	227.9	14.5	2.4	11.5	40.3	68.9	7717	123.3	10704	3.2	80.4			3.7	18.5	28.6	143
2008	366.8	214.5	32.5	2.9	5.7	39.4	61.5	6611	120	9720	3.2	80			2.6	10.9	27.2	108
2013	366.8	224.1	24.5	5.7	4.1	38	64.99	6307	125.39	9126	3.22	92.7			3.19	13.41	27.21	107.5
2008	366.8	240	15.4	8.6	2.5	35	77.92	7222	128.2	9943	3.1	92.4			3.25	13.64	27.42	108.3
2020	242.2	242.2					80	11056	128.3	10225	3.2	95.1			3.2	2.8	27.4	108.3
8. Karaganda region																		
1988																		
1993		99.8				106.3												
1998		99.8	0.3	0.2	4.1		27.3	31.2	24	1520	7.2	240		0	0		42.4	290
2003		98	1.1	0.7	3.8		25.37	30.54	22.73	1455.4	7.42	140.8		0.08	0.45		42.39	290
2008		104	1.3	0.7	5.5		25.4	3015	21	1376.1	7.6	144.2		3.4	19.4		46.6	192

2013		145.1	1.3	0.6	6.4		25.3	3018.1	23	1472.4	6.8	431.5		5.5	22.7		84.5	460
2018		155.67	1.8	0.1	6		25.51	3012.5	23.26	1476.2	6.77	130.2		5.33	31.68		94.8	510
2020		153.35					30.5	3475	28.23	1798.3	7.44	268.4		0.32	1.94		86.4	464
9. Kostanay region																		
1988	366.8	212.9	2	11.6	6.4	44.7	72.3	7550	125.8	10470	2.9	60			-		11.9	80
1993	366.8	210.6					73.4	6900	125.4	9900	3.1	50			-		8.7	70
1998	366.8	226.4	7.2	5.3	7.3	48.3	76.49	6584	127.62	9037	3.04	56.9			3.2	13.3	16.08	128.8
2003	366.8	227.9	14.5	2.4	11.5	40.3	68.9	7717	123.3	10704	3.2	80.4			3.7	18.5	28.6	143
2008	366.8	214.5	32.5	2.9	5.7	39.4	61.5	6611	120	9720	3.2	80			2.6	10.9	27.2	108
2013	366.8	224.1	24.5	5.7	4.1	38	64.99	6307	125.39	9126	3.22	92.7			3.19	13.41	27.21	107.5
2008	366.8	240	15.4	8.6	2.5	35	77.92	7222	128.2	9943	3.1	92.4			3.25	13.64	27.42	108.3
2020	242.2	242.2					80	11056	128.3	10225	3.2	95.1			3.2	2.8	27.4	108.3
10 Kyzyl-Orda region																		
1988	2132																	
1993	2132								0.8	16.8	1.1	40	1951	1420	3.3	60	175.8	460
1998	2224.1								0.79	16.7	1.3	28.04	1913.2	2666.7	11.43	207.2	270.4	708.5
2003	3069.7			24.4					0.4	5.8	0.8	41.8	2681.8	5141	12.9	234.5	373.8	979.3
2008	3078.6			27.4					0.4	6	0.8	41.8	2690.6	5921.4	12.8	232.7	373.9	979.6
2013	3057.7			55.3					0.45	5.8	0.83	41.8	2696.3	5876.7	12.61	227.8	343.6	1882.8
2008	3103.2			52					0.46	4	0.53	27.3	2758.2	5878	12	216.8	332.3	1804.3
2020	3146.7			54					0.5	4.2	0.5	28.4	2806.1	6436.3	11.8	210	327.8	1780

Continuation of table 6.2.2

1	2	3	4	5	6	7	8	9	10	eleven	12	13	14	15	16	17	18	19
11. Mangistau region																		
1988																		
1993		12.8											12.8	17.1				
1998		13.7											13.7	14.5				
2003		112.7											20	20.1	92.7	10.9		
2008		122.7											15.7	32.7	107	12,7,4		
2013		122.8											15.7	32.7	100.7	124.2		

2008		125.1											18.4	35.5	100.6	12,8,3		
2020		12.5.4											18.7	38.6	106.9	127.2		
12. North Kazakhstan region																		
1988		366.8		13.9			7.2	580	357.3	38200	2.3	50						
1993		379.2		13.9			8.3	610	358.1	36170	2.2	50			2.6	63.5	16.45	120
1998	52	478.2	4.1	13.9	3.1		50.57	6265	414.4	41082	2.28	51.3			2.6		10.85	122.2
2003	30.3	539.5	0.9	16.7	10.6		42.1	4749.9	477.3	50249.5	3.4	109.7			2.2	50	14.4	36
2008	29.7	525.2	1.7	18	25.2		38.5	5686.5	464.2	48562	3.7	157.9			2.5	60.7	16.3	136.1
2013	28.4	529.7	3.8	6.9	32.2		39.27	5655.9	466.8	46189.8	3.7	157.8			3.27	48	16.68	138.6
2008	27.6	537.2	5	7.9	23.9		39.66	5633.8	474.28	43776.3	4.22	192.8			2.62	63.5	16.45	137.4
2020		540.45		7.9			39.8	5824.4	477.3	49960	4.2	201.9			2.6	68	16.3	138
13. Pavlodar region																		
1988		287					194.2	18700	73.8	5800	8.2	50					eleven	110
1993		296.4					196.4	21750	73	8070	12.8	210					14.2	120
1998	53.4	272.78	5.3	13.3	25		171.67	21319	73.4	8035.5	13.3	215.8			0.27	0.8	14.1	119
2003	54.1	270.8	4.1	27.4	16		166.4	18461.3	74.3	8085.3	13	213.2			2.1	5.5	15	126.7
2008	53.4	243.2	6.6	2.7	67.8		139.2	18033.8	74.3	8215.1	12.5	275			3.3	8.6	14.3	120.8
2013	52.7	249.78	14.6	2.6	54.2		145.2	18652.1	74.28	8058.8	12.2	274.6			3.3	8.72	14.34	64.8
2008	53	258.422	18.5	2.5	41.6		153.12	18686.2	75.5	7919.6	12.156	272.8			3.33	8.72	14.31	64.8
2020		259.84					151.6	21240.0	79.3	8272	12.4	277.6			0.24	0.64	14.3	64.8
14. Turkestan region																		
1988																		
1993																		
1998																		
2003	2331.7	1609.8	2	4.6	2.7		8.028	168.4	1.09	46.4	1.368	59.8	1141	2878.2	28.5		429.714	
2008	2539.9	1597.6	11.9	5.5	25.1		0.464	53.3	4.75	462.7	21.963	502.3	1134	8.1	4.647		425.1	
2013	2534	1614.1	18.4	5.5	19.3		8.059	168.4	1.075	46.5	1.168	48.4	1154	2874.1	26.967		422.912	
2008	2538.1	1639.2	99.7	5.6	11.1		8.06	168.4	1.075	47.2	1.634	48.9	1179	2898.4	26.921		422.819	
2020	2537.8	1665.5	99.6	5.4	eleven		8.1	170.7	1.1	47.6	2.1	63.3	1204	3157.5	27.22		422.82	

Table 6.2.3 - Carbon stock for forest lands of the Republic of Kazakhstan with redistribution by accumulation reservoirs, calculated by administrative regions for 1988-2020

years	total stock		Coniferous-deciduous, including shrubs					Saxaul, including shrubs					Deciduous (shrubs)	
	thousand ha	thousand tons	Thousand ha	Phytoma t/ha	Shaft, t / ha	Wait. t/ha	Soil, t/ha	Thousand ha	Fitomas. t/ha	Shaft, t/ha	Sub-ka, t / ha	Soil t/ha		
1	2	3	4	5	6	7	8	9	10	eleven	12	13	14	15
1. Akmola region														
1988	304.7	52007	304.7	38.6	6.18	6.56		103.6						
1993	320.6	61742	320	36.39	5.66	6.19		102.1						
1998	376	58665	376	43.6	6.97	7.41		103.2						
2003	379.2	60878	379.2	41.1	6.64	6.99		104.3						
2008	375	58856	375	42.2	6.61	7.46		105.4						
2013	378	57887	378	43	7	7.31		106.5						
2018	382.1	59243	882.1	41.9	6.86	7.12		107.6						
2020	384.2	60609	384.2	44.5	7.14	7.55		107.6						
2. Aktobe region														
1988	38.8		38.8/2318	13.9	1.23	2.01		41.36						
1993	38.8		38.8/2318	13.9	1.23	2.15		41.36						
1998	40.3		40.3/2407	12.5	1.2	1.8		39.25						
2003	47.7		47.7/2506	10.35	1.02	1.93		39.67						
2008	48.8		48.81/2612	10.13	1.00	1.8		40.09						
2013	47		47.0/2603	10.54	0.85	1.8		40.51						
2018	51.9		51.9/2811	10.4	0.93	1.76		40.95						

2020	53.4		53.4/3107	10.05	1.30	1.71 _		41.36						
3. Almaty region														
1988	1546.4	13113	605.9	20.13	3.66	3.42	51.84	940	0.98	0.14	0.06	14.31		
1993	1663	13262	538.9	22.8	3.82	3.88	49.2	874	1.1	0.084	0.06	13.58		
1998	1779.7	15207	665.2	20.05	3.08	3.4	49.73	1474	1.27	0.09	0.08	13.72		
2003	1835.8	15269	661.7	20.6	3.51	3.5	50.25	1135	1.4	0.12	0.09	13.87		
2008	1801.8	15300	671.5	20.36	3.49	3.46	50.78	1130	1.44	0.12	0.14	14.02		
2013	1851.7	16250	716.8	20.39	3.41	3.47	51.31	1134	1.44	0.12	0.19	14.16		
2018	1929.7	19531	748.6	23.56	3.87	4	51.84	1180	1.61	0.23	0.11	14.31		
2020	2104.2	20130	745	24.23	3.95	4.12	51.84	1271	1.66	0.05	0.11	14.31		

Continued Table 6.2.3

1	2	3	4	5	6	7	8	9	10	eleven	12	13	14	15
4. Atyrau region														
1988	13.2						88	77.9						
1993	13.2	5.8	676	29.31	3.43	1.93	83.51	79.5	1.18	9.3				
1998	14.49	7.04	766	20.17	2.88	1.99	84.41	7.38	1.12	8.33				
2003	16.5	8.6	935	20.74	2.24	1.37	85.3	7.9	1.19	9.4				
2008	15.5	6.7	835	33.4	3.05	2.2	86.22	9.7	1.19	11.5				
2013	15.72	7.44	824	27	3.78	1.89	87	9.09	1	9.09				
2018	16.85	7.46	788	27.12 _	3.65	1.79	88	9.09	1	9.09				
2020	18.7	5.76	695	26.81	1.45	1.77		12.9	1.19	14.05				
5. East Kazakhstan region														
1988	1812.3		1812.3	33.34	5.36	5.67	101.9							
1993	1843		1843	33.3	5.5	5.66	96.7							
1998	1823.8		1823.8	33.97	5.62	5.8	97.76							
2003	1766.1		1766.1	33.68	5.64	5.7	98.8							
2008	1799.2		1793.2	33.28	5.91	5.6	99.8							
2013	1874.1		1874.1	36.4	6.02	6.2	100.9							
2018	2015.3		2015.3	35.81	6.08	6.08	101.9							
2020	2029.1		2029.1	37.31	6.18	6.34	101.9							

6. Zhambyl region														
1988	1229.2	3961	11.8/1587	4.83	0.76	2	64.6	1580	1.49					
1993	1229.2	4226	10.8/1853	4.83	0.76	2.9	64.6	1580	1.49	0.08				
1998	2040.2	4799	15.8/2090	7.06	1.56	3.67	64.6	1740	1.48	0.08				
2003	2305.6	4594	21.6/2090	5.17	0.82	3.77	64.6	1936	1.67	0.1				
2008	2209.1	4584	22.20/2066	7.18	1.79	1.21	64.6	1893	1.7	0.13				
2013	2222.3	4270	22.2/2001	7.13	1.79	2.22	64.6	1843	1.63	0.13				
2018	2364.2	5053	12.81/1937	16.6	3.95	2.17	64.6	1724	1.46	0.12				
2020	2302	5307	17.81/2191	17.4	4	2.92	64.6	1892	1.62	0.13				
7. West Kazakhstan region														
1988	93.5	8756	93.5	37.8	5.48	6.43	49.8							
1993	93.5	9078	93.5	37.84	5.48	6.43	47.3							
1998	94.1	9438	94.16	37.2	5.34	6.32	47.8							
2003	97.5	9467	97.5	35.52	5.22	6.04	48.3							
2008	98.6	10082	98.6	35.43	5.14	6.02	48.8							
2013	106	9041	100	33.78	5.05	5.74	49.8							
2018	91.1	9037	91.16	36.34	5.12	6.17	49.8							
2020	91.12		91.12	37.55	5.18	6.38								

Continued Table 6.2.3

1	2	3	4	5	6	7	8	9	10	eleven	12	13	14	15
8. Karaganda region														
1988	99.8	2173	99.8	2173				72.8						
1993	99.8	2173	99.8	2173	18.76	3.01	3.19	69						
1998	98	2032	98	20378	17.99	2.78	3.06	69.8						
2003	104	1991	104	1991	16.99	2.65	2.82	70.6						
2008	145.1	2057	145.1	2057	12.02	2.18	2.09	71.3						
2013	165.67	2086	155.65	2086	14.59	1.8	1.97	72.1						
2018	155.33	2389	155.33	2389	13.34	2.21	2.27	72.8						
2020	152.3	2254	152.3	2254	14.48	2.28	2.41	72.8						
9. Kostanay region														
1988	212.9	212.9	36031	31.89	4.79	5.42	114.9							
1993	210.6	210.6	36031	29.94	4.41	5.09	109.1							

1998	226.4	226.9	33666	56.56	3.83	4.34	110.3							
2003	227.9	227.9	38441	29.12	4.5	4.9	111.4							
2008	217.5	214.5	3465	27.64	4.24	4.69	112.6							
2013	224.1	224.1	3370	27.13	3.84	4.61	113.8							
2018	240	240	36117	27.01	4.01	4.59	114.9							
2020	242.2	242.2	33033	27.46	4.87	4.67	114.9							
10 Kyzylorda region														
1988	2132													
1993	2132	126	5.2	9.78	2.21	1.66	83.2	1951	0.41	0.03	0.027	14.10	175.8	112.5
1998	2124.1	153	13.5	8.87	1.72	1.33	83.2	1543	0.78	0.06	0.051	13.4	270.4	175.0
2003	3069.7	160	14.0	8.14	1.96	1.38	83.2	2682	1.09	0.068	0.072	13.5	373.3	239.2
2008	3078.6	163	13.7	8.65	1.53	1.47	83.2	2690	1.25	0.10	0.083	13.7	373.9	230.8
2013	3097.7	143	13.9	8.00	1.91	1.36	83.02	2696	1.24	0.10	0.082	13.8	346.5	221.8
2018	3103.2	134	12.9	7.57	1.81	1.30	18.02	2758	1.21	0.00	0.079	13.95	332.3	212.8
2020	3146.7	146	12.8	8.14	1.78	1.38	83.2	2400	1.30	0.10	0.086	14.10	328.0	209.2
11. Mangistau region														
1988														
1993	12.8	1530						12.8	1.34	0.11	6.09	14.10	0.0	0.0
1998	13.7	1508						13.7	1.06	0.09	0.07	13.4	0.0	0.0
2003	112.7	1701						20.0	1.01	0.045	0.066	13.5	22.7	109.4
2008	122.7	1888						15.7	2.08	0.11	0.137	13.7	107.0	127.4
2013	122.8	1886						15.7	2.08	0.16	0.137	13.8	107.0	124.1
2018	125.1	1808						18.4	1.98	0.16	0.127	13.95	106.3	128.2
2020	125.4	1943						18.7	2.06	0.165	0.136	14.10	106.9	127.2
12. North Kazakhstan region														
1988	366.8	46916	366.31	42.56	5.32	7.23	121.8							
1993	379.8	44816	379.5	43.90	4.88	7.46	115.6							
1998	478.2	50376	478.2	39.22	5.10	6.67	116.8							
2003	539.5	58855	539.5	40.95	5.32	6.96	118.1							
2008	525.2	59957	525.3	39.38	5.33	6.68	119.3							
2013	529.7	59991	529.3	38.22	5.21	6.50	120.3							
2018	537.2	65836	537.2	36.97	4.78	6.28	121.8							
2020	540.45	64973	540.45	37.72	4.88	6.41	121.8							

Continued Table 6.2.3

1	2	3	4	5	6	7	8	9	10	eleven	12	13	14	15
13. Pavlodar region														
1989	287.0		38579		5.07									
1993	296.4		296.4/42256	35.96	6.00	6.11	94.6							
1998	272.8		272.8/39837	38.42	6.50	6.53	89.7							
2003	270.8		270.8/38275	35.04	5.82	5.96	90.7							
2008	243.2		243.2/35543	28.93	6.45	6.65	92.6							
2013	249.8		249.8/37186	28.50	6.39	6.55	93.6							
2018	258.1		258.1/37395	37.14	6.11	6.31	94.57							
2020	259.8		259.8/38637	40.67	6.55	6.91	94.57							
14. Turkestan region														
1988							51.55							1.2
1993	1760.4	30.3	217.6	7.2	0.71	1.22	518.9	1040	0.83	0.004	0.05	13.4	696.1	1.2
1998	1502.4	36.5	355.5	9.2	1.48	1.56	49.4	1040	0.82	0.07	0.054	13.5	426.3	1.2
2003	1597.6	38.9	293.2	7.5	1.65	1.27	50.0	1141	1.40	0.10	0.09	13.7	429.7	1.2
2008	1614.1	31.8	292.6	9.2	2.05	1.55	50.08	1134	1.44	0.12	0.095	14.0	425.1	1.2
2013	1639.2	37.2	272.3	7.3	1.67	1.24	51.0	1104	1.42	0.11	0.092	14.3	425.1	1.2
2018	1654.4	37.7	275	7.3	1.64	1.24	51.55	1178	1.40	0.11	0.09	14.1	422.9	1.2
2020	1665.5	38.92	286.7	7.7	1.66	1.25	51.55	1204	1.49	0.12	0.09	14.1	422.8	1.2

Table 6.2.4 - Annual changes in carbon stock and absorption / release of CO2 for forest lands of the Republic of Kazakhstan, calculated by administrative regions for 1990-2020

years	Annual changes in carbon stocks, thousand tons / year																					Absorption / release of CO2, thousand tons / year	
	Coniferous-deciduous											Saxaul											
	Total, thousand ha	Remaining the same				TOTAL thousand ha	Reproduced				Total thousand tons per year	Total thousand ha	Remaining the same				Reproduced				Total thousand tons/year	Coniferous-deciduous, including shrubs	Saxaul
		Phytomass	deadwood	subst	The soil		Phytomass	deadwood	subst	The soil			Phytomass	deadwood	subst	The soil	Phytomass	deadwood	subst	The soil			
1	2	3	4	5	6	7	8	9	10	eleven	12	13	14	15	16	17	18	19	20	21	22	23	24
1. Akmola region																							
1988	304.7					0.0																	
1993	329	-23.3	-14.8	-4.0		00	-7	-7	-14	0	-56											205.1	
1998	376	461	83.8	24.0		16.4	6.6	-18.1	-0.1	11.4	568.7											-2087.1	
2003	379.2	-160	-23	10.4		16.4	-29.4	-36.3	68.4	-2.7	-241											884.5	
2008	375.1	70.8	5	21.1		59.2	-21.6	-7.1	4.2	-66	2.2											-8.1	
2013	378	44.8	23	-0.7		55.4	43.5	91.3	142.2	7.4	209.3											-768.2	

2018	382.1	-70.4	-9	-3.7		60	-eleven	13.1	1.5	-0.6	-86.1											299.5	
2020	384.2	168.4	19	22.4		61	78.1	23.2	101.3	3.6	314.7											-1155.1	
2. Aktobe region																							
1988	38.8																						
1993	38.8	0	0	-0.8			0.1	0	0	0.0	-0.7											2.6	
1998	40.3	6.4	-0.3	-0.2			3.8	0.7	-0.5	-1.3	8											-29.4	
2003	47.7	-16.4	-2.8	20			15	0.6	-1.2	-3.5	11.1											-40.7	
2008	47.7	5.6	1.6	0.9			1.2	0.8	0.5	0.8	10.4											-38.2	
2013	47.8	-5.6	-1.6	-44			-0.8	-1.2	-0.5	0.8	-51.7											189.9	
2018	51.9	-2.2	-1.6	-0.6			7.5	4.6	-1.2	0.3	3.3											-12.0	
2020	53.5	-5.3	-1	0.2			18.1	3.4	-0.2	2.5	14.3											-52.4	
3. Almaty region																							
1988	605.9																						
1993	558.9	90.2	19	12.5			72.9	5	0.0	-16	183.6	871.8	0	1	1.0		21	2		-1.6	23.4	-673.8	-85.9
1998	665.2	23	-90	21.2			92	11.3	3.8	15	76.3	1174	56	1	0.0		79.4	9.2		15	160.6	-280.0	-589.4
2003	661.7	29	52	4			-9	-13.5	1.9	-28.4	36.0	1138	25	6	-0.8		6	4.5		5.6	46.3	-132.1	-169.9
2008	671.7	-29	5	0			23.6	8.2	9.4	49.2	66.4	1130	7	0	5.2		1	1		5.6	19.8	-243.8	-72.7
2013	716.8	64	-17	19.6			90.7	7.1	0.0	-16.8	147.6	1135	0	0	0.0		2	1		5.6	8.6	-541.5	-31.6

2018	748.6	324	-17	61.3			145	25.1	5.5	-4.8	539.7	1180	32	21	2.0		19.6	2		6.6	83.2	-1980.7	-305.3
2020	745	82.4	82.4	57.8			4.0	10.1	0.0	-1.8	234.9	1231	9	9	0.6		47	2.5		8.6	76.7	-862.1	-281.5

Continued table 6.2.4

1	2	3	4	5	6	7	8	9	10	eleven	12	13	14	15	16	17	18	19	20	21	22	23	24
4. Atyrau region																							
1988																							
1993	13.2	3	0	0			0.00	0.00		0	3.0	7.5	0	3		-eleven						-11.0	0.0
1998	14.5	-10.6	-0.64	-0.24			5.00	0.94		2.34	-2.7	7.4	0.9	-1.8		6.7						10.0	-3.3
2003	14.1	2.8	0.74	-1.22			0.46	0.31		-1.62	1.5	7.9	1.1	2.6		-9.4						-5.4	-4.03
2008	16.4	12.8	1.64	1.42			0.81	0.79		-6.9	10.6	9.7	0	10.6		-31.8						-38.8	0.0
2013	15.72	-7	0.14	0.69			0.77	0.80		12.02	7.4	9.1	0.5	7.8		-28.7						-27.2	-1.8
2018	16.55	-0.44	0.44	-0.02			0.46	0.04		-0.24	0.2	9.1	0	0.2		-0.9						-0.9	0.0
2020	18.7	-1.2	-1.57	0.03			-1.10	-0.20		0.13	-3.9	12	1.2	-27		99						14.3	0
5. East Kazakhstan region																							
1988	1812.3																						
1993	1843	320.2	50.8	3.42			-9.2	0	0.0	365.0												-1339.6	
1998	123.8	330.6	43.4	-103.2			-116.6	-20.7		133.5												-489.8	
2003	1766.1	-836.2	-44.4	-180.5			-80.2	-13.3	1.0	-1153.6												4233.6	

2008	1799.2	697	98.8	-26.9			0	0	-20.8	748.1												-2745.5	
2013	1874.1	1001.8	92.6	15.5			305.9	76.7	-19.2	1473.3												-5406.9	
2018	2015.3	-39.8	66.8	-32.5			-39.8	16.3	0.0	-29.0												106.3	
2020	2029.1	924.5	-27	70.7			-20.8	-0.2	-117.6	829.6												-3044.8	
6. Zhambyl region																							
1988	11.8																						
1993	11.8	0.0		25.8						0	25.8	1028	0		0	0.0	0					-94.7	
1998	15.8	7.1	2.8	14.5						-3.9	20.5	1174	173		0	-21.4	-2.3				149.3	-75.1	-547.9
2003	21.6	8.2	-3.62	22.7						-4.2	23.0	1156	-154		7.7	-45.7	44.6				-150.0	-84.4	550.5
2008	22.2	-11.4	4.19	2						8.6	3.4	1113	-4.5		6.9	-115	6.9				-106.1	-12.6	389.2
2013	22.6	-3.0	0	19.1						2	18.1	1126	336		0	40	-6.9				190.7	-66.4	-699.7
2018	12.8	42.0	9.59	-1.2						-117.9	-67.5	1179	0		-24	109	40.2				66.9	247.7	-245.3
2020	17.2	6.9	0.2	0.5						39.6	47.2	1164	0		5.9	-21	94.3				79.2	-173.1	-290.7
7. W-Kazakhstan region																							
1988		0	0	0			0.0	0.0	0	0.0	0.0											0.0	
1993	93.5	0	0	2.33				0.0	0	0.0	0.0											0.0	
1998	94.2	-11.8	-2.6	0.9			0.0	0.0	-0.3	0.0	2.3											-8.6	
2003	97.5	-78.5	-2.2	1.1			4.8	0.0	-1.7	-0.3	-9.3											34.3	

2008	98.6	-1.6	-1.5	7			24.0	0.0	-0.2	-1.7	-59.0											216.4	
2013	106	-30.9	-1.2	2.2			7.9	4.8	-1.1	-0.2	16.2											-59.6	
2018	91.2	47.9	1.3	0.7			52.1	24.0	0.0	0.5	45.6											-167.4	
2020	91.2	56.6	2.8	2.8			0.0	0.0	0.0	-6.3	42.2											-154.7	

Continued table 6.2.4

1	2	3	4	5	6	7	8	9	10	eleven	12	13	14	15	16	17	18	19	20	21	22	23	24
8. Karaganda region																							
1988	99.8	0	0	0			0	0		0	0.0											0.0	
1993	99.8	0	0	0			0	0		0	10.7											-39.3	
1998	98	15.4	5.8	1.1			0	0		0	-15.5											56.7	
2003	104	-27.8	1.02	-1.7			14	2.2		-3.2	39.3											-144.2	
2008	145	-92.2	-11.6	0			94.8	17.2		31.1	-0.3											1.1	
2013	155.7	-9	-7.6	-3.9			20.2	0.8		-1.4	42.7											-156.7	
2018	155.4	34.8	10.4	5.0			13.2	3.5		-24.2	67.8											-248.9	
2020	152.3	57	-2	6.6			22.2	1.0		-17	0.0											0.0	
9. Kostanay region																							
1988	212.9	0	0	0			0	0		0	-128.0											469.7	
1993	210.6	-83.0	-16.2	-13.2			0	0		0	-154.3											566.3	

1998	226.4	-186.4	-24.5	-25.4			69	10.4		-15.6	189.5											-695.4	
2003	227.9	151.6	28.3	4.9			14.6	0.1		0.6	-124.7											457.6	
2008	214.9	-63.2	-10.0	-41.8			-32.3	0.3		-10	15.7											-57.6	
2013	224.1	-21.6	-17.0	-2.7			0	-5		22.3	183.0											-671.6	
2018	240	-5.2	7.2	11.4			86.1	13.1		62	122.4											-449.2	
2020	242.2	19.2	36.6	8.2			45.9	12.1		70	-128.0											469.7	
10 Kyzylorda region																							
1988	5.2																						
1993	5.2	0	0	0.0		1951	0	0			-142.7												523.6
1998	19	-5.2	-1.2	1.4		1913	-5.19	2.3		-147.0	42.2												-155.0
2003	14	0.8	0.5	2.2		2682	0.8	0.8		21.4	83.2												-305.5
2008	13.7	1.5	2	0.4		2691	1.48	0.9		46.4	24.4												-89.7
2013	13.9	-1.3	-1.1	-0.8		2696	-1.8	-1.1		35.6	-6.1												22.4
2018	12.98	-1.2	-0.3	-0.1		2758	-1.2	-0.6		4.8	24.8												-90.9
2020	12.8	-1.2	0.8	-1.2		2806	-1.19	-0.2		27.5	-142.7												523.6
11. Mangistau region																							
1988																							
1993	12.8												0	0	0	0					-1.8		6.6

1998	13.7												0	-0.7	0.1	-0.1					-2.2		8.2
2003	20												0.9	0	0	0					7.7		-28.1
2008	15.7												3.6	10.9	0.9	0.3					15.4		-56.6
2013	15.7												0.9	9.8	0.8	0					4.6		-17.0
2018	18.4												0.4	-4.9	0.1	-0.4					4.8		-17.7
2020	18.7												0	1.1	0	0.4					1.2		-4.5

Continued table 6.2.4

1	2	3	4	5	6	7	8	9	10	eleven	12	13	14	15	16	17	18	19	20	21	22	23	24
12. C - Kazakhstan region																							
1988	366.8	0	0	0			0	0		0												0.0	
1993	379.2	97.6	-33.4	44.8			4.7	-1.2		-15.4	97.1											-356.4	
1998	478.8	-343.2	17.2	-5.7			5	-3.8		33.2	-297.3											1091.1	
2003	539.5	132.8	16	-24.9			41.4	7.2		-48.3	124.2											-455.8	
2008	525.2	-121.2	0.2	-22.1			-54.2	-14.8		-28.9	-240.4											882.3	
2013	529.7	-85	-9	-9.1			-2.8	0.8		138	32.7											-120.0	
2018	337.2	-91.6	-35	-16.1			-9.2	-7.6		230	70.9											-260.4	

2020	540.5	137	2.9	29.6			87.2	1		108	366.0											-1343.2	
13. Pavlodar region																							
1988	287	0	0	0			0	0		0													
1993	296.4	0	0	0			0	0		0	453.8											-1665.4	
1998	72.2	355.6	53.4	44.8			0	0		0	37.3											-136.9	
2003	270.8	32	eleven	-5.7			0	0		0	-263.3											966.3	
2008	143.2	-198.2	-40.2	-24.9			0	0		0	-27.5											100.9	
2013	249.7	-21.2	-3	-9.1			50.8	8.4		-7.4	18.6											-68.1	
2018	258.4	-66.2	-13.6	-16.1			61.8	10.1		-33.4	-57.4											210.5	
2020	259.6	172.5	36.6	29.6			62.2	8.5		8	316.9											-1163.0	
14. Turkestan region																							
1988																						-26.4	0.0
1993	1040	7.2	0.0	0.0			0.0	0.0		0.0	7.2											-33.0	0.0
1998	1141	9.7	0.0	-1.1			0.0	0.7		-0.3	9.0											-130.1	-17.2
2003	1134	7.5	0.0	-0.5			29.0	1.1		-1.7	35.4											60.1	-240.8
2008	1154	9.2	-25.5	0.4			-0.3	0.0		-0.2	-16.4											-137.1	-325.9
2013	1179	7.3	25.5	-2.1			-1.3	7.5		0.5	37.3											57.0	8.4
2018	1204	7.3	3.2	-0.1			-19.6	0.0		-6.3	-15.5											-491.8	17.2

2020		7.4	3.2	1.4			126	0.0		-3.8	134.0											-26.4	--87.3

Table 6.2.5. Annual changes in the carbon stock for the forests of the Republic of Kazakhstan by reservoirs of accumulation and absorption (-) / release (+) of CO2 calculated for 1988-2020. with generalization at the national level.

years	Change in carbon stock, thousand tons / year					Absorption (-) / release (+) CO2, thousand tons/year
	Phytomass	Deadwood	bedding	The soil	Total	
1988	2.0	0.1	-0.2	-0.2	1.8	6.4225
1989	192.7	-8.3	9.8	14.4	208.6	765.488
1990	384.4	1.0	-4.2	13.3	394.5	-1445.03
1991	576.1	2.0	28.1	-11.1	595.1	-2182.03
1992	768.0	-26.4	-19.3	-2.8	719.5	-2638.16
1993	957.2	56.2	-8.0	37.3	1042.7	-3823.2
1994	931.5	32.3	-46.1	39.4	957.0	-3509.36
1995	905.7	8.4	-84.2	41.4	871.4	-3194.76
1996	880.0	-15.5	-122.3	43.5	785.7	-2880.9
1997	854.3	-39.4	-160.4	45.6	700.1	-2567.03
1998	711.7	27.2	-28.4	96.2	806.7	-2957.9
1999	214.4	-4.0	-46.8	72.2	235.7	-864.6
2000	-282.9	-35.2	-65.3	48.2	-335.3	1229.06
2001	-780.3	-66.4	-83.8	24.3	-906.2	3322.7
2002	-1277.6	-97.6	-102.3	0.3	-1477.2	5418.23
2003	-1032.3	-45.4	-144.1	-105.2	-1327.0	4865.66
2004	-610.4	-3.2	-135.2	-109.0	-857.8	3145.2
2005	-188.5	39.0	-126.4	-112.8	-388.7	1425.23
2006	233.4	81.2	-117.5	-116.6	80.5	-295.4
2007	655.3	123.4	-108.6	-120.4	549.7	-2015.56
2008	533.4	89.5	-117.1	-104.8	401.1	-1470.33
2009	726.2	132.0	-86.6	-83.3	688.3	-2523.76
2010	919.0	174.4	-56.2	-61.8	975.4	-3576.46
2011	1111.7	216.8	-25.7	-40.3	1262.5	-4629.16
2012	1304.5	259.3	4.7	-18.9	1549.6	-5681.86
2013	1551.2	300.7	12.0	176.7	2040.6	-7482.2
2014	1321.5	269.1	7.7	163.2	1761.5	-6458.8
2015	1091.9	237.6	3.3	149.7	1482.5	-5435.83
2016	862.2	206.1	-1.0	136.2	1203.5	-4412.83
2017	632.5	174.5	-5.3	122.8	924.5	-3389.83
2018	421.1	117.5	15.1	227.9	781.5	-2865.86
2019	1306.5	175.4	114.7	165.5	1762.2	-6461.03
2020	2192.0	233.3	214.3	103.2	2742.8	-10056.93

Table 6.2.6 - Annual GHG emissions from forest fires on forested lands of the State LF, calculated for 1990 ... 2020

Year s	Square, n fires, ha	CO_2 _ thousand tons / year	CH_4, thousand tons/year	N_2O, thousand tons / year	CH_4 and N_2O, thousand tons / year in eq. CO_2,	CO, thousand tons / year	NOx , thousand t / year	*NMLO* thousand tons / year
1	2	3	4	5	6	7	8	9
1990	1020	20.44	0.06	0.0034	2.51	1.422	0.039	0.367
1991	4330	86.76	0.26	0.0144	10.31	5.917	0.166 _	1,560
1992	1170	23.44	0.07	0.0039	2.91	1.599	0,045 _ _	0.421
1993	700	14.03	0.04	0.0023	1.69	0.956	0,027 _ _	0.252
1994	4590	91.97	0.28	0.0152	11.53	6.272	0.176	1.652
1995	20500	410.77	1.23	0.0681	51.04	28.013	0.785	7.381
1996	9160	183.55	0.55	0.0030	14.64	12.517	0.351	3.297
1997	182500	3656.88	10.95	0.6060	454.34	249.386	6.992	65,700
1998	12600	252.48	0.76	0.0418	31.46	17.218	0.428	4.536
1999	20700	414.78	1.24	0.0687	51.47	28.286	0.793	7.452
2000	12900	258.49	0.77	0.0428	32.00	17.628	0.494	4.644
2001	19020	381.12	1.14	0.0632	47.33	25.991	0.709	6.848
2002	15100	302.57	0.91	0.0501	37.68	20.634	0.576	5.373
2003	34100	683.29	2.05	0.1132	84.98	46.598	1.306	12.275
2004	45200	905.70	2.71	0.1501	112.48	61.666	1.732	16.272
2005	12900	258.49	0.77	0.0428	32.00	17.628	0.494	4.644
2006	21900	438.83	1.31	0.0727	54.41	29.926	0.839	7.877
2007	67398	1350.54	4.05	0.2238	167.94	92.099	2.582	25.153
2008	5800	116.22	0.35	0.0193	14.50	7.926	0.222	2.088
2009	2100	42.08	0.13	0.0070	5.34	2,870	0.080	0.756
2010	6535	130.95	0.39	0.0217	16.22	8,930	0.250	2.352
2011	2388	47.85	0.14	0.0079	5.85	3.262	0.091	0.853
2012	4042	80.99	0.24	0.0134	9.99	5.523	0.155	1.455
2013	953	19.10	0.06	0.0032	2.45	1.302	0.036	0.343
2014	1260	25.25	0.08	0.0042	3.25	1.722	0.048	0.454
2015	5605	112.31	0.3 0	0.0186	13.79	7.659	0.215	1.989
2016	275	5.52	0.005	0.0006	0.82	0.402	0.009	0.099
2017	6150	123.24	0.367	0.0204	15.26	8.40	0.235	2.182
2018	4271	85.58	0.25 _ _	0.0141	10.73	5.836	0.164	1,536 _ _
2019	34523	691.72	2.08	0.1146	86.03	47.18	1.322	12 , 43
2020	27661	554.26	1.62	0.092	67.76	37.78	1.060	9 , 88

6.2 . 2 *Methodological issues , information used*

In the process of calculating the dynamics of the stock of accumulated carbon and net absorption / emission of CO_2 for the category Forest land in the composition of LF lands, its subcategories were distinguished separately: forest remaining in the previous category (natural), renewable forest, which included an artificial forest of sowing - planting after 1990 and forest restored by promoting natural regeneration and overgrowing on areas of forest land temporarily

not covered with woody vegetation. In accordance with the requirements set out in the IPCC RP, 2006, $CO_{2\ fluxes}$ were calculated for identified strata, taking into account the redistribution of carbon over the main reservoirs of its accumulation: above-ground and underground living biomass (phytomass), deadwood biomass (mortmass), litter biomass (mortmass) and mineral soil (upper horizon 0…0.3 m). 10 - living biomass, 2.17, 2.19 - dead organic matter, 2.25 - mineral soil, 2.27 - GHG emissions from fires, which are generally presented in Appendix 2 of the IPCC SPM, 2006 .

Biomass living above and below ground (phytomass) and deadwood. Carbon stock accumulated by forest trees in phytomass and deadwood, carbon stock changes and $CO_{2\ fluxes}$ were calculated based on the stock difference method according to Equation 2.8 of Chapter 2, Volume 4 of IPCC 2006 SPM, using data on standing stocks of wood (Table 6.2.1 and 6.2.2) and conversion rates (table 6.2.7).

Table 6.2.7 - Conversion coefficients for calculating the carbon stock in phytomass and deadwood reservoirs by species groups and age groups of trees and shrubs of the State Forest Fund of the Republic of Kazakhstan

Breed	carbon reservoir	Age group			
		Young growth of the 1st and 2nd category	Medium-vegetable	ripening	Ripe and overripe
Conifers	Phytomass	0.615	0.665	0.711	0.711
	Deadwood	0.123	0.059	0.046	0.020
soft-leaved	Phytomass	0.764	0.794	0.830	0.830
	Deadwood	0.082	0.048	0.038	0.030
hardwood	Phytomass	0.950	1.043	1.147	1.132
	Deadwood	0.219	0.118	0.090	0.031
Saxaulniki	Phytomass	1.140	1.140	1.140	1.140
	Deadwood	0.042	0.042	0.042	0.042
Other breeds	Phytomass	0.709	0742	0.770	0.770
	Deadwood	0,,092	0.092	0.092	0.092
shrubs	Phytomass	0.453	0.439	0.545	0.545

The coefficients presented in the table were previously obtained jointly by the specialists of the State Enterprise "Kazakh Forest Inventory Enterprise" KLHZhM MEGPR and JSC "Zhasyl Damu" using archival materials from periodic forest inventory and published tables of the progress of the growth of the main forest-forming species (Standards for forest inventory in Kazakhstan, *Almaty* , 1987), other information.

It should be noted that the effect on the level of carbon emissions and removals from conversions from or to forest land is automatically taken into account when using data on wood stocks in forests from forest inventory materials. Due to the construction of the land conversion matrix, it is not possible to separate carbon stock changes in the living biomass pool separately for Forest Land Remaining Forest Land and Land Converted to Forest Land. Therefore, the resulting value is listed in the Forest Land subcategory remaining Forest Land.

The stock of carbon in the litter for coniferous and deciduous forests evaluated performers using cartographic data on the stock of organic matter in mortmass [4] and data on the stock of carbon in deadwood. To estimate the carbon stock in the litter of saxaul forests, empirical data

from field studies of forests in the Southern Balkhash region were used (ISTC Project K -1396, 2006…2011).

The assessment of changes in carbon stocks in litter was carried out using the stock difference method (IPCC 2006 SPM Equation 2.19) based on data on carbon stock in living biomass and coefficients of proportionality between the amount of carbon in litter and the amount of carbon in living biomass. For coniferous-deciduous trees, this coefficient is 0.126, for saxaul trees - 0.049.

The stock of carbon in the litter was carried out taking into account the fact that part of the litter burned down during the fire. In particular, it is assumed that the amount of burned litter is 45% of the litter reserves in forests. Accordingly, the stock of carbon in litter per 1 ha is only 55% of the stock of litter in forests. The areas of burnt areas were used as initial data (Table 6.2.2).

The assessment of carbon stocks in the litter in clear cuts was calculated based on the areas of clear cuts (Table 6.2.2), the stock factor of dry matter in the litter after felling (1.2 t of dry matter per 1 ha), as well as the coefficient of conversion of dry matter of the litter to carbon (0.37). The resulting value was calculated using the margin difference method.

It should be noted that the use of the method of stock difference in dead organic matter makes it possible to take into account the conversion of land from forest to other land uses. In particular, due to the lack of accurate data on areas of conversions from forest land to other land uses, any change in carbon stocks in dead organic matter due to conversions from or to forest land is included in the reporting under Forest Land Remaining Forest Land.

Soil (mineral). Calculation of changes in carbon stocks in mineral soil was carried out according to the level 1 method of IPCC 2006 WP. The areas of all forest areas by region were used as input data, including unvegetated areas (cutting areas, burnt areas, sparse areas).

For forest land soil, carbon stock dynamics was calculated using the national standards of soil organic carbon stock from the publication under section [5] and stock change factors associated with a change in activity regime (Table 5.5 in the IPCC SPM, 2006, Chapter 5).

It should be noted that, taking into account the approach to the construction of the land transition matrix, it is impossible to separate land converted to forest from forest land remaining forest. Therefore, the result of estimating carbon stock changes in Forest Land Remaining Forest Land includes carbon stock changes from all land converted to forest land.

In addition, an estimate was made of direct N_2O emissions associated with the loss of soil carbon. The calculation was made following the Tier 1 method using default coefficients according to Equations 11.1 and 11.8 of the 2006 IPCC SPM. The estimate was made according to soil carbon calculations - by region.

Emissions from fires were calculated in accordance with the IPCC RP, 2006 using statistics on the area of fires from Table 6.2.9 and information from the publication under section [6].

As sources of information ***used*** in the assessment of carbon stock and greenhouse gas fluxes for forest lands, data on forest inventory areas and standing stock for 1988 ... 2020 were used. according to the results of a one-time accounting (taxation) of forests of the state and private Forest Fund of the Republic of Kazakhstan, forest inventory is carried out in the country by the State Enterprise "Kazakh Forest Inventory Enterprise" of the Committee for Forestry and Wildlife of the MEGNR RK . The stock of timber was assessed in accordance with the methodological requirements set out in the Forest Inventory Instructions, 2012, KLKHZM MEGNR RK and the Rules for Forest Inventory in the State Forest Fund of the Republic of Kazakhstan, 2012,

KLKHZM. Information on the burnt area of forest lands was provided by the Republican State Enterprise "Kazakh base of aviation forest protection and forestry services" MEGNR RK.

6 . 2 . 3 Uncertainties and sequence of time series

Uncertainties in the calculation of absorption / emission of GHGs for the Forest Land category of the LHDVZ sector were assessed by the performers earlier at the expert level using information from the IPCC RP, 2006 and IPCC RD, 2000 [1,7]. Including the total uncertainty of CO2 release/removal calculations for forests was obtained at the level of ± 41.4%, The overall uncertainty in estimating GHG emissions from forest fires was ± 58.7% for CH_4 and ± 54.4% for NO_2, The overall uncertainty of the calculated GHG fluxes included an estimate of activity E (%) , taken equal to ± 5% and the uncertainty in the estimation of emissions/removals F (%), The sequence of time series is confirmed by using initial information from unified official sources for all years of data submission in the ND and unified methods for calculating GHG for forest areas.

6.2 . 4 QA/QC procedures and checks

The QA/QC procedures for the Forest Land category were carried out in accordance with the General QA/QC Plan for the NIR 1990…2020.

The QA procedures were carried out by an independent expert within the framework of the project of the Government of the Republic of Kazakhstan, UNDP and the GEF “Development of the Eighth National Communication of the Republic of Kazakhstan under the UNFCCC and preparation of two (fourth and fifth) Biennial Reports”. In particular, the initial data, emission factors and methods used in the calculations were considered. As a result of the audit, recommendations were made regarding the calculations in the category that were used for the recalculations.

6.2 . 4 Recalculations, the prospect of improvement .

In the current NIR, recalculations were made in order to further take into account data by regions. In particular, additional data checks were made on the time series in order to identify inaccuracies and the need to apply data splicing methods. In particular, this is especially true for data before 2003, which, for some regions, were fragmented.

Methodological errors in the approach to estimating changes in carbon stocks in living biomass have been corrected. In particular, the current RD uses the stock difference method, taking into account the peculiarities of forest inventory in the Republic of Kazakhstan for 5-year periods.

The approach to accounting for forest land areas has been changed. In particular, in order to prevent underestimation or double counting of greenhouse gas emissions, the calculations of carbon stocks in litter and soil carbon took into account all forest areas of the regions. The difference in carbon stocks in the region's reservoir between years was estimated using the appropriate equations from the 2006 IPCC SPM.

6.3. Cropland (category 4B in the CRF table **)**

6.3.1 Category description, main results

Cultivated land (CL), as a key category of activity related to land use, includes arable and arable land that has been in crop rotation for at least 20 years, as well as perennial plantations (Land Code of the Republic of Kazakhstan). There are 61.2 million hectares of arable land in the Republic of Kazakhstan, of which 52.9 million hectares are located on the flat territory in the

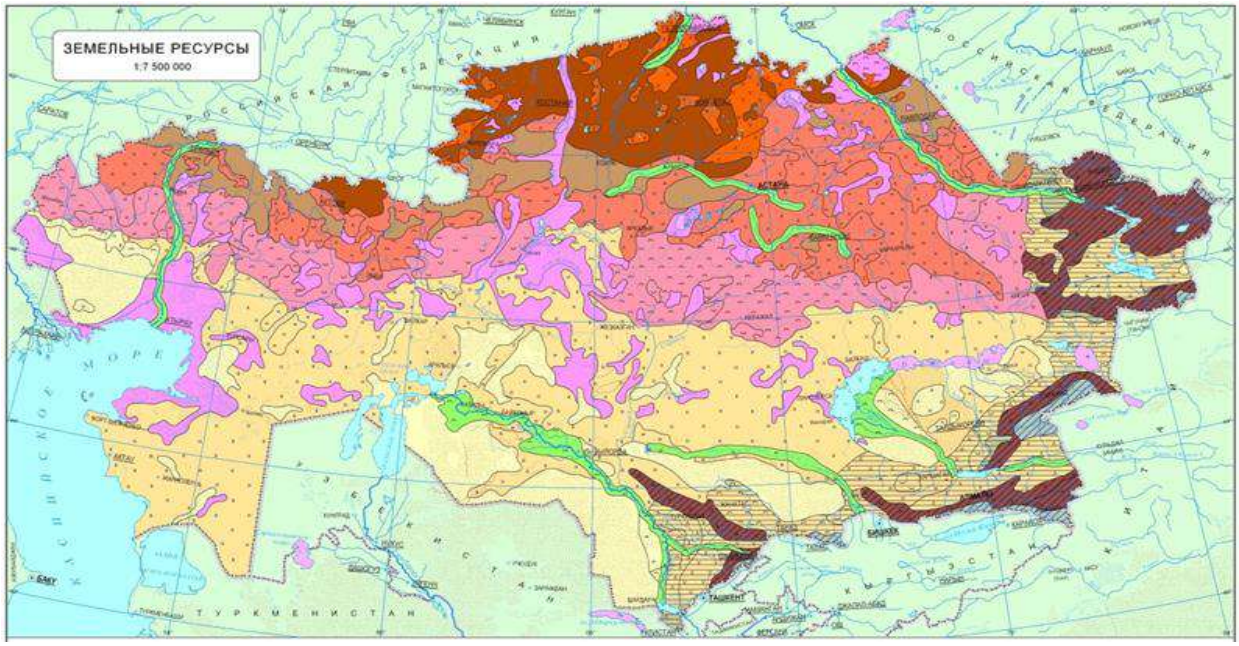
steppe zone and 8.3 million hectares in the foothill and mountain zone (table 6.3.1). The most fertile lands, mainly chernozems on an area of 16.8 million hectares (humus content 4..6% in the arable horizon of the soil), chestnut lands on an area of 27 million hectares (humus 3 ... 4% or more), as well as foothill sierozem, mountain chestnut and chernozem soils (humus from 1.5 ... 2.0% or more) have been plowed up in the last 150 years. In 1989, the total area of arable land reached its largest value - 35.6 thousand hectares.

Table 6.3.1 - Distribution and development of arable lands of the Republic of Kazakhstan by natural zones and soil types for 1988 ... 2020 million ha

Soil types and subtypes by natural zones	Arable suitable land	Dynamics of development of arable land (in arable land)			
		1989	2000	2014	2020
Chernozems of the steppe zone, incl. ordinary chernozems	16.8 8.0	14.5 7.1	- -	- 6.04	- 6.07
Southern Chernozems	8.8	7.4	-	5.24	5.36
Chestnut dry steppe zone incl. t. chestnut	27.0 14.0	15.1 10.1	- -	- 7.45	8.10
chestnut	8.3	3.7	-	1.78	2.17
Light chestnut semi-desert zone	4.7	1.3	-	0.07	0.05
Brown desert zone, including brown	9.1 4.3	0.5 0.1	- -	0.015	0.016
Gray - brown	4.8	0.4	-	0.19	0.2 3
Total in latitudinal zones	*52.9*	*30.1*	-	*21.03*	*22.00 _ _ _*
Serozems northern and southern desert-steppe zone	-	-	-	1.83	1.83
Total in high-altitude zones	*8.3*	*5.5*	-	*3.85*	*2.25 _*
Total	*61.2*	*35.6*	*21.4*	*24.88*	*2 6.08*

After 1990, the cultivated lands underwent significant changes associated with the partial withdrawal of arable land from crop rotation to fallow and pasture lands, mainly to reserve lands. In 2000, the area of arable land in crop rotation decreased to 21.4 thousand hectares, with subsequent partial recovery, mainly after 2010.

The distribution of cultivated land on the territory of the Republic of Kazakhstan by natural zones, including cultivated land, is shown on the map (Figure 6.3.1). The results of the assessment of the anthropogenic impact on agroecosystems, along with indicators of the natural resources of the territory, are taken into account in the development and implementation of state and regional programs for the rational use and protection of land, and the development of rural areas. other industry and activities for the use of each region of the country.



Rice. 6.3.1- Land resources of the Republic of Kazakhstan (NA RK, 2003).

Lands, mainly arable used for arable land, zonal groups:

- moderately arid and arid steppe / chernozem ordinary and southern;

- heavy, medium and light loamy soils and their complexes with solonetzes no more than 30%;

– dry steppe/dark chestnut and chestnut soils, partially light chestnut, light loamy and loamy soils;

- desert-steppe piedmont-foothill, steppe piedmont and intermountain serozems, ordinary and gray-brown, dark chestnut soils and chernozems;

Percentage of possible land use for arable land: 20-25 25-30 30-35.

By 2020, the area of arable land in the crop rotation continued to recover and amounted to 26011.0 thousand hectares, which is 324.3 thousand hectares more than the area in 2019. *Perennial* area *plantations, which are represented* mainly by horticultural crops, grape plantations, decreased from 164.8 thousand hectares (1990) to 116.3 (2010) with a subsequent increase to 146.9 thousand hectares in 2020 (table 6.2.2).

An analysis of empirical data on the dynamics of soil humus for arable lands of the Republic of Kazakhstan indicates that over the past 30 years, its content in the arable soil horizon has decreased by 30%, i.e., by 1% per year. At the same time, the content of nitrogen and phosphorus in the soil decreased by 20% and 14%, i.e. by 0.8% per year and 0.5% per year, respectively (Table 6.3.2). At the same time, as can be seen from Figure 6.3.2, the content of soil humus on arable land in the administrative regions of the Republic of Kazakhstan did not change unambiguously.

Table 6.3.2 - Dynamics of humus, readily hydrolysable nitrogen and mobile phosphorus in the soil of arable land of the Republic of Kazakhstan as their average content per area of agrochemical surveys for 1989 ... 2020

Year	Survey area, thousand hectares	Content in soil horizon 0…0.2 m (average per survey area)			
		humus, %	easily hydrolysable nitrogen, mg/kg	exchangeable phosphorus, mg/kg	potassium, mg/kg
1989	-	4.29	45.3	22.5	516.6
2010	17 610	3.47	42.5	21.3	587.5
2014	17 341	3.27	36.6	19.4	621.0
2018	18 419	2.99	-	-	-
2020	25 500	2.96	-	-	-

Information provided by the State Institution "RNMTs Agrohimsluzhba" of the Ministry of Agriculture of the Republic of Kazakhstan.

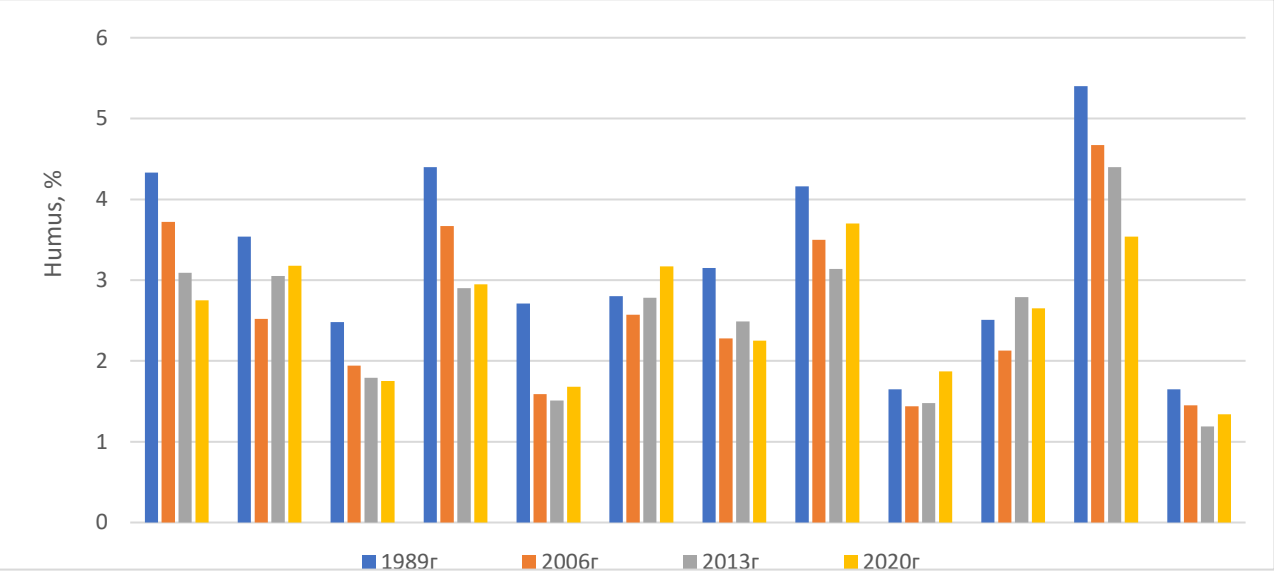


Fig.6.3.2 The content of soil humus on arable land (horizon 0 ... 0.03 m) in the context of the administrative regions of the Republic of Kazakhstan for 1989 ... 2020 according to the results of agrochemical surveys.

At the same time, as can be seen from Figure 6.3.2, the content of soil humus for arable land in the administrative regions of the Republic of Kazakhstan did not change unambiguously. The largest decrease in the content of humus in the soil of arable land remaining in the crop rotation (up to 40% on average per region), compared to 2020, was in the northern regions: North Kazakhstan, Akmola, and also East Kazakhstan, with highly productive chernozem soils. A less pronounced decrease in the content of soil humus (up to 8 ... 9% on average per region) was noted for the southern regions - Turkestan and Kyzylorda, with a significant participation of irrigated arable land, relatively provided with nitrogen fertilizers. Also, a less significant decrease in the content of humus in the soil of arable lands remaining in the crop rotation occurred in the West Kazakhstan, Pavlodar, Aktobe regions with less productive chestnut and light chestnut soils, which were first removed from the crop rotation.

In recent years, the deterioration of soil indicators for arable land in the Republic of Kazakhstan has continued, which is confirmed by additional information from Table 6.3.3. The table contains updated results of agrochemical surveys of agricultural fields carried out by the State Institution "RSMC "Agrokhim Service" of the Ministry of Agriculture of the Republic of Kazakhstan in the period 2014 - 2020, and updated results of agrochemical surveys of fields for

earlier years. The additional empirical data obtained on the content of humus in the plow horizon of the soil made it possible for the first time to perform for 1989-2020. once aggregated calculations of the dynamics of soil carbon stocks at the level of administrative regions of the Republic of Kazakhstan (12 regions in total), taking into account the soil differences of the territory. The results presented in Table 6.3.3 were used for subsequent calculations of annual changes in carbon stock and the amount of absorption / release of CO_2 for arable land in the Republic of Kazakhstan (Table 6.3.4). The information obtained allows us to perform a detailed spatial and temporal analysis of soil fertility for arable land in the Republic of Kazakhstan for the time period 1989-2020. and to objectively quantify the contribution of the Cropland category to national emissions of greenhouse gases into the atmosphere over the past two decades.

Table 6.3.3 - The weighted average content of humus in the soil (0-0.2m) based on the results of agrochemical surveys of arable land* and the carbon stock in the soil (0-0.3m), calculated** for the administrative regions of the Republic of Kazakhstan for 1989...2020 .

Region, soil type	1989 _			2002 - 2006			2007-2013			2014 -2020.		
	Area of arable land, thousand ha	Humus *** , %	C **, t/ha	Survey area, thousand ha	Humus * , %	C**, t/ha	Survey area, thousand ha	Humus * , %	C ** t/ha	Survey area, thousand ha	Humus * , %	C ** , t/ha
1	2	3	4	5	6	7	8	9	10	eleven	12	13
Akmola												
Chernozems are common.				340.4	5.15	89.1	457.8	5	86.4	826	4.21	72.24
Southern Chernozems				622.6	4.05	70.6	646.2	3.8	66.3	1632	3.28	56.88
Dark chestnut				504.2	3.34	61.4	1128.6	2.98	52.9	11.62	2.58	47.09
chestnut				929.6	2.78	52.6	383.9	2.66	45.2	1144	2.37	42.7
light chestnut				-	-		145.9	2.28	38.2	102	2.18	36.28
***Total** for the region*	***6385***	***4.81***	***87***	***2416.8***	***3.55***	***52.1***	***2771.4***	***3.41***	***54.9***	***6000.1***	***2.92***	***52.13***
Aktobe												
Southern Chernozems				84.4	3.43	58.3	58.6	3.71	62.93	144.7	3.42	59.2
Dark chestnut				310.9	2.55	45.29	348.3	3.29	59.16	538.8	3.14	52.1
chestnut				83.05	2.54	44.38	143.4	3.14	54.79	18.15	2.75	45.5
***Total** for the region*	***2190***	***3.86***	***62.31***	***478.3***	***2.71***	***47.81***	***550.3***	***3.29***	***58.36***	***7878***	***3.18***	***53.3***
Almaty												
light chestnut				37.8	2.55	42.13				216.1	1.97	53.3
chestnut										6.76	2.41	47.4
Dark chestnut				19.4	2.99	52.71				77.3	3.12	55
Meadow										23.6	2.26	38
Serozems light				67.4	1.29	23.72	14	1.2		43.7	0.82	14.2
Serozems ordinary				391.9	1.84	36.97	207.2	1.24		376.6	1.17	23.8
Meadow-serozem				27.6	2.18	44.68	4.76	1.31		58.2	1.68	34.2
mountain chernozems				2.9	2.65	39.46				1.01	2.9	43.6
foothill chernozems				2.73	3.82	69.63	25.46	3.34		50.97	3.93	72.6
Piedmont. light chestnut.				86.2	2.43	44.25	90.33	2.2		30.4	2.15	39.9
Piedmont. dark chestnut.				64.1	2.91	53.09	41.06	3.31		26.8	2.16	39.2

Meadow-swamp				3.86	1.2	21.38	0.1	2.5		12.6	1.95	39.2
***Total** for the region*	***1719***	***2.76***	***41.9***	***603.87***	***2.07***	***39.19***	***382.91***	***1.83***	***34.04***	***1099***	***1.75***	***31***

Continued Table 6.3.3

1	2	3	4	5	6	7	8	9	10	eleven	12	13
V-Kazakhstan												
mountain chernozems				32.16	5.44	90.82	28.7	5.64	93.19	94.3	4.7 5	78.6
Dark chestnut				197.6	3.13	50.32	286.4	3.06	51.04	428.2	2.47	45
chestnut				0.29	3.1	52.82	41.9	2.14	36.51	90.5	1.98	36.8
light chestnut				73.7	1.93	37.07	195.5	1.93	37.84	163.8	1.84	34.2
Serozems ordinary							9	0.9	18.16			
Serozems light										0.26	1.6	29.8
Gray-brown										0.29	1.8	27.9
foothill chernozems				188.8	5.07	92.59	114.6	4.69	85.56	32.3	4.53	83.8
Piedmont dark chestnut.							10.8	3.9	72.33	62.1	2.6	48.4
Piedmont light chestnut.				27.9	2.71	49.46	5.09	2.3	41.85	21	2.4	44.3
mountain browns							0.95	7.7	138.3			
Meadow-chernozem				0.14	6.8	106.6				1.83	4	62
Southern Chernozems				52.7	3.86	65.11	75.2	3.87	65.7	81	3.74	63.9
Chernozems are common.				2.67	5.73	86.99	29.12	5.3	91.82	251	4.13	71.6
***Total** for the region*	***2745***	***4.92***	***84.76***	***574.86***	***3.79***	***68.57***	***800.17***	***3.23***	***58.61***	***1329.45***	***2.95***	***48.6***
Zhambyl												
Serozems ordinary				226.7	1.6	33.15	96.4	1.64	32.91	660.9	1.69(1.66	33.95

Grey-brown										27.23	2.39	47.2
Serozems light				27.6	1.3	23.94	217.4	1.49	27.3	23.9	1.26	23.3
Meadow-chernozem				15.07	2.23	46.87	30.05	2.02	43.3	32.98	1.71	35.8
floodplain meadow										0.65	1.2	23.9
Meadow-marsh										0.09	1.2	22.5
Mountain chestnut				0.04	6.5	109.6				2.31	2	35.7
Piedmont. dark chestnut				11.85	3.23	56.83	5.41	4.23	74.63	5.21	3.8	66.5
Piedmont svetokasht				34.59	2.11	36.28	12.5	2.67	45.45	24.16	1.3	26.1
light chestnut				10.03	2.5	46.32	68.35	2.08	38.4	78.72	180	33.6
***Total** for the region*	***1028***	***3.06***	***59.8***	***325.81***	***1.73***	***34.72***	***430.09***	***1.73***	***32.91***	***935.86***	***1.68***	***34.2***
W-Kazakhstan												
Southern Chernozems										55.7	3.29	57.4
Dark chestnut				391.7	2.86	51.58	328.3	3.01	54.23	502.9	3.17	57.6
chestnut				25.1	2.4	42.03	77.5	2.56	44.78	43.65	3.09	54.4
***Total** about by area*	***24310***	***3.12***	***55.56***	***416.8***	***2.84***	***51***	***405.8***	***2.96***	***52.44***	***674***	***3.17***	***57.45***

Continued Table 6.3.3

1	2	3	4	5	6	7	8	9	10	eleven	12	13
Karaganda												
Chernozems are common.				0.5	4.5	78.18	0.51	2.6	45.18	0.16	2.3	40
Dark chestnut				431.3	2.47	45.51	127.5	3.44	60.5	524	2.48	46
chestnut				172.4	2.28	44.48	313.41	2.95	44.98	749.4	2.12	40.7
light chestnut				4	1.8	38.32	15.38	2.2	40.63	0.5	2.5	46.7
***Total** for the region*	***1062***	***3.53***	***60.84***	***638.20***	***2.44***	***45.33***	***456.81***	***3.07***	***49.05***	***1394.6***	***2.25***	***42.9***
Kostanay												

Chernozems are common.				885.95	4.42	76.64	1054	3.96	68.68	2011.5	4.4	76.3
Southern Chernozems				719.7	3.68	64.59	998.9	3.78	66.25	1249.2	3.7	63.7
Dark chestnut				485.2	2.8	50.44	10108	3	55.18	1663.4	3	54.5
chestnut				175.8	2.21	42.03	588.7	2.13	40.65	363.7	2.5	47.9
Total *for the region*	**6719**	**4.38**	**76.7**	**2269.6**	**3.62**	**64.54**	**3652.4**	**3.35**	**60.44**	***5801.9***	***3.7***	***64.5***
Kyzylorda												
floodplain meadow				31.9	1.93	35.96						
Meadow-swamp				83.74	1.45	28.35	23.97	1.62	31.76	72.6	1.99	39
gray brown				5.41	1.57	28.41	0.17	1.6	29.12	106.12	1.8	32.7
Total *for the region*	***306***	1.88	***36.4***	***121.05***	***1.59***	***30.6***	***24.14***	***1.62***	***33.17***	***222***	***1.87***	***35.85***
Pavlodar												
Southern Chernozems				110.85	3.06	53.7	518.44	3.78	66.74	513.24	3.54	62.58
Dark chestnut				350.9	2.12	37.35	374.57	2.26	40.64	600.6	2.25	40.24
chestnut				28.75	1.42	25.73	159.52	2.25	38.86	174.5	1.89	34.27
light chestnut				0.07	2.1	38.8	30.33	1.9	35.04	21.01	1.62	31.78
Total *for the region*	***3517***	***2.82***	***47.31***	***490.58***	***2.29***	***40.15***	***1082.86***	***2.97***	***52.7***	***1652.1***	***2.65***	***46.89***
C - Kazakhstani												
Chernozems are common.				2096.3	4.94	85.68	2023.6	4.74	82.24	3501	4.22	73.2
Southern Chernozems				172.3	4.16	7142	243.55	4.18	71.78	332.54	3.15	54.57
Dark chestnut							71.7	4.13	61			
floodplain meadow							1.43	2.3	36.52			
Total *for the region*	***1989***	***6.03***	***105.4***	***2268.56***	***4.9***	***84.53***	***2340.24***	***4.66***	***80.65***	***4623.07***	***4.15***	***71.75***
Turkestan												
Serozems ordinary				255.54	1.58	31.82	295	1.29	25.86	475	1.61	32.91
Serozems light				162.55	1.4	25.89	143.8	1.17	21.48	215.8	1.4	20.41
Piedmont dark chestnut.							3.45	2.44	42.57	-	-	
gray brown				9.91	1.4	25.56				101.3	1.84	33.42
Grey-brown							55.3	1.82	35.43	157.7	2.22	43.41

Continued Table 6.3.3

1	2	3	4	5	6	7	8	9	10	eleven	12	13
Meadow-serozem							9.15	0.8	16.09	-	-	
Total *for the region*	***1236***	***1.84***	***59.8***	***428***	***1.52***	***31.94***	***506.65***	***1.31***	***31.6***	***983.4***	***1.67***	***32.76***

***** -data obtained from RSE "RSPC" Agrohimsluzhba "of the Ministry of Agriculture of the Republic of Kazakhstan; ****** - calculations of Zhasyl Damu JSC; ****** * - information of the State Archive of the Kazakh SSR.

It should be noted that the volumes of $CO_{2\ released}$ from the soil of arable lands, in turn, serve as the initial data for assessing direct N_2O emissions from the soil during the mineralization of organic matter (IPCC RP, 2006). The results of N_2O emission calculations for arable lands of the Republic of Kazakhstan are shown in Section 5 (Table 5.22). Once aggregated annual changes in soil C stock at the oblast level (Table 6.3.4), it is possible to more accurately estimate the amount of direct N_2O emissions for cropland by excluding individual cases with positive annual changes in soil C stock from the calculations.

The total amount of $CO_{2\ emissions}$ from arable land in crop rotation, estimated for the Cropland activity category, was about 46,984.8 thousand tons per year at the national level for 2020 (Table 6.3.5). Taking into account the volumes of CO_2 absorbed by the regenerated natural vegetation in the areas of arable land temporarily withdrawn from crop rotation for a period of 5-18 years, the total emissions for the Cropland category for 2020 were estimated at about 31,905.13 thousand tons / year.

Table 6.3.4 - Annual changes in the carbon stock in the soil (0-0.3m) of arable and arable lands and $CO_{2\ emission\ /\ absorption}$, calculated in the context of the administrative regions of the Republic of Kazakhstan for 1989..2020. according to the results of agrochemical surveys (GU "RSPC" Agrohimsluzhba "of the Ministry of Agriculture of the Republic of Kazakhstan)

years	Arable land in crop rotation			Arable land bred into fallow (pasture)			Arable land returned to crop rotation			Total arable land and arable land		
	area, thousand ha	carbon stock, t/ha	stock change, thousand tons / year	area, thousand ha	carbon stock, t/ha	stock change, thousand tons / year	area, thousand ha	carbon stock, t/ha	change in stock, thousand tons / year	area, thousand ha	change in stock, carbon thousand tons / year	Emission / absorption of CO_2, thousand tons / year
1	2	3	5	6	7	8	9	10	eleven	12	13	14
Akmola region												
1989	6385	87			87	0				6385	0	
1990										0	0	
2000	4532	76	-4532	1852	81	-1010	0	0	0	6384	-5542	20339
2006	4532	64.71	-8528	1169	83	390	683	81	-113.8	6384	-8252	30284
2013	4532	59.76	-3505	874	85	250	978	76.83	-644	6384	-3899	14309
2020	4532	52.13	-4901	370	87	106	1483	69	-1318	6385	-6113	22435
Aktobe region												
1989	2190	65.3	0							2190	0	
1990										0	0	
2000	663	52	-802	1527	56	-1291	0	0	0	2190	-2093	7681

2006	663	47.81	-463	1407	58	509	120	56	-19.9	2190	26	-96
2013	663	58.36	999	1407	60	402	120	58.36	40	2190	1441	-5288
2020	663	53.3	-479	1006	62	402	520	53	-101	2189	-178	653
Alma-Ata's region												
1989	1719	41.9	0							1719	0	0
1990										0	0	0
2000	1082	40.5	-140	619	41	-51				1701	-191	701
2006	1082	39.98	-108	619	41.5	-51.6	18	41	-3	1719	-163	597
2013	1082	34.04	-912	619	42	44	18	41.5	1.3	1719	-867	3181
2020	1082	31.04	-457	619	42.5	44.2	18	38.5	-7.7	1719	-421	1543

Table 6.3.4 continued

1	2	3	4	5	6	7	8	9	10	eleven	12	13
V-Kazakhstan												
1989	2745	84.76	0							2745		
1990										0		
2000	867	75	-764	1878	80	-813	0	0	0	2745	-1577	5788
2006	867	68.5	-939	1653	81	275	225	80	-8.4	2745	-672	2468
2013	867	58.61	-1226	1346	83	385	200	70	-697	2413	-1538	5644
2020	867	48.62	-1238	1346	85	385	532	62.7	-615	2745	-1468	5388
Jambyl Region												
1989	1028	59.8	0							1028		
1990										0		
2000	824	40	-1483	204	50	-182	0	0	0	1028	-1665	6111
2006	824	34.72	-728	204	52	68	0	0	0	1028	-660	2422
2013	824	32.9	-212	204	54	44	0	0	0	1028	-168	617
2020	824	34.28	162	204	55.0	44	0	0	0	1028	206	-756
Z-Kazakhstan region												
1989	2431	55.6	0						-	2431		
1990									-	0		
2000	407	53	-95	2024	54	-230	0		0	2431	-325	1193
2006	407	51	-136	2024	57	674	1	54	-40	2432	498	-1829
2013	407	52	81	1851	59	385	173	52.44	-63	2431	403	-1479
2020	407	57	291	1851	60	193	173	56	249	2431	733	-2690
Karaganda region												
1989	2312	60.84	0							2312		
1990										0		
2000	1062	50	-1046	1249	53	-890	0	0	0	2311	-1936	7105
2006	1062	45.2	-850	1136	55	155	114	53	-19	2312	-714	2620
2013	1062	49.08	698	1136	56	243	114	49	-52	2312	889	-3263
2020	1062	42.91	-925	1031	59	365	219	50	7.5	2312	-553	2028

Kostanay region												
1989	6719	76.7	0			0				6719		
1990										0		
2000	5520	68	-4366	1199	72	-436	0	0	0	6719	-4802	17623
2006	5520	65	-3312	1199	74	300	0	0	0	6719	-3012	11054
2013	5520	60	-3154	682	75	146	517	74	101	6719	-2907	10669
2020	5520	65	3257	630	77	144	569	65	-711	6719	2690	-9872
Kyzylorda Region												
1989	306	36.4	0			0				306		
1990	306									306		
2000	124	33	-27	182	34	-36	0	0	0	306	-63	231
2006	124	30.6	-50	174	35	35	8	34	1.3	306	-14	50
2013	124	33.17	45	162	37	32	20	33.4	-2.2	306	75	-275
2020	124	36	47	142	38	20	40	33.4	0	306	67	-247
Pavlodar region												
1989	3517	47	0							3517	0	
1990										0	0	0
2000	1302	44	-392	2215	47	-62				3517	-454	1666
2006	1302	40	-835	2215	49	739	0	0	0	3517	-96	352
2013	1302	52	2204	1906	53	10	309	49	88	3517	2302	-8449
2020	1302	47	-950	1875	54	215	340	49	0	3517	-735	2697
S-Kazakhstan region												
1989	5460	105.4	0							5460		
1990										0		
2000	4061	91	-5316	1399	98	941	0	0	0	5460	-4375	16056
2006	4061	85	-4379	1383	100	346	16	98	-5.6	5460	-4039	14823
2013	4061	81	-2626	635	101	355	764	95	-216	5460	-2487	9127
2020	4061	72	-5163	504	103	94	895	84	-1380	5460	-6449	23668
Turkestan region												
1989	1236	34.9	0							1236		
1990										0		
2000	786	33	-136	450	34	-37	0	0	0	1236	-173	635
2006	786	32	-139	391	35	65	59	34	-9.8	1236	-84	308
2013	786	32	-38	316	36	63	134	32.35	-32	1236	-7	26
2020	786	32	6	278	38	44	172	32.56	5.2	1236	55	-201

Table 6.3.5 - Changes in carbon stock in the context of reservoirs of accumulation and emission / absorption of CO_2, generalized at the national level for the category Cropland for 1990 ... 2020

years	Area, thousand ha	Change in carbon stock, thousand tons/year	Emission / absorption of CO_2

	arable land remaining in the vooobo - company	arable land taken out of crop rotation into fallow land (pastures)	land returned to crop rotation	perennial plantations	the soil	phytomass and DOM	, thousand tons / year
1989	36048	0	0 , 0				
1990				163	-2100	573	5599
1991					-4193	493	13566.66
1992					-6224	413	21307.00
1993					-8002	333	28413.00
1994					-10004	253	35753.66
1995					-12016	173	43424.33
1996					-14044	93	51153.66
1997					-16032	13	58736.33
1998					-18739	-67	66407.00
1999					-20045	-150	74048.33
2000	21230	16047	0.0	151	-21925	-233	81246.00
2001					-20785	-18	76277.66
2020					-20049	2012	72735.66
2003					-19161	430	68680.33
2004					-18487	645	65420.66
2005					-17754	865	61926.33
2006	21230	13574	1761	151	-17147	1015	59150.66
2007					-16018	1100	54699.33
2008					-15116	1190	51062.00
2009					-14569	1280	48726.33
2010					-13612	1370	44887.33
2011					-12742	1460	41367.33
2012					-11840	1553	37719.00
2013	21230	11138	3347	151	-10977	1641	34232.00
2014					-11248	2112	33498.66
2015					-11513	2584	32739.66
2016					-11771	3056	31735.00
2017					-11822	3528	30411.33
2018					-12427	4100	30560.1
2019					-11839	4101	28372.66
2020	21230	3856	4961	148	-12802	4101	31905.13

6.3 . _ 2 Methodological principles of calculations, background information

The assessment of the dynamics of carbon stock and carbon dioxide fluxes for the Cropland category was carried out in accordance with the IPCC RP, 2006, at the 2nd - 3rd levels of calculations using regular data on the content of humus in the soil from the state land cadastre as initial regular data. In the process of calculations, the main category of land use "Cultivated land" was subdivided into separate subcategories: arable land remaining in crop rotation, arable land removed from crop rotation (for a period of 3.7 to 18 years) into fallow land and pastures (reserve lands), perennial plantations.

In comparison with the previous report, this report has changed the approach to the distribution of areas of arable and arable land. In particular, in the current report, arable land returned to the rotation was included in the sub-category of arable land in the rotation, as there is insufficient time series data to reconstruct a consistent time series.

As initial information for calculating the dynamics of carbon and carbon dioxide fluxes in the agroecosystem, the ND executors used data on soil humus for 2002–2020. (Table 6.3.2) obtained during agrochemical surveys of agricultural land on the territory of Kazakhstan State Institution "RSMC" Agrokhimservice "of the Ministry of Agriculture of the Republic of Kazakhstan. Also, to control the calculations, the results of long-term soil observations on a network of monitoring stationary and semi-stationary ecological sites for 1993 .... 2019 were used. Committee for Land Resources Management of the Ministry of Agriculture of the Republic of Kazakhstan and NJSC "SC "Government for Citizens" of the MTsRIAKP RK. Data on the distribution of agricultural land areas by purpose and mode of use were drawn from the Consolidated Analytical Report on the Condition and Use of Lands of the Republic of Kazakhstan for 2020 and earlier years of the Committee for management of land resources of the Ministry of Agriculture of the Republic of Kazakhstan [ ].

Absorption/emission of CO_2 for croplands, in accordance with the IPCC SPM, 2006, was estimated using the method of the difference in soil organic carbon stocks between two measurement periods in soils (Equation 2.25, Chapter 2 of Volume 4 of the IPCC SPM). Soil carbon stock (shown in Table 6.3.3) was calculated using the equation:

$$MS(t) = 0.01\, G \cdot V \cdot K_1 \cdot K_2 \cdot (1 - K_3) \quad (1)$$

where, MS (t) - carbon content in the surface soil horizon 0...0.3 m on the land area of one hectare per year t , tons / ha ; G - humus content (%) in the soil horizon 0-0.3 m; V - volumetric mass of soil in the horizon 0 ... 0.3 m, tons / m^3 ; K_1 - the volume of soil mass on an area of one hectare equal to 3000 m^3 ; K_2 - carbon content in organic matter equal to 0.58, dimensionless value; K_3 - the proportion of large fractions in the soil> 2 mm.

To calculate changes in carbon stock in soils of the agroecosystem, national “references” of organic carbon in soil and coefficients of influence of soil management and tillage regimes were used (Table 5.5, IPCC SPM, 2006). The national “standards” of soil carbon in the context of soil differences were calculated by the contractors from Zhasyl Damu JSC using physical and chemical indicators of soils on the territory of the Republic of Kazakhstan and published under the section earlier [7].

The resulting carbon stocks (Table 6.3.3) per 1 ha were applied to both sub-categories of cropland (arable land remaining in rotation and fallow land) because data from studies of humus in fallow soils need further analysis.

The value of 2.8 t/ha was taken as the reference carbon accumulated in the biomass of regenerated natural vegetation in accordance with the reference carbon stocks in natural pastures. The change in carbon stock in the biomass pool for arable land removed sequentially from the crop rotation after 1990 was estimated using the stock difference method according to Equation 2.8. As the values of the total amount of carbon in the reservoir of living biomass at time points t_1 and t_2 , the values of the areas of fallows in these periods of time, multiplied by the reference values of carbon in the living biomass of fallows, were taken.

Calculation of changes in carbon stocks in living biomass of perennial plantations has also been changed. In particular, in order to apply the gain-loss method (Equation 2.7, Chapter 2, Volume 4 of IPCC 2006 SPM), the 1990 permanent planting area was divided into equal parts in

the number of years of maturity (30 years by default) to obtain the conditional age of the perennial plantations. The total area of permanent plantations was multiplied by the annual carbon stock factor of permanent plantations (2.1 t C/ha according to Table 5.1 of Chapter 5, Volume 4 of IPCC SPM, 2006) to calculate carbon stocks. To calculate carbon losses, the 30-year-old plantation area was multiplied by the carbon stock factor in biomass (63 t C/ha according to Table 5.1, Chapter 5, Volume 4 of the IPCC 2006 SPM). The area of 30-year plantations in the next reporting year becomes the area of 1-year perennial crops, taking into account the difference in the total area of perennial crops between years to take into account the process of the cycle of renewal of perennial plantations.

N_2O emissions from carbon stock changes due to changes in cropland management include N_2O emissions from soil carbon mineralization due to land conversions. into cultivated ones. Accordingly, these emissions are accounted for in category 3. D of the Agriculture sector.

6.3.3 Uncertainties and time series consistency

In accordance with the IPCC RP, 2006, the total uncertainty of calculations of carbon dioxide emissions / removals for the land use category Cropland was performed earlier in the framework of previous RDs in accordance with [1, 9]. It is presented as the sum of the activity estimation uncertainty E (%), taken equal to ± 5% and the emission/removal estimation uncertainty F (%). Uncertainty in the estimation of emissions / removals F (%) is derived from partial errors in obtaining initial information: ± 30% - soil sampling for humus during field research; ± 1.5% - laboratory determination of humus content in soil samples; ±10% - estimates of standards of soil and biomass of herbaceous vegetation (by the method of small plots); ± 36% - estimate of the volume of wood of perennial plantations. Hence, the total uncertainty for the Cropland category is ± 34.71%.

6.3 . _ 4 QA/QC procedures and checks

The QA/QC procedures for the cropland category were carried out in accordance with the General QA/QC Plan for the NIR 1990…2020.

The QA procedures were carried out by an independent expert within the framework of the project of the Government of the Republic of Kazakhstan, UNDP and the GEF “Development of the Eighth National Communication of the Republic of Kazakhstan under the UNFCCC and preparation of two (fourth and fifth) Biennial Reports”. In particular, the initial data, emission factors and methods used in the calculations were considered. As a result of the review, recommendations were made regarding the category calculations that were used for the recalculations.

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IN process of the NG RD Review in October 2021, The GME from the UNFCCC Secretariat was recommended to continue activities in the Republic of Kazakhstan aimed at further development of the national GHG inventory system, including the section on land use .

In accordance with the recommendations received from ***the GME*** , within the framework of ND -2020, methodological work continued on the aggregation of GHG calculations at the regional level for the key category Cultivated land with the expansion of the archive of national carbon standards, the refinement of the coefficients of the management and cultivation regime. With the receipt of additional information on the content of humus in the soil of arable land based on the results of agrochemical surveys of fields for 2015 ... 2020, for the first time in the time series

(1990-2020), they were recalculated at the regional level (14 regions in total) and are presented in section 6.3 of the RD -2020 annual changes in carbon stocks and CO2 uptake/emissions for the Cropland category. In order to present the results in the CRF spreadsheets (C RF), regional indicators were preliminarily summarized at the national level. Comparison of the latter with the volumes of absorption / emission of CO2, presented for 2019 at the national level in ND - 2019, confirmed a decrease in total emissions by 12,364.34 thousand tons / year of CO2 for Croplands according to calculations made in ND - 2020. According to calculations, carried out within the framework of ND -2020 for the base year 1990, the CO2 flux changed its direction and amounted to CO2 emissions from the soil of about 5599 thousand tons.

In ND-2021, recalculations were made of changes in carbon stocks in the category "Cropland" in pools of living biomass and mineral soils.

The approach to calculating changes in carbon stocks in living biomass from perennial plantations has been changed (described in Section 6.3.2).

A natural grassland carbon stock factor was also applied to calculate changes in carbon stocks in living biomass of fallows.

C stock factors for mineral soils in cropland in crop rotation for fallows were also applied until a consistent series of carbon stock factors for mineral soils under fallows was obtained.

During the QA/QC procedures, some errors in the calculation files were also corrected, which also changed the final values of carbon stock changes.

6.4. Pastures and hayfields (land category 4.C in the CRF-C RF table **)**

6.4.1 Category description and results

The Grassland (G) land category is the key land category in the Republic of Kazakhstan both in terms of area occupied and in terms of contribution to the national carbon budget and its annual changes. In the Republic of Kazakhstan, the category is represented by natural and improved pastures and hayfields, mainly as part of agricultural land (Table 6.1.2), as well as pastures and hayfields as part of the Forest Fund lands (Table 6.1.3) and other categories of land use (Table 6.2.3). Legally, this category also included a part of the area under the former arable land, taken one-time from crop rotation to pastures (mainly from 1993 to 2000) and overgrown with natural vegetation. The results of greenhouse gas calculations for these lands are presented in Section 6.3.

Natural pastures and hayfields serve as a fodder base for developed animal husbandry in the Republic of Kazakhstan and extend to almost all natural zones - from the forest - steppe in the north to the southern deserts on the plain, rising in the mountain ranges in the east, southeast and south to the mountain - meadow alpine and subalpine zones (map in Fig. 6.1.2). In dry steppes, pastures are predominantly dominated by cereal types of vegetation on zonal soils. The deserts are dominated by forb-shrub communities, which are formed on sandy soil and sands, and wormwood-shrub groups with saltwort vegetation on brown and gray-brown clayey, often saline soils. In the southern deserts, herbaceous short-vegetative species (ephemers) are everywhere involved in the herbage. In the mountainous regions, forb-grass communities dominate, interspersed with shrubs and woody forms. Meadows, used mainly for hayfields, are represented mainly by cereal species and forbs, common in the floodplains of large rivers, natural depressions and estuaries, flooded during the floodplain and snowmelt in spring, as well as in mountain valleys. Primary production is estimated at 0.5 tons/ha to 16.0 tons/ha, in the mountains up to 30 tons/ha. On pastures, the humus content in the upper soil horizon varies from 1.0% or less (sandy deserts) to 8 ... 12% (mountainous areas).

According to the Committee for Land Resources Management of the Ministry of Agriculture of the Republic of Kazakhstan, at the beginning of the 90s of the last century, the pasture area in Kazakhstan was 182,069.7 thousand hectares, of which 5,908.8 thousand hectares were improved. The area of hayfields reached 5,172 thousand hectares, including improved ones on an area of about 250 thousand hectares (Table 6.2.2).

During this period, the number of livestock in the Republic of Kazakhstan reached its maximum value - 80078.6 thousand heads (in conditional heads of sheep), relatively evenly distributed over the pasture area, which provided an average load of animals of 0.455 conditional heads per hectare (Table 6.4.1).

Table 6.4.1 - Changes in pasture area and livestock load on used pastures in the Republic of Kazakhstan for 1990...2020

Pasture use indicators	1990	2000	2010 _	2019	2020
* Total pasture area, including arable land taken out of crop rotation, thousand ha * Area of used pastures, thousand ha	182 4 00 182 070	187,719.3 _ 52 304	188 801.6 60 415	*186156* *66 362*	*184318* *75599*
**Load of livestock per area of used pastures, conditional heads of sheep / ha	0.455	0.656	0.884	*1.185*	*1.173*

* - data of the Committee for Land Management of the Ministry of Agriculture of the Republic of Kazakhstan

** - calculations of ND performers

After 1990, the regime of pasture land management in the Republic of Kazakhstan changed significantly with the change in ownership and land management, the destruction of the grazing system and wells for watering livestock. About 70% of the areas of natural pastures and 50% of hayfields were withdrawn from use and put into reserve lands, which contributed to the partial restoration of pasture vegetation, an increase in projective cover, bioproduction and fodder reserves on these lands. At the same time, in a limited area of pastures where intensive grazing of animals was carried out (especially on rural pastures), the load of livestock increased and, according to calculations for 2020, amounted to 1.17 conditional heads per hectare of area, which significantly exceeded the average republican economic load on grazing pastures for 1990 .

Results of GHG absorption / emission assessment for natural and improved pastures and hayfields are presented in a generalized form for 1990 ... 2019. in table 6.4. 2. The table shows that under the conditions of continued extensive economic use of pasture and haylands in the Republic of Kazakhstan, over the past decade, there has been a noticeable decrease in the rate of absorption of CO 2 by the $_{natural}$ ecosystem due to an increase in the number of grazing livestock and an increase in the overall anthropogenic load per unit of grazing land.

The total amount of $CO_{2\ absorption}$ for the category of use Pastures was, according to calculations for 2020, -10129 thousand tons / year, while its value for 1990 remained at the level of -6911.67 thousand tons / year.

Table 6.4.2 - Dynamics of absorption (-) / emission (+) of CO_2 for the category Pasture land in the Republic of Kazakhstan according to calculations for 1990 ... 2020

years	Square, thousand ha	Change in carbon stock, thousand tons/year			Absorption / emission, thousand tons/year CO_2
		Phytomass	MoU	The soil	
1990	187344	125	40	1720	-6911.67
1991	187320	443	15.7	1905	-8666.90
1992	187295	761	-8.6	2090	-10422.13
1993	187271	1079	-32.9	2275	-12177.37
1994	187246	1397	-57.2	2460	-13932.60
1995	187222	1715	-81.9	2649	-15701.03
1996	187198	2033	-105.8	2827	-17432.07
1997	187173	2351	-130.1	3012	-19187.30
1998	187149	2669	-154.4	3197	-20942.53
1999	187124	2987	-178.7	3382	-22692.78
2000	187100	3305	-203	3567	-24453.00
2001	187071	2982	-178	3854	-24412.67
2002	187041	2659	-153	4141	-24372.33
2003	187012	2336	-128	4428	-24322.00
2004	186982	2013	-103	4715	-24291.67
2005	186953	1699	-76	5002	-24258.67
2006	186924	1367	-50	5292	-24233.00
2007	186894	1044	-28	5579	-24181.67
2008	186865	721	-2	5866	-24145.00
2009	186835	398	21.6	6153	-24099.53
2010	186806	75.5	46.5	6840	-25527.33
2011	186788	129	89	6105	-23184.33
2012	186769	183	133	5769	-22311.67
2013	186751	237	176	5432	-21431.67
2014	186732	290	219	5097	-20555.33
2015	186714	344	262	4762	-19682.67
2016	186696	398	305	4427	-18810.00
2017	186677	453	348	4092	-17941.00
2018	186659	390	305	3602	-1 57 75.66
2019	186640	050	105	3000	-1 3743.22
2020	186622	-110	-80	2950	-10129 .00

Preservation of CO2 uptake by the ecosystem is ensured mainly by pastures brought into the lands of the reserve. The most significant values of CO2 absorption by pastures fall on Mangistau, Atyrau, West Kazakhstan, Kostanay, Karaganda regions with vast areas of desert and semi-desert pastures and minimal livestock loads.

emissions from steppe fires covering pastures, as well as cultivated lands on an area of 120.02 hectares for 2020, were estimated at the following values: 0.400 thousand tons / year - CH4; 0.37 thousand tons / year - N_2O ; 11.40 thousand tons / year CO ; 0.684 thousand tons / year - N O x and 8.607 thousand tons / year - H M LO in CO_2 equivalent (table 6.4.3).

Table 6.4.3 - Annual greenhouse gas emissions from steppe fires on the territory of the Republic of Kazakhstan, calculated for 1990 ... 2020

Year s	Square,* fires, ha	CO_2 thousand tons tons/year	With H_4, thousand tons/year	N_2O, thousand tons / year	CH_4 and N_2O, thousand tons/year CO_2 equivalent.	CO, thous. t / year	N 0 x, thousand tons / year	NMLO, thousand tons / year
1990	50000*	117.88	0.17	0.015	8.72	4,750	0.285	3.586

1991	50000*	117.88	0.17	0.015	8.72	4,750	0.285	3.586
1 992	50000*	117.88	0.17	0.015	8.72	4,750	0.285	3.586
1993	50000*	117.88	0.17	0.015	8.72	4,750	0.285	3.586
1994	150000*	353.63	0.50	0.046	26.21	14.251	0.855	10.758
1995	725000*	1709.23	2.44	0.223	127.45	68.878	4.133	51.997
1996	300000*	707.27	1.01	0.092	52.67	28.501	1.710	21.518
1997	1200000*	2829.07	4.03	0.368	210.41	114.005	6,840	86.072
1998	425000*	1001.96	1.43	0.130	74.49	40.370	2.426	30.483
1999	725000*	1709.23	2.44	0.223	127.45	68.878	4.133	51.997
2000	450000*	1060.90	1.51	0.138	78.87	42.752	2.565	32.277
2001	650000*	1532.41	2.19	0.200	114.35	61.753	3.705	46.622
2002	509000*	1200.00	1.71	0.156	89.24	48.357	2.901	36.508
2003	1200000*	2829.07	4.03	0.368	210.41	114.005	6,840	86.072
2004	375000*	884.09	1.26	0.115	65.77	35.626	2.138	26.897
2005	445228	1049.65	1.50	0.137	78.33	42.298	2.538	32.277
2006	818 108	1928.74	2.75	0.251	143.55	77.724	4.633	58.680
2007	268 094	632.05	0.90	0.082	46.94	25.470	1.528	19.233
2008	111 106	261.94	0.37	0.034	19.38	10.555	0.633	7.969
2009	81 526	192.20	0.27	0.025	14.20	7.936	0.465	5,848
2010	148 414	349.90	0.50	0.046	26.21	14,100	0.846	10.645
2011	84 528	199.28	0.28	0.026	14.75	8.030	0.482	6.062
2012	40491	95.46	0.14	0.012	7.08	3.847	0.231	2.904
2013	4934	11.63	0.017	0.0015	1.10	0.469	0.028	0.354
2014	139 999	330.06	0.47	0.043	24.56	13,300	0.798	10.040
2015	292 880	704.34	1.003	0.092	52.50	28.383	1.704	20.960
2016	38 645	91.11	0.134	0.012	6.657	3.672	0.220	2.772
2017	848783	1994.95	2,976 _	0.280 _ _	145.33	78.50	4.540	60.883
2018	186689	440.14	0.630	0.58	32.97	18.68	1.064	13.99
2019	63892	150.63	0.21	0.21	13.34	6.07	0.360	4.58
2020	120017	282.95	0.400	0.37	21.05	11.40	0.684	8.607

6.4.2 Methodological issues, information used

The dynamics of the carbon stock and absorption / emission of CO_2 for the ecosystem was assessed at the national level in the context of individual strata (subcategories) distinguished from the primary category on the basis of use and land management regime options: *natural pastures; improved pastures; forested pastures; natural hayfields, taking into account improved ones* (mainly until 1990). *In* accordance with the IPCC RP, 2006, the assessment of carbon dynamics and $CO_{2\ fluxes}$ for the Grassland category was carried out based on the stock difference method (equations 2.3, 2.8 (live biomass), 2.18 (litter) and 2.25 (mineral soils) using carbon standards and land use regime coefficients (6.4.5).More detailed methodological approaches used in calculating carbon fluxes for pasture lands of the Republic of Kazakhstan are described in the publication under section [10].

Table 6.4.5 - Carbon standards and use mode coefficients for calculating changes in carbon stock by accumulation reservoirs for natural pastures and hayfields of the Republic of Kazakhstan

Indicators	Pastures natural	Wooded pastures	pasture improved	Natural hayfields
Reference carbon in vegetation phytomass, t/ha .	2.77	4.8	2.77	7.91
Reference carbon in dead biomass of vegetation, t/ha .	1.40	1.94	1.40	4.11
Standard soil carbon in the horizon 0..0.03m, t/ha	51.3	40.19	51.3	51.3

Use mode influence coefficients (biomass)	0.8655 [0.848….0.883]	0.915 [0.85..0.98]	1.06 [1.20…0.92]	0.98 [0.99(1.00)..0.97]
Coefficients of influence of the mode of use (soil)	0.9195 [0.91…0.929]	0.9195 [0.91..0.929]	0.9195 [0.87..0.97]	1.00

At the moment, there are no accurate data to obtain a standard of soil carbon for natural hayfields and a coefficient of influence of the use regime for soils in hayfields. Therefore, until the national values were obtained, the standard of soil carbon on natural pastures was used, and 1 was adopted as the use mode coefficient. After receiving the updated values, recalculations will be made.

The GHG emissions from steppe fires on pasture and other agricultural areas were estimated based on Equation 11.8, IPCC RP, 2006. fires on the territory of the Republic of Kazakhstan. The calculation results are presented in detail in the publication under section [6].

N_2O from soil carbon mineralization due to changes in management regime or conversions to category was made using Equations 11.1 and 11.8 and default factors. Emissions are presented under Grassland Remaining Grassland as it is not possible to subdivide emissions by sub-categories.

The initial information on the areas of pastures and hayfields, the ecological state of the soil and vegetation cover, was obtained from the Committee for Land Resources Management of the Ministry of Agriculture of the Republic of Kazakhstan (Consolidated analytical report on the state and use of lands of the Republic of Kazakhstan for 2014 ... 2020), from the Vegetation Degradation Map in the National Atlas of the Republic of Kazakhstan, V.3, Almaty, 2006 and other sources.

Information about the burnt area in the process of steppe fires was provided by the Ministry of Emergency Situations of the Republic of Kazakhstan. Information about fires
for non-forested lands, LFs were received from the Republican State Enterprise "Kazakh base for aviation forest protection and forestry services" KLKHZhM MEGPR RK.

6.4.3 Uncertainties and sequence of time series

For the land use category Pasture land, the activity uncertainty E was assumed to be ± 5% for all gas types considered. Uncertainty in estimating emissions/removals of CO2 , which was determined from partial errors in estimating standards of biomass and stock of organic matter in soil (taken at the level of ± 10%), errors in control coefficients (taken at the level of ± 12%), was calculated as ±26 , 9%, in accordance with the IPCC RD, 2000[9]. Uncertainties in estimating methane (CH_4) and nitrous oxide (N_2O) emissions from steppe fires were obtained from a partial error in accounting for aboveground biomass on pastures, taken equal to ± 16%, an error in the fuel combustion coefficient in a fire equal to 39%, and an error in the gas emission factor - ± 35% (methane) and 48% (nitrous oxide) in accordance with the IPCC RD, 2000. Hence, the calculated overall emission estimation uncertainty for methane was ±56.8% and for nitrous oxide ±65.6%. The sequence of time series is confirmed by unified sources of obtaining initial information and a unified calculation methodology.

6.4 .4 QA/QC and verification procedures

The QA/QC procedures for the grassland category were carried out in accordance with the General QA/QC Plan for the NC 1990-2020.

The QA procedures were carried out by an independent expert within the framework of the project of the Government of the Republic of Kazakhstan, UNDP and the GEF “Development of

the Eighth National Communication of the Republic of Kazakhstan under the UNFCCC and preparation of two (fourth and fifth) Biennial Reports". In particular, the initial data, emission factors and methods used in the calculations were considered. As a result of the audit, recommendations were made regarding the calculations in the category that were used for the recalculations.

6. 4 .5 IGE recommendations , recalculations, prospects for improved reporting

In ND-2021, recalculations were made in the category Pastures. In particular, the calculations in the calculation file for biomass, dead organic matter, and pasture soils have been corrected. Changes in carbon stocks from soils under hayfields were also estimated.

In addition, N_2O emissions due to soil carbon mineralization associated with a change in management regime and conversion in the grassland and hayfield category were estimated.

In the future, it is planned to improve the quality of calculations through their aggregation at the regional level with the refinement of carbon standards for soil and biomass reservoirs, as well as coefficients for the pasture management regime for individual regions. At the same time, a fundamental solution to the issue of assessing the ecological state of the soil and vegetation cover and changes in the fluxes of CO2 and other types of greenhouse gases for vast pasture areas in the Republic of Kazakhstan can be implemented by organizing multi-level environmental monitoring based on the Pasture model using space and ground-based information, the basis of which were developed in JSC "Zhasyl Damu" on the example of the Southern Balkhash region [25]. To solve this problem, additional funding is required.

6.5 Wetlands (category 4.D Wetlands in the CRF table **)**

6.5.1 Category description and results

Lands of the category Wetlands (WBUs) are not included in the list of key sources of absorption / emission of GHGs. Artificial reservoirs (reservoirs), as managed lands within wetlands (WBUs), are a source of GHG emissions.

Reservoirs in the Republic of Kazakhstan were built mainly before 1990 and in the period after 2010. They are primarily intended for irrigation of agricultural land and water supply, power generation, utilities and fisheries, as well as collectors for emergency water discharge. In the last decade, the largest amount of $CO_{2\ emissions}$ from reservoirs in the Republic of Kazakhstan was 342.80 thousand tons (2010) and accounted for the first year of filling with water the constructed Koksarai reservoir on the river. Syr Darya (Table 6.5.1). The total area of artificial reservoirs in the Republic of Kazakhstan, excluding the area of small temporary reservoirs with a volume of less than 250 m^3, according to data for 2020, was 800.9 thousand hectares. In 2019 and 2020, the area of artificial reservoirs did not increase, hence the emissions for these years are equated to zero values

Table 6.5.1 - Emission of CO_2 for lands flooded with water in the first years of filling artificial reservoirs of the Republic of Kazakhstan according to calculations for 1990 ... 2020

years	The area of artificial reservoirs, thousand hectares	lands flooded in the first year of filling, thousand ha	Losses of carbon from the mineralization of organic matter, thousand tons / year	Emission from the mineralization of organic matter, CO_2 thousand tons / year
1990	785.17	0.43	-1.16	4.25

1991	785.45	0.15	-0.40	1.47
1992	785.6	0.00	0.00	0.00
1993	785.5	0.11	- 0.30	1, 10
1994	785.6	0.00	0.00	0.00
1995	786	0.00	0.00	0.00
1996	786	0.00	0.00	0.00
1997	786	0.00	0.00	0.00
1998	786	0.00	0.00	0.00
1999	786	0.00	0.00	0.00
2000	786	0.00	0.00	0.00
2001	786	0.00	0.00	0.00
2002	786	0.00	0.00	0.00
2003	786	0.00	0.00	0.00
2004	786	0.00	0.00	0.00
2005	816.6	0.00	0.00	0.00
2006	816.6	0.00	0.00	0.00
2007	816.6	0.00	0.00	0.00
2008	816.6	0.00	0.00	0.00
2009	816.6	0.00	0.00	0.00
2010	816.6	34.55	- 93.49	3 42.80
2011	816.6	10.83	- 29.31	1 07.47
2012	816.6	2.94	- 7.96	29.19
2013	816.6	0.00	0.00	0.00
2014	816.6	0.00	0.00	0.00
2015	810.1	10.72	-29.01	106.37
2016	808.6	0.0 2	- 0.0 5	0.18
2017	870.8	1 , 50	-4.06	14.89
2018	870.8	0.00	0.00	0.00
2019	870.8	0.00	0.00	0.00
2020	800.9	0 , 00	0 , 00	0 , 00

6.5.2 Methodological issues, sources of information

Emissions were estimated at the 1st methodological level of calculations using Equation 7.10 in IPCC SPM, 2006[1]. The annual emission of CO_2 was estimated as a result of the mineralization of organic matter accumulated on lands that had gone under water. For this, data on the areas of flooded lands (conditionally pasture) and data on the amount of plant biomass that went under water in the first year of filling reservoirs with water were used. The amount of biomass was assumed to be 8.86 tons/ha per pasture vegetation. Data on artificial reservoirs and dynamics of land flooding during the period of their filling, received from the Water Resources Committee of the MEGPR RK, were used as initial information for calculations. Data on areas of wetlands in the Republic of Kazakhstan were submitted by the Committee for Land Management of the Ministry of Agriculture of the Republic of Kazakhstan.

6 . 5.3 Uncertainty assessment

The uncertainty of activity calculations was taken at the level of ±5%, and the emission uncertainty was equated to the value of the uncertainty in the assessment of biomass for pasture lands, which is estimated at the expert level as ±10%.

6.5 .4 QA/QC and verification procedures

The QA/QC procedures for the Wetlands category were carried out in accordance with the General QA/QC Plan for NC 1990…2020.

6 . 5.5 _ prospects improved reporting

Calculations of carbon dioxide emissions from artificial reservoirs can be improved by clarifying the composition of flooded land and the amount of organic matter for vegetation that has gone under water.

6.6 Settlements (use category 4.E in the CRF table **)**

6.6.1 Category description and results

Lands of the Settlement category, which, in accordance with the definition of IPCC WP, 2006[1], represent all developed land for buildings of any size, parks, squares, boulevards and transport infrastructure, do not belong to the key category in the LULUCF sector. According to the Committee for Land Management of the Ministry of Agriculture of the Republic of Kazakhstan, the area of land under settlements is about 0.78% of the total land area in the Republic of Kazakhstan (Table 4.2.3) and, in particular, in 2020 amounted to 2307.0 thousand hectares. According to the results of calculations, the annual absorption of CO_2 for 2020 was obtained for the Settlement category at the level of 3544.1 thousand tons / year (Table 6.6.1).

6.6.2 Methodological issues , recommendations of the IGE, background information

The dynamics of the carbon stock for lands additionally developed for settlements was estimated at the 1st level of calculations. Due to limited input information on soils for the Settlements category, GHG calculations were limited to the biomass pool using *Equation 8.1*, IPCC SPM, 2006.

Table 6.6.1 - Changes in carbon stock and annual values of absorption (-) / emission (+) of CO_2, calculated for lands additionally developed for Settlements in the Republic of Kazakhstan for 1990...2020.

years	Total land area under settlements, thousand ha	Additional developed area after 1980, thousand ha	The amount of carbon accumulated by the canopy on the additionally equipped area, thousand tons / year	Absorption / emission of CO_2 by the canopy for settlements, thousand tons / year
1980	1974.0	-	-	-
1990	2083.3	109.3	275.5	-1166.00
1991	2087.1	113.1	286.5	-1203.66
1992	2090.8	116.8	297.5	-1241.90
1993	2094.5	120.5	308.5	-1281.15
1994	2098.3	124.3	319.6	-1324.83
1995	2102.1	128.1	330.6	-1362.17
1996	2108.8	134.8	341.6	-1401.40
1997	2109.5	135.5	352.6	-1440.00
1998	2113.3	139.3	363.7	-1481.33
1999	2115.3	143.1	374.7	-1521.66
2000	2120.8	146.8	385.7	-1598.66
2001	2119.5	150.5	396.7	-1560.90
2002	2128.3	154.3	407.8	-1639.73
2003	2132.2	158.2	418.8	-1682.26

2004	2136.0	162.0	429.8	-1722.66
2005	2139.8	165.8	440.8	-1762.33
2006	2143.3	169.3	451.8	-1802.53
2007	2150.3	173.3	462.8	-1842.86
2008	2150.9	176.9	473.8	-1881.00
2009	2154.7	180.7	484.9	-1921.33
2010	2158.5	184.5	500.0	-1963.60
2011	2162.2	188.2	526.6	-2001.96
2012	2166.0	192.0	537.6	-2040.60
2013	2173.0	199.0	557.2	-2116.03
2014	2180.1	206.1	577.1	-2191.56
2015	2204.8	231.0	301.3	-2456.66
2016	2222.8	248.8	696.4	-2645.60
2017	2242.9	268.9	752.9	-2861.09
2018	2275.2	301.2	843.4	-3202.53
2019	2279.2	248.0	884.4	-3245.27
2020	2307.0	333.0	965.7	-3544.1

To estimate carbon change in biomass, a default carbon sequestration factor for tree canopy was used, equal to 2.9 tons/year/ha from IPCC SPM, 2006. At the same time, the carbon of the herbaceous component of biomass was not taken into account. As initial information, we used data on land areas under settlements received from the Committee for Land Management of the Ministry of Agriculture of the Republic of Kazakhstan (Consolidated analytical report on the state and use of land in the Republic of Kazakhstan for 2020 and earlier).

6.6 . _ 3 Calculation results, prospects for improvement

In the future, the assessment of the inventory of greenhouse gases for land developed for settlements can be improved by empirical data on the tree canopy per unit area obtained for settlements, taking into account natural conditions, species composition and age structure of tree and shrub vegetation in the planting sites, as well as clarification of the share of participation of various infrastructures in the total area of land occupied by settlements.

6.6 . _ 4 Uncertainties in calculations

The uncertainty of carbon flux calculations was estimated taking into account the statistical error of area accounting (±5%), the uncertainty of accounting for standing wood equal to (±36%), the error in estimating greening coefficients (±3.3%), and the coefficient of land management regime (±50%). Hence, the total uncertainty of $CO_{2\ \text{absorption / emission assessment}}$ for the Settlement land category was ± 62.88%.

6 . 6 . 5 QA/QC procedures and checks

QA/QC procedures for the settlement category were carried out in accordance with the General QA/QC plan for NIR 2023

6.7 Other sites (use category 4. F of the CRF table)

In accordance with the IPCC RP, 2006, for lands remaining in the category "Other lands", the inventory of greenhouse gases was not carried out, as for non-managed lands. However, for consistency in the balance of areas of all types of land at the national level, obtained from the cadastre of the State Forest Fund and the State Land Cadastre of the KLM of the Ministry of

Agriculture of the Republic of Kazakhstan, in ND -2020, the land area of the Other land category was recalculated for the entire time series. For 2020, it amounted to 22937.5 thousand rubles. ha.

Data source - Land Resources Management Committee of the Ministry of Agriculture of the Republic of Kazakhstan and the Committee for Forestry and Wildlife of the MEGNR RK .

6.8 Harvested timber (category HLWP in the CRF table)

6.8.1 Category description, results.

Due to the restriction in the Republic of Kazakhstan of felling of commercial coniferous wood on forest areas in the period 2003 ... 2013 , the volume of its harvesting has noticeably decreased. According to the Bureau of Statistics of the Ministry of National Economy of the Republic of Kazakhstan, after 2003, the area of felling of commercial timber decreased from 57.6 thousand hectares to 18.00 thousand hectares with a decrease in the amount of harvested wood (roundwood) to 42.4 thousand m 3 (2012). After 2013, the amount of harvested commercial timber increased slightly in the forests of the Republic of Kazakhstan.

A production approach was used to estimate the contribution of HWP to carbon stock change in the sector. Data from FAO were used as input data. Although FAO has been collecting statistics on harvested wood and wood products for many years, data for Kazakhstan are in most cases only available from 1998-1999, and what is available often has huge values for one to two years. compared to other years (for example, sawlog production in 2012 or harvested industrial roundwood in 2005).

Due to the lack of pulp production in the country, the contribution to paper and paperboard HWP is zero.

After calculations according to the IPCC 2006 methodology using default coefficients, the final results of changes in carbon stocks were significantly below 0.05% of total emissions and below 500 thousand tons of CO_2 -eq. Taking this into account, as well as the low accuracy and consistency of the data, the direct contribution of HWP to total emissions and removals was not included.

7 WASTE (SECTOR 5 CRF)

7.1 Overview by sector

The Waste sector presents the results of calculations of greenhouse gas emissions for the time period 1990-2021 in the following categories:

– disposal of municipal solid waste (MSW) (Category 5.A CRF);

– treatment and discharge of domestic and industrial waste water (WW) (category 5. D CRF);

– nitrous oxide emissions from domestic wastewater (Category 5. D CRF);

– incineration of medical waste (category 5.C CRF).

According to the environmental statistics “On the management of municipal waste in the Republic of Kazakhstan”, [105]for 2021, 4.2 million tons of MSW were generated in the Republic of Kazakhstan (according to the Ministry of Ecology and Natural Resources of the Republic of Kazakhstan), of which 3.2 million tons were municipal waste collected by specialized enterprises and individual entrepreneurs for the collection and transportation of waste, the number of which amounted to 676 units. The main share falls on household waste (65.6%), 20.2% was production waste (equivalent to household waste), 10.5% - street garbage, 2.2% - market waste. In 2021 officially operating landfills (landfills), facilities for sorting and processing municipal waste received 3.9 million tons of waste. Of these, 65.9% were received for their further deposit, 30.4% sorted.

At the end of 2021, more than 47.5 million tons of waste have been accumulated at officially operating landfills (landfills).

In the "Waste" sector, greenhouse gas emissions are generated from the disposal of municipal solid waste (SW) at landfills, the processing of wastewater (municipal and industrial), human waste products, and the incineration of medical waste. The total greenhouse gas emissions in the sector in 2021, as a result of the recalculation, amounted to 6260.82 Gg CO_2-eq. Compared to the previous year 2020, emissions increased by 3.9%. The main share of emissions in the total volume is accounted for by unmanaged solid waste landfills in Kazakhstan and municipal wastewater discharges. In 1990, the volume of emissions was 3839.09 Gg CO_2-eq. Over the entire period from 1990 to 2021, the growth in emissions in the sector increased by 1.6 times, due to an increase in the generation of solid waste and the population.

Figures 7.1 and 7.2 decipher greenhouse gas emissions in the Waste sector in 1990 and 2021, respectively. In 1990, the main contribution of emissions in the sector fell on the category of wastewater - 63%, in 2021, due to population growth and increased consumption of products, emissions from solid waste landfills made a greater contribution - 52%.

[105]https://stat.gov.kz/official/industry/157/statistic/5

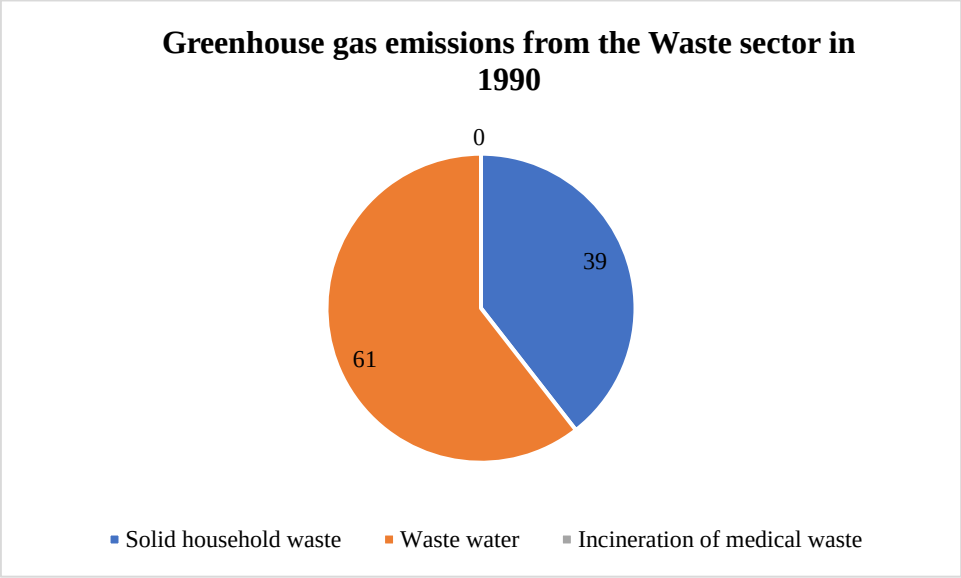

Figure 7.1 - Analysis of greenhouse gas emissions from the "Waste" sector in 1990, %

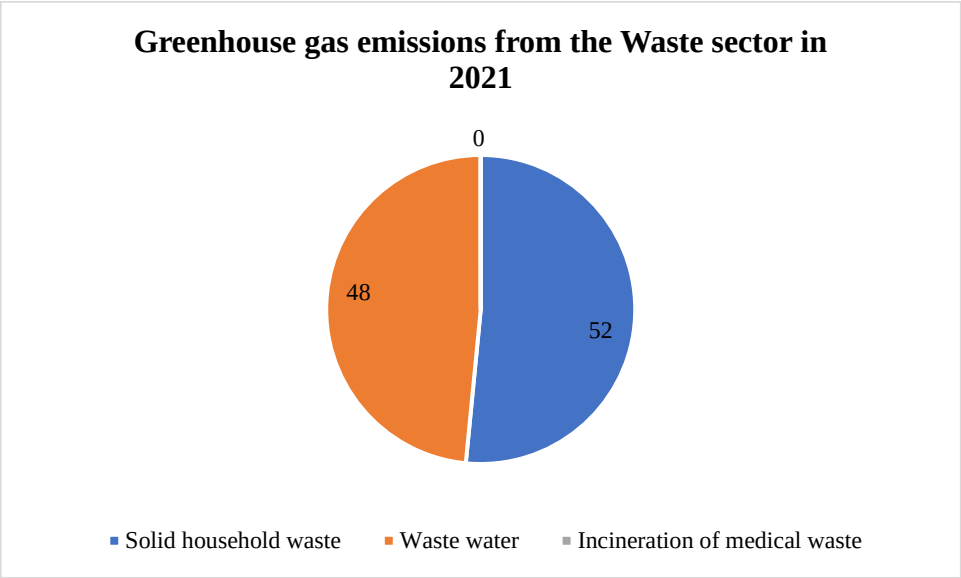

Figure 7.2 - Analysis of greenhouse gas emissions from the "Waste" sector in 2021, %

Greenhouse gas emission trends and general emission dynamics in the Waste sector. for 1990 - 2021 are presented in Table 7.1 and Figure 7.3.

Table 7.1 - Greenhouse gas emissions in the Waste sector for 1990 - 2021, Gg CO_2 equivalent

years	Solid waste landfill in Astana	Solid waste landfills, other cities of Kazakhstan	Municipal waste water	Industrial waste	Nitrous oxide N2O	Incineration of medical waste	Total emissions from the Waste sector
1990	45.19	1470.23	1344.17	715.00	264.50	0.00	3839.09
1991	44.46	1547.53	1350.89	611.96	266.01	0.00	3820.85
1992	43.74	1616.17	1346.09	437.79	271.78	0.00	3715.57
1993	43.26	1676.45	1331.01	284.13	270.27	0.00	3605.12
1994	42.93	1728.59	1296.30	165.38	264.01	0.00	3497.22
1995	42.79	1766.94	1273.63	97.26	262.35	0.00	3442.96

1996	42.75	1803.71	1258.57	88.78	261.96	0.00	3455.76
1997	42.78	1838.59	1236.40	73.32	257.01	0.00	3448.10
1998	42.94	1871.75	1220.11	67.80	250.29	0.00	3452.90
1999	45.01	1902.22	1216.52	52.08	246.55	0.00	3462.38
2000	48.98	1930.15	1215.71	70.12	245.96	0.00	3510.91
2001	55.44	1955.33	1215.94	119.75	245.72	0.00	3592.18
2002	63.84	1978.54	1145.20	121.81	248.81	0.00	3558.19
2003	71.68	2001.02	1152.23	102.92	253.00	0.00	3580.84
2004	79.04	2022.86	1178.62	125.26	255.09	0.00	3660.87
2005	86.45	2043.75	1180.06	159.10	260.43	0.00	3729.80
2006	94.12	2063.61	1270.98	175.47	269.26	0.005	3873.45
2007	100.25	2099.19	1251.71	203.17	275.20	0.7272	3930.25
2008	102.67	2187.90	1292.37	185.58	282.47	1.0752	4052.07
2009	104.82	2276.28	1318.88	291.39	292.46	9.6623	4293.48
2010	106.93	2388.73	1365.90	292.96	299.88	10.3689	4464.77
2011	111.14	2485.78	1394.18	167.48	304.14	8.2268	4470.94
2012	116.91	2588.01	1422.08	164.70	308.45	7.5744	4607.72
2013	124.20	2663.70	1450.28	159.79	300.55	9.3527	5556.71
2014	132.51	2732.75	1511.10	167.01	314.89	9.0884	4867.34
2015	142.28	2788.94	1525.73	143.95	324.03	7.8629	4932.80
2016	153.19	2828.95	1551.43	180.43	327.66	60.4491	5102.11
2017	170.40	2838.28	1586.52	202.00	336.71	33.366	5167.29
2018	184.01	2881.87	1632.26	194.34	364.82	25.9617	5283.26
2019	196.40	2938.44	1673.89	230.84	366.62	12.1909	5418.38
2020	210.93	2989.22	2185.37	219.74	381.22	30.9708	6017.44
2021	189.26	3037.72	2365.05	290.93	377.74	0.1224	6260.82

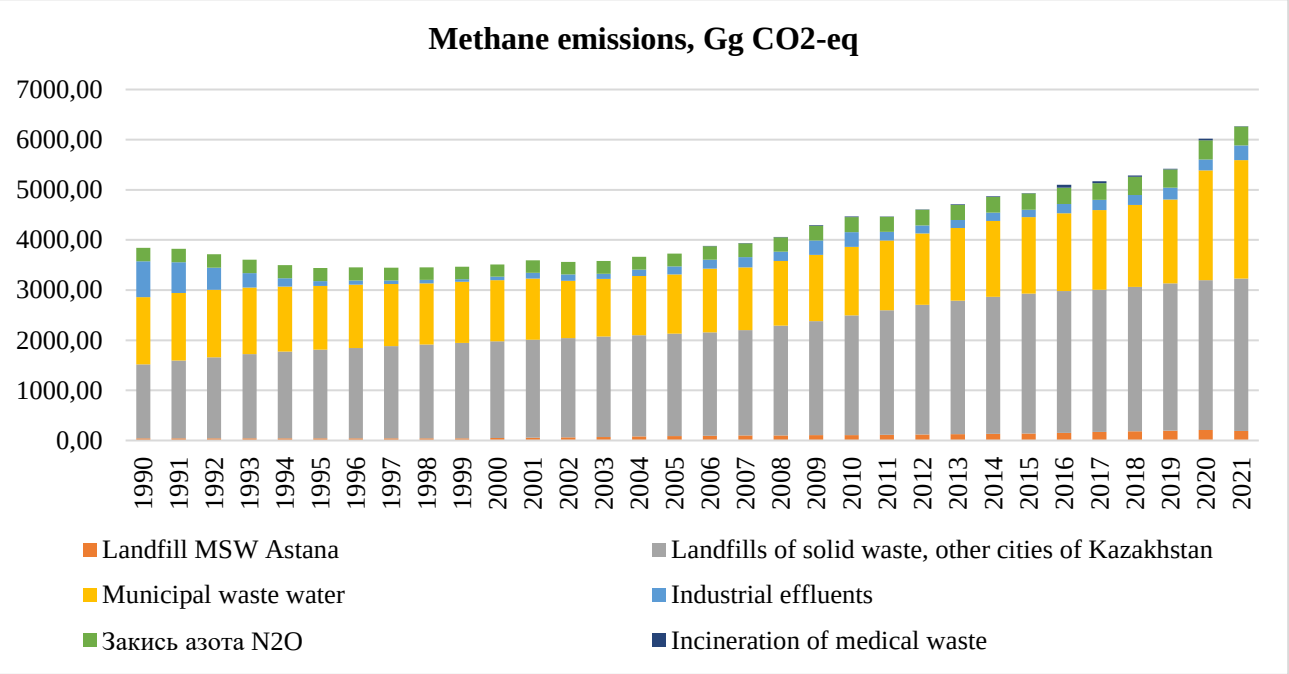

Figure 7.3 - General dynamics of greenhouse gas emissions from the Waste sector in Kazakhstan for 1990 - 2021

7.2. Solid domestic waste (Category 5.A CRF)

7.2.1 Initial data on the generation of municipal solid waste

Data on the population of the country for the period under review from 1990-2021. [106]and on the generation of municipal waste are formed by the Bureau of National Statistics ASPIR RK in annual reference books and bulletins. From 1990 to 2004, per capita waste data are estimated by interpolation and presented in Table 7.3. Historical data on the population of Kazakhstan since 1950-1989. taken from Book 1 "Population of Kazakhstan in the 20-30s of the XX century" [107].

Analysis of the total waste stream is combined with data on waste generation and management. The approach is complemented by modeling. It is good practice in modeling to validate the data against separately collected information on MSW generation, treatment, disposal, and waste morphology. The Tier 1 method is used to estimate methane emissions from municipal solid waste landfills. This method is described in more detail in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5, Chapter 3 [108].

Municipal solid waste (MSW), urban area

In urban areas, the main generators of municipal waste are not only households, but also enterprises and organizations.

Urban communities in Kazakhstan have a larger impact on GHG emissions than rural populations due to higher consumption and more GHG-intensive lifestyles and infrastructure.

In Astana and Almaty, the average volume of waste per capita is approximately 300-400 kg per year. Although the fleet of garbage trucks is relatively new, they barely cover existing needs [109].

For nine cities of Kazakhstan, an analysis of the composition of solid waste was carried out [110]. An analysis of the data on the study of the morphological composition by region shows very large discrepancies in the data. Additional studies for the capital of the Republic of Kazakhstan (Astana) and for the city of Almaty were carried out by a group of experts and published [111]. The results of these studies, as well as data collected in nine areas, are presented in Table 7.2.

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[106]Official statistics. Population of the Republic of Kazakhstan

[107]Tatimov M., Sarkenova K. “The population of Kazakhstan in the 20-30s of the twentieth century. Book one. Almaty, 2002.

[108]https://www.ipcc-nggip.iges.or.jp/public/2006gl/russian/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf

[109] Consolidated report. "Implementation of the Energy Efficiency Potential in the Cities of Kazakhstan", 2018

[110] The program for the modernization of the municipal solid waste management system for 2014–2050. (Government Decree No. 634 of 2014 , lost force)

[111] VJ Inglezakisetal. "Municipal solid waste management in Kazakhstan: Astana and Almaty case studies", Chemical Engineering Transactions, vol. 56 (2017), . https :// research . nu . edu . kz / en / publications / municipal - solidwaste - management - in - kazakhstan - astana - and - almaty -

Table 7.2 - Morphological composition of municipal solid waste,%

Type of waste	Kazakhstan	Nur-Sultan	Almaty city
food waste;	37.0	27.6	28.8
waste generated in gardens (yards) and parks	3.0	2.8	5
paper and cardboard	25.0	11.2	22.0
wood	3.0	0.6	0.6
textile	6.0	-	-
diapers	-	-	-
plastic and other types of inert waste	26.0	57.8	43.6
Total:	100	100	100

Table 7.3 presents data on the population of the entire country, urban and rural population, as well as the volume of municipal waste for the period from 1990-2021.

Table 7.3 - Population of the country, the number of urban and rural population, as well as the volume of generated municipal waste*

years	The entire population of the country	Urban population	Rural population	Total volume of municipal waste, thousand tons
1990	16297981	9300779	6997202	1988.2
1991	16358222	9366910	6991312	1995.6
1992	16451711	9403993	7047718	2002.6
1993	16426478	9343196	7083282	2008.7
1994	16334865	9162543	7172322	2015.8
1995	15956667	8884367	7072300	2022.9
1996	15675819	8730331	6945488	2029.6
1997	15480635	8635249	6845386	2036.8
1998	15188174	8499409	6688765	2043.4
1999	14955106	8414472	6540634	2050.7
2000	14901641	8397566	6504075	2057.3
2001	14965610	8413399	6452211	2064.2
2002	14851059	8429331	6421728	2070.9
2003	14866837	8457152	6409685	2078.4
2004	14951200	8518242	6432958	2085.2
2005	15074767	8614651	6460116	2092.1
2006	15219291	8696520	6522771	2400.9
2007	15396878	8833249	6563629	3351.9
2008	15571506	8265935	7305571	3411.9
2009	15982370	8662919	7319451	3928.2
2010	16203274	8819620	7383654	3784.5
2011	16440470	8973922	7466548	3919.2
2012	16673933	9127543	7546390	3588.1

2013	16910246	9277871	7632375	3547.6
2014	17160855	9433575	7727280	3445.9
2015	17415715	9837025	7578690	3235.5
2016	17669896	10035577	7634319	2813.3
2017	17918214	10250102	7668112	3415.2
2018	18157337	10423569	7733768	3692.3
2019	18631779	10938652	7693127	3674
2020	18879552	11151376	7728176	3708.5
2021	19503159	11991238	7511921	4006.4

* - Data from the Bureau of National Statistics ASPIR RK

Table 7.4 - Greenhouse gas emissions from urban managed landfills (Astana) and unmanaged landfills (other cities) for 1990 - 2021 In Kazakhstan

Year	**Unmanaged (deep) solid waste dumps**		**Managed (anaerobic) solid waste landfills, Astana**		**Total**
	CH4	CO2	CH4	CO2	CO2
1990	58.81	1470.23	1.81	45.19	1515.41
1991	61.90	1547.53	1.78	44.46	1591.98
1992	64.65	1616.17	1.75	43.74	1659.91
1993	67.06	1676.45	1.73	43.26	1719.71
1994	69.14	1728.59	1.72	42.93	1771.52
1995	70.68	1766.94	1.71	42.79	1809.73
1996	72.15	1803.71	1.71	42.75	1846.46
1997	73.54	1838.59	1.71	42.78	1881.37
1998	74.87	1871.75	1.72	42.94	1914.70
1999	76.09	1902.22	1.80	45.01	1947.22
2000	77.21	1930.15	1.96	48.98	1979.12
2001	78.21	1955.33	2.22	55.44	2010.77
2002	79.14	1978.54	2.55	63.84	2042.37
2003	80.04	2001.02	2.87	71.68	2072.70
2004	80.91	2022.86	3.16	79.04	2101.90
2005	81.75	2043.75	3.46	86.45	2130.20
2006	82.54	2063.61	3.76	94.12	2157.73
2007	83.97	2099.19	4.01	100.25	2199.44
2008	87.52	2187.90	4.11	102.67	2290.57
2009	91.05	2276.28	4.19	104.82	2381.09
2010	95.55	2388.73	4.28	106.93	2495.66
2011	99.43	2485.78	4.45	111.14	2596.92
2012	103.52	2588.01	4.68	116.91	2704.92
2013	106.55	2663.70	4.97	124.20	2787.90
2014	109.31	2732.75	5.30	132.51	2865.26
2015	111.56	2788.94	5.69	142.28	2931.22
2016	113.16	2828.95	6.13	153.19	2982.14
2017	113.53	2838.28	6.82	170.40	3008.68
2018	115.27	2881.87	7.36	184.01	3065.88
2019	117.54	2938.44	7.86	196.40	3134.84

2020	119.57	2989.22	8.44	210.93	3200.15
2021	121.51	3037.72	7.57	189.26	3226.98

Figure 7.4 shows greenhouse gas emissions in Kazakhstan from unmanaged solid waste landfills and managed landfills in Astana and Almaty, for 1990 - 2021, thousand tons of $CO_{2\text{-eq}}$.

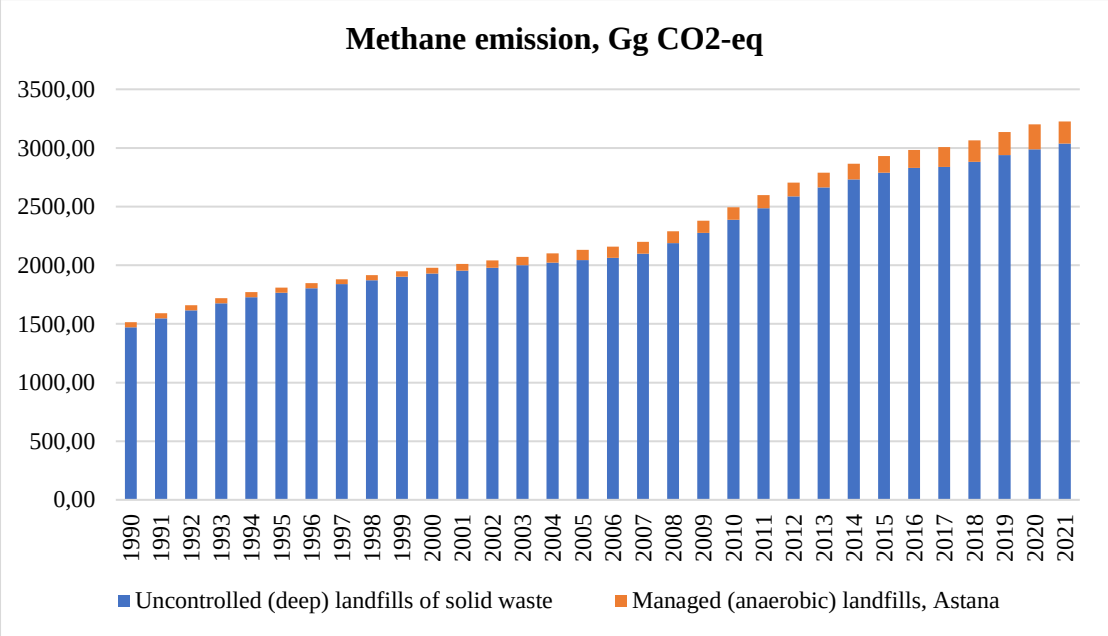

Figure 7.4 - Greenhouse gas emissions from urban managed landfills (Astana) and unmanaged landfills (other cities) for 1990-2021 in Kazakhstan

In rural areas, the morphological composition of waste is different from that of municipal waste in urban areas. It is dominated by organic waste, less plastic, packaging materials, paper and cardboard.

Data on the norms of accumulation of municipal solid waste of the rural population are not available. These landfills are considered unmanaged. Values between 150 and 300 kg per person per year may be realistic, according to international experience [112].

In accordance with the definition of the IPCC, 2006, the correction factors for methane (MC F) are: for Astana it is considered equal to 1.0, due to the fact that solid waste landfills in the capital of the Republic of Kazakhstan are considered manageable and anaerobic. For the rest of the cities of Kazakhstan, the MCF value is 0.4, since in this case, waste is delivered to landfills and landfills in a non-centralized way, and landfills can be considered unmanaged and shallow.

The value of the fraction of actually decomposed and degradable organic carbon (DOC_f) generated in landfills is 0.5, the fraction of methane F in landfill gas is 0.5 and are assumed by default according to the IPCC RP, 2006. Since the types of landfills of the country are to "Managed and unmanaged", then the methane oxidation factor (OC) for Kazakhstan is assumed to be zero, and the oxidation factor of 0.1 refers to covered, well-controlled landfills.

Half life

[112] The program for the modernization of the municipal solid waste management system for 2014–2050. (Government Decree No. 634 of 2014, no longer in force)

The value of the half-life $t_{1/2}$ applicable to any SWDS is due to a large number of factors related to the composition of the waste and the conditions in the landfill. This value of $t_{1/2}$ is the time taken for DOCm in the waste to decompose to half of its original mass. The first order damping model (FOD) and equations use the reaction constant k. The ratio between k and $t_{1/2}$ is equal to $k = \ln(2)/ t_{1/2}$.

The corresponding half-life values (k) for MSW in Kazakhstan are taken from the IPCC RP "Recommended level of default methane production values (k)" within Tier 1 and are: paper/textile waste - 0.06; wood waste/straw – 0.03; other (non-food organic waste subject to decay, waste generated in gardens and parks - 0.1; food waste / sewage sludge - 0.185. The content of organic carbon (DOC) depends on the composition of the waste and is different for different waste fractions . DOC value was estimated based on long-term results of studying the composition of MSW, the data of which are given in Table 7.2. The obtained average DOC values are 0.21 for the cities of Kazakhstan, 0.14 for the city of Astana. These values were taken into the model for calculating methane emissions from MSW disposal.

7.2.2 Methodology

The Tier 2 First Order Decay Method (FOD) was used to estimate methane emissions (formulas 3.4 and 3.5, IPCC SPM, 2006, Chapter 3 Solid Waste Disposal, Volume 5: Waste), using statistical data and by default. This category includes $CH_{4\ emissions}$ from managed anaerobic (5.A.1.a) landfills and unmanaged (5.A.2) solid waste dumps. This method assumes that the degradable organic components in the waste slowly decompose over decades, during which CH_4 and CO_2 are formed.

To obtain acceptable results by the FOD method, given that in landfills and landfills, the process of decomposition of organic substances in MSW ends 30-40 years after waste disposal, and the availability of data on the volume of MSW disposal and the economic development of Kazakhstan, a time series from 1950 was used.

The equations used in the calculation of greenhouse gases are taken from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5, Waste Sector [113].

7.2.3 Emissions from waste incineration (Category 5.C)

According to the Environmental Code of the Republic of Kazakhstan dated 02.01.21 No. 184-VII, art. 365. Environmental requirements in the field of municipal waste management, local executive bodies are responsible for organizing a rational and environmentally safe system for collecting municipal waste, providing for the separate collection, storage, regular removal, processing, disposal and neutralization of hazardous components of municipal waste, as well as cleaning the territory of the settlement . Control over compliance with environmental requirements when handling municipal waste is provided by local executive bodies as well as the authorized body in the field of environmental protection (environmental agency, currently - MENR RK) [114].

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[113] Chapter 3 Solid Waste Disposal, Volume 5 Waste. IPCC Guidelines for National Greenhouse Gas Inventories, 2006. https://www.ipcc-nggip.iges.or.jp/public/2006gl/russian/pdf/5_Volume5/V5_3_Ch3_SWDS.pdf

[114] Code of the Republic of Kazakhstan dated 09.01.2007 N 212-III ZRK "Environmental Code of the Republic of Kazakhstan"

The territory of Kazakhstan with its very low population density makes it possible not to burn waste. In accordance with the legislation, open burning of waste in Kazakhstan is officially prohibited. In case of violations of the law, unauthorized burning of garbage entails a fine in accordance with Article 410 of the Code of Administrative Offenses of the Republic of Kazakhstan "Violation or non-compliance with fire safety requirements". As a result, the amount of MSW burnt openly is very small. There are no statistical or other activity data available to estimate emissions from this source.

As commented by the ERT (W14.5.C.1 Incineration of CO_2, CH_4 and N_2O wastes), (W.11, 2017), (W.14, 2016), and in accordance with paragraph 37 of annex I to decision 24 / CP.19, when presenting the inventory for waste incineration, the keys "NE" were used in the CRF tables.

Based on the recommendations of the ERT, according to the 2006 IPCC Guidelines (Volume 5, Chapter 5.3.2, pp. 5.14–5.18), in the absence of data on the amount of waste subjected to open burning, in this NIR an estimate was made of the total amount of MSW that may have been subjected to open burning. incineration. Equation 5.7 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 5 "Incineration and Open Burning of Waste", Volume 5, "Waste" sector, was used, using data from 1990 to 2021. inclusive of rural population and default data. Waste composition data are in line with those reported in the NIR section for the Solid Waste Disposal category. According to the data of the Bureau of National Statistics of ASPIR RK, the rural population in 2021 amounted to 7,511,921 people. In accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, the rate of MSW generation per capita of the rural population is 0.4 kg / person / day, the total amount of municipal waste subjected to open burning is 263.4 Gg / year. Equation 5.7 from Chapter 5 Incineration and Open Burning of Waste was used for the calculation :

$$MSW_B = P \times P_{frac} \times MSW_P \times b_{frac} \times 365 \times 10^{-6}$$

Where:

MSW_B - Total amount of municipal solid waste subjected to open burning, Gg/year;

P – population (number of people);

P_{frac} – share of the population burning waste, (share);

MSW_P – generation of waste per capita, kg of waste/day of population/day;

b_{frac} – share of incinerated waste in relation to the total amount processed waste, (share);

365 - the number of days in a year;

10^{-6} is the coefficient for converting kilograms to gigagrams.

The estimated value of emissions of CH_4, N_2O and CO_2 from possible open burning of MSW was 213.42 thousand tons of CO_2-eq.

Thus, emissions from MSW incineration amounted to less than 500 thousand tons of CO_2-eq. and according to paragraph 37 b) of Annex I to decision 24 / CP.19 are not significant.

Table 7.5 - Greenhouse gas emissions from open burning of MSW for 1990 - 2021 In Kazakhstan

Year	**CO2 emissions**	**CH4 emissions**	**N2O emissions**	**Total emissions from waste incineration**
1990	23.56	35.09	96.52	155.17
1991	23.92	35.03	96.35	155.30
1992	24.78	35.59	97.91	158.29
1993	26.55	35.96	98.90	161.41

1994	26.97	36.86	101.41	165.24
1995	28.34	35.84	98.60	162.78
1996	29.50	34.57	95.09	159.16
1997	30.93	33.58	92.37	156.88
1998	31.74	32.06	88.19	151.99
1999	32.61	30.66	84.33	147.60
2000	34.63	30.32	83.39	148.34
2001	33.22	29.83	82.07	145.12
2002	32.08	29.55	81.29	142.93
2003	31.15	29.44	80.99	141.58
2004	30.58	29.66	81.58	141.81
2005	30.05	29.91	82.27	142.22
2006	29.34	30.49	83.87	143.70
2007	28.56	30.87	84.92	144.36
2008	42.26	38.25	105.21	185.71
2009	50.09	38.39	105.61	194.09
2010	48.64	39.07	107.47	195.18
2011	63.40	39.95	109.90	213.25
2012	64.75	40.81	112.25	217.81
2013	61.10	41.74	114.82	217.67
2014	62.63	42.79	117.71	223.13
2015	55.80	41.44	113.98	211.22
2016	56.74	42.14	115.91	214.79
2017	52.96	42.86	117.90	213.73
2018	52.46	42.46	116.80	211.72
2019	52.40	42.41	116.67	211.49
2020	52.88	42.80	117.73	213.42
2021	52.53	42.01	117.34	216.67

7.2.4 Uncertainties and sequence of time series

Uncertainty in estimating emissions from MSW disposal in landfills and landfills is made up of uncertainties in the estimating parameters. Statistical data in Kazakhstan have a fairly high accuracy. Therefore, the uncertainty of data on the urban population is considered to be minimal (±5%). The estimated default uncertainties, taking into account expert judgment, are given in Table 3.5 “Estimated Uncertainties Associated with Activity Data and Default Parameters Used in the FOD Method for CH4 Emissions from SWDS” (IPCC SPM, 2006 for methane emissions from MSW) are ±80.1%. The overall parameter uncertainty is derived from the following uncertainty values:

1. ±30% - uncertainty for activity data (MSW);
2. ±51% - uncertainty of the emission factor for managed landfills;
3. ±55% - uncertainty of the emission factor for unmanaged landfills;

It should be noted that special studies to determine the parameters of methane generation from MSW landfills in Kazakhstan have not been carried out. Therefore, the use of national values for all parameters required for calculations based on measurement data is not possible. In this regard, the uncertainty assessment was carried out according to the error data from the IPCC RP,

2006. Thus, the total uncertainty from the category "Solid Waste Disposal" is ±59% for managed landfills, and ±63% for unmanaged landfills.

7.2.5 QA/QC procedures

QA/QC procedures were carried out in accordance with the QA/QC plan. In preparing the section, the initial data on activities, correction factors and emission calculations, data on the morphological composition of waste and the volume of municipal waste per capita were rechecked. The correctness of the choice of coefficients was carried out using a system of technical control over the quality of data and the results of emission calculation.

General QA/QC procedures were carried out in accordance with Section 1.2.1 of the NIR.

7.2.6 Recalculations

Emissions were recalculated for the entire time series. The obtained values are reflected in the current NDK

7.2.7 Planned improvements

In order to improve the quality of the greenhouse gas inventory for preparing reports on greenhouse gas emissions in the Republic of Kazakhstan and obtaining the necessary national data on solid waste, it is planned to refine the morphological composition of solid waste based on the data of the Bureau of National Statistics of ASPIR RK. It is planned to further refine the model parameters that are used to calculate GHG emissions from MSW management and improve the calculations using the most reliable data.

7.3 Wastewater (Category 5. D CRF)

According to the IPCC SPM, 2006, Volume 5, [115]estimates of greenhouse gas emissions from the treatment of municipal and industrial wastewater include the following source sub-categories:

– methane emissions from domestic wastewater treatment;

– indirect emissions of nitrous oxide from domestic wastewater as a result of human activity;

– methane emissions from industrial wastewater.

results Estimates of greenhouse gas emissions from wastewater treatment are presented in Table 7.6 and Figure 7.5.

Table 7.6 - Greenhouse gas emissions from wastewater treatment

years	Emissions of methane and nitrous oxide, thousand tons per year			Emissions of methane and nitrous oxide. t eq. CO_2			
	Municipal sewage CH_4	Industrial effluents CH_4	$_2O$ emissions	Municipal sewage	Industrial effluents	$_2O$ emissions	Sum of emissions
1990	53.77	28.60	0.89	1344.17	715.00	264.50	2323.68

[115]https://www.ipcc-nggip.iges.or.jp/public/2006gl/russian/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf

years	Emissions of methane and nitrous oxide, thousand tons per year			Emissions of methane and nitrous oxide. t eq. CO_2			
	Municipal sewage CH_4	Industrial effluents CH_4	$_2O$ emissions	Municipal sewage	Industrial effluents	$_2O$ emissions	Sum of emissions
1991	54.04	24.48	0.89	1350.89	611.96	266.01	2228.86
1992	53.84	17.51	0.91	1346.09	437.79	271.78	2055.66
1993	53.24	11.37	0.91	1331.01	284.13	270.27	1885.41
1994	51.85	6.62	0.89	1296.30	165.38	264.01	1725.70
1995	50.95	3.89	0.88	1273.63	97.26	262.35	1633.24
1996	50.34	3.55	0.88	1258.57	88.78	261.96	1609.30
1997	49.46	2.93	0.86	1236.40	73.32	257.01	1566.73
1998	48.80	2.71	0.84	1220.11	67.80	250.29	1538.20
1999	48.66	2.08	0.83	1216.52	52.08	246.55	1515.16
2000	48.63	2.80	0.83	1215.71	70.12	245.96	1531.78
2001	48.64	4.79	0.82	1215.94	119.75	245.72	1581.41
2002	45.81	4.87	0.83	1145.20	121.81	248.81	1515.82
2003	46.09	4.12	0.85	1152.23	102.92	253.00	1508.14
2004	47.14	5.01	0.86	1178.62	125.26	255.09	1558.97
2005	47.20	6.36	0.87	1180.06	159.10	260.43	1599.59
2006	50.84	7.02	0.90	1270.98	175.47	269.26	1715.71
2007	50.07	8.13	0.92	1251.71	203.17	275.20	1730.08
2008	51.69	7.42	0.95	1292.37	185.58	282.47	1760.42
2009	52.76	11.66	0.98	1318.88	291.39	292.46	1902.73
2010	54.64	11.72	1.01	1365.90	292.96	299.88	1958.74
2011	55.77	6.70	1.02	1394.18	167.48	304.14	1865.80
2012	56.88	6.59	1.04	1422.08	164.70	308.45	1895.23
2013	58.01	6.39	1.01	1450.28	159.79	300.55	1910.62
2014	60.44	6.68	1.06	1511.10	167.01	314.89	1993.00
2015	61.03	5.76	1.09	1525.73	143.95	324.03	1993.71
2016	62.06	7.22	1.10	1551.43	180.43	327.66	2059.52
2017	63.46	8.08	1.13	1586.52	202.00	336.71	2125.24
2018	65.29	7.77	1.22	1632.26	194.34	364.82	2191.42
2019	66.96	9.23	1.23	1673.89	230.84	366.62	2271.35
2020	87.41	8.79	1.28	2185.37	219.74	381.22	2786.33
2021	94.60	11.64	1.27	2365.05	290.93	377.74	3033.72

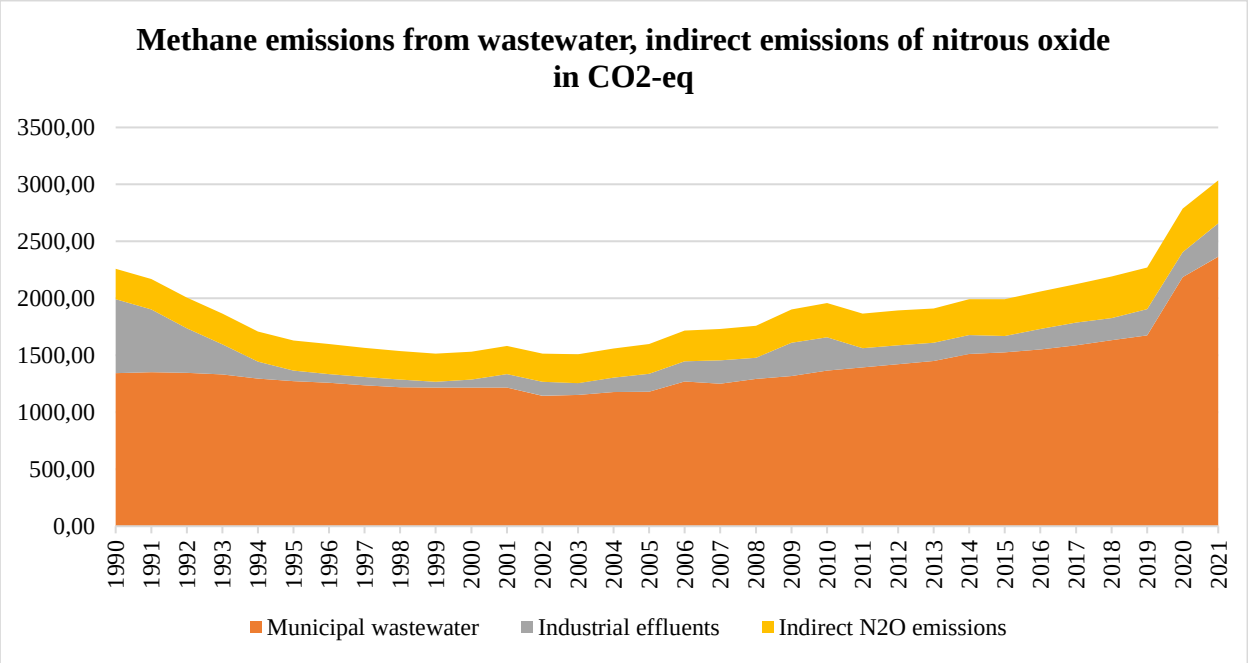

Figure 7.5 - Greenhouse gas emissions from domestic, industrial wastewater and indirect nitrous oxide emissions from housing and communal services for the period 1990-2021 thousand tons, CO_2 - eq.

7.3.1 Municipal wastewater treatment

In the Republic of Kazakhstan, the main consumers of water are housing and communal services and industry. In connection with the annual increase in the number of the population, the bulk of the withdrawn water is spent on household needs.

In Kazakhstan, mechanical, physicochemical and biological methods of wastewater treatment are used. The most common method of cleaning sewage from housing and communal services is biological, which is carried out under aerobic conditions. Systems providing aerobic conditions typically emit little or no CH_4. All municipal wastewater in the cities of Kazakhstan enters the sewer systems and undergoes complete biological treatment at aeration stations, which include three workshops: mechanical treatment, biological and wastewater disposal [116].

At present, facilities for biological wastewater treatment existing in Kazakhstan can be divided into two main types: 1) facilities in which treatment takes place under conditions close to natural; 2) facilities in which cleaning takes place under artificially created conditions.

Structures for biological treatment in natural conditions are divided into structures in which the treated wastewater is filtered through the soil (irrigation fields and filtration fields), and into structures that are reservoirs (bio-ponds) filled with flowing treated wastewater. Climatic conditions and a large occupied area allow the use of natural methods of biological wastewater treatment (bio-ponds, irrigation fields, filtration fields) in Kazakhstan.

The use of digesters for domestic wastewater treatment is not used in Kazakhstan. The accumulated sludge is not cleaned, and the accumulated sewage sludge is regularly transported to sludge sites. Thus, the emission of methane during the purification of domestic water is less than with anaerobic methods. In addition, in most parts of Kazakhstan, due to climatic conditions,

[116]Kurganov A.M., Fedorov N.F. Hydraulic calculations of water supply and sanitation systems. Spravochnik. L.: Stroyizdat, 1986-440 p.

anaerobic ponds and similar containers with a depth of more than 1.5 ... 2 meters, where significant methane formation is possible, are not used.

Disinfection (disinfection) is used to eliminate bacterial contamination of wastewater. The sanitary condition of natural water bodies in Kazakhstan largely depends on how effectively nearby facilities deal with pollution of their sewage waste [117, 118].

When choosing a method for the treatment and treatment of wastewater from settlements and industrial enterprises, as well as the location and types of treatment facilities, first of all, the possibility and expediency of the industrial use of treated wastewater and sludge (reuse or successive use of water resources in several production processes or in equipment without additional processing and cleaning or after appropriate cleaning)[119 120]

7.3.1.1 Methodological approaches to the calculation of methane emissions from municipal wastewater treatment

The assessment of greenhouse gas emissions from wastewater treatment (Category 5. D) was carried out on the basis of the IPCC Guidelines, 2006 using a methodology corresponding to Tier 1.

The total mass of organically degradable materials in domestic wastewater was determined by the following formula:

TOW \u003d P x BOD x 0.001 x I x 365 (7.1),

Where:

TOW is the total mass of organic materials in wastewater for the accounting year, BOD kg/year;

P is the population in the reference year according to the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan;

BOD - Biochemical Oxygen Demand (BOD) - 60 g/person/day, taken from Table 6.4 of IPCC 2006 SPM [121].

The value of BOD_5 for domestic wastewater is taken as a default for certain regions and countries. Due to lack of local values, values from nearby countries with similar climatic conditions have been used;

0.001 is the coefficient for converting from grams of BOD to kilograms of BOD;

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[117] Yakovlev S.V., Karelin Ya.A., Laskov Yu.M., Voronov.Yu.V. Drainage systems of industrial enterprises. M.: Stroyizdat, 1990.-511 p.

[118]23 National report on the state of the environment in the Republic of Kazakhstan, MEP RK, Almaty, 2007.

[119]Kedrov V.S., Palgunov P.P., Somov M.A. Water supply and sewerage. M-Stroyizdat, 1984-288 p.

[120]Ibraev T.T., Li M.A., KazNIIVKh LLP Some aspects of the influence of anthropogenic factors on the water resources of Kazakhstan - Water Management of Kazakhstan, 2010.ibraev_Li.pdf-google.

[121]https://www.ipcc-nggip.iges.or.jp/public/2006gl/russian/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf

I is a correction factor for additional industrial discharges of BOD into sewers (for the amount collected, the default value is 1.25.

to determine CH_4 emission factors for each route or system for domestic wastewater treatment/discharge:

$$EFj = Bo \times MCFj \quad (7.2),$$

Where:

EFj is the emission factor kg CH_4/kg BOD;

j - way or system of cleaning / dumping;

Bo is the maximum CH_4 generation capacity /kg BOD equal to 0.6kg CH_4/kg BOD (from Table 6.2 - Default Maximum CH_4 formation capacity (Bo) for domestic wastewater);

MCFj is the correction factor for domestic wastewater (from Table 6.3 - Default MCF values for domestic wastewater for each pathway/treatment/discharge system IPCC RP, 2006 (Table 7.7).

Table 7.7 - MCF and CH_4 emission factor values for different domestic wastewater treatment/discharge systems

Type of path or wastewater treatment system	**Correction factor for CH_4 MCF (from Table 6.3 IPCC RP, 2006)**	**CH4 emission factor for each route/system of wastewater treatment/discharge**
Centralized aerobic wastewater treatment plants	0.3	0.18
Septic systems	0.5	0.30
Latrine	0.1	0.06

used to estimate total CH4 emissions from domestic wastewater:

$$\textit{Emissions}\ CH_4 = [\ \sum(Ui \times Tji \times EFj)\ ]\ (TOW - S) - R \quad (3),$$

Where:

CH_4 emissions – CH_4 emissions *in the accounting year, kg/year;*

TOW is the total amount of organic matter in wastewater for the accounting year, BOD kg/year;

S is the amount of the organic component extracted as sediment in the accounting year, BOD kg/year (the default value is zero);

Ui are population classes in income groups i in the reference year (Table 7.6);

Tj is the degree of application of the cleaning/discharge system (Table 7.7);

EFj is the emission factor, *kg* CH_4 */kg BOD* (Table 7.5);

R is the amount of CH_4 recovered *in the accounting year, kg* CH_4 */year (assumed to be zero for Kazakhstan according to* IPCC RP, 2006 *).*

There are three domestic wastewater treatment/discharge systems in use in Kazakhstan: sewers, septic tanks and pit latrines.

Wastewater from septic tanks and cesspools is discharged into the city sewer for further treatment. In rural areas, cesspools are mainly used (more than 90%). Untreated domestic wastewater from sewers, septic tanks, cesspools is discharged into the sewer system for further treatment. To estimate methane emissions from domestic wastewater, data were used in terms of urban and rural population (table 7.8 and figure 7.6).

At the end of 2020, according to the Bureau of National Statistics of ASPIR RK, the population of Kazakhstan was 18,879,552 people.

Table 7.8 - Dynamics of demographic indicators in Kazakhstan

years	Total population in Kazakhstan, pers.	Population in Kazakhstan, pers.		Population in Kazakhstan, people in shares (urbanization Ui)	
		urban area	Countryside	urban area	Countryside
1990	16358222	9366910	6991312	0.57	0.43
1991	16451711	9403993	7047718	0.57	0.43
1992	16426478	9343196	7083282	0.57	0.43
1993	16334865	9162543	7172322	0.56	0.44
1994	15956667	8884367	7072300	0.56	0.44
1995	15675819	8730331	6945488	0.56	0.44
1996	15480635	8635249	6845386	0.56	0.44
1997	15188174	8499409	6688765	0.56	0.44
1998	14955106	8414472	6540634	0.56	0.44
1999	14901641	8397566	6504075	0.56	0.44
2000	14865610	8413399	6452211	0.57	0.43
2001	14851059	8429331	6421728	0.57	0.43
2002	14866837	8457152	6409685	0.57	0.43
2003	14951200	8518242	6432958	0.57	0.43
2004	15074767	8614651	6460116	0.57	0.43
2005	15219291	8696520	6522771	0.57	0.43
2006	15396878	8833249	6563629	0.57	0.43
2007	15571506	8265935	7305571	0.53	0.47
2008	15982370	8662919	7319451	0.54	0.46
2009	16203274	8819620	7383654	0.54	0.46
2010	16440470	8973922	7466548	0.55	0.45
2011	16673933	9127543	7546390	0.55	0.45
2012	16910246	9277871	7632375	0.55	0.45
2013	17160855	9433575	7727280	0.55	0.45
2014	17415715	9837025	7578690	0.56	0.44
2015	17669896	10035577	7634319	0.57	0.43
2016	17918214	10250102	7668112	0.57	0.43
2017	18157337	10423569	7733768	0.57	0.43
2018	18395567	10698210	7697357	0.58	0.42
2019	18631779	10938652	7693127	0.59	0.41
2020	18879552	11151376	7728176	0.59	0.41
2021	19 503 159	11991238	7511921	0.61	0.39

The degree of application of ways and methods of wastewater treatment/discharge for each year is taken from the Statistical Compendium "Living Standards of the Population in Kazakhstan", which is published annually on the website of the Bureau of National Statistics of

ASPIR RK and presented in table 7.9 [122]. For the period 1990-2004. data on the use of septic tanks are not available in national statistics.

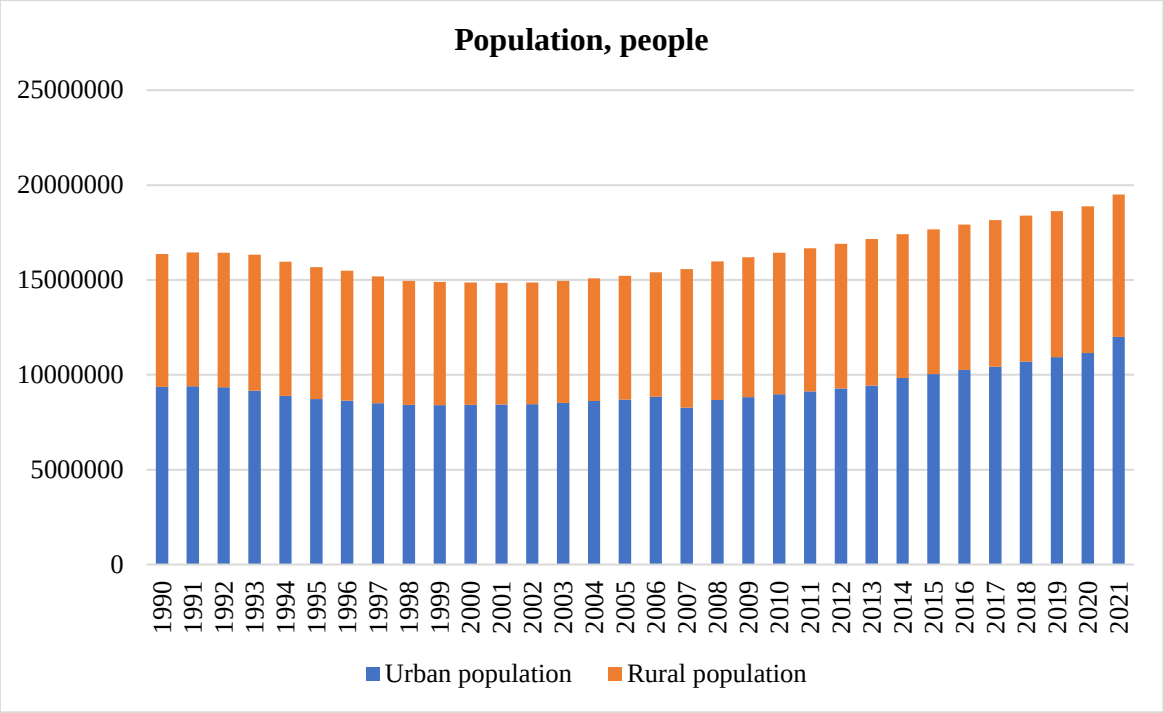


Figure 7.6 - Dynamics of demographic indicators in the Republic of Kazakhstan

Table 7.9 - Urbanization and degree of application of ways and methods of wastewater treatment/discharge in the Republic of Kazakhstan

years	Rural population			Urban population		
	septic tank	Latrine	Sewerage	septic tank	Latrine	Sewerage
1990	-	0.91	0.09	-	0.193	0.807
1991	-	0.91	0.09	-	0.193	0.807
1992	-	0.91	0.09	-	0.193	0.807
1993	-	0.91	0.09	-	0.193	0.807
1994	-	0.91	0.09	-	0.193	0.807
1995	-	0.91	0.09	-	0.193	0.807
1996	-	0.91	0.09	-	0.193	0.807
1997	-	0.91	0.09	-	0.193	0.807
1998	-	0.91	0.09	-	0.193	0.807
1999	-	0.91	0.09	-	0.193	0.807
2000	-	0.91	0.09	-	0.193	0.807
2001	-	0.91	0.09	-	0.193	0.807

[122] https://stat.gov.kz/official/industry/64/publication

2002	-	0.95	0.05	-	0.268	0.732
2003	-	0.957	0.043	-	0.263	0.737
2004	-	0.94	0.06	-	0.254	0.746
2005	0.018	0.959	0.023	0.014	0.281	0.705
2006	0.019	0.912	0.069	0.013	0.212	0.775
2007	0.02	0.908	0.072	0.013	0.21	0.777
2008	0.022	0.913	0.065	0.014	0.212	0.774
2009	0.025	0.91	0.065	0.017	0.211	0.772
2010	0.028	0.911	0.061	0.024	0.184	0.792
2011	0.029	0.905	0.066	0.026	0.182	0.792
2012	0.036	0.901	0.063	0.025	0.181	0.794
2013	0.036	0.889	0.075	0.024	0.182	0.794
2014	0.04	0.88	0.08	0.034	0.172	0.794
2015	0.04	0.889	0.07	0.035	0.179	0.785
2016	0.04	0.889	0.07	0.035	0.179	0.785
2017	0.041	0.875	0.083	0.036	0.177	0.786
2018	0.042	0.864	0.094	0.041	0.171	0.788
2019	0.04	0.867	0.093	0.045	0.155	0.8
2020	0.264	0.778	0.058	0.137	0.095	0.806
2021	0.32	0.762	0.062	0.139	0.094	0.806

Data on the results of calculations Methane emissions from municipal wastewater treatment for the period from 1990 to 2021 are shown in Table 7.10 and Figure 7.7.

Table 7.10 – Methane emissions from treatment/discharge of municipal wastewater in Kazakhstan, thousand tons*

Year	**Population in the Republic of Kazakhstan, pers.**	**The total amount of organic matter formed, thousand tons of CH_4**	**Net methane emissions – urban areas, thousand tons CH_4**	**Net methane emissions - rural areas, thousand tons CH_4**	**Net emission of methane from domestic wastewater, thousand tons CH_4**
1990	16358222	447.81	40.22	13.55	53.77
1991	16451711	450.37	40.38	13.66	54.04
1992	16426478	449.67	40.11	13.73	53.84
1993	16334865	447.17	39.34	13.90	53.24
1994	15956667	436.81	38.14	13.71	51.85
1995	15675819	429.13	37.48	13.46	50.95
1996	15480635	423.78	37.08	13.27	50.34
1997	15188174	415.78	36.49	12.96	49.46
1998	14955106	409.40	36.13	12.68	48.80
1999	14901641	407.93	36.05	12.61	48.66

2000	14865610	406.95	36.12	12.51	48.63
2001	14851059	406.55	36.19	12.45	48.64
2002	14866837	406.98	34.23	11.58	45.81
2003	14951200	409.29	34.61	11.47	46.09
2004	15074767	412.67	35.26	11.88	47.14
2005	15219291	416.63	35.22	11.98	47.20
2006	15396878	421.49	37.75	13.09	50.84
2007	15571506	426.27	35.38	14.69	50.07
2008	15982370	437.52	37.05	14.64	51.69
2009	16203274	443.56	37.84	14.92	52.76
2010	16440470	450.06	39.50	15.13	54.64
2011	16673933	456.45	40.30	15.47	55.77
2012	16910246	462.92	40.96	15.92	56.88
2013	17160855	469.78	41.59	16.42	58.01
2014	17415715	476.76	44.01	16.43	60.44
2015	17669896	483.71	44.70	16.33	61.03
2016	17918214	490.51	45.66	16.40	62.06
2017	18157337	497.06	46.54	16.92	63.46
2018	18395567	503.58	48.15	17.14	65.29
2019	18631779	510.04	49.95	17.01	66.96
2020	18879552	516.83	58.57	28.84	87.41
2021	19 503 159	524.76	59.95	32.59	92.54

Compared to the previous year, in 2021, the use of septic tanks and sewers in rural areas increased significantly, thanks to the development and improvement of the regions. As a result, total emissions rose slightly, despite the high rate of population growth.

Wastewater after mechanical and biological treatment is discharged into storage ponds [123]. According to IPCC RP, 2006, vol. 5, p. 6.11, when using the recommended default emission factors, emissions of wastewater and sewage sludge are estimated together, since the necessary statistics on sewage sludge are not available.

[123] Ibraev T.T., Li M.A., LLP "KazNIIVKh" Some aspects of the influence of anthropogenic factors on the water resources of Kazakhstan - Water management of Kazakhstan, 2010 ibraev_Li . _ _ pdf - google .

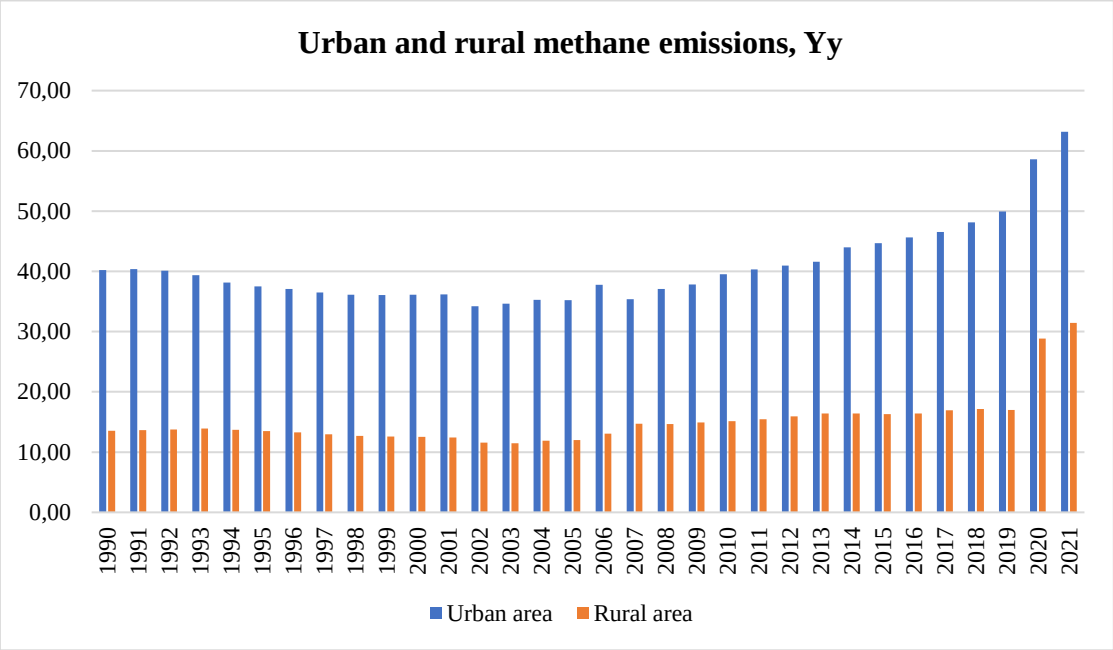


Figure 7.7 - Methane emissions in urban and rural areas of the Republic of Kazakhstan from wastewater treatment

7.3.1.2 Uncertainty estimation and time series consistency

According to the IPCC methodology, uncertainty data are taken from Table 6.7 [124](Chapter 3, Volume 1 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories) by default for the emission factor and activity data for domestic wastewater and presented in Table 7.11. The following parameters are considered unreliable: the degree of wastewater treatment in latrines, septic tanks; the amount of wastewater disposed of to the sewers for high- and low-income urban and rural populations (Tji); the number of open sewer systems, the degree of methane emissions from them; the amount of industrial TOW that is released into open or closed tanks.

Table 7.11 – Default IPCC Uncertainty Ranges for Domestic Wastewater

Parameter	Uncertainty range
Max. the ability to form CH_4 (In)	±30%
Anaerobically Treated Quantity (MCF)	Raw systems and latrines ±50%, Sumps, poorly managed wastewater treatment plants ±10%
Activity Data	
Population (P)	±5%
BOD per capita	±30%
Degree of application of wastewater treatment or discharge system for different income groups	±50%
Correction factor for additional industrial BOD discharged into sewers	±20%

[124]https://www.ipcc-nggip.iges.or.jp/public/2006gl/russian/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf

Income category data	±15%

Thus, the activity data uncertainty is 63.6%, the emission factor uncertainty is 65.6%. The uncertainty of methane emissions from this category is 91%.

Methods and datasets for the entire time series from 1990 to 2021 were used to estimate methane emissions from wastewater. The MCF values for various treatment systems are presented in Table 7.6 treatment/discharge , IPCC RP, 2006). Data on sludge removal and methane recovery are not available. The number of population in the reference year and the degree of application of ways and methods of wastewater treatment/discharge for each year are taken from the statistics of the Bureau of National Statistics (Department of Statistics of Labor and Living Standards of the Republic of Kazakhstan).[125]

7.3.1.3 QA/QC procedures

During the preparation of the NIR, the activity data and parameters used in the calculation of methane emissions from domestic wastewater were verified and analyzed. The values of methane emissions for different years are compared. These activities were carried out in accordance with the QA and QC procedures (IPCC RP, 2006) in accordance with Section 1.2.1. Comments and corrections received from state bodies and departments are included in the text and tables of the National Report.

7.3.1.4 Recalculations

Recalculations in the provided NDK were made for the entire period in connection with the specification of the total mass of organic materials in wastewater.

7.3.1.5 Planned improvements

It is planned to continue collecting data to clarify the technical features of the operation of domestic wastewater treatment / discharge systems in the Republic of Kazakhstan to adjust the ratio of the use of various wastewater treatment systems, to clarify the share of anaerobic treatment, the share of silt, their further processing and the use of dry residue.

7.3.2 Calculations of methane emissions from industrial wastewater treatment

Methane is not utilized in industrial wastewater treatment in Kazakhstan.

7.3.2.1 Methodological approaches

An estimate of $CH_{4\ emissions}$ from industrial wastewater treatment was calculated based on the methodology outlined in IPCC SPM, 2006 using default parameters.

The total mass of organically degradable materials in industrial wastewater was determined by the following formula:

$$\text{Emissions } CH_4 = \Sigma[(TOWi - Si)\ EFi - Ri] \quad (7.4),$$

Where:

$_4$ emissions = CH_4 emissions in the reference year, kg CH_4 /year;

TOWi is the total amount of organically degradable material in industrial wastewater i , kg COD/year;

i - industrial sector;

[125]Demographic Yearbook of Kazakhstan. Statistical collection. Astana. http://www.stat.gov.kz/faces/publicationsPage

Si is the amount of organic component removed as sewage sludge, kg COD per year of wastewater treatment/discharge systems used in the reference year;

Ri is the amount of CH_4 recovered during the accounting year, kg CH_4 / year.

to determine CH_4 emission factors for industrial wastewater treatment/discharge:

$EFj = Bo \times MCFj$ (7.5),

where: EFj is the emission factor kg CH_4 /kg COD (from Table 6.8 - Aerobic Wastewater Treatment Plants);

J - each path or cleaning / discharge system;

B_o - the maximum ability to form CH_4 kg CH_4 /kg COD;

MCFj is the correction factor for methane (fraction), (from Table 6.9 - Default MCF Values for Industrial Wastewater IPCC, 2006).

Table 7.12 - Parameters used to calculate organic pollution of industrial wastewater

Type of production	**Education Wastewater m^3 / ton**	**COD kg / m^3**	**Type of production**	**Education Wastewater m^3 / ton**	**COD kg / m^3**
Alcohol distillation	24	eleven	Paper pulp and paper (combined)	162	9
Beer and malt beverages	6.3	2.9	Oil refining	0.6	1.0
Milk products	7	2.7	Vegetables, fruits, juices	20	5.0
Meat and poultry	13	4.1	Wine, vinegar	23	1.5

The following equation was used to estimate total organically degradable carbon (TOW):

$$TOW_i = P_i \times Wi_{_} \times COD_i \quad (6),$$

where :

TOW_i is the total amount of organically degradable material in industrial wastewater i, kg COD/year;

i - industrial sector;

P_i is the total volume of production of the industrial sector i, t/year;

W_i - collected wastewater, m^3 / t of product;

COD_i – chemical oxygen demand (industrial degradable organic components in wastewater), kg COD/m^3.

To calculate methane emissions from industrial wastewater treatment according to the 2006 IPCC methodology, data were selected for three industrial sectors: oil, chemical and food.

The oil industry is represented by the production of petroleum fuel (fuel oil) and gas oils (diesel fuel).

The chemical industry was previously calculated based on the production of nitrogen and phosphate fertilizers, but this type of fertilizer is mineral and does not fit into the category of organic chemical.

The food industry is represented by meat processing, the production of meat products, the processing and canning of fruits and vegetables, the production of dairy products, the production of alcoholic products (wine, cognac, alcohol and vodka), ethyl alcohol, and the production of beer.

The pulp and paper industry category has also been added. These types of industrial production in Kazakhstan are key in generating wastewater with a large amount of organic carbon.

Due to the lack of data on the volume of industrial wastewater discharge in the national statistics, the data on the volume of industrial production (Table 7.11) and tons of COD produced per ton of product by default from Table 6.9 of the IPCC WP, 2006 (Table 7.10) were adopted. The calculations were made for the period from 1990 to 2019. inclusive and are given in Table 7.12.

The maximum ability to form CH_4 is denoted as B_o. The default Bo value of 0.25 g CH_4 / g COD was used in the calculations (IPCC SPM, 2006). The value of the correction factor for methane (MCF) is taken by default and equals 0.3 (Table 6.8 IPCC SPM, 2006). Therefore, according to the above, the methane emission factor for industrial wastewater EF1 is 0.075. Specific wastewater generation (WW) – the volume of industrial wastewater undergoing biological treatment is taken as default from the IPCC RP, 2006 (Table 6.9) for the specific wastewater generation from various sectors of industrial production. The COD values used in the calculations for industrial effluents are based on the default average values of the IPCC SPM, 2006 and are shown in Table 7.10. In accordance with the recommendations of the IPCC 2006 RP, the proportion of COD removed with silt is assumed to be 0; the amount of CH_4 recovered during the accounting year, kg CH_4 /year, is assumed to be 0.

All methane emissions from the decomposition of organic matter in industrial wastewater treatment systems were considered to be from wastewater. To calculate greenhouse gas emissions, data on the volume of industrial production in the Republic of Kazakhstan for the period 1990-2021 were used. from the manufacturing industry database of the Bureau of National Statistics ASPIR RK [126]and are presented in Table 7.11.

7.3.2.2 Uncertainty estimation and time series consistency

As recommended (IPCC SPM, 2006), uncertainties for B_o, MCF, P, W and COD were taken from Table 6.10 by default and presented in Table 7.15. Activity data uncertainty is 28.4%, emission factor uncertainty is 40.9%. The uncertainty of methane emissions from this category is 50%.

7.3.2.3 QA/QC procedures

During the preparation of the National Report, the activity data and parameters used in the calculation of methane emissions from industrial wastewater were verified and analyzed. Methane emissions from industrial wastewater have been recalculated.

General QA/QC procedures are described in Section 1.2.1 of the NIR.

[126]Official Statistical Information - Live Data-Industry-Time Series 1990-2019 - Production in the manufacturing industry by region in physical terms http://www.stat.gov.kz/faces/wcnav_externalId/homeNumbersIndustry

Table 7.13 - Volumes of output of certain types of industrial products *

Year		food industry						
	Petroleum fuel (fuel oil) and gas oils (diesel fuel); petroleum distillates (tonnes)	**Meat production, by-products, t**	**Fruit juices, vegetable t**	**Dairy products t**	**Wine production, thousand liters**	**Production of ethyl alcohol, thousand liters**	**Beer production, thousand liters**	**Paper pulp and paper (combined)**
1990	15586900	1074753	38411.1	1597835	65900	29950	298030	157748
1991	15746200	1034589	28452.8	1493675	78310	29520	313300	125350
1992	14766900	780726	23300.3	1162254	47230	28720	230110	82083
1993	12818200	727671	18366.8	852361	23780	28170	169220	44837
1994	10101000	490042	12790	621847	12170	24580	129070	16502
1995	9524600	320858	4631.2	324417	10940	22700	81210	8489
1996	9717100	197825	4244.7	275514	8790	25520	63600	7506
1997	8809100	178346	3852.4	156012	9020	52010	69330	3890
1998	7976100	113106	6358.2	159527	16989.4	57652	85029.9	2975
1999	5488200	94520	12584.5	143904	23744.3	41571.4	82441.2	1487
2000	6241400	79412	27239.6	178022	46093.3	42453.3	135678	5524
2001	7039200	76851	39879.6	187918	41031.8	38987.1	173189.1	22726
2002	7460200	69743	45429.8	210644	45693.8	36315.1	201956.6	22904
2003	8648400	67546	56980.2	256930	39300.1	18428.5	234846.4	17171
2004	8872600	68846	77297.2	278528	40352.1	18161.9	278041.4	23012
2005	10843500	85686	99458.6	326601	52869.3	28405.3	323470.9	29102
2006	11202000	91451	129997.2	389137	36794.9	27491.2	363838.8	31865
2007	11384000	112348	168035.1	433092	19414.6	26359.6	410960.2	38005
2008	11790500	113526	122509.5	426581	13284.8	23517.2	361163.2	35853
2009	11716800	129263	136816.8	411280	17193.2	20159.9	361534	73740
2010	12793500	157177	180087.4	466982	17231.6	21397.4	495173.6	67262
2011	13392800	164934	223826.5	532742	15758.3	19446.3	425794.6	18236
2012	13668100	188058	188224.8	586427	15504.7	22339.5	481147.4	16795

2013	13843600	210268	173501.8	686937	20901.9	22323.2	460572.3	13953
2014	14542600	218868	166503.3	725198	21993.2	18315.4	490007.3	16310
2015	13534700	228277	135796.3	712595	24205.3	18306.4	474844.1	10351
2016	12863200	220331	141894.6	729418	29853.1	18184.7	506171.8	23124
2017	12974300	248043	152619.1	742881	34409.6	19170.7	564337.9	28031
2018	13400100	263529	122844.9	807969	50104.7	19797.2	638726	24266
2019	14037600	303767	74856.3	857813	44,479.30	14,419.60	664,202.80	39317
2020	12620100	295421	69936.2	936341	43,783.30	14,414.70	692,468.70	35128
2021	13849900	339009	58876.2	949666	23,342.50	15516.1	722714.8	60113

Table 7.14 - Methane emissions from industrial wastewater treatment/discharge in Kazakhstan, thousand tons

Year	**Total amount of organically degradable material in industrial wastewater**	**Methane emission from industrial wastewater treatment/discharge**
	thousand tons COD/year	(thousand tons of CH_4)
1990	346298608.5	25.97
1991	294646317.2	22.10
1992	207862105.1	15.59
1993	141143372.6	10.59
1994	78538756.8	5.89
1995	49641991.4	3.72
1996	41152272.1	3.09
1997	39105277.7	2.93
1998	36162398.67	2.71
1999	27777346.27	2.08
2000	37396794.51	2.80
2001	63866152.86	4.79
2002	64964975.08	4.87
2003	54890177.98	4.12
2004	66805152.43	5.01
2005	84855302.09	6.36
2006	93583553.33	7.02
2007	108355768.2	8.13
2008	98977558.76	7.42
2009	155408195.1	11.66
2010	156246555.4	11.72
2011	89322975.89	6.70
2012	87840514.85	6.59
2013	85219303.97	6.39
2014	89074240.97	6.68
2015	76770791.76	5.76
2016	96230266.04	7.22
2017	107735480.2	8.08
2018	103645684.8	7.77
2019	123112118.2	9.23
2020	117192496	8.79
2021	155965747.1	11.70

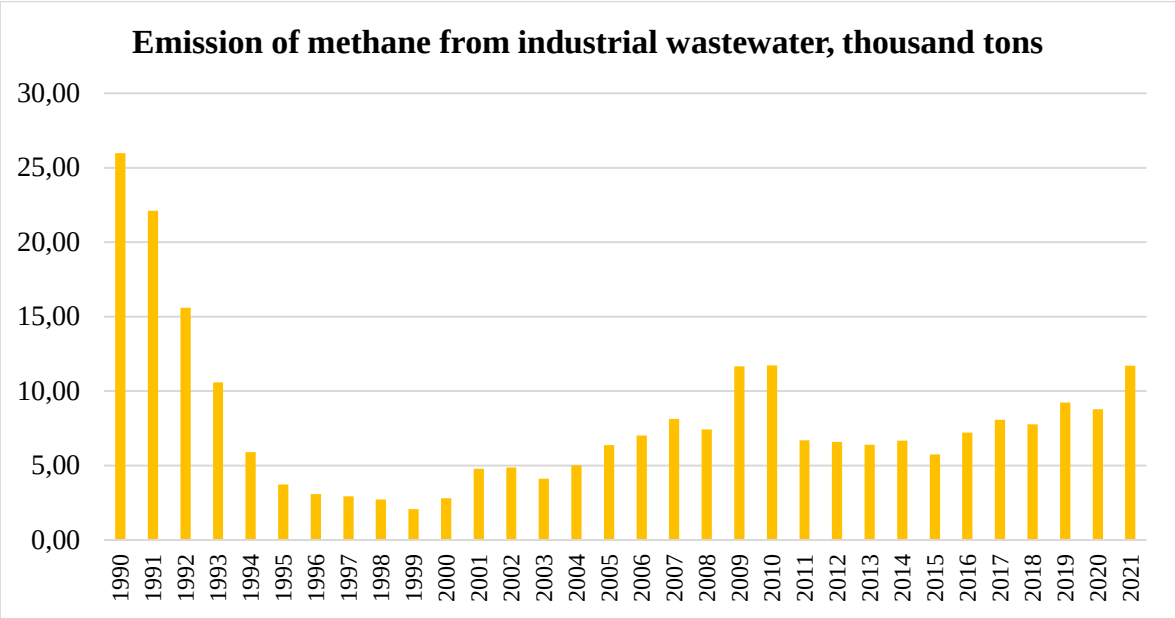


Figure 7.8 - Dynamics of methane emissions from industrial wastewater in Kazakhstan

Table 7.15 - Uncertainty ranges for industrial wastewater

Parameter	Uncertainty range (default)
Max. the ability to form CH_4 (In)	±30%,
Correction factor for methane (MCF)	±27.8%,
Activity Data	
Industrial production (P)	±25%,
Waste water/product units (W)	±9%,
COD/waste water units (COD)	±10%,

7.3.2.4 Recalculations

Recalculations in the current AIT were made for the entire period in connection with emissions from the pulp and paper industry.

7.3.2.5 Planned improvements

It is planned to clarify greenhouse gas emissions after collecting more detailed data on the applied industrial wastewater treatment technologies and data on the activities of industrial enterprises, the use of national data on B 0 - the $_{maximum}$ methane generation capacity COD i , Wi - the volume of collected wastewater by industrial sectors, the amount of organic component removed as industrial wastewater sludge.

7.3.3 Indirect emissions of nitrous oxide from human waste

Emissions of nitrous oxide N_2O are considered as indirect emissions from the disposal of treated wastewater, since the Republic of Kazakhstan is not a country with a predominance of centralized treatment systems with nitrification and denitrification stages (Table 7.17, Figure 7.8).

7.3.3.1 Methodological approaches

Calculations of indirect N_2O emissions from municipal wastewater in accordance with the recommendations of the IPCC RP, 2006 are carried out according to equation 7:

Emissions N_2O \u003d N_{sink} x EF_{sink} x 44/28 (7),

Where

N_2O emissions - N_2O emissions in the accounting year, kg N_2O / year;

N_{stock} - nitrogen in the discharge of wastewater discharged into the aquatic environment, kg N /year;

EF_{stock} - emission factor N_2O for wastewater discharge, kg N_2O- N / kg N ;

44/28 - conversion factor kg N_2O- N to kg N_2O;

Default N_{2O} emission factor IPCC WP 2006 from domestic wastewater nitrogen outflow EF_{runoff} is 0.005 kg N_2O- N /kg N .

The total amount of nitrogen in the wastewater outlet is calculated using formula 8:

$N_{stock} = (P \times Protein \times F_{NPR} \times F_{NON-CON} \times F_{IND-COM}) - N_{sucks}$ (8),

where: N_{runoff} is the total annual amount of nitrogen in the wastewater discharge, kg N / year;

P is the population, people;

Protein – annual protein consumption per capita, kg/person/year;

F_{NPR} is the proportion of nitrogen in the protein;

$F_{NON-CON}$ - coefficient for unconsumed protein discharged into wastewater;

$F_{IND-COM}$ - coefficient for industrial and commercial protein, incidentally discharged into the sewer system;

N_{sludge} - nitrogen removed with sewage sludge, kg N / year,

Population (P) - population in the reference year, taken from the data of the Bureau of National Statistics of ASPIR RK .

The annual per capita protein intake was obtained from the FAO database (FAOstat , 2013) [127]for the period 1990-2012. For those years when data were not available, the FAO data series was continued based on estimates using the data series of the Bureau of National Statistics of ASPIR RK on population and per capita food consumption in households. For the period 2013-2021 presents data on protein consumption in the Republic of Kazakhstan per capita based on the results of a sample survey of households in terms of living standards (Bureau of National Statistics ASPIR RK, Department of Labor Statistics and Living Standards). Calculations to determine indirect emissions of nitrous oxide from the products of the life of the population were made for the period 1990-2021.

The default values of the coefficients used in the calculations of IPCC RP, 2006 [128]are given in Table 7.16.

Table 7.16 - Parameters and coefficients used to estimate indirect N_2O emissions from human waste products

Index	Meaning	Dimension
FNPR _	0.16	N /kg protein
$F_{NON-CON}$	1.1	coefficient
$F_{IND-COM}$	1.25	coefficient
EF_{stock}	0.005	kg N_2O- N /kg N
N_{sucks}	0	kg N /year

[127]FAO (Food and Agriculture Organization of the United Nations). FAOSTAT Statistical Database - http://faostat.fao.org.

[128]2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5, Waste, pp.6.10-6.30.

Table 7.17 – Indirect emissions of nitrous oxide N_2O from human waste products in the Republic of Kazakhstan

Year	**Population of the country**	**Protein consumption in the country**	**Total amount of nitrogen in wastewater**	**N_2O emissions from wastewater**
	Human	kg/person/year	Thousand t N /year	Thousand t N_2O/year
1990	16358222	31.39	112.97	0.89
1991	16451711	31.39	113.61	0.89
1992	16426478	32.12	116.08	0.91
1993	16334865	32.12	115.43	0.91
1994	15956667	32.12	112.76	0.89
1995	15675819	32.49	112.05	0.88
1996	15480635	32.85	111.88	0.88
1997	15188174	32.85	109.76	0.86
1998	14955106	32.49	106.90	0.84
1999	14901641	32.12	105.30	0.83
2000	14865610	32.12	105.05	0.83
2001	14851059	32.12	104.94	0.82
2002	14866837	32.49	106.27	0.83
2003	14951200	32.85	108.05	0.85
2004	15074767	32.85	108.95	0.86
2005	15219291	33.22	111.23	0.87
2006	15396878	33.95	115.00	0.90
2007	15571506	34.31	117.54	0.92
2008	15982370	34.31	120.64	0.95
2009	16203274	35.04	124.91	0.98
2010	16440470	35.41	128.07	1.01
2011	16673933	35.41	129.89	1.02
2012	16910246	35.41	131.73	1.04
2013	17160855	34	128.36	1.01
2014	17415715	35.1	134.48	1.06
2015	17669896	35.6	138.39	1.09
2016	17918214	35.5	139.94	1.10
2017	18157337	36	143.81	1.13
2018	18395567	38.5	155.81	1.22
2019	18631779	38.2	156.58	1.23
2020	18879552	39.2	162.82	1.28
2021	19 503 159	37.6	161.33	1.27

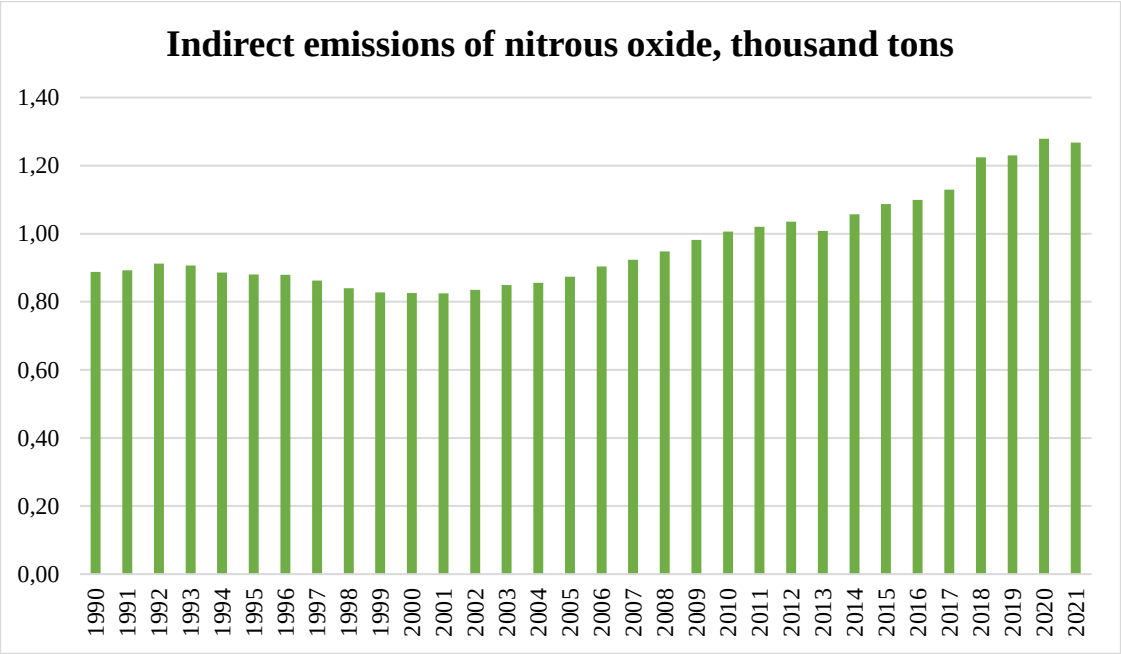


Figure 7.9 - Dynamics of indirect emissions of nitrous oxide from human waste products, thousand tons

7.3.3.2 Uncertainty estimation and time series consistency

As recommended by the IPCC, the input data for quantifying the uncertainties in emission factors and activity data are taken from Table 6.11 (IPCC SPM, 2006) and presented in Table 7.18 of this report. The activity data uncertainty is 25.7% and the emission factor uncertainty is 50%. The uncertainty of methane emissions from this category is 85%.

Table 7.18 - Default Methodological Data for Indirect N_2O Emissions from Human Waste Products

	Definition	Default Data	Range
Emission factors			
EF_{stock}	Coeff. emissions (kg N_2O- N /kg- N)	0.005	0.0005-0.25
$EF_{stations}$	Coeff. emissions (g N_2 Person/year)	3.2	2-8
Activity Data			
R	Population in the country		±10%
Protein	Annual protein intake per capita		±10%
FNPR _	Protein nitrogen content (kg N /kg protein)	0.16	0.15-0.17
$T_{station}$	Degree of application of large wastewater treatment plants (WWT)		±20%
$F_{NON-CON}$	Factors for accounting for the amount of unconsumed protein	1.1	1.0-1.5
$F_{IND-COM}$	Factor taking into account the discharge of industrial nitrogen into sewer systems	1.25	1.0-1.5

7.3.3.3 QA/QC procedures

During the preparation of the NIR, the activity data and parameters used in the calculation of indirect emissions of nitrous oxide from human waste were verified and analyzed. The values of indirect nitrous oxide emissions from human waste products have been recalculated. The values

of indirect emissions of nitrous oxide from human waste products for different years are compared. These activities were carried out in accordance with the QA and QC procedures (IPCC RP, 2006). All performed recalculations and corrections have been agreed with the interested government agencies and departments. Comments and corrections received from state bodies and departments are made to the text and tables of the NDK,

General QA/QC procedures are described in Section 1.2.1. NDK.

7.3.3.4 Recalculations

Recalculations in the current NIR for indirect emissions of nitrous oxide N_2O from human waste products were not made.

7.3.3.5 Planned improvements

In the future, it is planned to collect updated national data on protein consumption per capita.

7.5 Greenhouse gas emissions from medical waste incineration

7.5.1 Description of emission category

The legal system that exists in Kazakhstan in the field of medical waste management is based on several regulations adopted by the Ministry of Health, indicated above. According to the requirements of the current regulations, the disposal of untreated epidemiologically hazardous waste at landfills is prohibited.

In accordance with these standards, medical waste began to be divided into five classes from A to D. [129]Only waste of class B (hazardous waste) is subject to mandatory incineration - epidemiologically dangerous: infected and potentially infected materials and tools, objects contaminated with blood and other biological fluids, pathoanatomical and organic operational waste. These are organs, tissues, food waste from infectious diseases departments, waste from microbiological, clinical diagnostic laboratories, pharmaceutical, immunobiological industries working with microorganisms of pathogenicity groups 3 and 4, biological waste from vivariums, live vaccines unsuitable for use. They should be collected in special disposable containers that decompose during incineration. Hazardous medical waste (infectious, chemical and radiological) that is incinerated typically accounts for about 15% or less of the total waste generated by healthcare facilities.

Class B incinerated medical waste includes disposable instruments (plastic, syringes, systems) and anatomical waste. Heat treatment is carried out mainly in muffle swords, electric furnaces and rotary kilns, which are equipped with a rotating drum that keeps the waste in constant motion, which ensures good air access and rapid combustion of high-calorie substances.

In Kazakhstan, almost 90% of epidemiologically dangerous (infected and potentially infected) medical waste is destroyed by thermal means - incineration. The following amounts of medical waste were incinerated in stationary and polyclinic medical institutions: in 2006 - 4.701 tons, in 2007 - 677.2 tons, in 2008 - 1001.3 tons, in 2009 - 8998, 238 tons, in 2010 - 9656.315 tons, in 2011 - 7661.4 tons, in 2012 - 7053.8 tons, in 2013 - 8709.9 tons, in 2014 - 8463.8 tons, in 2015 - 7322.5 tons, in 2016 - 7348.1 tons, in 2017 - 6781.3 tons, and in 2018 - 7000, 5 tons, in 2019 - 6 819.097 tons, in 2020 - 28,842.22 tons, in 2021 - 113.97.

A significant increase (by 4.2 times) is due to the fact that the coronavirus pandemic began in 2020. Throughout the year, medical masks and syringes were used on a daily basis in huge volumes, and the amount of waste disposed of increased accordingly.

In 2021, there was a significant decrease in emissions from the incineration of medical waste (253 times less) - these are the initial data entered into the system by enterprises. In the course of informal correspondence, it was found that in 2021, approximately 400 enterprises out of 1,000 did not report, which affected the strong decrease in the final figure. Unfortunately, it is not possible to find out which enterprises did not report or influence them: the system does not provide for any technical support or rechecking of data from the site https://ecoportal.kz .

Initial data for the period up to 2018 were provided by the Ministry of Health of the Republic of Kazakhstan, for 2019-2021. - Information and Analytical Center (IAC). There is no such information in the public domain.

[129] https://adilet.zan.kz/rus/docs/V2000021934

7.5.2 Methodological issues

7.3.2.1 CO $_2$

Emissions of greenhouse gases are estimated only for carbon dioxide, since emission factors for nitrous oxide are not given in the IPCC methodology, and national factors are not currently available. The assessment takes into account the indicator of the completeness of waste combustion, the value of which is taken by default. The activity data are the amount of medical waste put into incinerators, and the emission factors are based on their carbon content. Only wastes of fossil origin are considered.

Calculations were made in accordance with the equation:

$_2$ emissions (thousand tons/year) = IW • CCW • FCF • EF • 44 / 12, (7)

Where:

IW - amount of incinerated medical waste (thousand tons/year);

CCW is the proportion of carbon content in medical waste;

FCF - fraction of fossil carbon in medical waste;

EF - completeness of combustion when incinerating medical waste in incinerators;

44 / 12 - coefficient for converting C to CO $_2$.

The default emission factor values for calculating carbon dioxide emissions from medical waste incineration were taken from the 2000 IPCC Good Practice Guidance, Chapter 5, Table 5.6, and are given in Table 7.1.

Table 7.1 - Default data for estimating CO $_{2\ emissions}$ from medical waste incineration

Waste carbon content	50…70%, default value: 60%
Fossil carbon as % of total carbon	30…50%, default value: 40%
Completeness of combustion	50…99%, default value: 100%

In calculations, the values of all conversion factors were taken by default, since there are no national data for these parameters:

the proportion of carbon content - 0.6;

share of fossil carbon content - 0.4;

completeness of combustion - 1.0;

the proportion of biogenic carbon is 0.6.

CO $_{2\ emissions}$ from medical waste incineration are divided into biogenic and fossil fractions. When calculating emissions from the incineration of medical waste, the biogenic share of CO $_{2\ emissions}$ is excluded and only the share of fossil carbon is taken into account (Table 7.2).

7.5.2.2 CH $_4$

CH $_{4\ emissions}$ from waste incineration are highly dependent on the duration of the incineration process, incineration technology and management practices applied. Calculations were made in accordance with the equation:

CH $_{4\ emissions}$ (thousand tons/year) = Σ• (IWi • EFi) • 10 $^{-6}$, (8)

Where:

IWi - amount of incinerated medical waste (wet weight) (thousand tons/year);

EFi is the CH_4 composite emission factor , kg CH_4 /thousand tonnes of waste.

10^{-6} is the coefficient for converting kilograms to gigagrams.

The default emission factors for calculating CH_4 emissions from medical waste incineration have been taken from the 2006 IPCC Good Practice Guidance, Chapter 5, Table 5.3, and are given in Table 7.2.

$_4$ emission factor for medical waste incineration

Technology type		CH_4 emission factor (kg/kt of insulated waste based on wet weight)
periodic	stoker	0.6 _

7.5.2. 3N2O _ _ _

Nitrous oxide is released at relatively low combustion temperatures - 500-950 °C. The calculation of N_2O emissions is based on the amount of waste incinerated in the kilns as well as the Tier 1 default emission factors. The calculations were made according to the equation:

N_2O emissions (thousand tons/year) = Σ• (IWi • EFi) • 10^{-6} , (9)

Where:

IWi - amount of incinerated medical waste (wet weight) (thousand tons/year);

EFi is the composite emission factor for N_2O, (kg N_2O/thousand tonnes of waste).

10^{-6} is the coefficient for converting kilograms to gigagrams.

The default emission factor values for calculating N_2O emissions from medical waste incineration were taken from the 2006 IPCC Good Practice Guidance, Chapter 5, Table 5.6, and are given in Table 7.3.

$_4$ emission factor for medical waste incineration

Technology type	CH_4 emission factor (kg/kt of insulated waste based on wet weight)	Weight type
periodic	0.6	Wet weight

7.5.4 Calculation results

Emissions from medical waste incineration in Kazakhstan are presented in Table 7.4.

Table 7.4 - Emissions from medical waste incineration in Kazakhstan

years	2006	2007	2008	2009	2010	2011	2012	2013

$_2$ emissions , thousand tons (not biogenic)	0.004 1	0.5 9 59	0.8811	7, 9 184	8.4975 _ _	6.7420 _ _	6, 2073	7.6647 _ _
$_4$ emissions , thousand tons	0.000003 _	0.0 004 1	0.0006 _ _	0.0054 _ _	0.00579 _ _	0.00460 _ _	0.00423 _	0.00523 _ _
Emissions of N $_2$ O thousand tons	0.000003 _	0.0 004 1	0.0006 _ _	0.0054 _ _	0.00579 _ _	0.00460 _ _	0.00423 _	0.00523 _ _

years	2014	2015	2016	2017	2018	2019	2020	2021
$_2$ emissions , thousand tons (not biogenic)	7.4481 _ _	6.4438 _ _	49.5392	27.3441	21.2761	9.9907	25, 3812	0.1003
$_4$ emissions , thousand tons	0.00508 _ _	0.0044 _	0.03378 _ _	0.01864 _ _	0.01451 _ _	0.00681 _ _	0.01731 _	0.00007
Emissions of N $_2$ O thousand tons	0.00508 _ _	0.0044 _	0.03378 _ _	0.01864 _ _	0.01451 _ _	0.00681 _ _	0.01731 _	0.00007

Emissions in CO2 equivalent in the Republic of Kazakhstan for the period from 2006 to 2021 presented in Table 7.5.

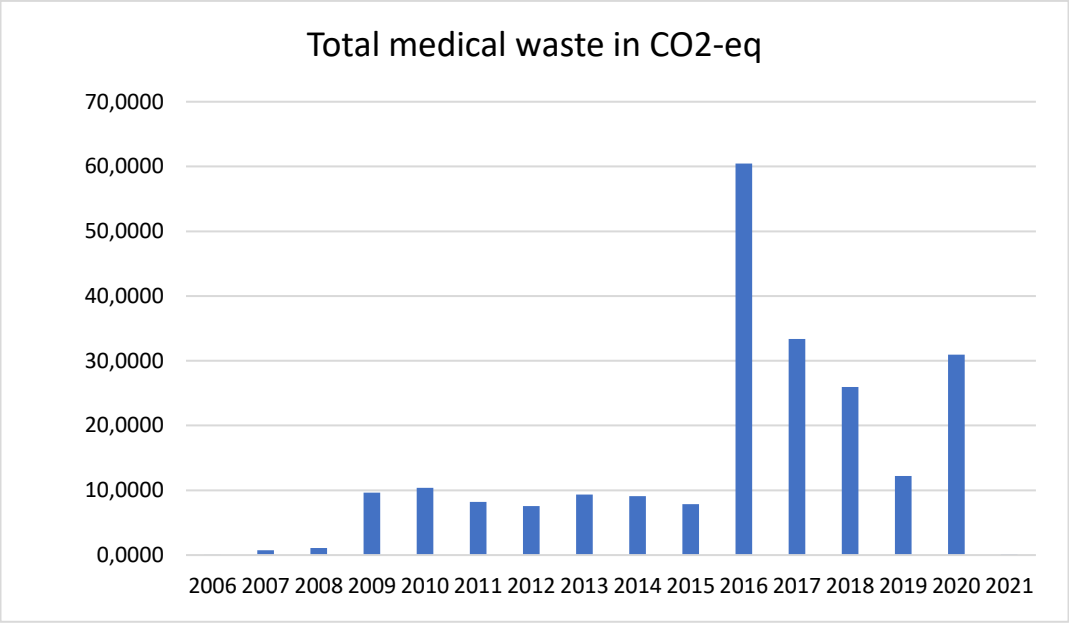
Table 7.5 - Emissions from medical waste in CO2 equivalent.

years	2006	2007	2008	2009	2010	2011	2012	2013
$_2$ emissions , thousand tons (not biogenic)	0.004 1	0.5959 _ _	0.8811	7, 9 184	8.4975 _ _	6.7420 _ _	6, 2073	7 , 6647
$_4$ emissions , (CO2-eq)	0.00084 _	0.1210	0.1790	1.608 9	1.7265	1.369 9	1.2612	1.5573
Emissions of N $_2$ O (CO2-eq)	0.0001	0.0102	0.0150	0.1350	0.1448	0.1149	0.1058	0.1306
Total	0.0050	0.72 72	1.07 52	9.6 623	1 0.3 689	8.2 268	7.5 744	9.3 527

Continuation of Table 7.5

years	2014	2015	2016	2017	2018	2019	2020	2021

$_2$ emissions , thousand tons (not biogenic)	7.4481	6.4438	49.5392	27.3441	21.2761	9.9907	25.3812	0.1003
$_4$ emissions , (CO2-eq)	1.5133	1.3093	10.0655	5.5558	4.3229	2.0299	5.1570	0.0204
Emissions of N $_2$ O (CO2-eq)	0.1270	0.1098	0.8444	0.4661	0.3627	0.1703	0.4326	0.0017
Total	9.0884	7.8629	60.4491	33.3660	25.9617	12.1909	30.9708	0.1224



Rice. 7.1 - Emissions from medical waste in CO2 equivalent

7.5.4 Uncertainties and sequence of time series

The uncertainty in estimates of CO $_{2\ emissions}$ from medical waste incineration was assessed using the Good Practice Guidance. Based on ranges for emission factor estimates for CO $_{2\ emissions}$ from medical waste incineration, their uncertainty could be ±20% or more. Since monitoring data are not used in calculations in this subcategory, it may be higher. In many developed countries, uncertainties associated with the amount of waste incinerated are estimated to be around 5%, however, for healthcare waste it can be higher, especially in developing countries. The main uncertainty for CO $_2$ is related to the estimate of the fossil carbon fraction. When using default data for N $_2$ O and CH $_{4\ emission\ factors}$, the degree of uncertainty may vary within ±100% or even exceed it. Therefore, the expert estimate of the uncertainty for emissions from this subcategory is assumed to be about ±100%.

7.5.5 QA/QC procedures

Standard procedures were applied for quality assurance and quality control procedures. The correctness of the calculations was checked by comparing the data on the calculation of emissions from the incineration of medical waste obtained by other countries. Verification of the initial data and data on the composition of incinerated medical waste, correction factors and

emission calculations, the correctness of the choice of coefficients was carried out using a technical quality control system for data and emission calculation results. The correctness of the data for estimating emissions and compliance with the IPCC methodology were checked.

7.5.6 Recalculations and corrections based on ERT comments and results of the 2019 NIR review

Recalculations have been made in this NIR in accordance with the comments of the ERT.

Also, additional recalculations were made from 2016-2021. in connection with the receipt of updated baseline data from the IAC ("Information and Analytical Center for Environmental Protection").

Due to the fact that the initial data on medical waste incineration for 2021 raise questions and doubts about their reliability, as part of the work on the NIR-2024, a request will be made for the entire time series for the purpose of rechecking.

Since it is not possible to separate medical waste into biogenic and non-biogenic waste, emissions are shown in CRF Table 5.C.1.2 .