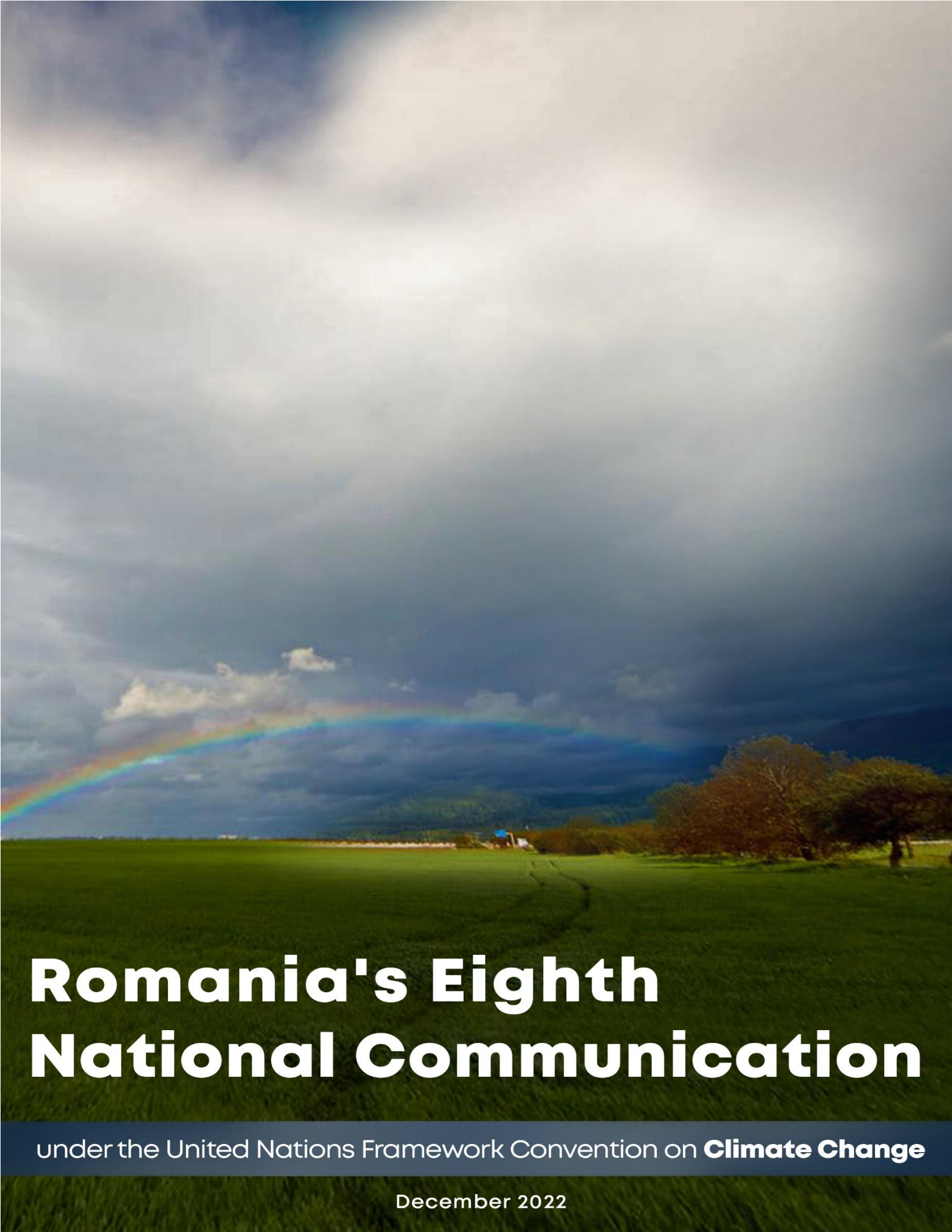

Romania's Eighth National Communication

under the United Nations Framework Convention on **Climate Change**

December 2022

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ANRE	National Electricity and Heat Regulatory Authority
CMIP	Coupled Model Intercomparison Project
CNDIPT	National Centre for Development of Vocational and Technical Education (including dual)
CRF	Common Reporting Format
CTF	Common Tabular Format
CVET	Continuous Vocational Education and Training
ECA&D	European Climate Programme and Dataset
ECOMET	Economic Interest Grouping of the National Meteorological Services of the European Economic Area
ECVs	Essential Climate Variables
EF	Emission Factor
EGO	Emergency Governmental Ordinance
ERT	Expert Review Team
ERTMS	European Railway Traffic Management System
ESIF	European Structural and Investments Funds
EU	European Union
EU-ETS	European Union-Emission Trading Scheme
EUMETNET	European Organization for the Exploitation of Meteorological Network
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
GCOS	Global Climate Observing System
GD	Governmental Degree
GDP	Gross Domestic Product
GEO	Government Emergency Ordinance
GeoEcoMar	National Institute of Research and Development on Marine Geology and Ecology
GEOSS	Global Earth Observation System of Systems
Gg	Giga gram
GHG	Greenhouse Gas
GOOS	Global Ocean Observing System
GVA	Gross Value Added
IEE	Intelligent Energy Europe programme
IPCC	Intergovernmental Panel on Climate Change
IPCC 2006	IPCC Guidelines for National Greenhouse Gas Inventories
ISPE	Institute for Studies and Power Engineering
IVET	Initial Vocational Education and Training
JPI	Joint Program Initiative
KCA	Key Category Analysis
KP	Kyoto Protocol
LULUCF	Land Use, Land Use Change and Forestry
M/A	Mitigation/Adaptation
MECC	Ministry of Environment and Climate Change, nowadays Ministry of Environment, Waters and Forests

MoEO	Ministry of Environment Order
MS	Member States
NAQ	National Authority for Qualifications
NAPCC	National Action Plan for Climate Change
NACPEVT	National Agency for Community Programs in the Field of Education and Vocational Training (ANPCDEFP)
NAE	National Agency for Employment (ANOFM)
NCCC	National Commission on Climate Change
NE	Not Estimated
NECP	National Integrated Energy and Climate Changes
NEPA	National Environmental Protection Agency
NGHGI	National Greenhouse Gas Inventory
NGO	Non-Governmental Organization
NIR	National Inventory Report
NIS	National Institute for Statistics
NMA	National Meteorological Administration
NPP	Nuclear power plant
NPS	National Power System
NSCC	National Strategy for Climate Change
NTS	National Transmission System
OHL	Overhead Electric Lines
PCF	Prototype Carbon Fund
PMU	Project Management Unit
PNAEE	National Action Plan on Energy Efficiency
PNRR	National Recovery and Resilience Plan
PTG	Power Transmission Grid
QA	Quality Assurance
QC	Quality Control
RBCN	Regional Basic Climatological Network
RBSN	Regional Basic Synoptic Network
RCP	Representative Concentration Pathways (concentration scenario for GHG concentrations in future)
RES	Renewable Energy Sources
SIMIN	National Meteorological Integrated System
SME	Small and Medium Enterprises
UEFISCDI	Executive Unit for the Financing of Higher Education, Research, Development and Innovation (UEFISCDI)
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNHCR	United Nations High Commissioner for Refugees
UPB	University "Politehnica"of Bucharest
WAM	with Additional Measures
WCRP	World Climate Research Programme
WEM	with Measures

WMO	World Meteorological Organization
WOM	without Measures

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1. EXECUTIVE SUMMARY

Romania is firmly committed to the international legal framework developed by the United Nations, the 2030 Agenda for Sustainable Development, The Paris Agreement, and the United Nations Framework Convention on Climate Change (UNFCCC) which put the climate change topic on the top of the UN agenda. Also, Romania is committed to the implementation of the Paris Agreement and highly aware of the urgency of action to keep the global average temperature to well below 2°C above preindustrial levels and shifting towards low greenhouse gas emissions development pathway while fostering climate resilience.

This report constitutes the Romania's Eighth National Communication and Fifth Biennial Report under Article 12 of the UNFCCC, Article 7 of the Kyoto Protocol and decision 2/CP.17 of the Conference of the Parties. It provides an overview of action to address climate change in the Romania – including progress made to reduce greenhouse gas emissions and adapt to the effects of a changing climate, covering the period between 1989 – 2020.

The main body of this report – the Eighth National Communication - is structured into 8 chapters which are summarized below. The Romania's fifth Biennial Report is attached in Annex 1 and the related Common Tabular Format is provided in Annex 2.

NATIONAL CIRCUMSTANCES RELEVANT TO GREENHOUSE GAS EMISSIONS AND REMOVALS

Romania is a presidential Republic based on the principle of separation and balance of powers in the state - legislative, executive, and judicial - under the rules of constitutional democracy.

The responsibility for addressing climate change in Romania is shared between the Romania Government and 42 local government authorities (including Bucharest). The Ministry of Environment is the lead authority in the Romania Government's responses to climate change.

Romania joined the European Union in January 2007. The Romanian economy is a market-based economy, promoting freedom of trade, protection against unfair competition, stimulation of domestic and foreign investments and protection of private property.

The economic development of Romania is strongly linked to the worldwide economic development and to that of the European Union one, as it occurs in special complex international environment affected by the global economic-financial crisis and pandemic.

According to the results of the 2011 Population and Housing Census, Romania had a population of 20,121 mil. inhabitants in 2011, out of which 51.4% were women. The preliminary results of the 2021 Census indicate that Romania population in 2020 was 19,262 mi. inhabitants.

Romania is situated in the south-eastern part of the Central Europe inside and outside of the Carpathians Arch, on the Danube lower course. Romania's climate is a transitional temperate-continental one with oceanic influences from the West, Mediterranean modulations from the South-West and excessive continental effects from the North-East.

Romania's main export goods are machinery and equipment for transport, metals and metal products, textiles and footwear, chemicals, agricultural products, minerals, and fuels. In the structure of exports, the main

categories in 2018 includes: machinery and transport equipment 49, processed products, classified mainly by raw material 19%, miscellaneous goods 15%, chemicals and related products 7%, mineral fuels 3%, lubricants and related materials, and other goods 7%.

More information about the structure of the Romania's economic sector is provided in the Chapter 2.

GREENHOUSE GAS INVENTORY INFORMATION

As a Party to the Convention, Romania develops and regularly update the National GHG Inventory (NGHGI). The last NGHGI for the period 1989–2020 was compiled according to the recommendations for GHG inventories set out in the Updated UNFCCC reporting guidelines on annual inventories (FCCC/CP/2013/10/Add.3), using IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006) as well as associated support documents.

The national greenhouse gas emissions/removals estimates were estimated for the period 1989-2020. The results are presented for every year of the analyzed period and include information on trend analysis, data sources, key categories, uncertainties, and quality assurance and quality control (QA/QC) activities.

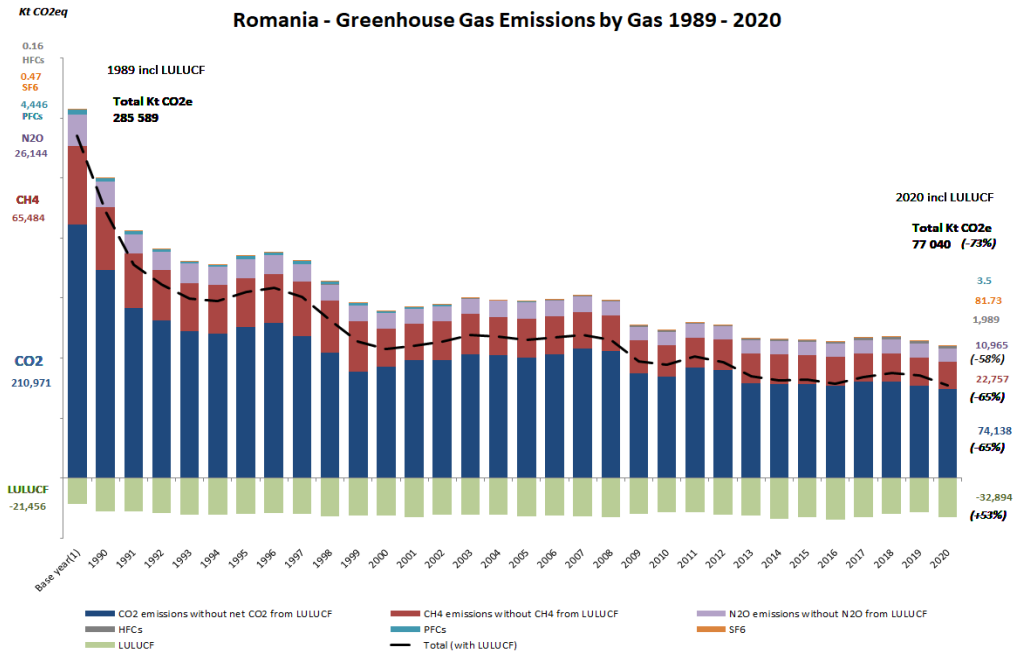


Figure 1-1 Romania Greenhouse Gas emissions by gas, 1989 – 2020

The total GHG emissions in 2020, excluding removals by sinks, amounted to 110,366.83 kt CO_2 equivalents. The total GHGs emissions (without considering sinks) decreased by 64.09% in 2020 in comparison to 1989 while the net GHG emissions/removals (considering the CO2 removals) decreased by 72.90%.

The National Inventory Arrangements (NIA), including the National System, is based on the provisions provided by the Decision 24/CP. 19 on the Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention and on Article 5 of the Kyoto Protocol, and complies with the provisions of the subsequent decisions of the CMPs of the Kyoto Protocol. It also complies with the provisions of the Regulation

(EU) no. 525/2013 of the European Parliament and of the Council on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision no. 280/2004/EC, as well as with the Commission Implementing Regulation (EU) no. 749/2014 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) no. 525/2013.

POLICIES AND MEASURES

Romania, as an EU Member State has implemented mitigation policies and measures for many years which has already contributed successfully to the reduction of greenhouse gas emissions in recent years. These include the European Union Emissions Trading System (EU ETS) and a wide range of policies and measures addressing all sectors of the economy. At EU level the climate policies are already extended as such to achieve in 2030 the NDC target communicated by the EU and its Member States, which is an economy-wide net domestic emission reduction of at least 55 % by 2030 compared to 1990. The European Union and its Member States have a comprehensive system in place which helps them fulfil their climate change mitigation commitments under the Convention, under the Kyoto Protocol and under the Paris Agreement. In addition, since 2020, the European Green Deal, a comprehensive and holistic plan to become the first carbon neutral continent by 2050 has been adopted. It acts as a catalyst for more ambitious targets.
The adopted and planned policies and measures take into considerations the GHG emissions of each sector, their potentials of the reductions and the national priorities for economic development.

PROJECTIONS AND TOTAL EFFECT OF POLICIES AND MEASURES

The GHG projections for 2025, 2030, 2035 and 2040 considered different scenarios related to the economic-social, demographic, and technological evolution, to allow the highlight of the measures undertaken by Romania to achieve the GHG emissions mitigation goals at EU level and of the Convention considering the Kyoto Protocol.

The GHG emission projections are carried out for three scenarios, respectively: the scenario without measures (WOM) with the reference year – 2005, the scenario with measures (WEM), and the scenario with additional measures (WAM), both with the reference year – 2020.

In Figure 1-2 is presented the GHG emissions evolution in the period 1990-2040 for all scenarios (WOM, WEM, WAM). Romania achieved the joint quantified economy-wide greenhouse gas emission reduction target of 20 per cent below the 1990 level by 2020 ("the Cancun pledge") under the UNFCCC.

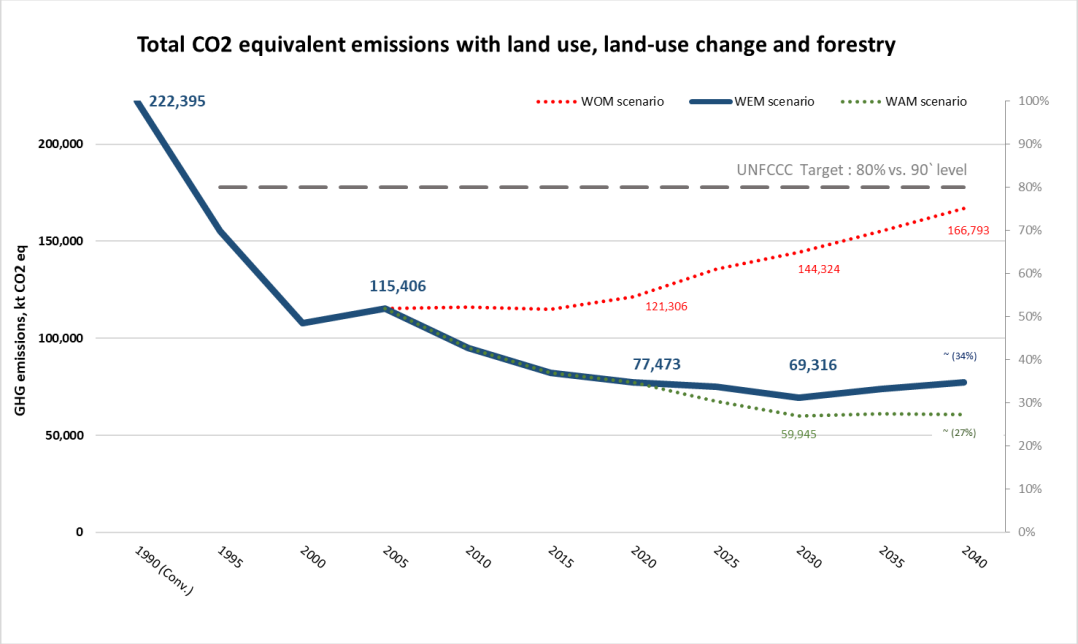


Figure 1-2 Romania GHG emissions projections

In the WOM scenario, the GHG emissions increased in 2005-2020 from 115,405.87 kt CO2 eq. to 121,305.66 kt CO2 eq. and are higher by about 56 % in comparison with the value determined by National Inventory of Greenhouse Gas Emissions for 2020.

In the WEM scenario, GHG emissions are expected to decrease between 2020 and 2025 with about 3.1%. GHG emissions in 2025 will be lower by about 45% compared to the emissions from WOM scenario.

In the WAM scenario, GHG emissions are expected to decrease between 2020 and 2025 with about 12.7 %. GHG emissions in 2025 will be lower by 51% compared to the emissions from WOM scenario.

VULNERABILITY ASSESSMENT, CLIMATE CHANGE IMPACTS AND ADAPTATION MEASURES

During the last years, the impacts of climate change on Romanian society and ecosystems have grown and climate change issues have become increasingly important on the Romanian political agenda. Expected impacts affect all socio-economic sectors in Romania. For instance, a net increase in thermal-related mortality, caused by the sharp increase in mortality associated with high temperatures, is identified in urban environment, under the pessimistic scenario RCP 8.5, by the end of the century. Another example of climate change impact is on water supply/demand and agriculture.

Significant climate changes are still expected during the next decades in Romania. The updates made using the new CMIP6 climate models under new scenarios (SSP 5 RCP 4.5 and SSP5 RCP 8.5) did not significantly change the climate change image obtained with the projections of the CMIP3 and CMIP5 climate models.

Romania elaborates a new strategy and associated action plan dedicated to adaptation to climate change which covers the period 2021-2030, with vision elements up to 2050. The new strategy for adaptation will also have a dedicated platform (RO-ADAPT), following the model of the European platform Climate – ADAPT.

FINANCIAL, TECHNOLOGICAL AND CAPACITY-BUILDING SUPPORT

Romania is not a Party included in Annex II to the Convention, therefore it is not mandatory to have in place measures to fulfil the obligations regarding the financial, technological, and capacity-building support provided to Parties not included in Annex I to the Convention (non-Annex I Parties).

Romania is firmly committed to the international legal framework developed by the UN, the 2030 Agenda for Sustainable Development, The Paris Agreement, and the UNFCCC. Therefore, Romania has and will continue to offer financial support for the purpose of assisting non-Annex I Parties to mitigate GHG emissions and to adapt to the side-effects of climate change.

Romania reports information on financial contribution for 2019 and 2020 provided through multilateral channels related to implementation of the Convention. In 2019, Romania provided 2,196,729.47 RON (518,353.30USD) through multilateral channels ("Other multilateral climate change fund"). In 2020 Romania provided 4,754,288.18RON (1,120,237.55USD) through multilateral channels.

RESEARCH AND SYSTEMATIC OBSERVATION

Research activities in Romania consist of topics related to the climate system, climate-related impact, risk reduction and adaptation for policy support. National research activities have been carried out together with participation in international and European programs such as Horizon 2020, Horizon Europe, Joint Programming Initiative (JPI) Climate, JPI Water, European Cooperation in Science and Technology (COST). The main coordinator of Romanian research is the Ministry of Research, Innovation and Digitization, which supports the basic funding of national research and development institutes and, together with the Ministry of Education, offer financial support for research projects selected from national calls organized by the Executive Unit for the Financing of Higher Education, Research, Development and Innovations (UEFISCDI). Also, the Ministry of Research, Innovation and Digitization financially supports for Romanian teams a part of the contributions to European and international research.

The Ministry of Environment, Water and Forests coordinates and financially supports applied research on water management, climate-related environmental risks, and sustainable planning. The Ministry of Development, Public Works and Administration manages the Transnational Danube Program, which supports projects on climate change adaptation and climate risk assessment in relation to disaster management in the Danube basin regions. The Ministry of Agriculture finances projects related to the impact of climate change on agriculture.

Regarding systematic observations, Romania has participated in different fields of climate monitoring, both at national level and within European and global programs (such as GCOS). Romania continued the international data exchange and contributed to the European and global databases. The National Meteorological Administration as institution and with an expert contributed to the report on the climate state of Europe in 2022, developed under the auspices of the World Meteorological Organization (WMO) and the Copernicus Program of the European Union. Also, the National Meteorological Administration has added information to the annual reports on the global state of the climate developed by the WMO.

EDUCATION, TRAINING AND PUBLIC AWARENESS

The National Sustainable Development Strategy of Romania for 2030 is mentioning that the Romanian educational and training system is a priority objective of strategic importance and basic preconditions for an effective implementation of the principles of sustainable development in the medium and long run, through the National Action Plan 2016-2020.

The educational system in Romania strives to connect with the concept of education for sustainable development, with thematic content integrated into formal, non-formal and informal educational systems on the three dimensions: socio-cultural, environmental, and economic, such as: biodiversity conservation, environmental protection and improvement, environmental quality, environmental regeneration, recycling and reuse of materials.

Thus, through President Klaus Iohannis Project "Educated Romania" (2018-2030), strategic objectives and targets were established within the 10 priority directions, following an in-depth analysis of the existing situation of Romanian education in the period 2016-2020.

The integration of sustainable development principles into initial education and training systems (pre-university, university, and post-secondary education) is achieved at the level of the developed learning instruments and methodologies, by raising the awareness of environmental protection, pollution prevention and control, biodiversity conservation.

The role of civil society is increasingly better defined and consolidated in the process of information-education, involvement, and awareness; actions developed through various NGO projects / campaigns addressed to the general public.

2. NATIONAL CIRCUMSTANCES RELEVANT TO GREENHOUSE GAS EMISSIONS AND REMOVALS

A. Governmental and administrative structure

Romania is a presidential Republic based on the principle of separation and balance of powers in the state - legislative, executive, and judicial - under the rules of constitutional democracy.

The legislative power is held by the Parliament, which gathers the Chamber of Deputies and the Senate. The Chamber of Deputies and the Senate are elected for a four-year mandate and have as their main tasks the adoption of laws and the state budget. The legislative initiative (i.e. the proposal of draft laws) belongs, as the case may be, to members of parliament, members of the government, but also to citizens if a draft law is signed by at least 100,000 citizens with voting rights[1] from at least a quarter counties of the country.

The executive power belongs to the Government, which is responsible for enforcing laws. The government includes the prime minister, ministers and other members appointed by organic law. The prime minister is proposed by the president, following consultation with the party or parties holding the parliamentary majority. He, in turn, proposes to Parliament for approval a list of ministers. The government is politically accountable only to the Parliament for its entire activity.

The president of Romania is elected by universal, equal, direct, secret and freely expressed vote. The term of office of the President is 5 years, but he cannot be elected for more than two consecutive terms. The fundamental role of the President is to exercise the mediation function between the powers of the state, as well as between the state and the society. The President has the following duties: to appoint the Prime Minister, to promulgate the laws (countersign them for approving their entry into force), he may dissolve the Parliament, once in a year, if it has twice rejected a government, is the supreme commander of the army, concludes international treaties, which he proposes to the approval of the Parliament, issues decrees, confers decorations and titles of honor, grants pardon.

Justice (the judicial power) is represented by the High Court of Cassation and Justice, which ensures the unitary interpretation and application of the law by the other courts. Judges are independent of political power and irremovable (they cannot be transferred, replaced, or dismissed except by the Superior Council of Magistracy).

The Superior Council of Magistracy guarantees the independence of the judicial power and consists of 19 members whose mandate is of 6 years3. The Superior Council of Magistracy has the role of a court in the field of disciplinary liability of judges and prosecutors.

The Public Ministry represents the general interests of society, defends legal order, as well as the citizens' rights and freedoms and discharges its powers through public prosecutors, constituted into public prosecutor's offices.

Administrative institutions at territorial level

According to the Constitution, in terms of administration, Romania's territory is organized in counties, towns and communes, some towns being declared municipalities. Romania has 41 counties and the capital city of Bucharest,

[1] Romanian Senate; Romanian Constitution: https://www.senat.ro

which has a similar status to that of the county (Figure 2-1). The 41 counties are structured in 2,861 communes (for rural areas) and 320 cities (for urban areas), out of which 103 are municipalities. Communes are divided into villages (which lack individual administration, and therefore cannot be considered administrative divisions). Bucharest capital has an official division into six sectors, each sector having a sectoral town hall and a council[2].

The Prefect, appointed by the Government for each county, as well as for Bucharest, is the representative of the Government at local level and directs the decentralized public services of ministries and other central public administration bodies in the territorial - administrative units.

The public administration authorities through which local autonomy is achieved in communes, towns and municipalities are the local, communal, town and municipal councils, which have deliberative authority, and the mayors, who are executive authorities. The mayors' term of office is 4 years[3].

The county council coordinates the activities of the communal and town councils to provide public services for the county.

Figure 2-1 Administrative map of Romania

source: Hotnews

According to the law no. 315/2004 on regional development in Romania, 8 development regions have been established on the territory of Romania because of a free agreement between the county and local councils, corresponding to the level NUTS-2 (Nomenclature of Territorial Units of Statistics) of EU divisions but without regional administrative capacities (Figure 2-2). They were grouped into four development macroregions. Macroregions are not administrative and territorial units and do not have legal personality, they are set up to ensure the collection, compilation, and transmission of harmonized regional statistics at EU level. The

[2] Ministry of Regional Development, Public Administration and European funds: http://www.dpfbl.mdrap.ro/nr_uat-uri.html (accessed in October 2017)
[3] Law no. 215/2001 – Local public administration law

development regions refer to the regional subdivisions of Romania, created in 1998, and operate, mostly, for the coordination of regional development projects.

The development regions are presented in Table 2-1:

Table 2-1 Counties grouping, by macroregion and development region

Macroregion	Development region
MACROREGION 1	North - West
	Center
MACROREGION 2	North - East
	South - East
MACROREGION 3	South - Muntenia
	Bucharest - Ilfov
MACROREGION 4	South - West Oltenia
	West

Figure 2-2 Development regions map of Romania

source: cursdeguvernare.ro

The eight territorial development regions have been created by gathering several counties and have the following structure[4]:

1. **The North-East Development Region** includes the counties Bacău, Botosani, Iasi, Neamt, Suceava, Vaslui, and has 3,989,236 inhabitants in 2020 and an area of 36853 km², the headquarter of Regiona Develoment Agency at Piatra Neamt, density 100 inhabitants /km², the biggest city Iasi

[4] National Institute of Statistics, http://statistici.insse.ro/shop/ (accessed in October 2017)

2. **The South-East Development Region** includes the counties Brăila, Buzău, Constanţa, Galaţi, Tulcea, Vrancea, and has 2,780,532 inhabitants in 2020 and an area of 35,762 km², the headquarter of Regiona Develoment Agency at Braila, density78 inhabitants/km^2 ,the biggest city Constanta

3. **The South-Muntenia Development Region** includes the counties Prahova, Dâmboviţa, Argeş, Ialomiţa, Călăraşi, Giurgiu, Teleorman, and has 3,125,086 inhabitants in 2020 and an area of 34,489 km² the headquarter of Regional Development Agency at Calarasi, density 90 inhabitants/ km 2, the biggest city Ploiesti

4. **South-West Development Region Oltenia** includes the counties Mehedinţi, Gorj, Vâlcea, Olt, Dolj and has 2,115,230 inhabitants in 2020 and an area of 29,212 km² the headquarter of Regional Development Agency at Craiova, density 72 inhabitants /km^2, the biggest city Craiova

5. **The West Development Region** includes the counties Arad, Caraş-Severin, Timiş and Hunedoara and has a population of 1,980,995 inhabitants in 2020 and an area of 32,028 km² the headquarter of Regional Development Agency at Timisoara, density 62 inhabitants /km^2 , the biggest city Timisoara

6. **The North-West Development Region** includes the counties Bihor, Bistriţa-Năsăud, Cluj, Maramureş, Satu-Mare and Sălaj and has 2,818,287 inhabitants in 2020 and an area of 34,159 km² the headquarter of Regional Development Agency at Cluj Napova , density 83 inhabitants /km^2 , the biggest city Cluj- Napoca

7. **The Center Development Region** includes the counties Alba, Sibiu, Mureş, Harghita, Covasna, and Braşov and has 2,613,892 inhabitants in 2020 and an area of 34,100 km² the headquarter of Regional Development Agency at Alba Iulia, density 77 inhabitants / km^2 the biggest city Brasov

8. **The Bucharest-Ilfov Development Region** includes the Municipality of Bucharest and Ilfov County and has 2,633,690 inhabitants in 2020 and an area of 1,811 km², the headquarter of Regional Development Agency at Bucharest, density 1254 inhabitants /km^2, the biggest city Bucharest (the capital of Romania).

B. Population profile

According to the results of the 2011 Population and Housing Census, carried out according to the provisions of Regulation (EC) no. 763/2008 of the European Parliament and of the Council on the Population and Housing Census, Romania had a population of 20,121,641 inhabitants in 2011, out of which 10,333,064 were women (51.4%). From the 2011 census until now, Romania's population has continued to decrease constantly.

The evolution of the Romanian population shows a decrease of approximately 5% between 2011 and 2020 (Table 2-2).

Table 2-2 Evolution of Romania's population, 1990 -2020

Year	1990	2005	2010	2011*	2017	2018	2019	2020
Population (mill. inhabitants)	23,207	21,320	20,247	20,122	19,593	19,484	19.375	19,262

Source: National Institute of Statistics-Statistical Yearbook-2021 - The final results of the population and census

By the number of resident population, the first 7 counties in size in 2020, with the exception of Bucharest (2,161,347 inhabitants), are the following: Iasi (776,586 inhabitants), Prahova (7775,278 inhabitants), Cluj (739,575nhabitants), Constanta inhabitants), Timiş (760,284 inhabitants), Dolj (679,151 inhabitants) and Suceava (629,498 inhabitants).

According to the number of stable population, the first 7 counties in size in 2020 with exception of the city Bucharest (2,161,133 inhabitants) are the following: Iasi (976,586 inhabitants), Prahova (775,278 inhabitants), Cluj (739,575 inhabitants), Constanta (758,186 inhabitants), Timis (760,274 inhabitants), Dolj (679,151 inhabitants) and Suceava (763,762 inhabitants)[5].

According to the number of stable populations, the counties with lowest number in 2020 are: Covasna (224,009 inhabitants), Tulcea (229,953 inhabitants), Sălaj (241,167 inhabitants), Mehedinţi (272,760 inhabitants), Giurgiu (264,437 inhabitants) and Ialomiţa (281,000 inhabitants)[5].

The main causes that led to the decrease of Romania's population by 17% in the period 1990-2020 were migration abroad (labour migration, in particular), rising mortality rates and declining birth rates during this period.

In 2020, 20.95% of Romania's population consisted of Romanians under the age of 20, while 59.9% of the population was between the ages of 20 and 64 years old, 11.1% of the population was between 65 and 74 years old, 8.05% of the population was over 75 years old[5].

Life expectancy in 2020 was 79.75 years for women and 72.54 years for men. The average life expectancy in 2020 was 77.44 years in urban areas (74.09 years for men, 80.6 years for women) and 74.41 years in rural areas (70.69 years for men, 78.60 years for women)[5].

The number of Romanians who emigrated abroad in 2018, 2019 and 2020 varied between 192,631 and 233,736 people, which represented approximately 1% of Romania's population5. Population migration has a negative influence on the development of economic activity in Romania, because the largest part of the people who go abroad for a job are young and active people.

C. Economic profile

Romania joined the European Union in January 2007. The Romanian economy is a market-based economy, promoting freedom of trade, protection against unfair competition, stimulation of domestic and foreign investments and protection of private property.

The economic development of Romania is strongly linked to the worldwide economic development and to that of the European Union one, as it occurs in special complex international environment affected by the global economic-financial crisis and pandemic.

The analysis of the Gross Domestic Product (GDP) evolution during 2000 – 2012, revealed that the Romania economy experienced three separate periods and respectively: the period 2000 – 2008 of development when the annual average percentage of growth of the GDP was 6.27%, the period 2009 - 2010 of recession and the period 2011 – 2012 of coming out from recession (the Figure 2-3).

[5] National Institute of Statistics - Statistical Yearbook of Romania 2021

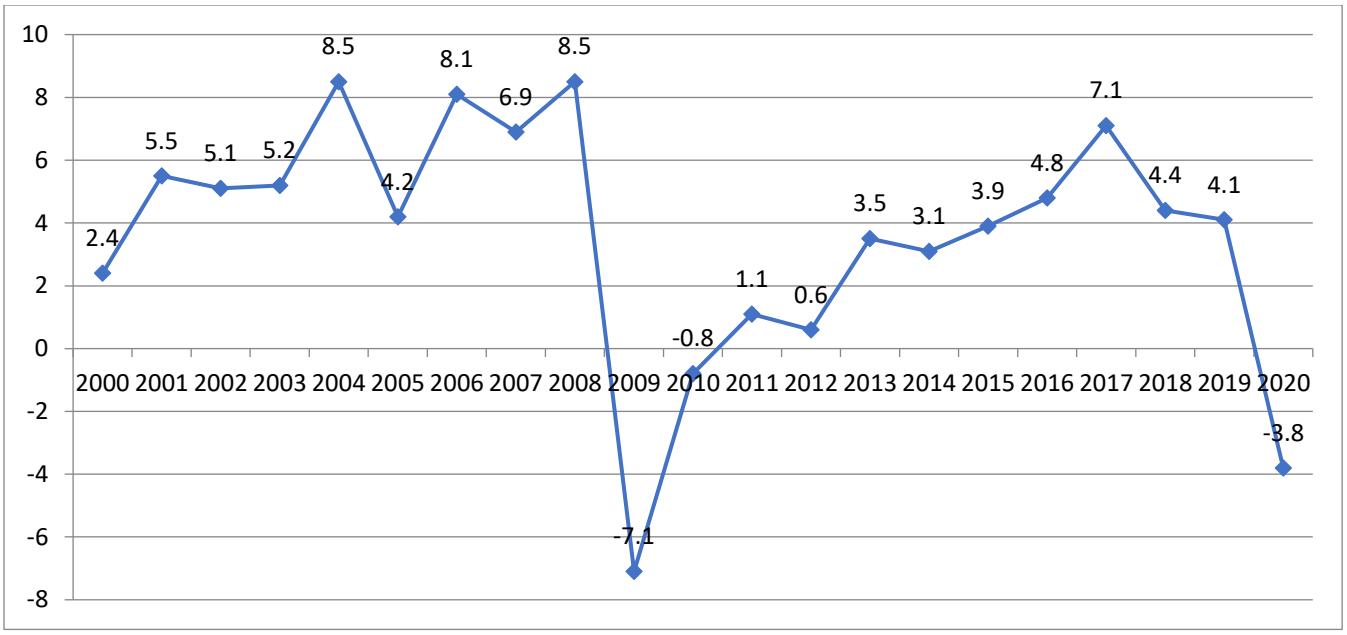


Figure 2-3 GDP growth rate during the period 2000-2020

Romania's main export goods are machinery and equipment for transport, metals and metal products, textiles and footwear, chemicals, agricultural products, minerals, and fuels. In the structure of exports, the main categories in 2018 includes: machinery and transport equipment 49, processed products, classified mainly by raw material 19%, miscellaneous goods 15%, chemicals and related products 7%, mineral fuels 3%, lubricants and related materials, and other goods 7%[6].

Romania's imports increased by 14.7% in 2018 compared to 2017. Sectors representing 80% of total imports are: transport and equipment (38%), manufactured goods classified mainly by raw material (23.0%), mineral fuels, lubricants, and derived products (12%) and chemicals and derived products (14%) (Source: National Institute of Statistics - Statistical Yearbook of Romania 2018)[6].

The official currency in Romania is" LEU" (plural lei). 1 leu (RON)=100bani (ban)

According to the data provided by the National Agency for Employment, the number of unemployed registered in 2020 was 296,051, higher than that of 2018 (288,895) and that of 2019 (257,865). Unemployment rates were 3.3% in 2018, 2.6% in 2019 and 3.4% in 2020.

Table 2-3 shows the evolution of GHG emissions and of GDP in $Euro_{2020}$ in the period 2015-2020.

Table 2-3 Evolution of GHG emissions in function of GDP in period 2015-2020

	2015	2016	2017	2018	2019	2020
GHG Emission, in kt	82251.94	78952.74	84588.38	88296.20	85896.96	77472.87
GDP in billions $Euro_{2020}$	186.76	190.24	203.96	217.8	227.4	218.9
GHG emissions/ GDP in $kgCO_{2echiv}$ / $Euro_{2020}$	4.40	4.15	4.14	4.05	3.77	3.34

[6] National Institute of Staistics – Romanian Statistical Yearbook 2018

GHG emissions per unit of GDP continue to decrease due to technical improvements, the implementation of reduction policies and the structural change in GDP. (Figure 2-4).

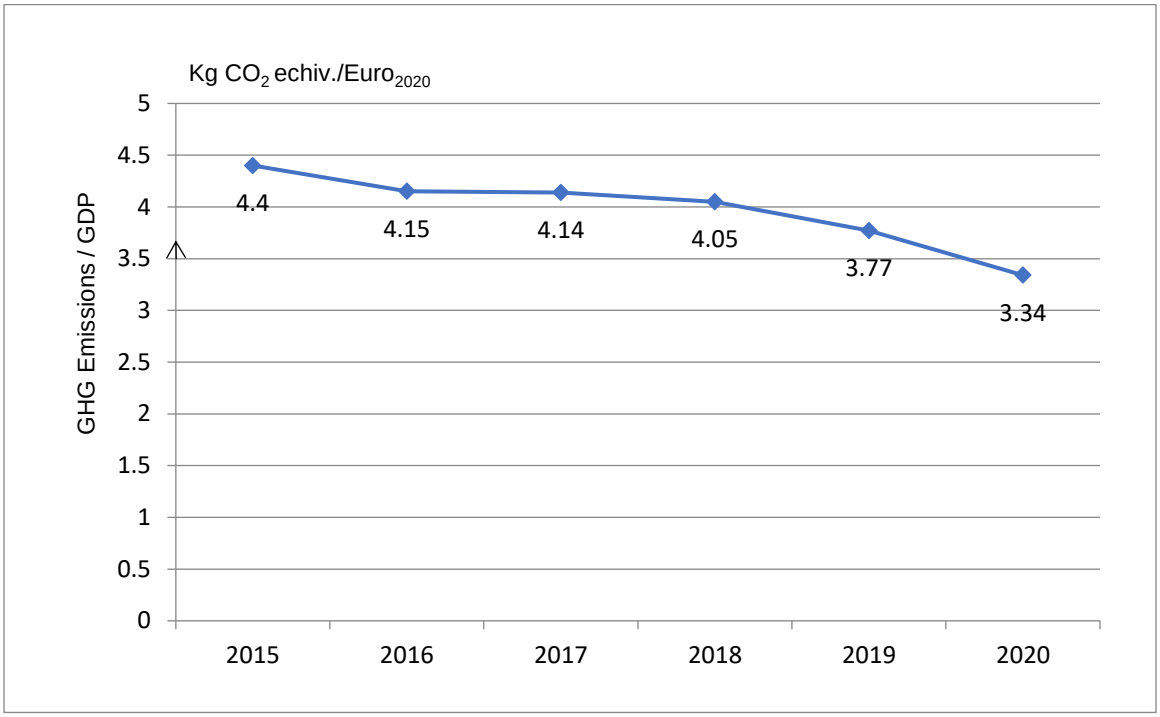


Figure 2-4 Evolution of GHG Emissions in function of GDP

D. Geographic profile

D.1. Geographical position

Romania is situated in the northern hemisphere; at the intersection of 45° parallel Northern latitude with the 25° meridian Eastern longitude.

In Europe, Romania is situated in the South-Eastern Central Europe, half the distance between the coast of the Atlantic Ocean and the Ural Mountains, inside and outside the Carpathians arch, within the lower basin of the Danube, having a gateway to the Black Sea.

The Romanian territory is between parallels 43°37'07" and 48°15'06" Northern latitude and between meridians 20°15'44'' and 29°41'24'' Eastern longitude. Having an area of 238,391 km^2, plus 23,700 km^2 represented by the Black Sea platform, it is the 13th largest country in Europe.

Romania's neighbours are: Ukraine to the North, Republic of Moldova to the East (the complete border being represented by the Prut River), Bulgaria to the South (mainly being a fluvial border, the Danube River), Serbia to the South-West, and Hungary to the West.

The Romanian borders stretch on a distance of 3,149.9 km, out of which, in 2007, 1,876 km became EU borders (towards Serbia, Moldova and Ukraine).

The Black Sea border measures 194 km along the continental platform and 245 km on shore, the Romanian Black Sea coast stretching out between the border with Ukraine (Musura) and the border with Bulgaria (Vama Veche). The exit to the sea enables water way connections with the countries in the Black Sea basin and the rest of the world. Figure 2-5 presents the political map of Romania.

Figure 2-5 Political map of Europe

The total length of Romania's frontiers is 3,149.9km, out of which 1,085.5 km land and 2,064.3 km rivers and sea.

D.2. Relief

The relief of Romania has three major morphologic steps, proportionately distributed in the form of an amphitheatre. The high step, of the Carpathians (the highest peak Moldoveanu 2,544 m), the medium step, corresponding to the Sub-Carpathians, hills and plateaus and the low step, of the plains, river meadows and Danube Delta (the youngest relief unit, continuously developing and with an average altitude of 0.52 m). The main characteristic of these relief components is their proportional distribution in form of an amphitheatre, characterized by four elements: variety, proportionality, complementary and symmetrical layout, with approximately equal distribution of the main relief units (35% mountains, 35% hills and plateaus and 30% plains) (Figure 2-6).

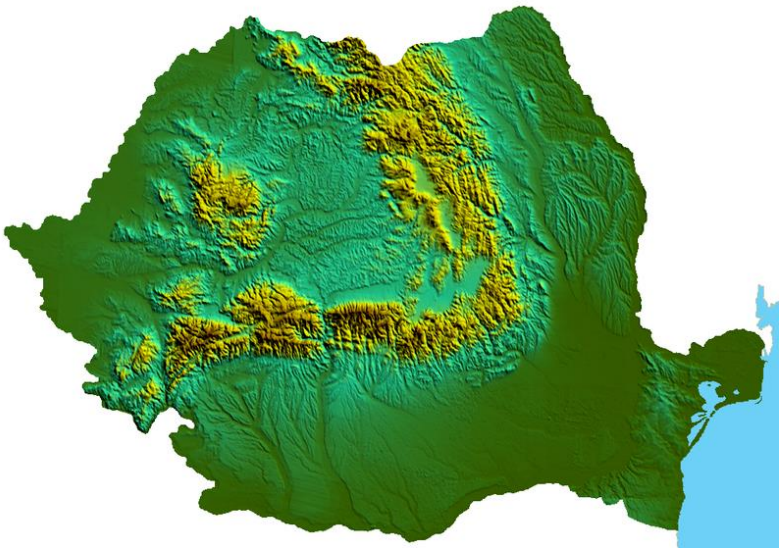


Figure 2-6 Physical map of Romania showing the Carpathian Mountains

source: https://en.wikipedia.org/wiki/Geography_of_Romania

The Carpathians have an area of 66,303 km^2, which represents approx. 27.9% of the total area of the country, on a length of 910 km.

In eastern and southern regions there are three large plateaus (Moldova, Dobrogea and Getic) and Mehedinti Plateau, while two great plains lay in the south and west, the Romanian Plain (narrowed towards East) and the Western Plain (Figure 2-7).

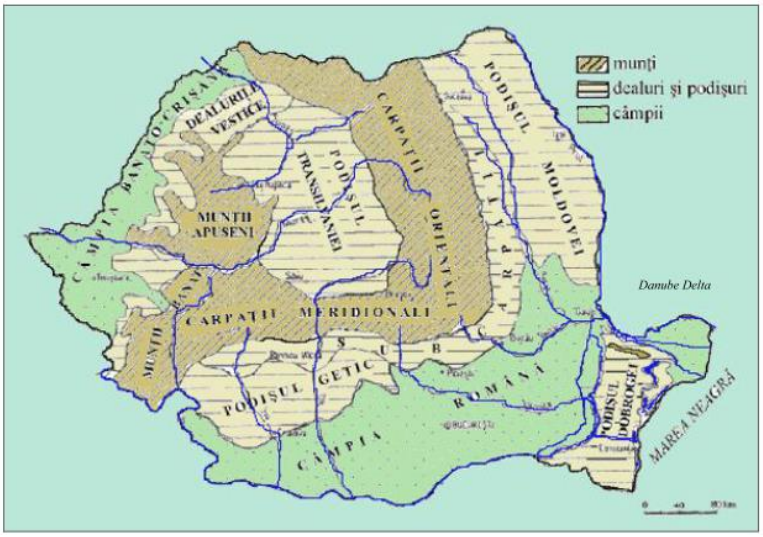


Figure 2-7 The main relief units of Romania

D.3. Black Sea

The Black Sea is Romania's gate towards seas and oceans, and Black Sea seaside and coast area offers a variety of conditions for harnessing the underground (petroleum, natural gas), aquatic (the fish fauna) and land riches (tourism and leisure). The Black Sea exit gives Romania the possibility of developing the waterways transport.

D.4. Danube and Danube Delta

The Danube, the second longest river in the European Union after the Volga, flows into the Black Sea within Romania's territory forming the Danube Delta, a region with a medium-low altitude (31 cm), the biggest part of this area being under water.

The Danube Delta is the second largest (total surface of 4,178 km^2) and best-preserved delta in Europe. The Danube delta hosts over 300 species of birds as well as 45 freshwater fish species in its numerous lakes and marshes.

Lakes are interconnected by narrow channels featuring huge expanses of aquatic vegetation. This is the largest continuous marshland in Europe and the second-largest delta (the Volga being the largest), which includes the greatest stretch of reedbeds in the world. The marsh vegetation is dominated by reeds which form floating or fixed islands of decaying vegetation Reeds cover some 1,700 km^2 and the floating reed islands (plaur) 1,000 km^2, whereas the total area not inundated is only 148 km^2.

The Danube Delta has been included in the UNESCO World Heritage List in 1991 as a natural reserve of the biosphere.

D.5. Rivers

Romania benefits from all types of aquatic facilities: rivers and streams, lakes, groundwaters, marine waters. Romania's hydrographical and hydrological peculiarities are determined mainly by its geographic position within the temperate continental climate and the presence of the Carpathian arch.

A large part of Romania's border with Serbia and Bulgaria is formed by the Danube. The Prut River, one of its major tributaries, forms the border with the Republic of Moldova. Other major rivers are the Siret (596 km), the Olt (614 km), the Someș (388 km), and the Mureș (761 km).

D.6. Natural mineral resources

Given the variety and complexity of the geologic structures, the Romanian territory has optimum conditions to accumulate useful mineral substances: gold and silver deposits, bauxite ore deposits, mineral combustible deposits, salt deposits and salts, useful rocks, mineral waters, geothermal waters, etc. Important reserves of hydrocarbons, gases and coals are quartered within the platform areas and in the intermountain depressions (Transylvania, Pannonian).

A special category of subsoil riches consists of more than 2,000 mineral water springs, with consumption and medical treatment characteristics.

The mineral water is a renewable resource, but insufficiently capitalized, even though some of the mineral water springs received world appreciation for their quality. From the total mineral water reserve of 122,000 m^3/day, which can be bottled, about 40% is capitalized.

D.7. Biodiversity

The vegetation varies, with a high tendency of diversity. The following three areas of vegetation may be distinguished: alpine, forest and steppe. The alpine vegetation from mountain areas is very vulnerable to environmental factors and anthropogenesis ones, as they regenerate in an extremely difficult manner. Therefore, some species are only a few left and are easily disappearing as a result of the activity of the interfering factors. The main dangers are uncontrolled pasturage and tourism.

The steppe and silvo-steppe vegetation spreading in areas short on humidity on Dobrogea's Plateau, the Romanian Plain, Moldova's Plateau and West Plain, were mostly replaced by agricultural cultures.

The significant variety of the flora and fauna in Romania derives from the complexity of the relief. Romania's flora and fauna are harmoniously divided and form a highly valuable wealth, based on controlled and rational exploitation. Romania is a country with a great biological variety and a high percentage of natural ecosystems. The fauna is rich in species, some protected, as the black goat, bear, rock aquila, lynx, blackcock, birch cock and other species that present hunting interest.

Romanian forests preserve a genetic fund of great diversity. To preserve this valuable natural capital and to ensure a favorable conservation status for natural habitats of great natural and community importance, Romania has taken important steps, by implementing the legislative elements specific to the European Union, as well as of some programs and projects dedicated to preserving the biodiversity.

In Romania there are protected areas comprising of 79 scientific reservations, 13 national parks, with the largest one named Domogled - Valea Cernei, 190 natural monuments, 671 natural reservations, 15 natural parks (including Danube Delta) 3 biosphere reservations (Danube Delta, Retezat and Rodna) and 273 sites of communitarian importance.

E. Climatic profile

Romania's climate is transitional temperate continental, with oceanic influences from the west, Mediterranean influences from the southwest and strong continental effects from the northeast. Climatic variations are modulated by geographical characteristics: the position of the Carpathians, the altitude, the proximity of the Black Sea (Figure 2-8 and 2-9).

E.1. Temperature

The average annual temperature varies by latitude and altitude, from 8 °C in the north to 11 °C in the south, and from about 2.6 °C in the mountains to 11.7 °C in the plains (see Figure 2-8). In the last 121 years, the warmest year was 2019 (with an average temperature of 12.1 °C) and the coldest one was 1940 (with an average temperature of 8.1 °C). The absolute minimum temperature of - 38.5 ° C was recorded in Bod, Brașov on 25th of January 1942. The absolute maximum temperature of 44.5 ° C was recorded in Ion Sion village (Bărăgan plain) on 10th of August 1951. During the period 1901-2021, the annual average air temperature increased by more than 1 ° C (see Figure 2-10). The upward trend has been stronger, especially since the 1980s.

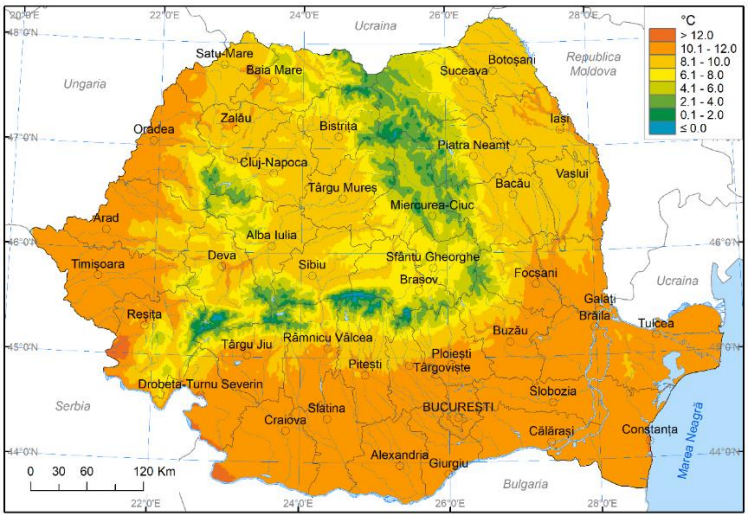


Figure 2-8 Multiannual average of air temperature (in ° C) for the interval 1961-2021.

E.2. Precipitations

Average annual precipitation amounts generally vary between values below 400 mm and above 1200 mm (see Figure 2-9).

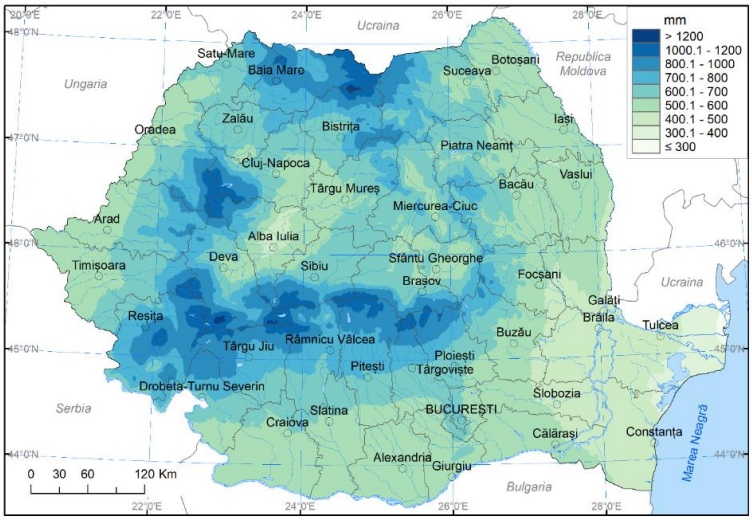


Figure 2-9 Multiannual average of the amount of precipitation (in mm) for the interval 1961-2021.

The highest annual amount of precipitation recorded in Romania was 2401.5 mm in 1941, at the mountain station Vîrfu Omu. The highest monthly amount of precipitation - 588.4 mm - was recorded in June 2011 at the mountain station Bâlea Lac. The absolute maximum value of the amount of precipitation in 24 hours was recorded at the meteorological station Deva, on 19.07.1934. In the context of precipitation variability, the year 2015 is one with the most abundant precipitation amount. The convective season of the year 2005 recorded several unusual meteorological events in Romania: flash floods, hail, intense lightning and many severe events with wind intensifications, such as tornadoes, downdrafts, waterspouts and funnel clouds. The annual amount of precipitation does not show a significant trend in the period 1901-2016 (see Figure 2-10).

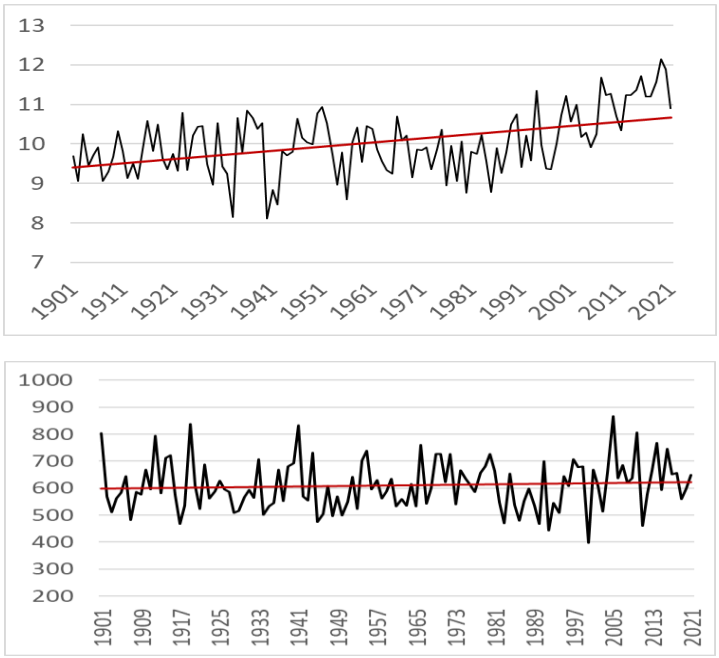


Figure 2-10 Evolutions of annual temperatures (in °C, top) and amounts of precipitation (in mm, bottom) for the interval 1901-2021.

E.3. Other observed phenomena

The annual number of hot days and tropical nights increased in the period 1991-2020 compared to 1961-1990, and their evolution in Romania shows a significant change in the years 1987-1988 (Figure 2-11). The increases in the number of hot days and tropical nights are higher in the southern, western, and south-eastern plain regions of the country. The number of frost days has decreased, especially in the north, east and southeast of the country, but also in some areas in the south and in the Apuseni Mountains (Bojariu et al. 2021).

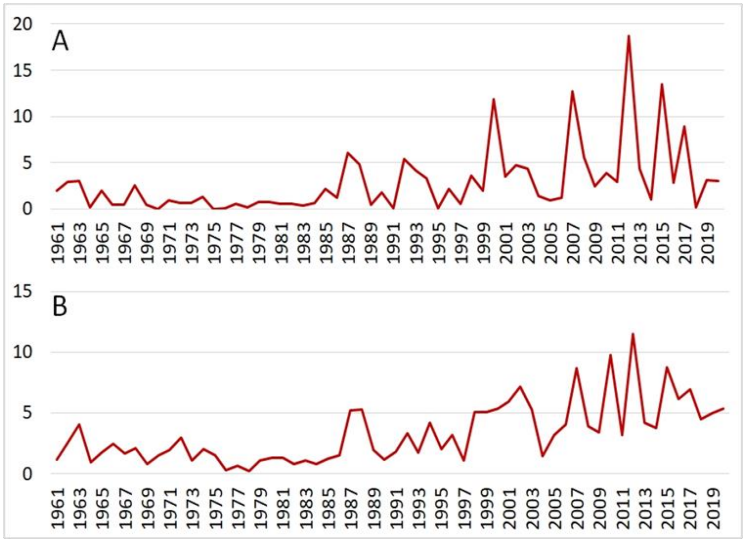


Figure 2-11 Average annual number of hot days (Tmax > 35 °C; A) and tropical nights (Tmin< 20 °C; B) for the period 1961-2020.

For the number of hot (tropical) days ra Average annual number of hot days (Tmax > 35 °C; A) and tropical nights (Tmin< 20 °C; B) for the period 1961-2020. For the number of hot (tropical) days, the data from 61 (70) stations with a complete string, covering the territory of Romania, were used (according to Bojariu et al., 2021).

The evolution of the scorching heat intensity in Romania between 1961 and 2021 indicates an increasing trend, especially after 1981. Considering the multi-year averages of the scorching heat intensity, a phenomenon quantified by the sums of air temperatures equal to or greater than 32 °C recorded in in the summer, a significantly higher thermal stress was found in the critical interval for crops (June-August) in more recent years. Thus, there is an increase in the multiannual average of scorching heat intensity from 13 units in the interval 1961-1990 to 44 units, in the interval 2011-2020 (Figure 2-12). From 1901 to the present, Romania had in each decade from one to four extreme dry/rainy years, with an increasing number of droughts being identified after 1981 (table 2-4).

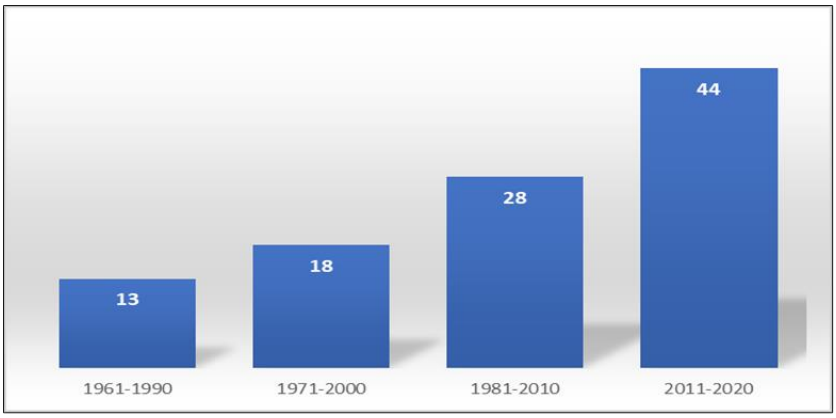


Figure 2-12 Evolution of scorching heat intensity (∑Tmax≥32°C, VI-VIII) in Romania in the period 1961-2020.

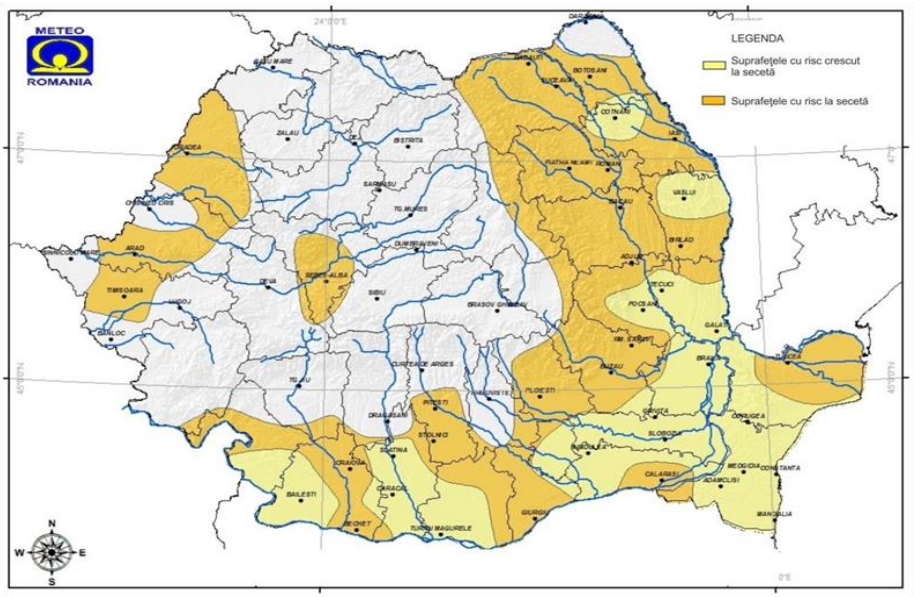


Figure 2-13 Agricultural areas in Romania affected by drought

The analysis of the annual amounts of precipitation showed that the multi-annual average at the level of agricultural areas in Romania is 583.0 mm in the period 1961-1990, 569.8 mm in the period 1971-2000, and

575.1 mm in the period 1981- 2010, which makes the rainfall regime in Romania moderately dry (less than 600 mm / year) from the point of view of farmers. The region of Dobrogea (south-eastern Romania) is the driest

region from the agricultural point of view, with the following multiannual averages of precipitation amounts recorded between 1 September and 31 August of the next year (agricultural year): 400.9 mm for 1961-1990, 397.7 mm for 1971-2000 and 410 .2 mm for 1981-2010. In each agricultural region, the frequency of years with low annual precipitation varies from 37.4% in Banat - Crișana (western Romania) to 91.2% in Dobrogea (south-eastern Romania). The 2021-2022 agricultural year recorded an average annual amount at the country level of less than 400 mm.

Table 2-4 Extreme dry/rainy years in Romania, in the period 1901-2022

DECADE	EXTREME DROUGHTY YEARS	YEARS WITH EXTREME PRECIPITATION
XX CENTURY		
1901-1910	1907-1908	1910
1911-1920	1917-1918	1911, 1912, 1915, 1919
1921-1930	1923-1924, 1927-1928	1929
1931-1940	1934-1935	1937, 1939, 1940
1941-1950	1945-1946, 1947-1948, 1949-1950	1941, 1944, 1947
1951-1960	1952-1953	1954, 1955, 1957, 1960
1961-1970	1962-1963, 1964-1965	1969, 1970
1971-1980	1973-1974, 1975-1976	1972, 1974, 1975, 1976
1981-1990	1982-1983, 1985-1986, 1987-1988, 1989-1990	1981, 1990
1991-2000	1992-1993, 1999-2000	1991, 1997
XXI CENTURY		
2001-2010	2000-2001, 2001-2002, 2002-2003, 2006-2007, 2008-2009	2005, 2006, 2008, 2010
2011-2020	2011-2012, 2014-2015, 2015-2016, 2016-2017, 2017-2018, 2019-2020, 2021-2022	2013

Areas characterized by arid, semi-arid or sub-humid climate cover about 30% of the total surface of Romania, and they are situated in Dobrogea, Moldova, southern Romanian Plain and Western Plain (Figure 2-13). These areas are mainly used for agriculture (about 80% of the total, 60% of which are arable lands), forestry (about 8%) and water resources (Ministry of Agriculture and Rural Development, 2008).

F. Energy

In the more than 30 years since 1990, the Romanian energy industry has been put in a position to face the economic changes that have marked Romania, most of them being characterized by the general restriction of energy-consuming economic activities.

Through Romania's accession to the European Union, the concept of energy independence was supplemented and gradually replaced by that of energy security. The main challenge for the energy sector consists in reconfiguring the energy system and reforming the energy market to face market competition.

An additional long-term challenge for the Romanian energy sector will be to contribute to the achievement of the European Union's objective of becoming the first neutral continent with "net zero" emissions.

From 1990 until now, the Romanian energy sector has continuously transformed, with several capacities for the exploitation of primary energy resources, as well as to produce electricity and thermal energy, being closed. The main reasons for these closures were related to the general reduction of economic activities, the low degree of profitability or the failure to adapt to the new environmental conditions.

Although part of the activities in the field have been privatized or concessioned to private investors, a significant part is still under state control.

Although some of the activities in the field have been privatized or concessioned to private investors, a significant part is still under state control.

The electricity sector in Romania consists of the following operators and companies:

- the transport network and the system operator (CN Transelectrica SA)
- the electricity market operator (OPCOM is a subsidiary of Transelectrica)
- electricity producers in dispatchable units (16)
- electricity producers in non-dispatchable units but who also participate as suppliers on the competitive market (10)
- distribution network operators (8)
- traditional suppliers (5)
- electricity suppliers acting exclusively on the wholesale market (37)
- electricity suppliers (40)

The Romanian government had as a strategic objective for the energy sector: meeting energy needs, both now and in the medium and long term at the lowest possible price, suitable for a modern market economy and a civilized standard of living, in quality conditions, safety in supply, respecting the principles of sustainable development.

Romania's energy strategy for the period 2022 - 2030 has the following eight fundamental strategic objectives. These objectives will be met simultaneously through a set of policies and measures summing up priority actions and investments staggered over time in the short, medium, and long term.

The strategic objectives are the following:

Modernization of the corporate governance system and institutional regulatory capacity

The state has a dual role in the energy sector: on the one hand, it is the legislator, regulator, and implementer of energy policies, and on the other hand it is the owner and manager of assets or a significant shareholder, both in the natural monopoly segments (crude oil transport, transport and distribution of electricity and natural gas), as well as in production.

In a consolidated market system, the state has the essential role of arbiter and regulator of markets. In this sense, a transparent, coherent, fair, and stable legislative and regulatory framework is needed.

The need for a corporate governance based on competence, efficiency and integrity in the Romanian energy sector will be promoted and an analysis of the financial and managerial performance of companies in the energy field, in which the Romanian state holds shares, will be carried out.

Regarding the state's role as legislator, regulator and implementer of energy policies, the development of institutional capacity represents an important strategic objective.

Clean energy and energy efficiency

In the context of the legislative package Clean Energy for all Europeans and the European Ecological Pact, which require the transformation of the energy sector towards another system model, based on clean, innovative technologies, which can face competition on an integrated electricity market, the accommodation of the sector is required energy from Romania to the new development trends. In this context of profound transformation of the energy system, decarbonization, energy demand and energy security are and will be interdependent.

This interdependence must be matched with technological progress, storage, decentralization, digitization, and adaptation of network architecture.

The process of transforming the energy system requires a large volume of investments and coordinated multi-year planning and efficient use of funds for financing are mandatory conditions. Acting on time means saving. Funding must be efficiently directed to investments that consider domestic specificities and respond in a timely manner to the needs of the energy system.

In recognition of the fact that energy efficiency is the most important domestic source of energy in Europe, it is considered a fundamental principle applied in the development of policies and investment plans, in the energy sector, to achieve climate neutrality targets, and at the same time, a priority strategic at the level of the European Union.

Ensuring access to electricity, heat, and natural gas for all consumers

With a degree of connection of household consumers to the electrical distribution network of over 90%, electricity is the most widespread form of energy in Romania, however, compared to the consumption of electricity per inhabitant, it is clearly lower than the average at the level of the Union European – 2.4 times lower than the EU average.

In terms of access to natural gas, less than half of households in Romania are connected to the natural gas network (approximately 44%), one third of Romania's homes being heated directly with natural gas. Also, the average natural gas consumption of a household consumer is lower than the EU average

The objective aims to continue the electrification program, ensure access to natural gas infrastructure, as well as the development and profitability of heating systems. At the same time, considering the small purchasing power of households in Romania compared to the European Union, ensuring the affordability of the energy price to the final consumer in Romania is a first-order concern, which emphasizes the need to protect vulnerable consumers. According to EUROSTAT, the annual study on incomes and living conditions for European citizens, the number of households that have difficulties paying their utility bills within a year was 14.4% in Romania in 2018, Romania ranking 4th, after Greece, Bulgaria and Croatia, while at the opposite pole are member states such as the Netherlands, the Czech Republic, Sweden and Austria, with a percentage of 2%.

Protection of the vulnerable consumer and reduction of energy poverty

At the center of policies for the development of the energy sector must be the consumer, especially through measures to protect the vulnerable consumer, to expand the population's access to energy and to implement appropriate environmental policies. An energy policy focused on energy efficiency must have as an absolute

priority the protection of vulnerable consumers. All citizens must have access to and be able to benefit from energy, especially those who are disadvantaged or who are part of disadvantaged communities.

The measures dedicated to the protection of vulnerable consumers will include improving the performance of the social assistance system in protecting those with low incomes, energy efficiency measures dedicated to vulnerable consumers with the aim of reducing final consumption (e.g. public programs for the thermal insulation of buildings), the modification and use of the National Informatics System of Social Assistance to ensure fair and transparent granting of existing subsidies for home heating or access to energy. Also, they will be correlated with the measures regarding the fair transition and the reconversion of regions with a mono-industrial profile and other initiatives with an impact on vulnerable consumers, and the adopted measures will aim at the implementation of support mechanisms given to vulnerable consumers directly, without distorting the competitiveness of the market energy.

Competitive energy markets, the basis of a competitive economy

The energy system must operate based on free market mechanisms, the main role of the state being that of policy maker, regulator, guarantor of the stability of the energy system and investor.

Ambitious energy and climate goals for 2030 require the development of a new electricity market model aimed at increasing energy efficiency, production from renewable sources, security of supply, sustainability, decarbonization and innovation.

The transposition into national legislation of Directive (EU) 2019/944 on common rules for the internal electricity market, as well as the way of applying the provisions of Regulation (EU) 2019/941 on risk preparation in the electricity sector, Regulation (EU) 2019/942 establishing the European Union Agency for the Cooperation of Energy Regulatory Authorities and Regulation (EU) 2019/943 on the internal electricity market, aim at non-discriminatory access to the electricity market, ensuring competitiveness, energy storage, facilitating demand aggregation and the distributed offer, facilitating the creation of a functional and transparent market that contributes to increasing the level of security in the supply of electricity and that provides for mechanisms to harmonize the rules for cross-border exchanges of electricity.

The complexity of the new European provisions requires the creation of legislation that is fully compliant with the new package.

Increasing the quality of education and innovation in the field of energy and the continuous training of human resources

The training and continuous improvement of an energy worker, regardless of his workplace or the type of studies completed, is a complex one. Increasing the number of professionals in the field of energy means increasing the quality and attractiveness of specialized education.

The development and cultivation of the competences and abilities of energy workers means the development of specific educational packages at all levels: high schools and public vocational schools and in the dual system, continuous training at the workplace, modern bachelor, and master programs, as well as doctoral schools in the field.

Innovation based on scientific research and technological development requires the encouragement and development of centers of excellence in the field of energy, in particular renewable energies, capable of carrying out complex projects with themes defined by the expected evolutions of the energy sector, thus offering robust

know-how to ensure performance optimal for new investments, respectively for the exploitation and re-technology of existing equipment.

The success of implementing the vision and objectives of Romania's Energy Strategy is directly proportional to the investment in the quality of education and training in the field of energy.

Romania, regional supplier of energy security

The current international context of energy markets is marked by volatility, and the evolution of technologies can significantly change the way energy markets operate.

Regarding the security of the supply of energy resources, the development of energy production capacities from renewable energy sources and from sources with low emissions of greenhouse gases will ensure a balanced and diversified energy mix.

Also, by exploiting the potential of hydrocarbons and offshore renewable sources in the Black Sea, Romania can become a regional supplier of energy security.

Strengthening and modernizing networks, digitization, diversification of sources and supply routes, increasing and modernizing storage capacities, compatible with the use of new gases and hydrogen, as well as increasing interconnection capacities with neighboring states, are factors that will primarily contribute to ensuring national energy security, but also to Romania's objective of having the status of a regional supplier of energy security.

In this context, there are premises that, through the development of the energy sector, considering the availability of resources and the stability given by the effective transition to decarbonization and the maturity of new technologies, Romania will consolidate its status as a regional supplier of energy security.

Increasing Romania's energy contribution to the regional and European markets

The objective expresses Romania's vision of development in the regional and European context and the desire to be a main actor of the EU in this field.

Romania participates in an extensive process of energy market integration at the EU level, resulting in increasingly open competition on the energy markets.

Romania has the necessary primary energy resources, they must be harnessed coherently, in profitable conditions, respecting the environmental conditions, with beneficial effects for the country's economy, simultaneously with the increase in the degree of interconnectivity.

F.1 Energy resources

Romania has a wide but quantitatively reduced range of fossil and mineral energy resources as: oil, natural gas, coal, uranium ore, and a great potential of renewable energy resources.

A fair assessment of the possibilities for covering the primary energy needs in the future should start from the current situation of proven reserves combined with realistic estimates of potential resources in close correlation with resource consumption forecasts determined by the final energy demand. In the Table 2-5 and Table 2-6 the evolution of primary energy production and of the primary energy consumption in the period 2005 - 2020 are presented. Based on the exploitation of fossil energy reserves, coal and oil as well as those of uranium ore, primary energy production in Romania, in the most optimistic case, will not grow in the next 2 - 3 decades.

Table 2-5 Domestic Primary Energy Production (thou toe)

Year	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Primary energy production, out of which:	27,090	27428	27468	27112	25853	26314	26387	24798	25417	24979	24535	22351
Total coal, out of which:	5793	6795	6663	6346	4657	4449	4711	4233	4466	4868	4790	3304
- other hard coals	1082	821	730	654	649	603	443	367	277	603	149	156
- lignite	4698	5946	5933	5692	4008	3846	4268	3865	4189	3846	3778	2435
- brown coal	13	28	0	0	0	0	0	0	0	0	0	0
Firewood and agricultural wastes	3229	3900	3476	3795	3657	3646	3521	3579	3564	3646	3456	3401
Crude oil	5326	4186	4129	3891	4028	3952	3906	3713	3548	3952	3490	3381
Natural gas	9536	8705	8724	8770	8686	8854	8873	7862	8607	8854	8273	7391
Other fuels	87	88	152	159	188	171	232	269	272	171	368	558
Energy from unconventional sources	18	26	37	50	46	48	48	54	60	48	59	40
Hydroelectric	1739	1769	1407	1290	1743	2332	2242	2319	2075	2332	2113	2098
Nuclear energy	1362	2841	2880	2811	2848	2862	2854	2766	2821	2862	2846	2887

Source: National Institute of Statistics, Energy Balance - Collections 2005- 2020

Table 2-6 Domestic primary energy consumption (thou toe)

Year	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Primary energy internal consumption, out of which:	37868	34817	35648	34851	31633	31537	31844	31638	33,391	33,510	33,015	32,171
Coal	8,742	6,911	8,147	7,552	5,725	5,719	5,858	5,434	5,821	5,079	4,925	3,505
Crude oil and crude oil products	9,163	7,855	8,472	8,303	7,706	7,864	8,600	8,217	8,015	8,624	8,519	8,247
Natural gas	13,820	10,897	11,187	10,924	9,892	9,458	9,015	9,098	9,716	9,942	9,229	9,682
Firewood and agricultural wastes	3,185	3,982	3,458	3,654	3,590	3,618	3,514	3,606	3,639	3,462	3,458	3,394
Hydroelectric	1,489	1,573	1,242	1,312	1,569	1,719	1,663	1,875	1,826	2,035	2,244	2,338
Nuclear energy	1,362	2,850	2,880	2,811	2,848	2,862	2,853	2,766	2,821	2,789	2,846	2,887
Other fuels	88	723	225	244	257	249	293	360	418	498	597	783
Energy from unconventional sources	18	26	37	51	46	48	48	54	60	61	59	40
Non-energy	2,231	1,511	2,032	1,953	1,635	1,705	1,299	1,149	1,075	1,020	1,138	1,295

Source: National Institute of Statistics, Energy Banlance - Collections 2005- 2015

Oil

The history of the Romanian oil industry begins in 1857, when the first well was drilled in Ploiesti. In 1938, the publication "Petroleum Science" certifies the fact that Romania was the first country in the world, with an oil production of 275 tons officially registered in international statistics. Since then, Romania has proven to be a major oil producer in the region over the past 150 years.

In 2017, domestic crude oil production covered nearly 32% of demand. The decline in average annual production has been 2% over the last five years, being limited by investments in drilling new wells, restarts, secondary recovery, etc. Romania's proven crude oil reserves will be exhausted in about 16 years at a consumption of 3.4 million t/year.

The largest player on the oil market is Petrom, which also explores international crude reserves located in Kazakhstan, India, Hungary, the former Yugoslav countries and the Republic of Moldova through its subsidiaries, joint ventures with other companies.

The second private player is Rompetrol. Rompetrol's main activities are in the fields of refining, marketing, and petroleum products, with adjacent interests in crude oil exploration and production.

Petrotel - LukOil is another major private player, a subsidiary of the Russian group Lukoil, which has owned over 90% of the company since 1998.

Romania has a crude oil processing capacity greater than the domestic demand for petroleum products. Romanian refineries, which purchase the national production of crude oil and import about two-thirds of what is needed, currently have an operational capacity of 12 million t/year. In recent years there has been a decline in indigenous refining activity, both against the background of the relatively high price of energy in the EU compared to competing non-EU countries, as well as the costs generated by European regulations regarding the reduction of CO2 and nox emissions

The refining sector in Romania consists of four operational refineries: Petrobrazi (owned by OMV Petrom), Petromidia and Vega (owned by Rompetrol), Petrotel (owned by Lukoil), which have a total operational capacity of approximately 12 million tons per year. In 2019, Romanian refineries processed 12.1 million tons of crude oil and additives, of which 3.4 million tons were domestic production and 8.6 million tons were imported.

In 2019, the net import of crude oil and crude products was 9.141 million tons, mainly from the Russian Federation and Kazakhstan, but also from Georgia, Iraq, Iran, Azerbaijan, Turkmenistan, Angola, and Tunisia. Romania is an exporter of petroleum products - according to statistical data, in 2017, Romania exported petroleum fuels and lubricants worth 2,285.3 million euros (of which 943.4 million euros were motor fuels).

The demand for petroleum products depends on the evolution of the transport sector. In the last decade, because of increasingly strict regulations, technology has evolved towards high-efficiency internal combustion engines. At the same time, worldwide, there is a diversification of the way motor vehicles are powered, using biofuels, natural gas and biogas, but also electricity and, to a lesser extent, hydrogen. In the process of creating a sustainable economy, with low carbon emissions, the role of biofuels and "green gases" or of gases obtained from other technologies with low carbon emissions in the energy transition, as well as in achieving the climate and energy objectives assumed by Romania for year 2030 as an EU Member State, it is expected to be enhanced in the following period. Biofuels, along with energy from renewable sources and hydrogen, will contribute substantially.

Natural gas

Natural gas accounts for approximately 30% of domestic primary energy consumption. Their important share is explained by the relatively high availability of domestic resources, by the low impact on the environment and by the ability to balance the electricity produced from intermittent renewable energy sources. The existing infrastructure of extraction, transport, underground storage, and distribution is extended throughout the country. The natural gas market is advantaged by the favorable position of Romania in relation to the transport capacities in the region and the possibility of interconnecting the national transport system with the central European

transport systems and with the gas resources of the Caspian Basin, the eastern Mediterranean Sea, and the East Middle, through the Southern Corridor

In 2019, the total consumption of natural gas was 121.2 TWh, of which domestic production covered 78%, and import 22%.

Currently, in Romania, approx. 400 crude oil and natural gas fields, of which:

- OMV Petrom operates more than 200 commercial oil and natural gas fields in Romania. In the Black Sea, OMV Petrom operates on seven fixed platforms
- Romgaz carries out its activity, as the sole oil agreement holder, on 8 exploration, development, exploitation perimeters.

For another 39 deposits, oil development-exploitation and oil exploitation agreements were concluded, with various companies as holders. Most of these deposits are mature, having an exploitation period of over 25-30 years.

Coal

Romania has important coal reserves, although its quality is rather poor. The largest coal reserves are lignite. Half of the gross coal production in Romania is made only in the Petroșani Depression. A large lignite mine in Valea Motru (Gorj) supplies lignite to two of the largest power plants in the country, Rovinari and Turceni.

Lignite resources in Romania are estimated at 690 million tons [124 million toe], of which 290 million tons [52 million toe] are exploitable in concession areas. At an average consumption of resources of 4.5 million tboe/year, the degree of insurance with lignite resources is 28 years under the conditions that in the next 25 years the consumption will remain constant, and no other deposits will be developed of lignite. The average calorific value of lignite exploited in Romania is 1,800 kcal/kg. Since the lignite deposit in Oltenia consists of 1-8 layers of exploitable coal, their superior exploitation requires the urgent adoption of regulations to guarantee rational exploitation in safe and efficient conditions, with minimal losses.

The known coal resources in Romania are 232 million tons [85 million boe], of which 83 million tons [30 million boe] can be exploited in concession areas. At an average consumption of the reserves of 0.3 million tboe/year, the degree of insurance with coal resources is 104 years, but the exploitation of this primary energy resource is conditioned by the economic feasibility of the exploitations. The average calorific value of oil exploited in Romania is 3650 kcal/kg.

Considering the characteristics of the coal extracted in Romania (coal with a calorific value of 3650 kcal/kg; lignite with a calorific value of 1800 kcal/kg), it can only be used in power plants equipped for this type of fuel and located near the respective exploitations.

Table 2-7 shows the evolution of coal production in the period 2005-2020 and it can be noted that lignite production represented approximately 94% of total coal production in 2020.

Regarding primary energy resources at the national level, it is obvious that lignite will be used in accordance with the national strategy regarding the reduction of GHG emissions.

Table 2-7 Coal Production (thousand toe)

Year	2005	2010	2015	2016	2017	2018	2019	2020
Coal, of which	5,793	5,903	4,386	4,233	4,466	4,016	3,927	2,592
Lignite and brown coal	4,698	5,173	4,152	3,865	4,189	3.823	3,778	2,435

Source: National Institute of Statistics, Energy Balance - Collections 2005- 2020

Nuclear

The Cernavoda Nuclear Power Plant is the only nuclear power plant in Romania. Cernavoda NPP is located in the Dobrogea region in the South-East of Romania, near the Danube-Black Sea Canal. The construction began in 1982 with the intention of completing all five reactors.

Currently, Romania has two nuclear reactors: Cernavoda NPP Units 1 and 2, with an installed capacity that produces about 18% of the country's electricity. Unit 1 has been in operation since December 1996 and Unit 2 is in operation since October 2007.

In 2020, Cernavoda NPP, with both units in operation, produced a total of 11.5 TWh, out of which 10.6 TWh delivered to the National Electricity System.

The owner of CNE Cernavoda is Nuclearelectrica National Company SA, a Romanian state company established in 1998. Both units have a installed capacity of 706.5 MW and are equipped with CANDU 6 type reactors that use natural uranium as fuel and heavy water moderator and cooling agent.

The existing and exploitable ore reserves in Romania ensure the demand for natural uranium for the operation of two nuclear-electric units for the entire duration of operation.

Renewable energy resources

Romania has rich and varied renewable energy resources: biomass, hydropower, geothermal potential, respectively for wind and photovoltaic energy. They are distributed throughout the country and will be able to be exploited on a wider scale as the performance-price ratio of the technologies improves, through the maturation of new generations of related equipment and installations. The hydropower potential is used to a good extent, although there is the possibility to continue the hydropower development of the main watercourses, in compliance with good practices for the protection of biodiversity and ecosystems. In the last six years, Romania has advanced in the use of an important part of the wind and solar energy potential

Hydroelectric power

Romania benefits from a high potential of hydropower resources. The current estimates regarding the technical-economic developable potential, diminished following the regulations, show that works can still be carried out, ensuring a technical-economic developable potential of about 27.10 TWh.

S.P.E.E.H. Hidroelectrica S.A., a company to which the state has concessioned public property in the field of electricity production in hydroelectric power plants for the purpose of exploitation, rehabilitation, modernization, retechnology as well as the construction of new hydropower facilities, operates power plants that, according to the technical documentation, total 17.46 TWh/year.

Approximately 0.80 TWh/year is the project energy of all micro hydropower plants owned by other operators, most of them private. They invested in small-scale hydropower projects, especially in the period 2010-2016, being stimulated by the support scheme of Law 220/2008

The evolution of the hydropower sector for the period 2020-2030 will be realized depending on the implementation of specific energy policies, harmonized with European policies on environmental protection.

Wind energy

Due to its geographical position, Romania is at the eastern limit of the atmospheric circulation generated in the North Atlantic basin, which manifests itself with a sufficiently high intensity to allow energy utilization only at high altitudes on the ridges of the Carpathians.

The atmospheric circulation generated in the Black Sea and the Russian Plain, in conjunction with the North Atlantic one, offers possibilities for energy utilization in Dobrogea, Bărăganu and Moldova.

Also, local atmospheric circulations are manifested in small areas that allow economic capitalization through small-scale wind farm projects. A systematic inventory study of the theoretical wind potential for the entire national territory provided a potential value of approximately 23 TWh/year by installing capacities with a total power of approx. 14,000 MW.

The theoretical wind potential, determined in 2006, must be adjusted considering the technical-economic potential and the subsequent establishment of Natura 2000 protected areas as well as the flight paths for wild bird populations, elements that reduce the options for developing new projects in Dobrogea region.

At the end of 2019, projects totaling a power of 2961 MW and totaling a project energy of about 6.21 TWh/year were completed. In 2019, considering the specific conditions of that year, wind power plants in Romania produced 6.83 TWh, a value that is around the project energy value. Investments for the development of wind farms in Romania were encouraged between 2009 and 2016 through a support scheme using the granting of green certificates, according to Law 220/2008.

Solar energy

Solar energy can be harnessed for energy purposes either in the form of heat, which can be used for preparing domestic hot water and heating buildings, or to produce electricity in photovoltaic systems.

The distribution of solar energy on the national territory is relatively uniform with values between 1100 and 1450 kWh/m2/year. The minimum values are recorded in depression areas, and the maximum values in Dobrogea, eastern Bărăganu and southern Oltenia

Correlated with the way of development of houses or other buildings inside the localities, solar collectors with an area of 34,000 m2 could be used to produce an energy of 61,200 TJ/year. The maturing of the capture technologies and the experience of the current users in Romania currently lead to the idea that this use can be extended on a large scale in Romania, during the whole year, at least for the preparation of domestic hot water.

The utilization of solar potential for the purpose of electricity production using photovoltaic panels allows, according to the studies carried out, the installation of a total capacity of 4000 MW and the production of an annual energy of 4.8 TWh.

At the end of 2016, solar parks with a total power of 1360 MW were installed in Romania, which, according to the project energies, produce 1.91 TWh/year. In 2019, the photovoltaic parks in Romania produced 1.40 TWh.

The construction of photovoltaic parks benefited in the period 2009-2016 from a support scheme according to Law 220/2008.

The establishment of Natura 2000 protected areas, as well as the restriction of the development of photovoltaic parks on agricultural land surfaces, limits the options regarding the installation of new large photovoltaic parks only on degraded or unproductive land.

Biomass, bioliquids, biogas, waste and waste and sludge fermentation gases

The energy potential of biomass is assessed at a total of 318,000 TJ/year, having an equivalent of 7.6 million toe.

Data on solid biomass production show a high degree of uncertainty (around 20%), the central estimate being 41 TWh in 2018. The main form of biomass for energy purposes produced in Romania is firewood, burned in low-efficiency stoves.

In 2018, the domestic production of woody biomass (firewood, including biomass) was 14,991 thousand tons, 3652 ktep respectively, being higher than the domestic consumption (14,391 thousand tons, respectively 3506 ktep). In 2018, only 0.35 TWh of the electricity produced nationally came from biomass, bioliquids, biogas, waste and waste and sludge fermentation gases, in capacities totaling 124MW of installed power.

Geothermal energy

On the territory of Romania, several areas were identified where the geothermal potential is estimated to allow economic applications, on an extended area in the west of Transylvania and on smaller areas in the north of Bucharest, north of the Rm. Vâlcea and around the town of Șăndărea.

Research prior to 1990 revealed that the potential of known geothermal resources in Romania amounts to approximately 7 PJ/year (approx. 1.67 million Gcal/year). The records from the period 2014-2016 record that of all this potential, between 155 thousand and 200 thousand Gcal are utilized annually in the form of thermal agent or hot water. Most of the wells through which geothermal energy is harnessed were executed before 1990, being financed with funds from the state budget, for geological research. Current costs for drilling a geothermal water well are similar to the costs for drilling a hydrocarbon well. Under these conditions, for the depths of over 3000 meters that characterize most geothermal resources in Romania, the amortization of investments for the use of geothermal energy exceeds 55 years; such projects are considered unprofitable. Therefore, the pool of geothermal water production wells has not increased.

F.2 Energy transmission infrastructure

National crude oil network

The National Crude Oil Transmission System (SNTT) in Romania is 3800 km long and is operated by CONPET a natural monopoly on the national crude oil transport market, being the only company that carries out such activities in Romania (Figure 2-14).

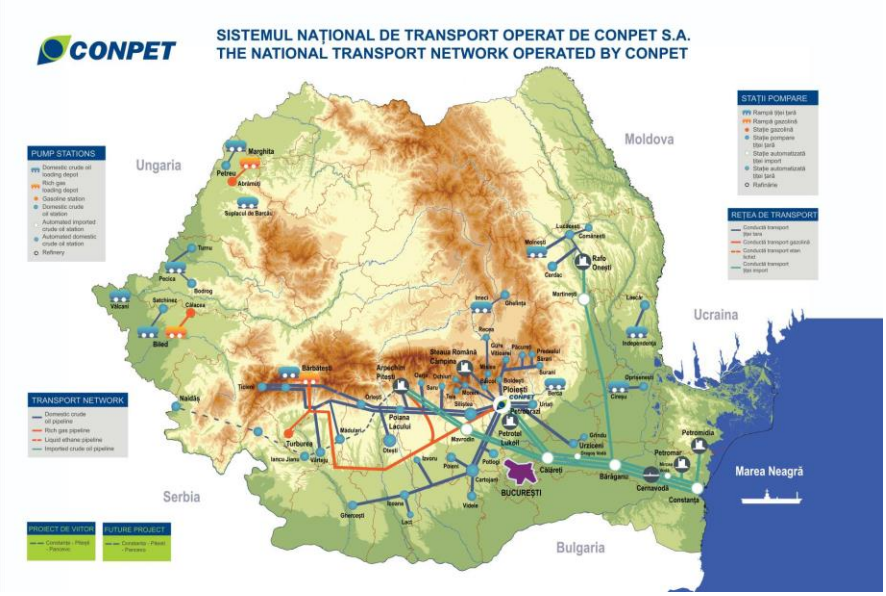


Figure 2-14 Crude oil national pipeline system

source: CONPET, 2022

The National Pipeline Transportation System has a transportation capacity of about 30 million tons/year. The transport capacity was used to a maximum of 60%. Between 1995 and 2005, the system was rehabilitated and modernized:

- internal crude oil transport pipelines with a total length of 1450 km and a capacity of 10 million tons/year
- transport pipelines for imported crude oil, with a total length of 1200 km and a capacity of 18 million tons/year
- enriched gas and ethane transport pipelines, with a total length of 1150 km and a capacity of 314 thousand. tons/year for enriched gas and a capacity of 72 thousand tons/year for liquid ethane
- railway transport.

Constanța Port, which is connected to the national pipeline network, has the largest oil terminal in Southeast Europe (operated by Oil Terminal Company), specializing in the import of crude oil and other oil products and the export of refined oil products. The oil terminal can operate vessels with capacities up to 165,000 tdw (tons deadweight) and has a maximum capacity of 24 million tons/year and a crude oil storage capacity of 550,000 tons.

Rompetrol invested over 175 million US dollars in the period 2007-2008. in the construction of a marine terminal off the Black Sea and for the 350% expansion of the transit capacity for final products through the port of Midia (from 90,000 tons/month to 310,000 tons/month). The oil terminal is located 8.6 kilometers off the Black Sea, has an annual transit capacity of a maximum of 24 million tons of crude oil and can receive ships of up to 160,000 tdw (Rompetrol, 2009).

The national natural gas transport and distribution network

The National Natural Gas Transport Company, CN Transgaz SA is the technical operator of the national natural gas transport system and is responsible for its operation in conditions of quality, safety, efficiency, and compliance with environmental protection measures.

Established based on GD no. 334/April 28, 2000, CN Transgaz SA is a Romanian legal entity operating as a joint-stock company, in accordance with Romanian legislation. To support the main object of activity, CN Transgaz SA can also carry out other related activities, in accordance with the legislation in force and its own regulations, except for the purchase and sale of natural gas from domestic production or from import.

The main components of the national natural gas transport system as of 31.12.2020 are:

- 13,925 km of main pipelines and natural gas supply connections, of which 369 km are transit pipelines, and 479 km are related to the BRUA main
- 1128 gas measurement stations/1233 gas measurement directions
- 4 gas measuring stations for international transport
- 7 imported natural gas measuring stations
- 58 valve control stations/technological nodes
- 7 physical entry/exit points connected to the storage warehouses
- 6 gas compression stations (SCG)
- 1041 cathodic protection stations (SPC)
- 962 gas odorization stations (SOG).

The total technical capacity of the entry/exit points in/from the NTS is 149,034 thousand cubic meters/day (54.39 billion cubic meters/year) at the entrance and 243,225 thousand cubic meters/day (88.77 billion cubic meters/year) at the exit. The total technical capacity of the interconnection points located on the international transport pipelines is about 70,000 thousand cubic meters/day (25.55 billion cubic meters/year), both at the entrance and exit of the country.

During 2020, the national transport system registered the following changes:

- The total length of pipelines and connections increased by 3.7%, through the construction of 497.5 km of new pipeline sections and supply connections and the decommissioning of 2.5 km of pipelines
- 8 new adjustment-measurement stations were modernized
- 3 new cathodic protection stations were put into operation, their total number thus reaching 1041
- The international transport pipeline T1, respectively Isaccea 1-Negru Vodă 1 was connected to the SNT, so that currently the SNT has two new points of interconnection with the neighboring transport systems, a fact that leads to the increase of the efficiency of the operation of the SNT by increasing the import capacity /export
- 80 new gas odorization stations were put into operation, their total number thus reaching 982, representing an increase of approx. 9% compared to the previous year
- A new gas compression station (GCS) was put into operation, thus bringing their number to 6, to balance the pressure in the internal network with that of the adjacent systems and to increase the amount of natural gas transported internally.

The National Natural Gas Transmission System (SNT) is illustrated in Figure 2-15.

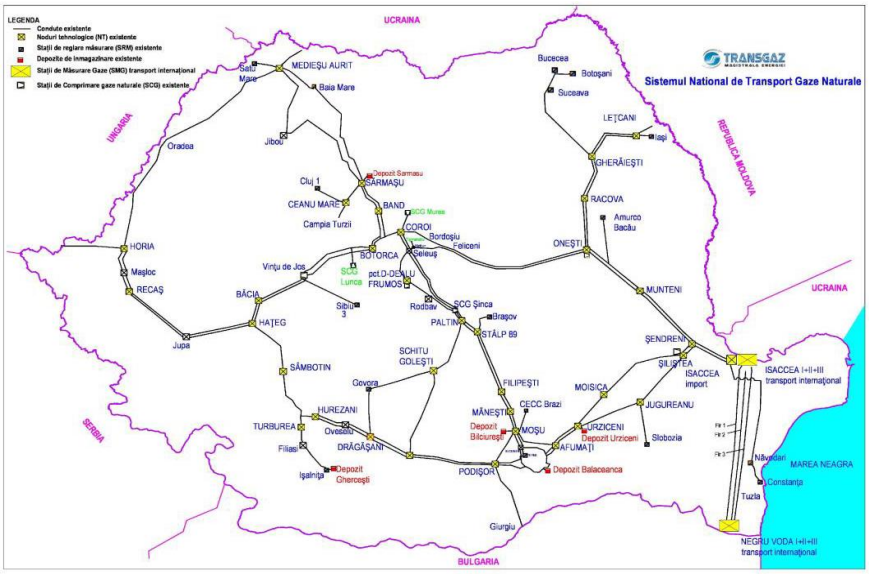


Figure 2-15 National Gas Transportation System

source TRANSGAZ 2020[7]

SNT has a maximum technical capacity of 51,316.80 MWh/day and a reserve capacity of 27,060.41 MWh/day, which is much more than the current consumption, therefore, there has been no grid congestion so far.

The transmission and system operator carries out sustained activity to improve the technical condition of the transmission system through constant development, rehabilitation and modernization of the system, expansion to new areas of consumption, as well as interconnection with similar systems in neighboring countries, to diversify the sources of supply with imported natural gas.

Romania participates or has declared its interest to participate in a series of interconnection projects, in the construction and development of cross-border natural gas transport capacities by interconnecting the SNT with similar neighboring systems, to ensure the security of natural gas supply and maintain the balance between demand and supply.

In terms of access to natural gas, less than half of households in Romania are connected to the natural gas network (approximately 44%), one third of Romania's homes being heated directly with natural gas. Also, the average natural gas consumption of a household consumer is lower than the EU average.

The natural gas distribution system consists of approximately 43,000 km of pipelines - of which 39,000 km are operated by the two large distributors, Delgaz Grid (20,000 km) and Distrigaz Sud Rețele (19,000 km) - which supply approximately 3.5 million consumers.

On the natural gas market in Romania, another 35 local distribution system operators are active, operating approx. 4000 km of network.

[7] Transgaz, Planul de dezvoltare a sistemului național de transport gaze naturale 2020-2029, available at https://www.transgaz.ro/sites/default/files/Planul%20de%20Dezvoltare%20a%20Sistemului%20Na%C8%9Bional%20de%20Transport%20gaze%20naturale%20pentru%20perioada%202020-2029.pdf (accessed November 2022)

Electricity network and interconnections

CNTEE "Transelectrica" - SA carries out the activity of electricity transmission through the Electricity Transmission Network (RET), consisting of electric stations and lines. RET is the national and strategic electricity network with nominal voltage higher than 110 kV.

The number of installations managed by CN "Transelectrica" SA consists of:

- 81 electric substations, of which:
  - One 750 kV substations
  - 38 substations at 400 kV
  - 42 substations at 220 kV
- 8759.4 km overhead electric lines (OHL), of which:
  - 155.62 km at 750 kV
  - 4706.8 km at 400 kV
  - 3059.4 km at 220 kV
  - 38 km at 110 kV

of which interconnection lines: 425.8 km

- 216 main transformer units amounting to 37,794 MVA.

At present the Romanian Power System is interconnected to the neighboring power system by means of the following lines (Figure 2-16):

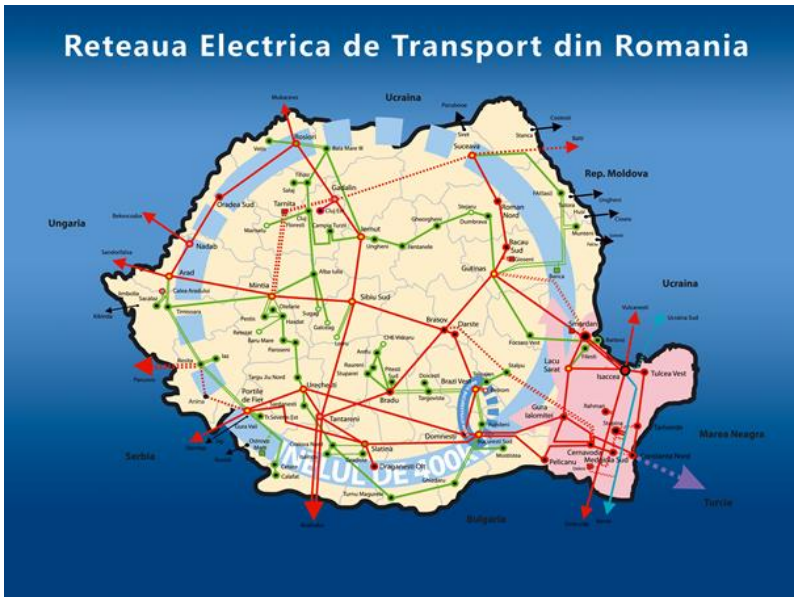


Figure 2-16 Romanian electricity Transmission Network

Source: Transelectrica 2022[8]

The Romania - Bulgaria section includes the followings overhead power lines (OHL) and sections:

[8] Transelectrica, https://www.transelectrica.ro/ro/web/tel/transport-detalii, (accessed November 2022)

- OHL 400 kV Isaccea – Dobrudja
- OHL 400 kV d.c Ţânţăreni – Kozlodui.

Section 400 kV Romania – Serbia includes:

- OHL 400 kV Porţile de Fier – Djerdap.

Section 110 kV Romania – Serbia includes:

- OHL 110 kV Ostrovul Mare – Kusjak
- OHL 110 kV Gura Văii – Şip
- OHL 110 kV Jimbolia – Kikinda.

Section Romania – Hungary includes:

- OHL 400 kV Arad – Sandorfalva
- OHL 400 kV Nadab-Bekescsaba.

Section Romania – Ukraine includes:

- OHL 400 kV Roşiori – Mukacevo.

Section Romania – Moldavia Republic with island function includes:

- OHL 400 kV Isaccea – Vulcăneşti (line only for National Power System imports)
- OHL 110 kV Stânca – Costeşti
- OHL 110 kV Cioara – Huşi
- OHL 110 kV Ţuţora – Ungheni.

F.3. Electricity, generation and consumption

The Romanian Power Grid (SEN) had an installed capacity of 20,584 MW in 2020 (Table 2-8).

Table 2-8 Installed capacity in power plants in 2020

Type of plant	Installed capacity, MW
Thermal Power Plant	
- on coal	4786.969
- on liquid hydrocarbons	87.494
- on gaseous hydrocarbons	3340.142
Nuclar Power Plant	1414.000
Hydro Power Plant	6560.797
Wind Power Plant	3012.527
Photovoltaic Power Plant	1382.539
TOTAL INSTALLED POWER	20584.468

Source: National Institute of Statistic Energy Balance 2021

Table 2-9 illustrates the main features of NPS within the 2000 – 2020 period as well as the electricity generation evolution per types of power plants.

Table 2-9 Main features of NPS

Year	Gross electricity generation [TWh]	Net electricity generation [TWh]	Gross peak of electricity demand [MW]
2000	51.935	47.066	8265
2005	59.413	54.804	8970
2010	60.979	56.546	9349
2015	66.296	61.277	8356
2016	65.104	60.256	8761
2017	64.296	59.355	8970
2018	64.876	60.176	9850
2019	59.623	55.177	9526
2020	55.935	51.924	9559

Source: National Institute of Statistics - Energy Balance - collections - 2000- 2020, CN TranselectricaSA

The structure of electricity resources in the period 2010-2020 is presented in Table 2-10. It should be noted that in 2017, 18% of electricity was produced in CNE Cernavoda, and in 2020, it was 21%. The share of electricity produced in hydroelectric plants is between 23% and 33%, depending on the hydrological conditions.

Table 2-10 Structure of electricity resources

Type of plant	Gross production, TWh						
	2010	2015	2016	2017	2018	2019	2020
Thermal power plant	28.83	28.545	26.458	28.581	26.986	23.366	19.955
Nuclear power plant	11.6	11.7	11.7	11.6	11.7	11.7	11.6
Hydro power plant	20.243	17.007	18.536	14.853	18,097	16.006	15.701
Wind power plant	0.306	7.062	6.590	7.406	6,322	6,772	6,946
Solar power plant	-	1.982	1.820	1.856	1.771	1.778	1.733
Total	60.979	66.296	65.104	64.296	64.876	59.623	55.935

Source: National Institute of Statistics – Energy balance – collection – 2000 - 2020

The evolution of electricity consumption on the economy's main sectors is presented in Table 2-11 for the period 2010-2020.

Table 2-11 Electricity consumption during period 2010-2020

Sector	Electricity consumption [GWh]						
	2010	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Energetic	17302	11415	11670	11622	11831	11100	10656
Industry (including construction)	30521	20524	21246	21724	22225	21949	20244
Transport	1355	1082	1048	1089	1056	1060	1086
Agriculture and Forestry	671	921	744	742	753	753	537
Services	7582	8405	8153	8547	8752	8827	8897
Population	11329	12095	12067	12597	12780	12984	13620
Total final electricity consumption	51458	43027	43258	44699	45566	45573	44024

Source: National Institute of Statistics – Energy balance – collection – 2000 – 2020

As a result of economic restructuring and the transition to a free-market economy and the crisis, the final consumption of electricity in Romanian industry decreased in the period 1992-2011.

In the 2010-2020 period, there is an increase in electricity consumption in the service sector, because of its development, and among the population, because of the increase in equipment with different electrical equipment.

The entire economic and technical development operation of the electricity sector is regulated, supervised, and monitored by the National Energy Regulatory Authority (ANRE), established in October 1998 as a public, independent and autonomous institution.

The GHG emissions related to the electricity sector might vary broadly, depending on the intensity of hydro power use, fossil fuels prices, availability factors etc. From National GHG Inventory data it is obvious that in 2020, there was a decrease in GHG emissions, due to decrease of electricity consumption and also due to the increasing share of the renewable electricity generation.

G. Transport

Romania has a national transportation system (infrastructure, transport equipment, etc.) largely at the same level with the average standards of conventional transport systems in Europe from the point of view of both the functional structure and services rendered.

Strategic framework for sustainable transport policy in Romania has aligned European policy defined in the White Paper of transport.

In the Transport sector, Romania holds a key position at the eastern border of the EU as a transit area both on the east-west direction (link to Asia via the Black Sea) and north-south (from the Baltic Sea to the Mediterranean Sea). Three of the TEN-T priority axes cross Romania.

Road transport

The public roads network in Romania is classified into five categories:

- Motorways - A
- Express Roads – E
- National Roads – DN
- County Roads – DJ
- Communal Roads – DC.

The motorway and national road network account for only 20% of the entire network as summarized below.

According to data from the National Institute of Statistics (INS), in 2020 public roads have totaled 86,791 km[9], out of which:

- 17,913 km (20.6%) were national roads (including motorways and European roads),
- 68,878 km (79.4%) were county roads and communal roads.

[9] National Institute of Statistics, Statistical Yearbook of Romania 2021

Romania has a very limited network of motorways; in 2021, only 931 km of motorways were finalized[10]. The status of road infrastructure and low density of public roads lead to enhanced distance, traveling time and excessive fuel consumption, with harmful effects on the environment.

The National Road Infrastructure Administration Company (CNAIR) manages all national roads and highways in Romania. There are no private operators and/or concessionaires involved in this activity. The road network in Romania is presented in Figure 2-17.

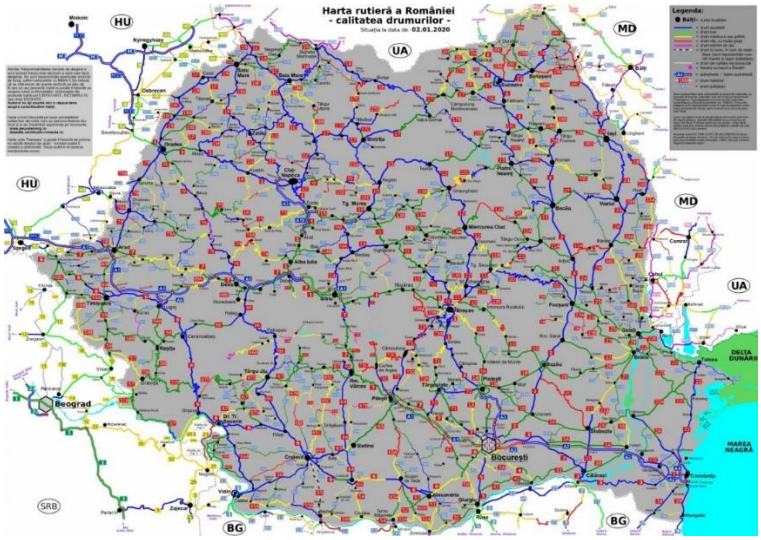


Figure 2-17 Roads map of Romania

Source: e-transport.ro

Rail transport

According to INS, in 2020 the Romanian network of rail lines open to commercial traffic was 10,7590 km long [11] (the eighth largest in the EU), out of which the length of electrified rail lines was 4,030 km, which represents 37.4% of the rail network in operation. Between 1990 and 2020, the length of electrified lines increased by about 10%. The map of the railway network is presented in the following Figure 2-18.

The network is maintained by the state-owned infrastructure company CFR-SA (Compania Naţională de Căi Ferate). Since 1998, the Railway Regulatory Authority (Autoritatea Feroviară Română - AFER) monitors the rail sector, including the infrastructure.

[10] Economedia: https://economedia.ro/romania-avea-86-199-km-de-drumuri-publice-la-finalul-anului-trecut-date-ins-autostrazile-reprezinta-doar-53-din-total.html#.Y20JN9ZBzIU (accessed in November 2022)

[11] Institutul Național de Statistică, Anuarul Statistic al României: https://insse.ro/cms/ro/tags/anuarul-statistic-al-romaniei (accessed in November 2022)

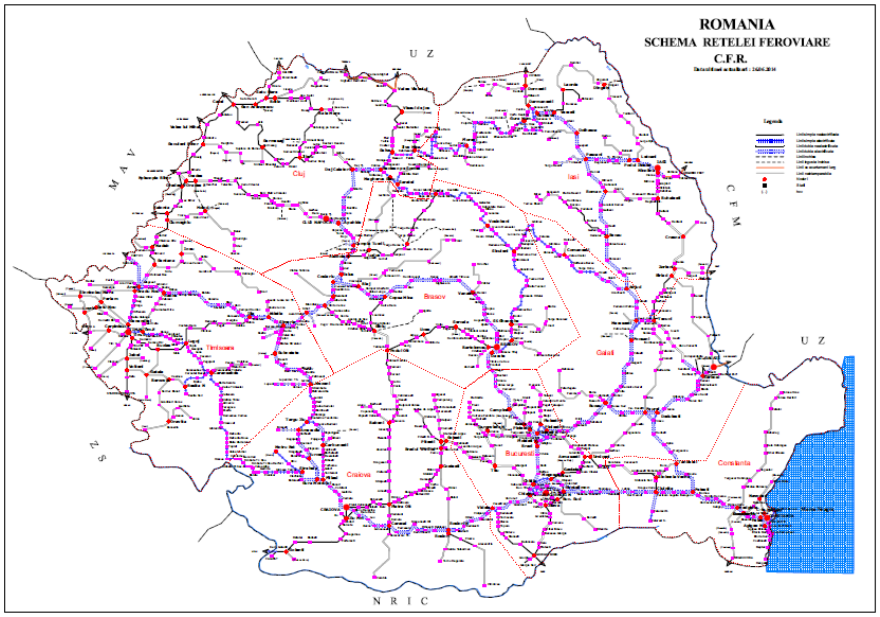


Figure 2-18 Railway network map

Source: Ministry of Transport, 2022

The rail network is in an advanced state of disrepair due to a chronic lack of maintenance. Rail lines and the track-related assets need to be rehabilitated and the rolling stock must be replaced (some with a history of over 30 years). Therefore, the rail system is very inefficient, and it continues to deteriorate. On certain routes, the wear state of railways led to taking measures regarding the restriction of the speed limit, thus increasing the duration of the journey. Moreover, a lot of lines (71.6% of which are single track) are closed for maintenance during the morning. This results in low commercial speeds and poor frequencies. All these factors have contributed to the collapse of the traffic volume; the volume of passengers dropped by 87,8 between 1990 and 2020, while the volume of freight by 75%.

It is estimated that the Trans-European Transport Network (TEN-T) accommodates about 50% of the total rail traffic in Romania and covers some 20% of the total Romanian rail system length. Two core network corridors cross the country: the Rhine - Danube Corridor and the Orient - East-Med Corridor. EU standards for minimum speeds on the Core TEN-T network entailed heavy upgrading work on those segments. The general objective of the rehabilitation and upgrading works, in line with the European Agreement on Main International Railway Lines (AGC) requirements, is to meet speeds of 120 km/h for passenger trains and 120 km/h for freight trains, while implementing interoperability.

The TEN-T infrastructure rehabilitation program started in 1999 with a European Investment Bank (EIB) loan under which the Bucharest – Campina section (90 km) of the Bucharest – Brasov line has been rehabilitated. The Bucharest – Constanta line (225 km), Bucharest Băneasa – Fundulea sector, has been rehabilitated in 2009 under ISPA funding. During 2009-2011 upgrading works mainly targeted on sectors "Hungarian border - Curtici - Arad" and "Simeria - Coslariu - Sighisoara" have been performed.

Water transport

The Romanian water transport network includes seaports, river ports, and inland waterways. Constanta is the major seaport and the largest on the Black Sea. It is linked via the Danube to Serbia, Hungary, and Austria, and

then via the Rhine-Main-Danube Canal to the Rhine as far as Rotterdam on the North Sea. The seaports of Constanta, Mangalia and Midia are on the Black Sea, while Braila, Galati, Tulcea and Sulina on the Danube operate as river/seaports. The maritime section of the Danube consists of 170 km length from Sulina to Braila.

Constanta has a strategic geographic location that has the potential to provide access to Europe from the Black Sea and a transhipment point between the maritime network and the road, rail and inland waterway networks. It is located at the crossing of TEN-T priority axes 7 (Road), 18 (Rhine/Meuse-Main-Danube inland waterway), and 22 (Rail) and thus has the potential to become an alternative gateway for the Central/East Europe – Asia corridor. Its two satellite ports, Midia and Mangalia, are located nearby, and share functions with the main port. The direct access to TEN-T priority axis 18 is done via the Danube Black Sea Canal, potentially offering lower cost waterway transport links with Central Europe. It has good links to rail, road, river, air transport and pipeline modes. Its container capacity has grown with the development of a new Container Terminal on Pier II South, and it has Ro-Ro terminals allowing development of short sea shipping serving the Black Sea and Danube riverside countries.

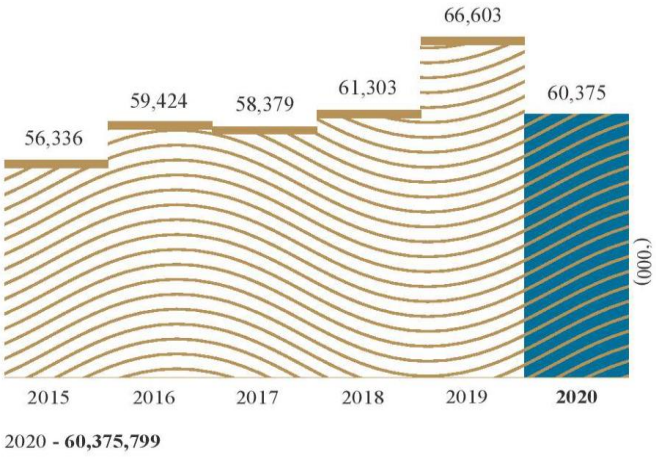


Figure 2-19 Total traffic in Constanta Port (thousand tons)

Source: Constanta Port Annual Report 2020

Traffic through the Port of Constanta (Figure 2-19) increased from 46 to 66 million tons between 2011 and 2019, then decreased in 2020, the first year of the pandemic, to 60 million tons. Correspondingly, maritime traffic increased from 37 to 51 million tons, then decreased to 45 million tons in 2020, while river traffic increased between 2011 and 2020 by 76% to 15 million tons. The new status of Constanța Port as HUB for the Black Sea is reflected in the 80% increase in transit traffic, up to almost 18 million tons in 2020[12].

The Romanian sector of the Danube, between Baziaș and Sulina, has a total length of 1,075 km, of which 320 km are entirely on Romanian territory. The rest is a shared state border with Ukraine (55 km), Moldova (0.97 km), Bulgaria (470 km), Serbia and Montenegro (230 km). In practice, this means that rehabilitation projects for all, except the section where Romania has sole responsibility, must be agreed, and coordinated by both countries and implemented simultaneously.

[12] Constanta Harbour, Annual Report 2020

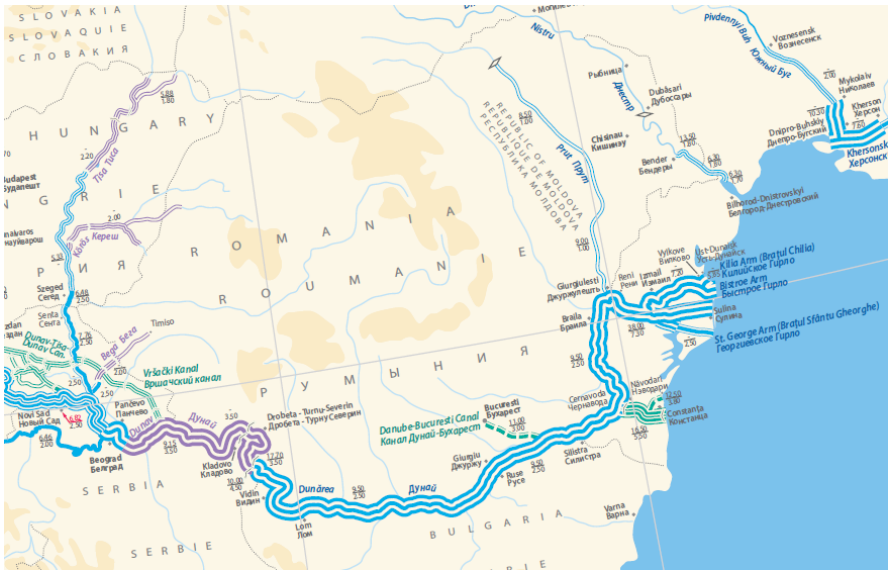


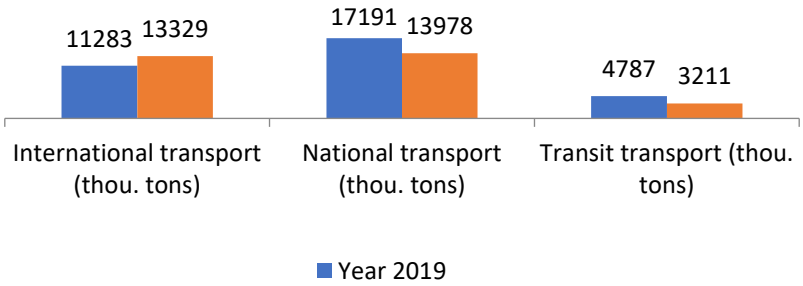
Figure 2-20 Romanian inland waterways

Source: UNECE 2018[13]

The Romanian inland waterway system is shown on the map above. It is focused on the Danube in the south of the country. It also includes the secondary navigable branches of the Danube and the Danube - Black Sea and Poarta Alba - Midia Navodari canals between the Danube and the coast in the vicinity of Constanta. In addition, there are various small branches, including in the Danube Delta, mostly used for leisure and local (low volume) freight traffic. The branches of the Danube offer an additional 530 km of navigable waterway.

In Romania, a section of 170 km between Braila and the Black Sea can handle maritime shipping. The remainder, also called fluvial Danube, can handle ships, and barges up to 2,000 dwt. The whole Romanian section of the Danube is navigable, but transport is hindered by seasonal low water levels and in 2003 traffic volumes declined sharply due to an unusually long low-water period in the summer.

The Danube is part of the TEN-T Priority axis no. 18: Rhine/Meuse-Main-Danube inland waterway axis and it provides Romania and the other countries through which it passes with major new opportunities for the development of water transport.



[13] United Nations Economic Commission for Europe (UNECE) website, https://unece.org/DAM/trans/main/sc3/AGN_map_2018.pdf (accessed in November 2022)

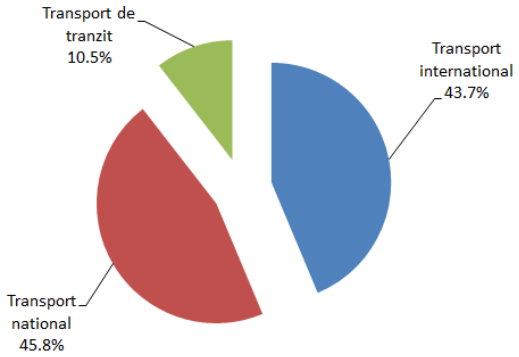


Figure 2-21 Inland waterways transport in 2020

Source: National Institute of Statistics, Statistical Yearbook of Romania 2020

Table 2-12 presents the transport of goods by waterways in the period 2006-2020.

Table 2-12 Goods transport by inland waterways, 2006 – 2020

UM / Year	2006	2010	2014	2015	2016	2017	2018	2019	2020
Thousand tonnes	29305	32088	27834	30020	30484	29043	29714	33261	30518
Million tonne-kilometre	8.158	14.317	11.760	13.168	13.153	12.517	12.261	13.957	13.638

Source: National Institute of Statistics, Statistical Yearbook of Romania 2020

In 2007, the year when Romania joined the European Union, cargo traffic on the Romanian inland waterways accounted for 29.4 million tons and 8,195 million ton-km, much higher than the new EU member states achieved in the same year: 1.1 million tons in the Czech Republic, 8 million tons for Hungary and Slovakia, and 6.4 million tons for Poland [14]. This suggests that the greater portion of inland waterway traffic in Romania starts and ends within the country.

Air transport

In terms of air transport, The Aeronautical Information Publication (AIP) lists a total of 21 aerodromes on the territory of Romania. Fifteen of these airports currently carry out scheduled flight operations:

- Bucharest – Henri Coandă – classified as major international airport
- Constanţa/Mihail Kogălniceanu - classified as strategic international airport due to its use by NATO
- Craiova, Timişoara, Iaşi, Cluj-Napoca – classified as international hubs
- Sibiu, Bacău, Târgu Mureş, Suceava, Tulcea, Baia Mare, Oradea - classified as regional airports
- Satu Mare, Arad - classified as small regional airports

In some cases, these planned services cannot be provided throughout the year, but only in certain seasons.

Four airports operate under the authority of the Ministry of Transport (Henri Coandă - the main airport in Bucharest, Baneasa - Bucharest, Traian Vuia from Timisoara, and Mihail Kogalniceanu in Constanta), the other airports being subordinated to the local authorities. (Figure 2-22).

[14] EUROSTAT website, http://ec.europa.eu/eurostat/web/transport/data/main-tables

The location of the key Romanian airports is shown on the following map.

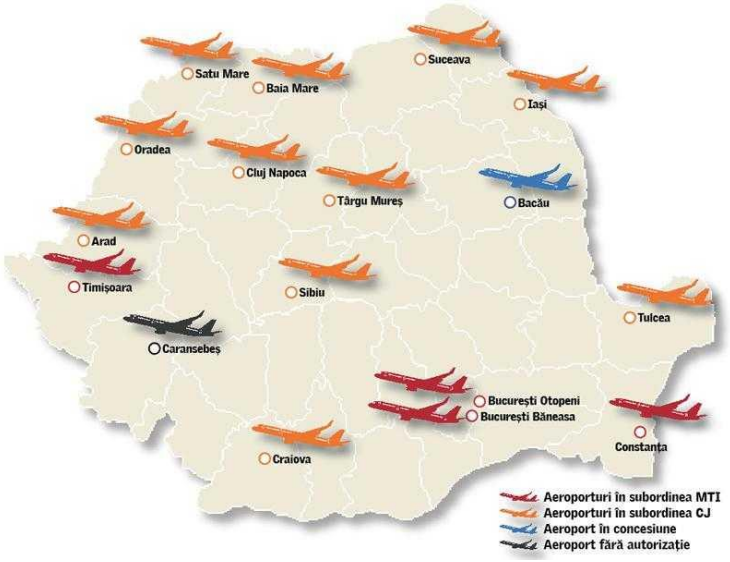


Figure 2-22 Operating airports Romania, in 2019

Source: https://airlinestravel.ro/aeroporturi-din-romania

The number of air passengers during 2005 and 2020 is presented in Figure 2-23.

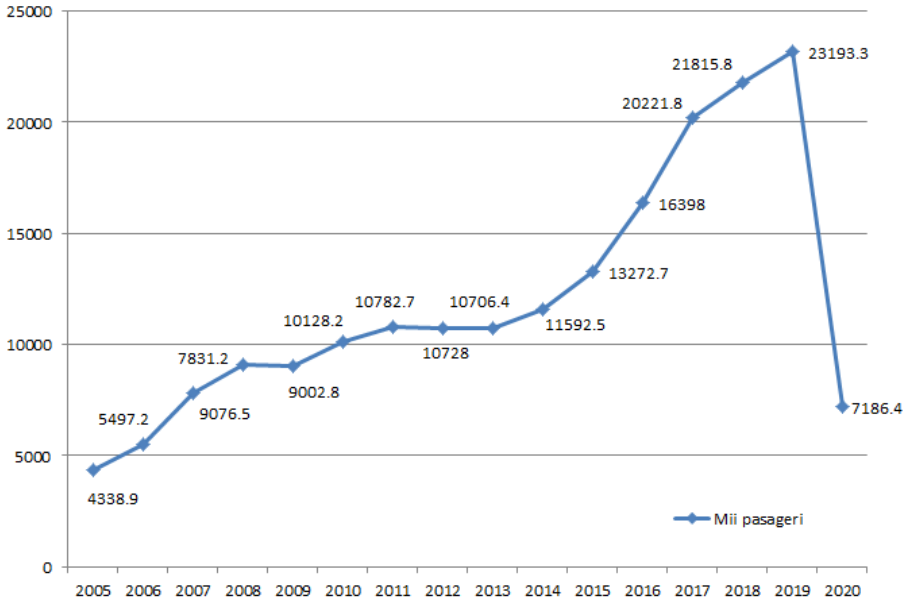


Figure 2-23 Commercial air transport, 2005-2020

Source: National Institute of Statistics, Statistical Yearbook of Romania 2020

The number of air passengers in Romania increased constantly from 4.3 million to 23,2 million during 2005 ÷ 2019, then dropping drastically in 2020 to 7.2 million, due to the Covid-19 pandemic of the approximately 17 million

passengers, about 7 million passengers in 2020, transited the Henri Coanda International Airport in Bucharest (NIS2020).

The volume of transported goods (freight and mail) increased from 20,226 tons in 2005 to 47.315 tons in 2019, after which it was considerably reduced to 10,236 tons in 2020 (NIS2020). Romanian airfreight market is not significant in terms of volume and is largely served by the Henri Coanda Airport gateway that handles around 80% of all air cargo in Romania.

The transport sector is one of the most important sectors both from the point of view of energy consumption and environmental implications. Transport sector development is done in tightly correlation with socio-economic development of Romania.

H. Industry

Romania's industry has been severely affected by the transition from a planned to a market economy and the collapse of the existing market within the CAER (Mutual Economic Assistance Council). Between 1990 and 2005, some industrial enterprises were restructured and privatized, and those that had no market or could not cope with the competition ceased their activities. After 2008, because of the global economic crisis, enterprises that had no market (metallurgical enterprises, heavy machinery enterprises, etc.) ceased operations.

After 1989 Romania suffered a structural adjustment of the economy. Thus, in 2000, industry, agriculture and construction contributed 46.43% of GVA (Gross Value Added) compared to 67.8% in 1990. There was a relatively continuous upward trend until 2005 in the contribution of the services sector to the detriment of the other economic branches.

Table 2-13 shows the evolution of GVA by sector over the period 2000-2020. It shows that industry and agriculture have reduced their contribution to GVA at the detriment of construction and services.

Table 2-13 Changes in the structure of Gross Value Added over the period 2000-2020 [%]

Indicator	2000	2005	2010	2015	2018	2019	2020
TOTAL VAB of which:	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Industry	29.02	28.10	31.85	33.02	27.2	22.7	22.4
Agriculture	12.06	9.52	6.4	7.48	5.2	5.0	4.4
Construction	5.35	7.39	10.24	9.76	5.5	6.3	7.3
Services	53.57	54.99	51.51	49.74	62.1	66.0	65.9

The main sectors of the Romanian economy are industry, energy, construction, agriculture, tourism, communications (internet, mobile and fixed telephony), finance-banking, trade and the budget sector.

Romania's main industrial sectors are textiles and footwear, metallurgy, light machinery and machine assembly, mining, wood processing, construction materials, chemicals, food processing and oil extraction and refining. Pharmaceuticals, heavy machinery and household appliances, and IT show steady annual growth. Today, the machine-building industry is very large and market-oriented.

Romania's economic strength is primarily concentrated on the production of goods by small and medium-sized enterprises in industries such as precision machinery, motor vehicles, chemicals, pharmaceuticals, household appliances and clothing.

The evolution of Romania's various industrial branches depends on the economic development of the country, as well as on the policies adopted in this field within the EU, but also on the global social and economic context.

An analysis of the contribution of industry to the creation of Gross Value Added (GVA) over the period 2000-2020 shows that manufacturing industry has the largest share (around 80%). Important contributions to the formation of GVA are made by the food industry, the manufacture of beverages and tobacco products (around 20%), the means of transport industry (around 11%), the energy industry (around 13%) and the metal industry (around 8%).

I. Waste management

Waste management is one of Romania's current problems. The integrated approach to waste management, which covers the collection, transport, treatment, recovery and disposal of waste, includes the construction of waste disposal sub-systems, together with measures to prevent waste generation and recycling, in accordance with the hierarchy of principles: prevention of waste generation and its negative impact, recovery of waste through recycling, re-use and safe disposal of waste when recovery is no longer possible.

Responsibility for waste management activities will fall on producers, in line with the „polluter pays", „pay-as-you-throw" principle or, where appropriate, with producers, in line with producer responsibility.

Each type of waste generated in the country is officially classified in one of the following categories:

- municipal waste
- industrial waste
- medical waste.

Municipal waste is all waste generated in urban and rural areas from households, institutions, commercial establishments, economic establishments (household and similar waste), street waste collected from public spaces, streets, parks, green spaces, as well as construction and demolition waste collected by sanitation operators and sludge from wastewater treatment.

The evolution of the quantities of municipal waste generated between 2015 and 2019 and their composition are presented in Table 2-14 and Table 2-15 respectively.

Table 2-14 Evolution of municipal waste generated between 2015 and 2019, tons

	2015	2016	2017	2018	2019
Total municipal waste generated, of which:	4,903,535	5,142,542	5,333,171	5,296,239	5,430,341
- waste generated and not collected	600,345	523,670	419,444	314,022	178,470
- household waste collected from the general public and similar waste from economic operators	3,685,250	3,894,853	4,162,921	4,249,988	4,632,802
- other municipal waste	429,286	454,170	400,228	430,097	419,429
- recyclable waste from the population, collected by authorised economic operators other than sanitation operators	188,654	269,849	350,578	302,132	199,640

Source: NIR 2022

Table 2-15 Composition of municipal solid waste, %

Type of waste	2005	2010	2015	2016	2017	2018	2019	2020
Paper and textiles	12.76	9.88	10.17	10.34	10.33	11.16	10.59	9.93
Waste from parks and gardens	14.50	20.31	18.25	16.83	17.44	17.44	14.84	12.95
Food waste	38.6	32.19	34.45	34.74	37.92	33.49	36.62	37.53
Wood waste	1	2.11	1.71	1.72	1.71	1.95	1.81	1.74

Source: NIR 2022

Municipal waste management involves the collection, transport, recovery, and disposal, including the monitoring of landfills after closure.

Municipal waste collection is the responsibility of municipalities, either directly (through the specialized services of local councils) or indirectly (by contracting out this responsibility to specialized sanitation companies).

In Romania, landfill is the main disposal option for municipal waste. According to ANPM (National Agency for Environment protection) data, in 2019, the material recycling rate was about 11.48%.

In 2020, there were 46 compliant landfills in operation nationwide. Table 2-16 shows the evolution of landfills in Romania.

Table 2-16 Number of warehouses in Romania in the period 2010-2020

Warehouses/Year	2010	2015	2016	2017	2018	2019	2020
Compliant warehouses	27	35	37	42	43	44	**46**
Non-conforming deep storage	40	25	19	7	-	-	-
Non-compliant surface storage	35				-	-	-

Source: NIR 2022

Compliant landfills are built and operated on the basis of the operational and technical requirements and measures for waste disposal in order to prevent or reduce as much as possible negative effects on the environment (surface water, groundwater, soil and air) and on the health of the population caused by waste disposal, based on the OG (Government order) no. 2/2021 on waste disposal, the Order of the Ministry of Environment and Water Management no. 757/2004 for the approval of the Technical Regulation on waste disposal and the EGO no. 92/2021 on the waste regime.

According to preliminary data reported by ANPM, the amount of waste deposited in landfills in 2020 was approximately 4,811,810 tons.

The evolution of the quantities of waste recycled and recovered in Romania in the period 2015-2019 is shown in Table 2-17.

Table 2-17 Evolution of recycled and recovered waste quantities in Romania 2015-2019

	2015	2016	2017	2018	2019
Amount of municipal waste collected separately (tonnes)	430,305	580,602	696,742	634,536	576,816
Amount of waste recycled from municipal waste (tonnes)	649,591	689,443	745,427	586,406	623,214
Recycling rate of municipal waste (%)	13.25	13.41	13.98	11.07	11.48

Source: NIR 2022

Biodegradable waste

Of the total amount of municipal waste, most of it is household and household-like waste (about 72%) and about 45% is biodegradable waste. This comes from households as well as from economic operators, commercial premises, offices, public institutions, health facilities and public spaces (parks, public gardens, squares, streets).

Table 2-18 presents data on the quantities of municipal waste generated (including estimated quantities of waste generated and not collected) and the quantities of waste collected by the municipalities' own specialized services or by sanitation companies in 2015-2019. The table also shows data on biodegradable waste generated.

Table 2-18 Quantities of waste generated and collected (including biodegradable waste) during 2015-2019

Waste categories	Amount of waste - mil. tons/year				
	2015	2016	2017	2018	2019
Total municipal waste generated, of which:	4.903	5.142	5.333	5.296	5.430
- Biodegradable waste from landfilled municipal waste	1.856	1.913	2.159	2.068	2.120

Source: NIR 2022

An analysis of the data presented in Table 2-18 shows a slight increase in the total amount of municipal and similar waste generated at national level in 2019 compared to 2018, by about 2.5%, as well as a slight increase in the amount of biodegradable waste deposited.

Biological treatment of waste

In 2020, there were 38 composting plants nationwide. The evolution of the quantities composted in the period 2010-2020 is shown in Table 2-19.

Table 2-19 Evolution of the quantities composted between 2010-2020

	2010	2015	2016	2017	2018	2019	2020
Amount of composted waste (tons)	259.820	146.050	140.960	141.030	135.090	131.420	149.830

Source: NIR 2022

Analyzing the data presented shows a slight increase in the total amount of composted waste in 2020 compared to 2019, by about 14%.

Waste incineration

In Romania, waste incineration is not a common practice for the treatment/disposal of municipal and similar waste. So far, no municipal waste incineration plants have been put into operation in Romania.

The amount of medical waste generated in 2019 was 14,050 tons of which 10,730 tons were incinerated and 16,560 tons were generated in 2020 of which 13,380 tons were incinerated.

The amount of hazardous industrial waste incinerated in 2019 was 3,960 tons and 3,180 tons in 2020.

J. Housing stock and urban structure

Construction was the economic sector that suffered the most during the economic crisis. If in 2008 the construction sector represented 11% of GDP, in 2014 it reached 6.3% of GDP. However, in the last years 2017, 2018, 2019, this sector shows signs of recovery

According to the National Institute of Statistics (INS), in 2020 the following figures were recorded:

- number of households: 7.47 million
- number of dwellings: 9.156 million
- habitable surface: 438,014,624 m2 (54.97% in the urban environment).

Figure 2-24 shows the housing stock, by property types and residence environments, in 2020.

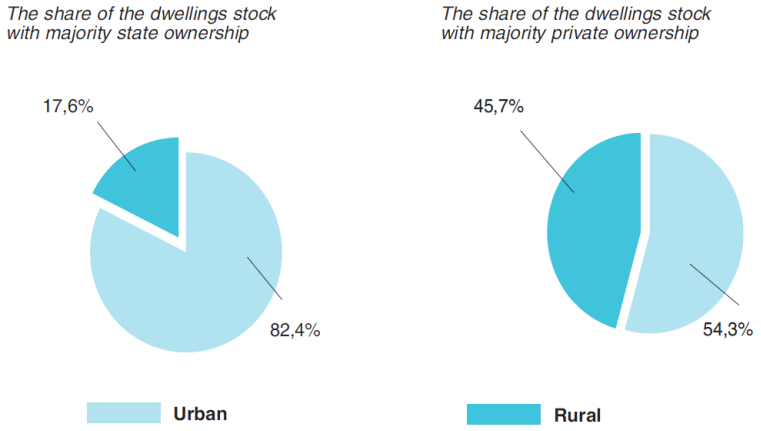


Figure 2-24 Dwellings stock, by type of ownership and by area of residence, in 2020

Source: National Institute for Statistics – Romanian Statistical Yearbook 2021

Figure 2-25 shows the houses completed in 2015 and 2020 by residence.

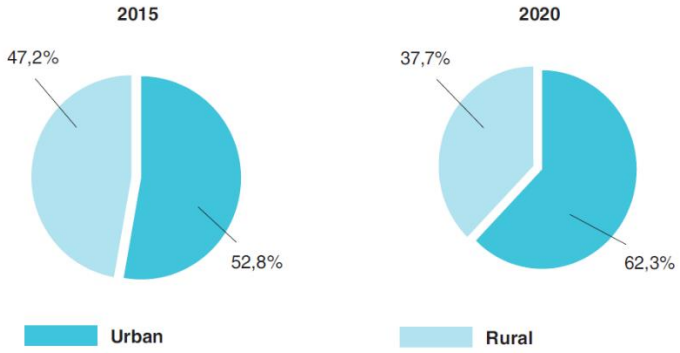


Figure 2-25 Completed dwellings, by area of residence

Source: National Institute for Statistics – Romanian Statistical Yearbook 2021

Figure 2-26 shows the evolution of completed housing in the period 2015-2020 depending on the financing sources

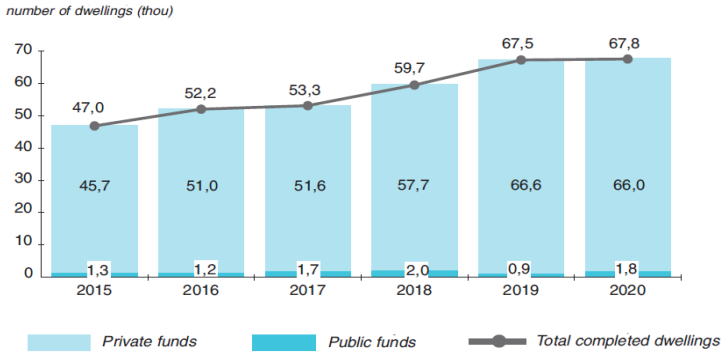


Figure 2-26 Completed dwellings, by financing sources

Source: National Institute for Statistics – Romanian Statistical Yearbook 2021

Figure 2-27 shows the evolution of houses completed in 2015 and 2020 after their endowment in the urban and rural environment and the funds used.

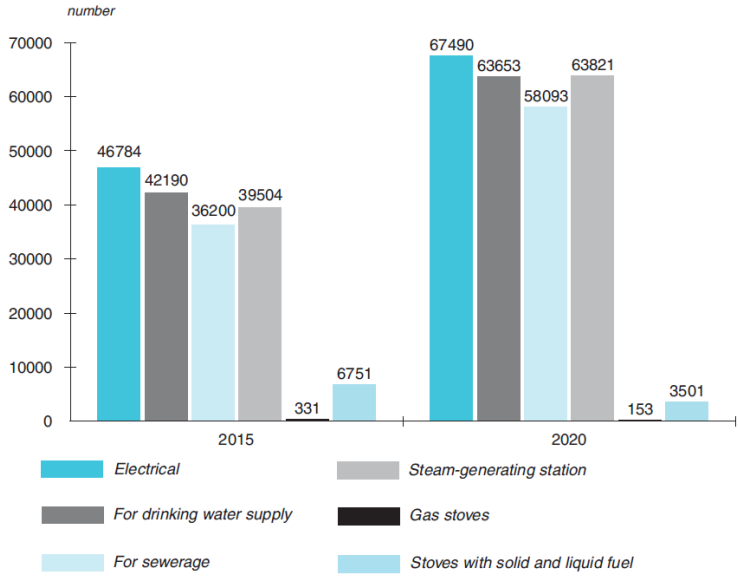


Figure 2-27 Completed dwellings, by type of installation they are endowed with, in 2020

Source: National Institute for Statistics – Romanian Statistical Yearbook 2021

Table 2-20 shows the finished houses, according to the types of installations with which they are equipped, and the financing funds in the period 2018-2020.

Table 2-20 Completed homes, according to the type of equipment and financing funds, in 2020

Type of installation	Year			Of these from private fonds
	2018	2019	2020	
TOTAL	**59713**	**67486**	**67816**	**57.709**
Electric	59646	67386	67490	57.642
Water supply	55808	63526	63653	53805
Sewerage	49664	57358	58093	47661
Heat plant (including district heating)	54246	62498	63621	52274
Natural gas stoves	168	125	153	168
Stoves with solid fuel and wood	4950	4473	3501	4926
Urban	**34896**	**40564**	**42238**	**32906**
Electric	34887	40553	41960	32897
Water supply	33416	38685	40302	31426
Sewerage	32791	37911	39671	30804
Heat plant (including district heating)	33912	39630	41568	31953
Natural gas stoves	41	30	48	41
Stoves with solid fuel and wood	786	773	522	763
Rural	**24817**	**26924**	**25578**	**24803**
Electric	24759	26835	25530	24745
Water supply	22392	24841	23351	22375
Sewerage	16870	19447	18422	16857
Heat plant (including district heating)	20334	22868	22253	20321
Natural gas stoves	127	95	105	127
Stoves with solid fuel and wood	4164	3700	2979	4163

From the analysis of the presented data, the following conclusions result for the newly completed houses:

- less than 0.05% do not have access to electricity
- about 7% do not have access to drinking water
- between 15% and 17% do not have access to sewage
- about 90% have thermal power plants
- in the rural area, about 16% of homes are built with solid fuel and wood stoves.

Figures 2-28, 2-29 and 2-30 show the evolution of the number of localities with drinking water supply facilities, with sewage facilities and with the natural gas distribution network in the period 2010-2020. The investments made in these types of utilities have increased due to the increase in the standard of living.

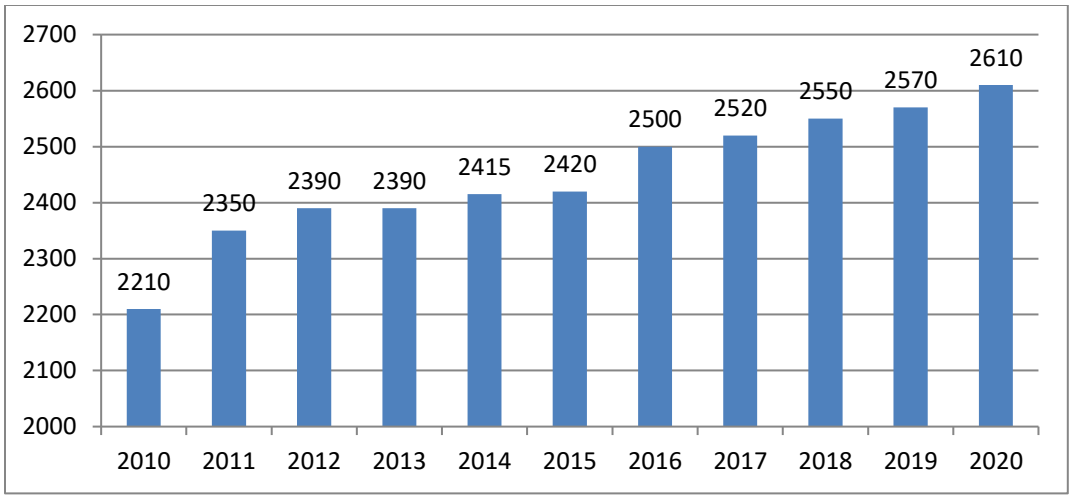


Figure 2-28 The evolution of the number of localities with drinking water installations

Source: National Institute of Statistics – Romanian Statistical Yearbook 2021

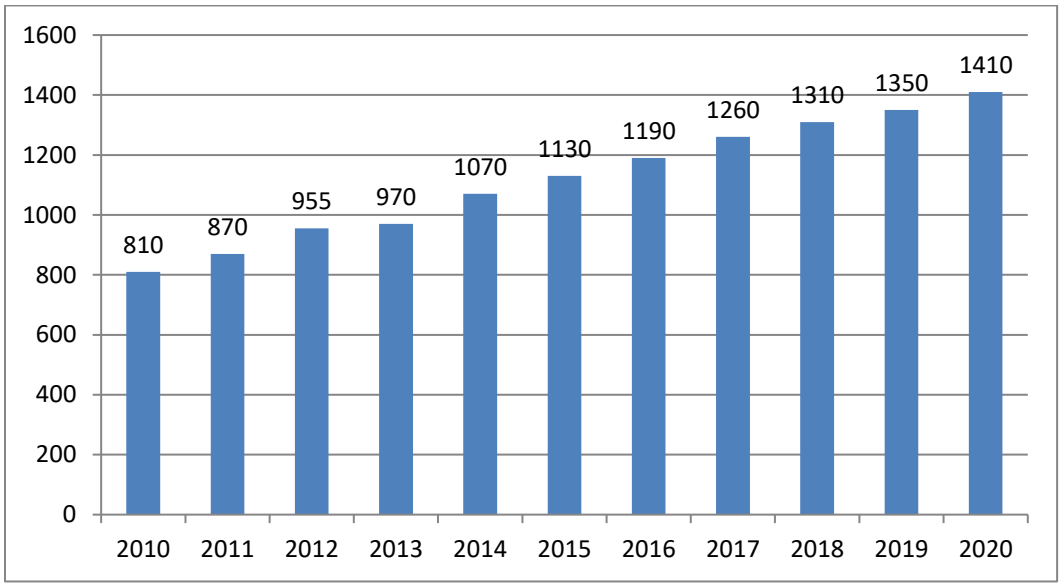


Figure 2-29 Evolution of the number of localities with sewerage facilities

Source: National Institute of Statistics – Romanian Statistical Yearbook 2021

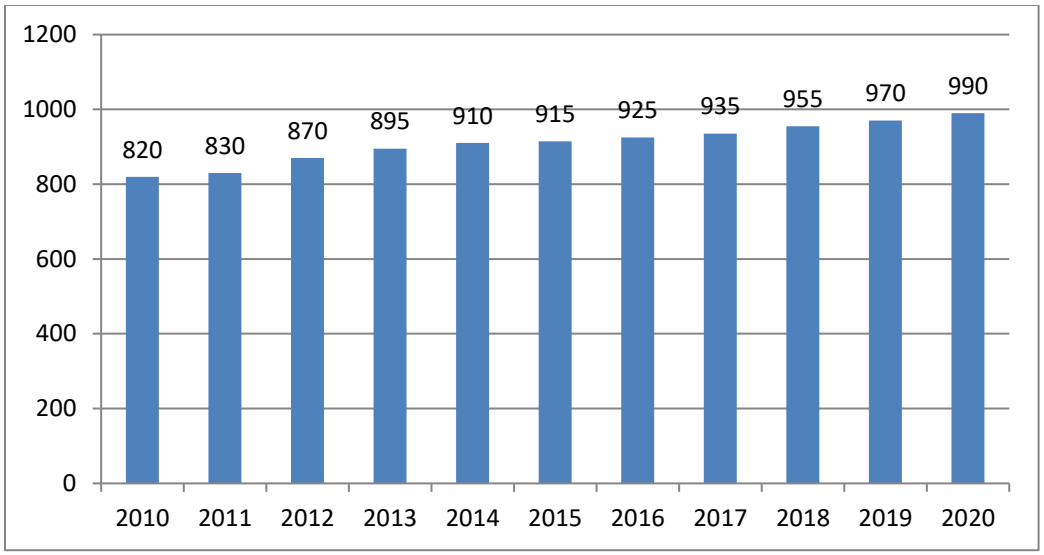


Figure 2-30 The evolution of the number of localities with a natural gas distribution network

Source: National Institute of Statistics – Romanian Statistical Yearbook 2021

Regarding public transport systems, since the 1990s there has been a sharp downward trend in the number of localities with public transport services from 175 to 97 in 2007, starting to increase again reaching 150 in 2011 (101 localities in the urban environment and 49 localities in the rural environment). It is estimated that in 2020 there are around 160 public transport systems.

In the period 2018-2020, the length of city streets increased from 31,548 km to 31,893 km, modernizing around 70%.

Figure 2-31 shows the passengers transported in local public transport, by types of transport vehicles, in 2020.

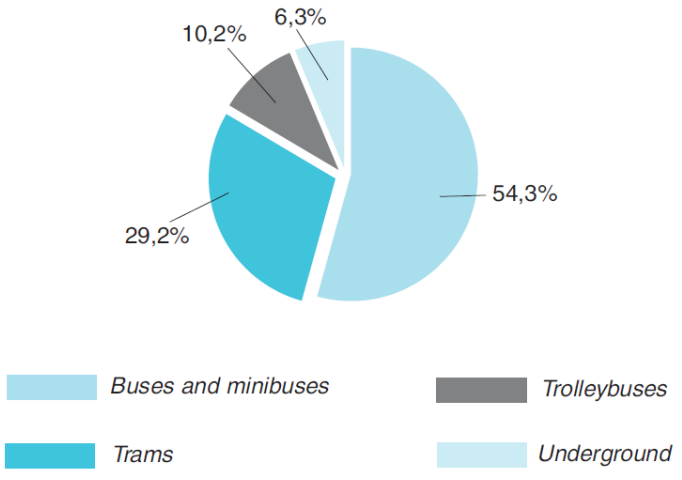


Figure 2-31 Passengers transported in local public transport, by type of transport vehicle in 2020

Source: National Institute of Statistics – Romanian Statistical Yearbook 2021

Table 2-21 presents information on the length of the single line for trams, trolleybuses, metro as well as the number of vehicles (trams, buses and minibuses, trolleybuses, metro) in the period 2018-2020.

Table 2-21 Characteristics of local public transport in the period 2018-2020

	2018	2019	2020
Length of the single transport line, km			
• Trams	837,0	836,9	828,9
• Trolleybuses	466,4	471,9	443,1
• Subway	171,4	171,4	188,9
Number of vehicles in inventory			
• Trams(wagons)	1203	1105	1102
• Buses and minibuses	4709	4948	5146
• Trolleybuses	537	527	516
• Subway (wagons)	594	594	574

Source: National Institute of Statistics – Statistical yearbook of Romania 2021

Table 2-22 presents information on local public passenger transport by types of transport vehicles.

Table 2-22 Local public transport by types of transport vehicles, in the period 2018-2020

	2018	2019	2020
TOTAL passengers (thousand)	1.863.981[1]	1.763.285[1]	1.428.035
Trams	463.165[1]	468.722[1]	416.854
Buses and minibuses	1.071.581[1]	962.337[1]	775.570
Trolleybuses	149.532[1]	153.056[1]	145.540
Subway	179.703	179.170	90.071

1 The data do not include, for the year 2018 and the first and second trimesters of 2019, retired passengers residing in the Municipality of Bucharest, beneficiaries of gratuities according to the provisions of the H.C.G.M.B. no. 139/2006.

Source: National Institute of Statistics - Yearbook of Romania

In the period 2018-2020, the length of the single line for the public transport infrastructure (tram and trolleybus) recorded a downward trend similar to the trend in the period 2015-2017.

The number of vehicles had a different evolution; the number of trams and trolleybuses has steadily decreased, while the number of buses and minibuses has increased.

An increase in the level of greenhouse gas emissions in cities would be expected because electric trams and trolleybuses have been reduced and replaced by buses and minibuses that consume petrol or electricity.

The metro, a means of transport specific to the capital Bucharest, has registered a positive evolution and there is a strategy regarding the development of the metro in the period 2022-2030.

There are large discrepancies between rural and urban areas in terms of public transport services, which are provided in 33% of villages in rural areas compared to 67% in urban areas.

Romania has an important heritage of buildings built, predominantly, in the period 1960-1990, with a low degree of thermal insulation, a consequence of the fact that, before the energy crisis of 1973, there were no regulations regarding the thermal protection of buildings and perimeter elements of closure, and which are no longer suitable

for the purpose for which they were built. The final energy consumption of these buildings varies between 150 and 400 kWh/m2 per year.

After Romania's accession to the European Union, the first National Action Plan in the field of Energy Efficiency (PNAEE, 2007 - 2010) was approved.

During the preparation of the second PNAEE, it was highlighted that the total value of the final energy savings achieved in 2010 was 2223 thousand toe, far exceeding the assumed target of 2800 thousand toe for the year 2016. Within the second PNAEE, it was established the national target for primary energy savings in 2020.

In accordance with the 3rd and 4th National Energy Efficiency Action Plan, the thermal rehabilitation of the buildings was carried out in accordance with the "Strategy regarding the mobilization of investments in the renovation of the stock of residential and commercial buildings, both public and private, existing at the national level.

K. Agriculture

Agriculture is an important sector in the Romanian economy contributing during 2005 - 2020 with 4 – 10 % of GDP, depending on the year and climatic conditions. Although agriculture was collectivized by the government in 1949, a land reform program instituted in 1991 returned more than 80% of the country's agricultural land to nearly 5.5 million small farmers.

The Romanian agricultural surface decreased slightly from year to year. Transfer of land to forestry and building sector was the main cause of reducing agricultural area in the past 20 years. The main crops on arable land are:

- Cereals for grains (wheat, rye, barley, maize etc.)
- Dried legumes (peas, dried beans)
- Roots crops (potatoes, sugar beet, fodder roots)
- Industrial crops (fiber crops, oilseed crops, etc.)
- Vegetables (tomatoes, dry onion, dry garlic, cabbage, green peppers, melons)
- Green fodder from arable land.

GHG emissions related to agricultural sector are due to:

- Fuel combustion (CO2)
- Enteric fermentation (CH4)
- Manure management (CH4 and N2O)
- Rice cultivation (CH4)
- Agricultural soils (N2O)
- Field burning of agricultural residues (CH4, N2O)
- Urea application (CO2)
- Liming (CO2)

At the level of 2020, methane emissions from enteric fermentation represented 86.07% of total methane emissions from agriculture, and 6.57% of total national GHG emissions. In terms of waste management, methane emissions accounted for 7.44% and nitrous oxide 10.81%, together contributing 0.57% to the national total of GHG emissions.

Livestock dynamics from the data provided by the NIS (National Institute of Statistics) in 2022shows that in 2020 pig and cattle herds decreased by 33.1% and 9.8%, respectively, and sheep and goats increased by 15.8% and 3.5%, respectively of those recorded in 2010. In addition, the Work Volume in agricultural holdings, expressed in

annual work units (UAM), in 2020, recorded a decrease of approx. 39% compared to that recorded in the General Agricultural Census of 2010[15].

Based on the report of the National Institute of Statistics on the Structural Investigation in Agriculture (2016) and the Agricultural Census (2020 – provisional data), the structure and legal status of farms, respectively the percentage of animals in households (entities without legal personality) or in industrial system is known. For pig herds, in the data request address of the Ministry of the Environment to the Ministry of Agriculture and Rural Development, it was established that 50% of the herd is in an industrial exploitation system, with a system for collecting manure on grates and a water cushion.

According to the data published by the NIS in 2017, regarding the Structural Investigation in Agriculture (2016), the structure of farms is as follows:

- for dairy herds, 82.25% were in holdings without legal personality, which can be assimilated to individual households or subsistence farms (with 1-2 heads or 3-9 heads)
- for the total herds of cattle, 95.74% are in holdings without legal personality
- 67.86% of the poultry flocks are in holdings without legal personality, as well as 98.73% of the horse flocks
- 45.84% of the total herds of pigs are found in the industrial system.

These data regarding the structure of animal husbandry in 2016, in the opinion of the expert, have not changed significantly in 2022, but other factors intervene that can change these weights, such as:

- The COVID 19 pandemic, which caused a numerical decrease in the population employed in animal husbandry, either because of contacting the disease or death (2019-2021)
- The aging of the population in this agricultural sector and not replacing it with younger people
- The increase in the price of energy, which determined the closure of some large farms (especially of dairy cows), in whose cost structure, energy occupied the largest percentage
- Bird flu from 2021
- Swine fever (2020-2021).

Regarding poultry flocks: the statistical data shows a polarization of farms according to technology and, implicitly, from the point of view of capital, i.e., very rich farms and very poor farms, the latter being predominant, with a percentage of over 55 %.

At the level of 2017, the birds exploited in the intensive system represented 44.15% of the total flock of birds, and in the household system, 55.85% of the total. If an average is made per household, compared to the more than 1,800,000 peasant households in the ANSVSA (National Sanitary, Veterinary and Food Safety Agency) records, the result is an average livestock per household of approximately 24 birds, which have a low genetic potential, unbalanced fodder recipes and small productions.

By type of production: laying hens represents 40.90% of the total flock, and in the broiler sector the percentage is 59.10%[16].

[15] https://insse.ro/cms/sites/default/files/com_presa/com_pdf/rga_2020r.pdf
[16] https://www.revista-ferma.ro/articole/zootehnie/gaina-multimilionara-avicultura-intre-statistici-si-proiecte-tip

The breakdown of GHG emissions by animal breeding systems is particularly important, because many parameters differ in the two systems (the level of ingested energy – GE and excreted nitrogen - Nex, the number of days of housing, or the number of days of life in fattening animals – broiler pigs for fattening.

Regarding the manure management system, based on the data provided by the Animal Husbandry Policy Directorate (MADR - Ministry of Agriculture and Rural Development), the liquid storage (sludge) is found in pigs, in a proportion of 50% (industrial system), the rest of the categories using solid storage, 100%.

Although the number of farms in the household system (subsistence farms) is high, due to the implementation of the regulations related to the Nitrates Directive and the Code of Good Agricultural Practices, the farmers who receive subsidies from APIA (Agency for Payments and Interventions in Agriculture) respect the eco-conditionality and environmental protection rules.

The number of animals and animal production from 2005-2018-2020 are presented in tables 2-23 and 2-24.

Table 2-23 Number of animals reported in 2005, 2018, 2019 and 2020

NFR Category	Category	Year			
		2005	2018	2019	2020
3B1a	Dairy cows	1626000	1143000	1124000	1107000
3B1b	Non-dairy cows	1191000	815000	779000	749000
3B2	Sheep	7611000	10176000	10358000	10281000
3B3	Fattening pigs	6128000	3616000	3525000	3469000
3B3	Sows for reproduction	494000	309000	308000	316000
3B4a	Buffalo	45000	19000	19000	20000
3B4d	Goats	687000	1539000	1594000	1612000
3B4e	Horses	834000	448000	406000	408000
3B4gi	Laying hens	49725000	38134000	40728000	36525000
3B4gii	Broilers	36827000	35859000	34636000	34412000
3B4h	Rabbits	570000	259000	275000	254000

Data presented regarding the number of animals reveal a drastic decrease in the herds of bulls, pigs, buffaloes, horses, and rabbits, in 2020, compared to the reference year, 2005. Birds also decreased as a herd, but the decrease did not is significant. The flocks of sheep and goats register increases in the number of animals.

Table 2-24 Livestock production, by product type, reported in 2005, 2018, 2019 and 2020

Production	Year			
	2005	2018	2019	2020
Cow and buffalo milk (thousands hl)	60614	46471	46161	46357
Sheep and goat milk (thousands hl)	5280	6094	6407	6455
Wool (tons)	18390	23459	23824	23289
Eggs (million pieces)	7310	5713	5564	5446
Extracted honey (tons)	17703	29162	25269	30724

Considering the animal production, a decrease in the milk production of cows and buffaloes are registered, while the milk of sheep and goats are increases (following the dynamics of the herds of these species). Egg production

decreased in 2020 compared to 2005, although flocks did not show significant decreases, which means that the share of laying hens in the total number of birds was lower than that of broilers.

Following the enforcement of the restitution laws in 2010 almost all the total agricultural surface was privatized. In the present public property fields account for only 0.5% of arable land, 0.7% of pastures total area and 0.2% of meadows total area.
In 2020, in Romania there were 2887 thousand agricultural holdings that used 12.8 million hectares of agricultural land. Provisional results of the General Census Agricole round 2020 shows that, within 10 years, the number of agricultural holdings has decreased by 972 thousand, respectively by 25.2%, and the used agricultural area decreased by 543 thousand ha, respectively by 4.1% with the following structure:

- the number of agricultural holdings without legal personality was 2862 thousand, 25.3% lower than in 2010
- the number of agricultural holdings with legal personality was approx. 25 thousand, 17.3% lower than in 2010.
- agricultural holdings under 1 ha, although they represented 54.0% of the total number, used only 4.6% of the agricultural area
- agricultural holdings with sizes between 1 and 5 ha represented 36.3% of the number total and used 18.2% of the agricultural area
- large agricultural holdings, over 50 ha, had a very small share (approx. 1%) in terms of their number, but they used 54.0% of the surface agricultural.

A large part of the used agricultural area (44.6%) is owned by those who uses. In 2020, from the point of view of ownership of the used agricultural area, owned areas including common land (48.9 %) and leased (37.5%) had the largest shares.

Privatization process of arable land generated in Romanian agriculture two structural disadvantages: large area of fields and small farms, and large area of fields owned by farmers at retirement age.
Almost half of the total surface and livestock exist in subsistence farms which diminishes the agriculture sector performance. To strengthen the subsistence farms and make them become viable and competitive restructuring measures are required. Associative actions will play an important role.

L. LULUCF

LULUCF Sector plays a key role in the economy, ecology, and culture of the Romania and have the following structure: (i) forests, (ii) cropland, (iii) grassland, (iv) wetlands, (v) built areas and roads/railways, (vi) other lands. Figure 2-32 below shows the subcategories structure related to LULUCF Sector, respectively their % distribution, according to their activity data (kha).

Figure 2-32 LULUCF Sector structure

Sequestration was primarily the result of carbon uptake by standing Romania's forests, forest management, increased tree covers in urban areas, storage in harvested wood products, and the management of agricultural soils. Natural disturbances such as wildfires, drought, pest outbreaks, and wind throw may also increase over time, further affecting the rate of net sequestration. The net impact on emissions over time depends on the specific event, and on subsequent policy responses. Many of the grasslands are used for livestock grazing or have been converted to cropland or settlements, but others remain in their natural state and serve as habitat for numerous native and migratory species while also preserving soil resources and storing carbon in soils and perennial biomass.

Table 2-25 Land use in Romania

LU	1989 (kha)	2000 (kha)	2010 (kha)	2020 (kha)
Forests	6864.23	6919.32	6969.4	6989.47
Arable land	8509.1256	7759.9046	6946.4186	6146.1286
Vineyards	489.2814	661.7764	766.0264	707.9764
Orchards	531.9046	694.0446	976.9046	1103.5346
Grassland woody	311.6377	429.6197	500.4617	517.7717
Grassland grassy	4678.2566	4658.6046	4775.9526	5330.7626
Settlement	1281.8771	1409.3571	1449.0671	1547.0671
Wet areas with vegetation	423.6179	449.6999	520.8019	558.3619
Waters/ponds	335.5919	410.2899	465.6679	466.2479
Other lands	413.4949	446.4009	468.3169	471.6969

LULUCF's Sector greenhouse gas emissions related to GDP. Figure 2-33 shows the most significant trend indicator of GDP and GHG emissions, related to LULUCF Sector, decoupling which was achieved in Romania in past years. Also, the evolution of the last inventory year, 2020, is evidence of the continuation of the decoupling process started in 2008, whereby carbon emissions did not follow GDP growth. It is also expected that a similar trend will continue in the future, in accordance with EC/COM policies and measures, respectively with the planned investments in the step-by-step construction of a carbon-neutral AFOLU Sector.

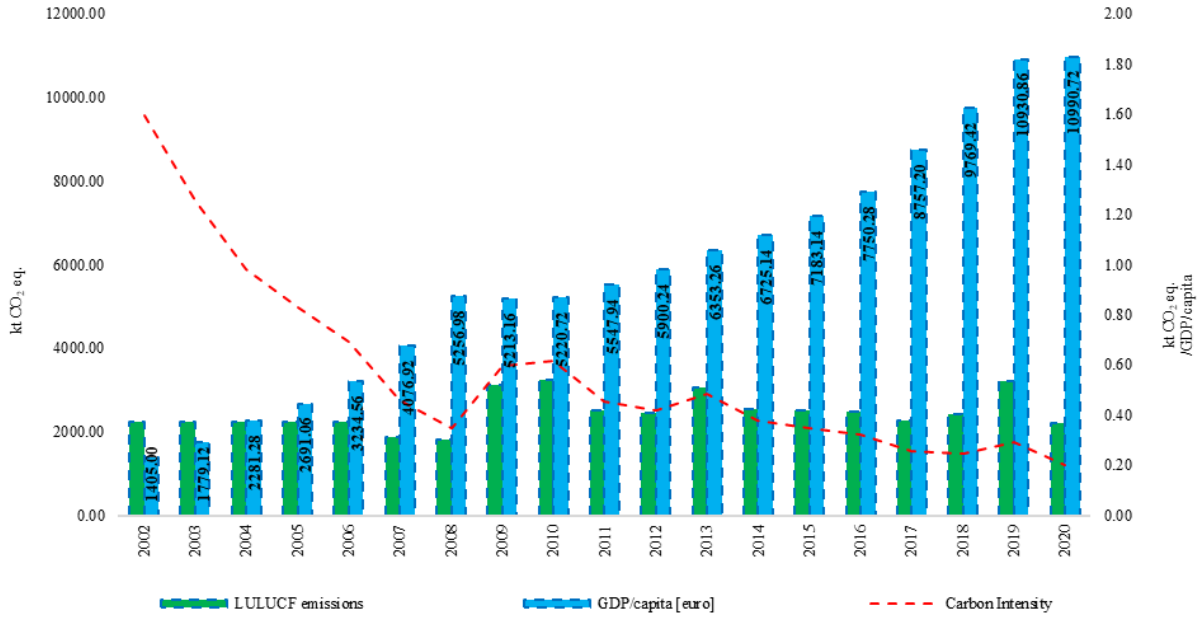


Figure 2-33 Carbon intensity related to the LULUCF Sector

3. GREENHOUSE GAS INVENTORY INFORMATION

This chapter presents information on 2022 (last) submission of Romania's National GHG Inventory (NGHGI) of anthropogenic greenhouse gas emissions, submission to the UNFCCC Secretariat. The national greenhouse gas emissions/removals estimates were calculated for the period 1989-2020. The results are presented for every year of the analyzed period and include information on trend analysis, data sources, key categories, uncertainties, and quality assurance and quality control (QA/QC) activities. The 2022 submission comprises the CRF Reporter database, CRF Tables and the National Inventory Report (NIR).

As a Party to the Convention, Romania is required to develop and regularly update the National GHG Inventory. The last NGHGI for the period 1989–2020 was compiled according to the recommendations for GHG inventories set out in the Updated UNFCCC reporting guidelines on annual inventories (FCCC/CP/2013/10/Add.3), using IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006) as well as associated support documents (2013 Revised Supplementary Methods and Good practice Guidance Arising from the Kyoto Protocol; 2013 Supplement to the 2006 Guidelines for the National Greenhouse Gas Inventories: Wetlands).

The last NGHGI submission covers the obligation of Romania under the UNFCCC. It also constitutes Romania's voluntary submission under the Kyoto Protocol. The inventories cover all sectors and most of the IPCC source categories. The direct GHG (including groups of gases) included in the national inventory are:

- Carbon dioxide (CO2)
- Methane (CH4)
- Nitrous oxide (N2O)
- Hydrofluorocarbons (HFCs)
- Perfluorocarbons (PFCs)
- Sulphur hexafluoride (SF6)
- Nitrogen trifluoride (NF3)

The report also contains data on calculations of emissions of the indirect GHGs: NO_x, NMVOC, CO and SO_2, which should be included according to the reporting guidelines. GHG emissions inventories have been reported since the 2005 submission using the CRF Reporter software, delivered by the UNFCCC Secretariat. The last NGHGI refers to figures generated using the 6.0.1.1 version of the CRF Reporter.

The GHG inventories submitted annually by Parties are subject to reviews by expert review teams (ERT), coordinated by the UNFCCC Secretariat. Up to now, the GHG inventories of Romania were reviewed as follows:

Table 3-1 Information on reviews of the Romanian NGHGIs coordinated by the UNFCCC Secretariat

Year	Submission	Review process
2002	CRF tables and draft NIR submitted (late submission)	No Review
2003	CRF tables and NIR submitted	In - country Review
2004	CRF tables and NIR submitted	Desk Review
2005	CRF Reporter database, CRFs for LULUCF and NIR submitted	Centralized Review
2007	2nd version of the 2006 submission: CRF Reporter database, CRF Tables and NIR + Initial Report of Romania under the Kyoto Protocol	In - country Review
2008	2007 and 2008 submissions: CRF Reporter database, CRF Tables and NIR	Centralized Review
2009	2009 submission: CRF Reporter database, CRF Tables and NIR	Centralized Review

2010	2010 submission: CRF Reporter database, CRF Tables and NIR	Centralized Review
2011	3rd version of the 2011 submission	In - country Review
2012	2nd version of the 2012 submission	Centralized Review
2013	1st version of the 2013 submission	Centralized Review
2014	1st version of the 2014 submission	Centralized Review
2016	2nd version of the 2015, 2016 submissions	Centralized Review
2018	3rd version of the 2018 submission	In - country Review
2019	3rd version of the 2019 submission	Centralized Review
2020	9th version of the 2020 submission	Centralized Review
2022	7th version of the 2022 submission	Centralized Review

The ERT's reports following these reviews can be found on the UNFCCC website.

A. Summary tables

Summary tables on emission trends by gases and by sectors are presented, using the common reporting format, for 1989-2020, in BR5, CTF Table 1.

B. Descriptive summary

B.1. GHG emissions evolution

The total GHG emissions in 2020, excluding removals by sinks, amounted to 110,366.83 kt CO_2 equivalents. The total GHGs emissions (without considering sinks) decreased by 64.09% in 2020 in comparison to 1989 while the net GHG emissions/removals (considering the CO2 removals) decreased by 72.90% (Figure 3-1).

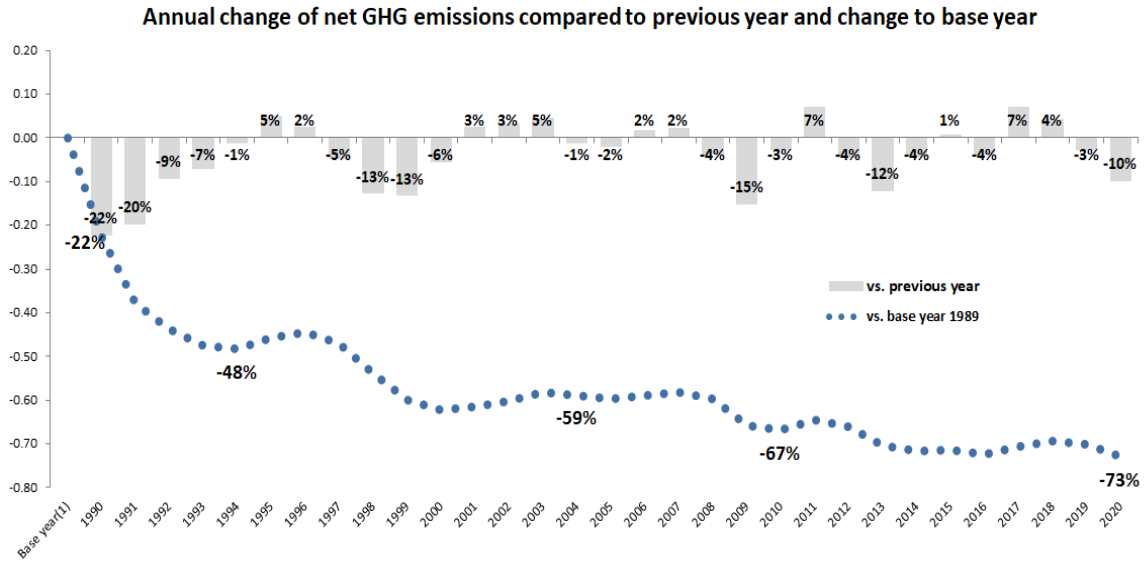


Figure 3-1 Annual change of net GHG emissions compared to previous year and change to base year

The emissions trend presented in Figure 3-1 reflects the changes in this period characterized by a process of transition to a market economy and integration into European Union. The emissions trend can be split in three

parts: the period 1989-1999, the period 2000-2007 and the period 2008-2015. The decline of economic activities and energy consumption in the period 1989-1992 had directly caused the decrease of the total emissions in that period. With the entire economy in transition, some energy intensive industries reduced their activities, and this is reflected in the GHG emissions reduction. Emissions have started to increase until 1996, because of the economy revitalization. Considering the starting of the operation of the first reactor at the Cernavoda nuclear power plant (1996), the emissions decreased again in 1997. The decrease continued until 1999. The increased trend after 1999 reflects the economic development in the period 2000-2007. The limited decrease of GHG emissions in 2005, compared with 2004 and 2006 levels was caused by the record-breaking hydrological year positively influencing the energy produced in hydropower plants. Due to the economic crisis, the emissions have significantly decreased in 2010 comparing with 2008. The trend of GHG emissions during the period 2010-2015 was relatively constant. In 2017-2018, GHG emissions slowly increased following the economic activities level, followed by a downward trend starting in 2019, due to the COVID-19 pandemic situation.

B.2. Emissions trends by gas

According to Romania's most recent inventory submitted to the UNFCCC in 2022, all GHG emissions, except HFCs and SF6, decreased compared with the base year, as depicted in Figure 3-2.

Carbon dioxide (CO2) – the most significant anthropogenic greenhouse gas is carbon dioxide. The decrease of CO2 emissions (from 210,970.96 kt in 1989 to 74,138.01 kt in 2020) is caused by the decline of the amount of fossil fuels burnt in the energy sector (especially in the public electricity and heat production, and manufacturing industries and constructions sectors) because of activity decline.

Methane (CH4) – the methane emissions, related mainly to the fugitive emissions from fossil fuels extraction and distribution and to the livestock, decreased in 2020 by 65.25% compared with the level in 1989 (from 65,484.39 kt $CO2_{eq}$ in 1989, to 23,197.83kt $CO2_{eq}$ in 2020). The decrease of CH4 emissions in agriculture is due to the decrease of the livestock level.

Nitrous oxide (N2O) – the N2O emissions are mainly generated within the Agricultural Soils activities in the agriculture sector and within the chemical industry activities in the industrial processes sector. The decline of these activities (decline of livestock, decline of N synthetic fertilizer applied on soils amounts, decrease of the crop productions level) is reflected in the N2O emissions trend. The N2O emissions in 2020 decreased by 58.06% in comparison with the level in the base year (from 26,143.75kt $CO2_{eq}$ in 1989, to 10,994.51 kt $CO2_{eq}$ in 2020).

Fluorocarbons and SF6 (HFCs, PFCs, SF6) – Fluorocarbon emissions showed a strong decrease (99.92% in 2020 comparing with the level in 1989) for the PFCs emissions from the primary aluminum production and an increase for HFCs and SF6 emissions.

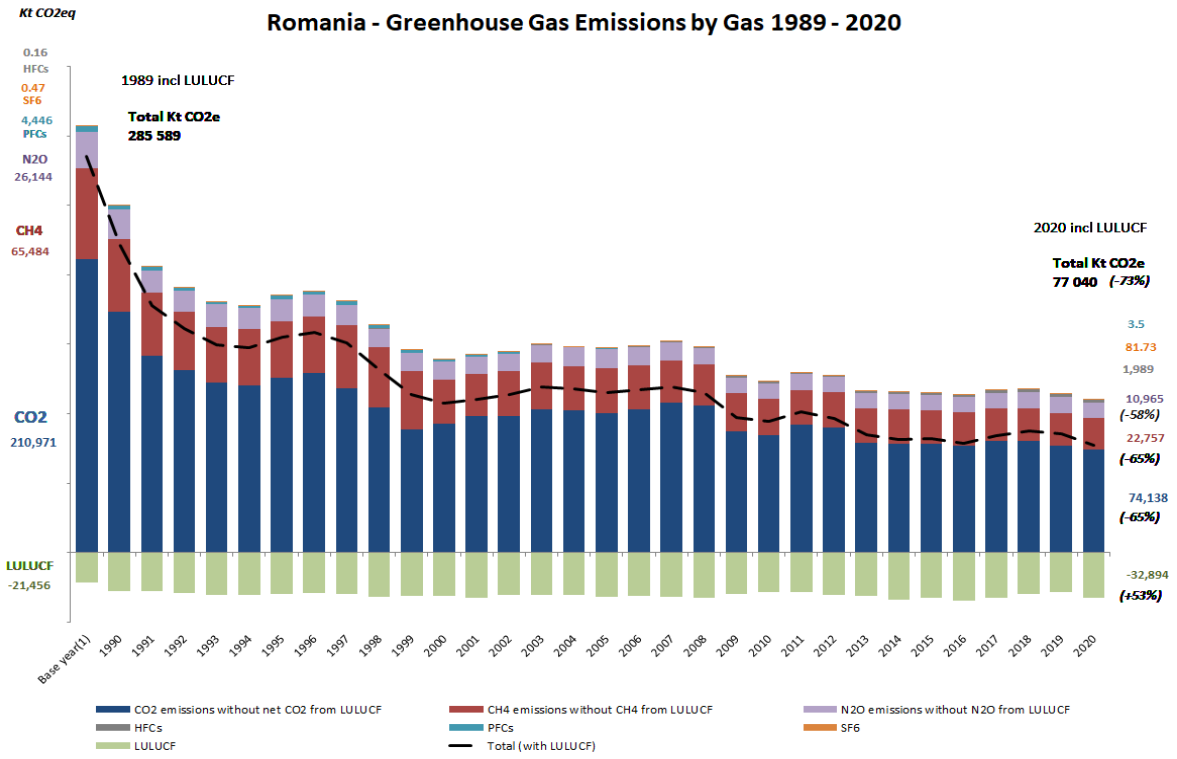


Figure 3-2 Greenhouse gas emissions by gas 1989 - 2020

The chart in Figure 3-3 shows that the shares of GHG emissions have not significantly changed during the analyzed period. The largest contributor to total GHG emissions is CO2, followed by CH4 and N2O.

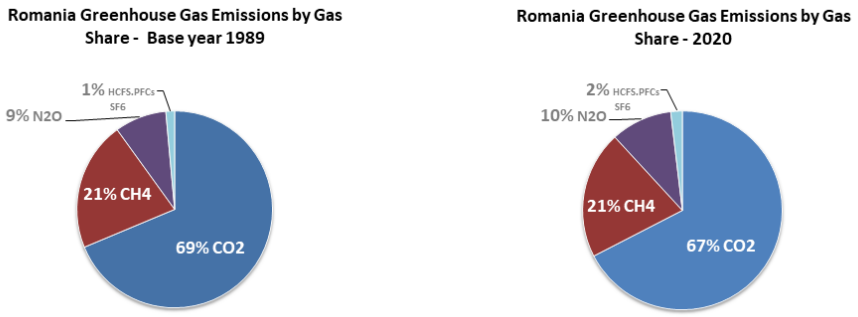


Figure 3-3 Romania's GHG gas emissions by gas; base year (left); 2020 (right)

In the base year, the shares of GHG emissions (excluding LULUCF) were: 68.71% CO2, 21.33% CH4, 8.51% N2O, 1.45% PFCs; the HFCs and SF6 are negligible (0.16 kt CO2 eq. for HFCs and 0.47 kt CO2 eq. for SF6). In 2020, excluding LULUCF, the largest contributing substance to the GHG emissions is CO2, amounting to 67.44% of total emissions, followed by CH4 with 20.70% and N2O with 9.97%. The F gases started to be used as substitutes for ODS in refrigerating and air conditioning systems since 1991. In 2020, the contribution of these gases to the total GHG emissions is negligible: 1.81% HFCs, 0.0032% PFCs and 0.07% SF6.

B.3. Emissions trends by sector

According to Romania's national inventory report submitted to the UNFCCC in 2020, the sectors that contribute the most to the total GHG emissions are the energy sector, industrial processes and product use, agriculture and LULUCF. Figure 3-4 depicts the decreasing trend in the evolution of GHG emissions/removals by sectors during 1989 - 2020 period.

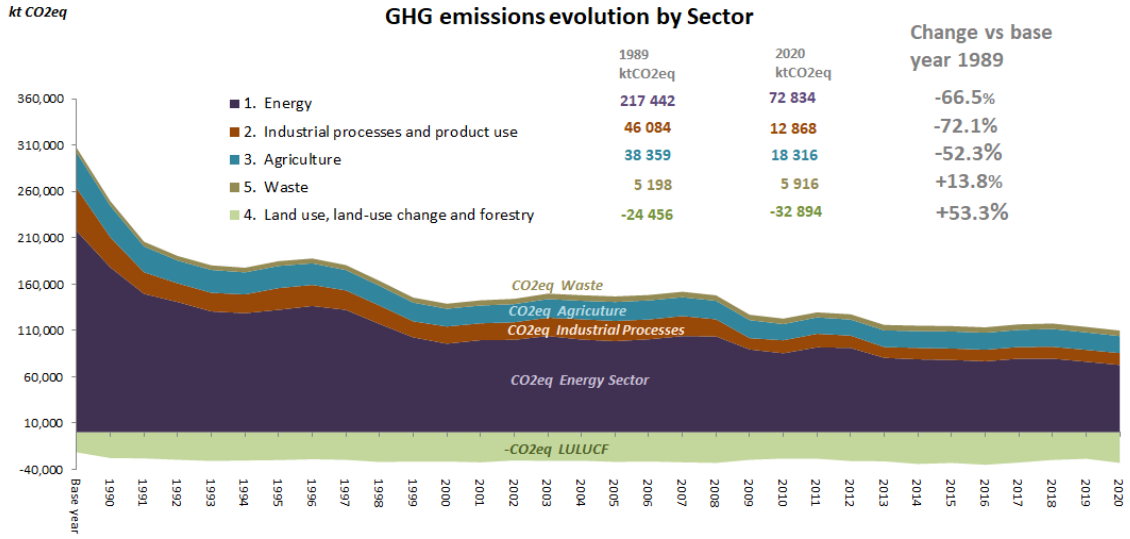


Figure 3-4 The evolution of GHG emissions/removals by sector

Energy represents the most important sector in Romania. In 2020, the GHG emissions (excluding LULUCF) from the energy sector decreased by 66.25% compared with the base year; the main reason for the reduction of the GHG emissions from the energy sector is the transition to a market-based economy, which led to a sharp drop in electricity production demand from power plants.

Industrial Processes and Product use contributes to total GHG emissions (excluding LULUCF) with 11.71%. The direct GHG emissions reported in this sector are associated with CO2, CH4, N2O, HFCs, PFCs, SF6. In 2020, mineral industry, metal industry and chemical industry have the highest share of GHG emissions of the Industrial Processes and Product Use sector, 36.67%, 29.87% and 13.13% respectively. Compared with 1989, GHG emissions from this sector have decreased by 72.06% in 2020, mainly due to the decline or the termination of certain production activities.

For the *Agriculture* sector, the GHG emissions have also decreased. The GHG emissions (excluding LULUCF) in 2020 are 52.25% lower in comparison with the 1989 emissions due to:

- the decline of livestock
- the decrease of rice cultivated area
- the decrease of crop productions level
- the decline of N synthetic fertilizer applied amounts.

For the *LULUCF*, the net GHG removals/emissions level is 53.31% higher in 2020 in comparison with the level in the base year. The Romanian land use sector acts as a net sink, at an average uptake of 20,531.11 kt/year, being relatively stable over the last 27 years.

For the *Waste* sector, the total GHG emissions (excluding LULUCF) have significantly increased in 2020 with 13.82 % in comparison with the level in 1989, due to the increase of population consumption in parallel with the increase of living standards. The contribution of the waste sector to the total GHG emissions (excluding LULUCF) in 2020 is 5.38%.

The participation of the sectors to GHG emissions (including LULUCF) is presented in Figure 3-5.

Figure 3-5 Sectorial GHG emissions; base year (left); 2020 (right)

In terms of the sectorial share of the total GHG emissions, in 2020, the Energy sector has the biggest share, amounting to 66.25%, followed by the Agriculture sector with 16.66% and Industrial Processes and Product use with 11.71%.

B.4. Description and interpretation of emissions trends

Energy

This chapter includes GHG emissions description in the Energy Sector. According to IPCC the following categories are included in this sector:

- 1.A.1 Energy industries
- 1.A.2 Manufacturing Industries and Construction
- 1.A.3 Transport
- 1.A.4 Other sectors (commercial/institutional, residential, agriculture/ forestry/ fisheries)
- 1.A.5 Other (stationary, mobile)
- 1.B Fugitive Emissions from Fuels
- 1.C CO2 Transport and storage
- 1.D Memo items.

Compared to the other GHG emissions sectors (Industrial Processes, Agriculture, LULUCF, Waste), the Energy sector represents the largest source of anthropogenic GHG emissions in Romania. In 2020, the Energy sector was responsible for about 66.25% of the total GHG emissions of 109,934.33 kt CO2 equivalent. The emissions trend reflects the changes in this period characterized by a process of transition to a market economy (Figure 3-6). In 2020, emissions from the Energy sector have decreased by 66.50% (72,834.34 kt CO2 equivalent compared to 217,441.87 kt CO2 equivalent in 1989, base year).

With the entire economy in transition, some energy intensive industries reduced their activities, and this is reflected in the GHG emissions reduction. The decline of economic activities and energy consumption in the period 1989-1992 had directly caused the decline in total emissions in that period. Emissions started to increase until 1994, because of economy revitalization. Considering the starting of the operation at the first reactor at the Cernavoda nuclear power plant (1996), the emissions started to decrease again. The decrease continued until 1999. The increased trend after 1999 reflects the economic development in the period 1999-2004. At the end of 2007, the second unit of the Cernavoda nuclear plant was functioning, therefore the decrease in emission trend is not very noticeable; for the period 2008-2010 it was noticed a slight tendency of decrease of emissions due to the economic crisis that had affected entire Europe.

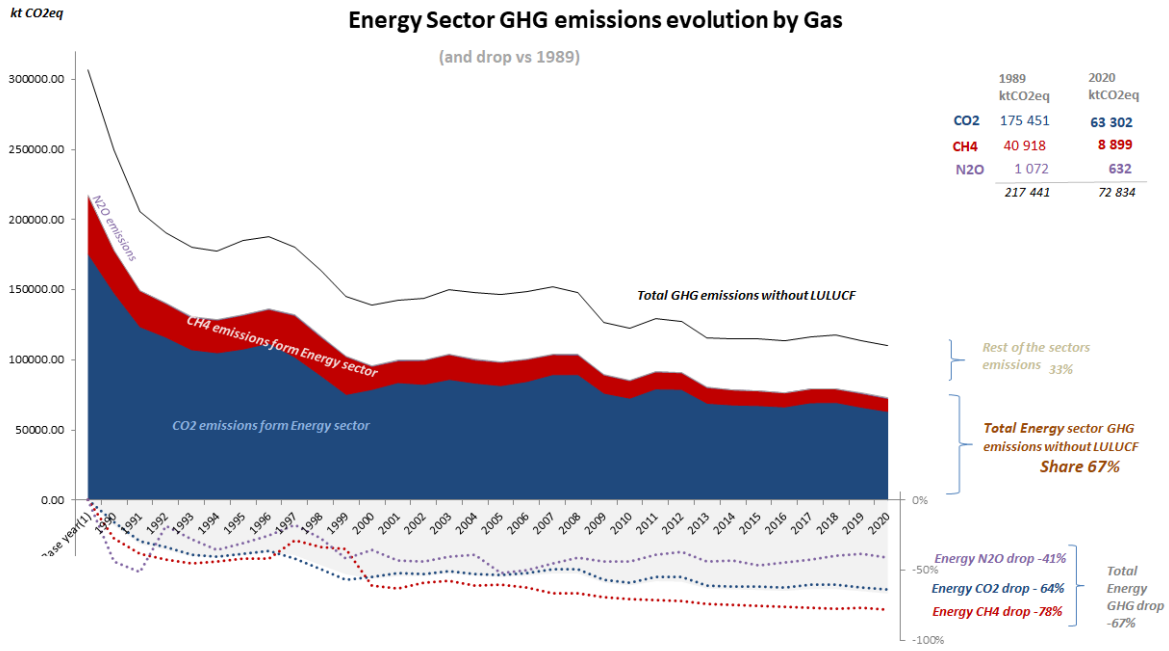


Figure 3-6 Energy sector GHG emissions evolution by gas

The main emissions from this sector are: CH_4, CO_2 and N_2O. In terms of evolution from base year, the most significant reduction was observed for CH_4 emissions (78%), followed by CO_2 (64%) and N_2O (41%), illustrated in Figure 3-6.

Figure 3-7 present the share of each emission within the Energy sector, from the total emissions, by gas. Therefore, in 2020, the CO_2 emissions contribution from Energy sector add up to 58 % from the total CO_2 equivalent emissions in all sectors, CH_4 emissions represent 8% and N_2O emissions represent 1 %.

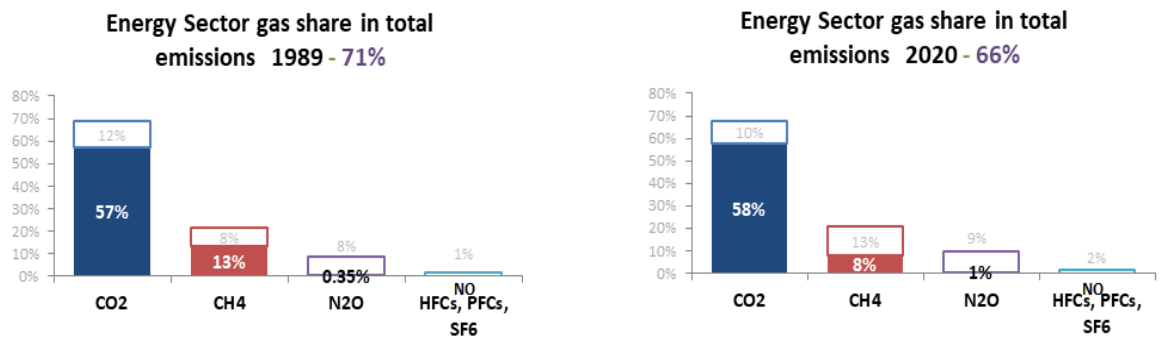


Figure 3-7 Energy sector gas share in total emissions

In 2020, the Energy sector contributes with 66 % to the total GHG emissions. The total emissions of the Energy sector showed a decrease by 67%, 72,834 kt CO2 eq. compared to 217,442 kt CO2 eq. in 1989 (base year), illustrated in Figures 3-8 and 3-9. Within this category, the main contributing sub-sectors are Energy industries (with a share of 25% of total emissions from the Energy sector), Transport (25%) and Manufacturing Industry and Construction (20%).

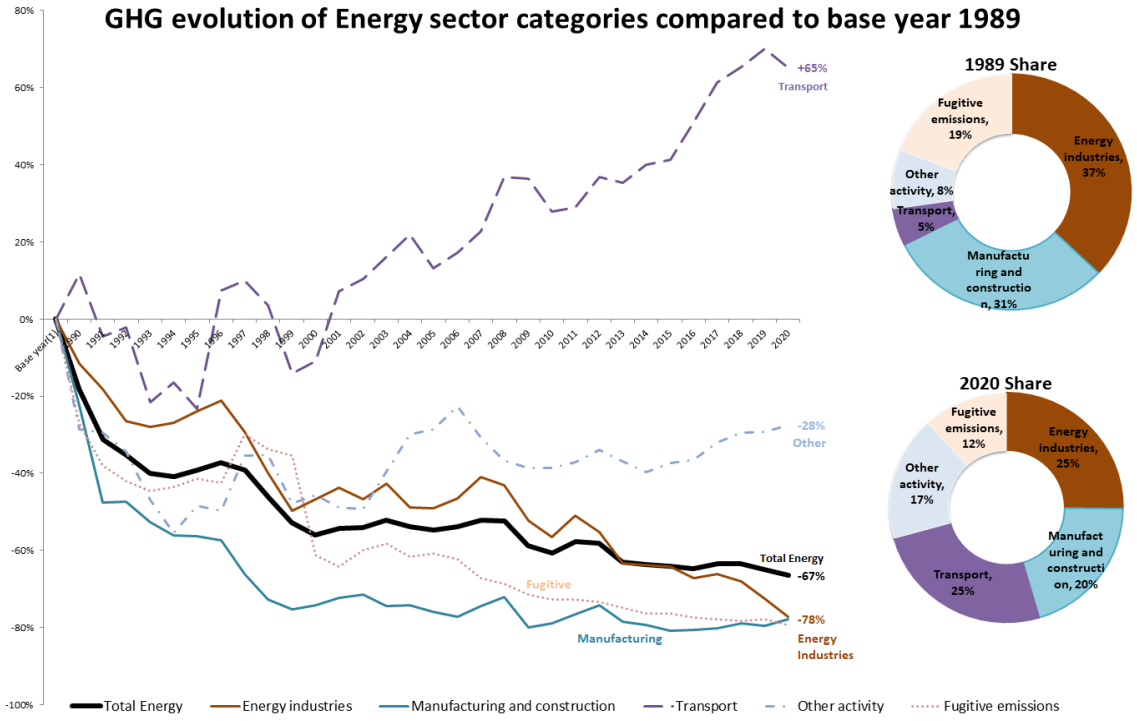


Figure 3-8 GHG evolution of Energy sector categories compared to base year (1989)

The trend of GHG emissions between 1989 and 2020, was defined by a substantial decrease of emissions in Fugitive Emissions from Fuels (80%), followed by the Manufacturing Industry and Construction (78%) and by Energy industries (77%), as well as a clear increase of emissions from Transport (65%).

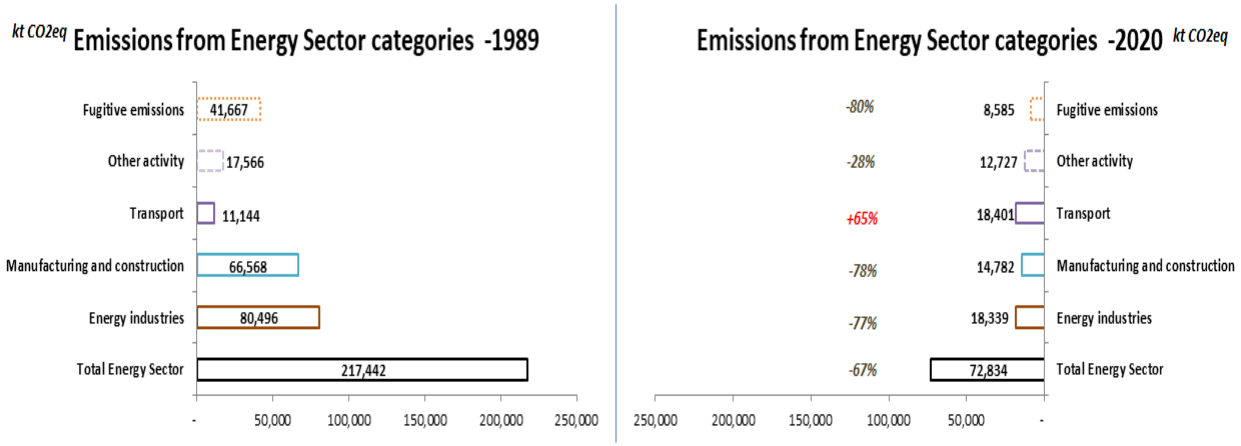


Figure 3-9 Emissions from Energy sector by category

GHG emissions from the Energy industries have decreased by 77 %, 18,339 kt CO2 eq. compared to 80,496 kt CO2 eq. in 1989 as a result of transition to a market-based economy, which led to a sharp drop in electricity production demand from power plants. GHG emissions from the Manufacturing Industries and Construction have decreased by 78%, from 66,568 kt CO2 eq. in 1989 (base year) to 14,782 kt CO2 eq. due to the decrease of several productions levels. Transport sub-sector has registered an increment of 65 % of GHG emissions, 18,401 kt CO2 eq. compared to 11,144 kt CO2 eq. in 1989, base year. GHG emissions from the Other Sectors sub-sector have decreased by 28 %, from 17,566 kt CO2 eq. in 1989, base year to 12,787 kt CO2 eq. while those from Other sub-sector have decreased by 81.39 %. GHG emissions from the Fugitive Emissions from Fuels sub-sector have decreased by 80 %, 8,595 kt CO2 eq. compared to 41,667 kt CO2 eq. in 1989, base year.

Industrial processes and Product Use

The GHG emissions analysis from Industrial processes and Product use (IPPU) sector only considers the process related emissions. According to IPCC 2006, GHG emissions from this sector are grouped in the following Sub-sectors:

- 2.A Mineral products
- 2.B Chemical industry
- 2.C Metal Industry
- 2.D Non-energy products from fuels and solvent use
- 2.E Electronic industry
- 2.F Product uses as substitutes for ODS (ozone depleting substance)
- 2.G Other product manufacture and use
- 2.H Other.

Emissions from this sector estimated in 2020 decreased by 72% compared with 1989 and increased with 0.64% compared with 2019. The decrease from 1989 to 2020 is the result of the restructuration and privatization in various activity sectors. After 1989, total GHG emissions related to IPPU sector began to decrease due to reduced production levels of minerals and metals products and especially in the chemical industry. The evolution of total GHG emissions for this sector in the period 1989-2015 is shown in Figure 3-10. In 2020 the GHG emissions from IPPU sector contributed with 12 % to the total GHG emissions in Romania (Figure 3-10).

After 1989, the production of cement, lime and glass began to decline. Starting with 2002, cement production has started to grow slightly; between 2009-2013 production has fallen again due to the economic crisis, followed by a slight increase. The lowest level of emissions from ammonia production was recorded in 1998, due to the activity data whose level fell by approximately 50% compared to the previous and next year. This happened as one producing plant has stopped its activity since 1998 and another plant has been closed in 1998 and reopened in the next year. Nitric acid production recorded a decrease after 1989, followed by a slight increase since 2010. Adipic acid production stopped at the end of 2001 and the activity was permanently suspended since 2002, Calcium carbide production recorded a decrease after 1989 and the activity was suspended starting with 2007, Iron and steel production recorded a decrease after 1989. Ferroalloys production has recorded a decrease after 1989. The lowest level of GHG emissions from this sector was recorded in 1999, as a result of reduced production levels. Ferroalloys production has stopped in 1999. In the next year (2000) the production was restarted and stopped again during 2013-2015, Starting with 2003, the PFC emissions of the aluminum production sector have decreased due to changes in technologies used. In 2019 the emissions decreased due to decrease of various production activities (lime production, glass production, limestone and dolomite consumption, ammonia production, nitric acid production, soda ash production, aluminum production, petroleum coke use, product uses as substitutes for ODS subsectors - domestic refrigeration and stationary air-conditioning). In 2020, compared to 2019 there is a minor increase in emissions by total sector due to increase of various production activities (cement production, glass production, ammonia production, product uses as substitutes for ODS subsectors – commercial refrigeration, industrial refrigeration, mobile air-conditioning, SF6 consumption in electrical equipments). Other activities recorded decreases in their production (lime production, limestone and dolomite consumption, nitric acid production, iron and steel production, aluminum production).

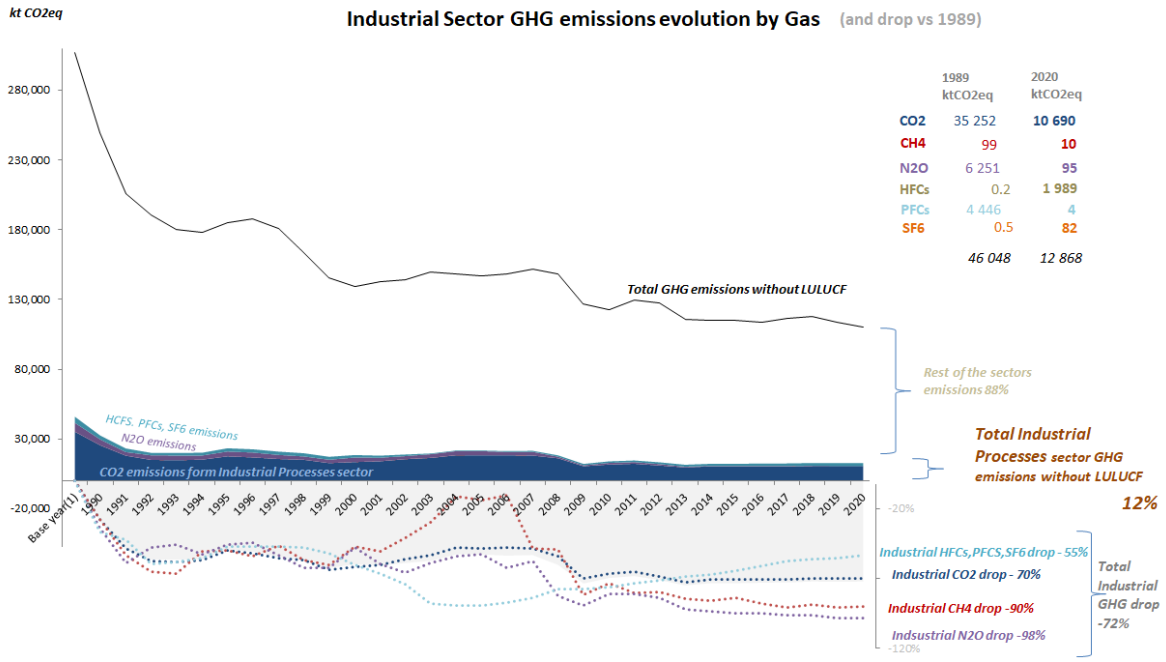


Figure 3-10 Industrial sector GHG emissions evolution by gas

The direct GHG emissions reported in this sector are CO2, CH4, N2O, HFCs, PFCs and SF6. In terms of evolution from base year, the most significant reduction was observed for N_2O emissions (98%), followed by CH_4 (90%) and CO_2 (70%) illustrated in Figure 3-6. Other emissions (HFCs, PFCs, SF_6) showed a 55% decrease in 2020 compared to base year.

Figure 3-11 depicts the share of each emission within the IPPU sector, from the total emissions, by gas. Therefore, in 2020, the CO_2 emissions contribution from this sector add up to 10 % from the total CO_2 equivalent emissions in all sectors, CH_4 emissions represent 0.01%, and N_2O emissions represent 0.09%. HFCs, PFCs, SF_6 represent 2% from the total CO_2 equivalent emissions in all sectors.

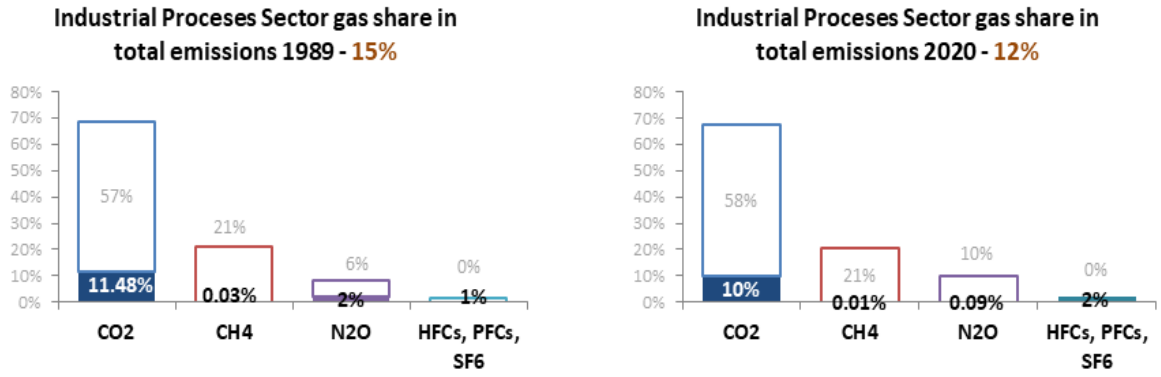


Figure 3-11 Industry sector gas share in total emissions

Mineral Industry and Chemical Industry are the two main contributing categories with 36.67% and 13.13%, respectively, of the total GHG emissions in this sector in 2020. Metal Industry contributes with 29.87% to the total GHG emissions from Industrial Processes and Product Use Sector in 2020. The contribution of Non-energy product from fuels and solvent use category to the overall sector is low: 4.23%. The contribution of Product uses as ODS substitutes Subsector to the overall sector is 15.45%. Other product manufacture and use contributes with 0.65% to the total GHG emissions from Industrial Processes and Product Use Sector in 2020. In the base year, various Industrial Processes and Product Use categories contributions were: Mineral Industry 16.77%, Chemical Industry 29.47%, Metal Industry 50.64%, Non-energy product from fuels and solvent use 3.11%, Product uses as ODS substitutes 0.0003% and Other product manufacture and use 0.0021% (Figures 3-12 and 3-13).

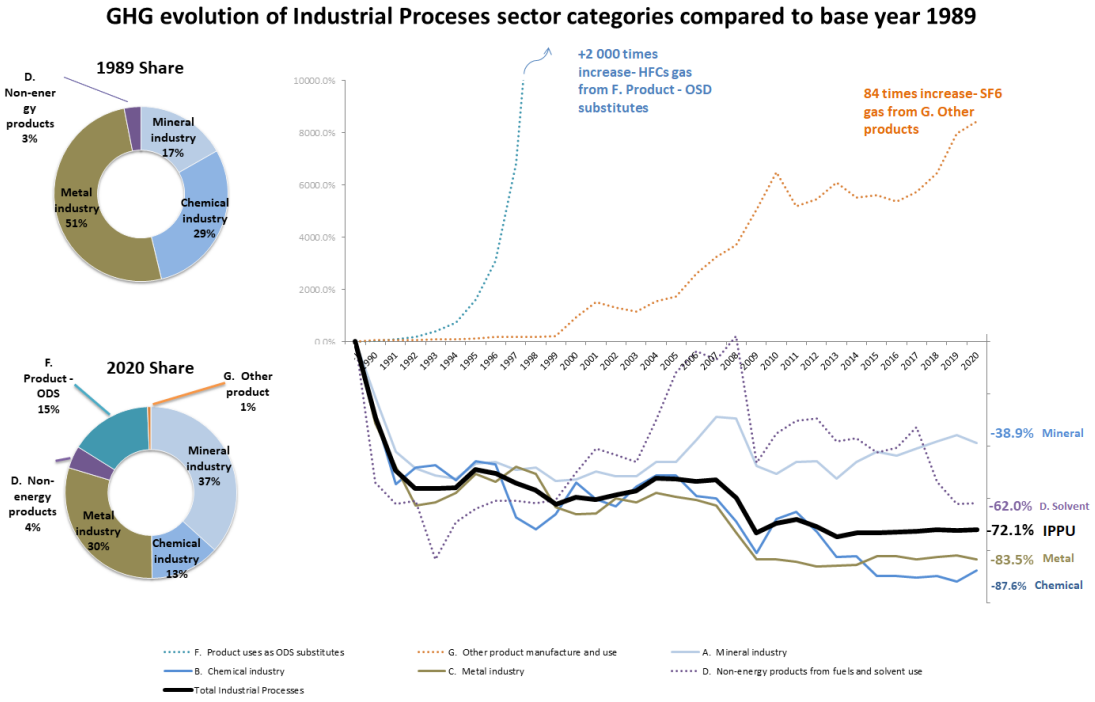


Figure 3-12 GHG evolution of Industry sector categories compared to base year (1989)

GHG emissions from the IPPU sector have decreased by 72 %, compared with base year, from 46,048 kt CO2 eq. to 12,868 kt CO2 eq. in 2020. Between 1989 – 2020, the trend of GHG emissions was defined by a substantial decrease of emissions for the following sectors: Chemical industry (88%), from 13,570 kt CO2 eq to 1,689 kt CO2 eq, Metal industry (84 %), from 23,321 kt CO2 eq to 3,844 kt CO2 eq, Non-energy products from fuels and solvent use (62 %), from 1,433 kt CO2 eq to 544 kt CO2 eq, Mineral industry (39%), from 7,723 kt CO2 eq to 4,718 kt CO2 eq. The evolution of total GHG emissions in these sub-sectors reflects changes in the structure of the economy between 1989 and 2020. A significant increase in emissions for the period 1989-2020 occurred for the sub-sector Products used as ODS substitutes (from 0.16 kt CO2 eq to 1,989 kt CO2 eq in 2020), as well as Other products sector (0.98 kt CO2 eq to 84 kt CO2 eq), based on PIB growth and legislative changes (Figure 3-12).

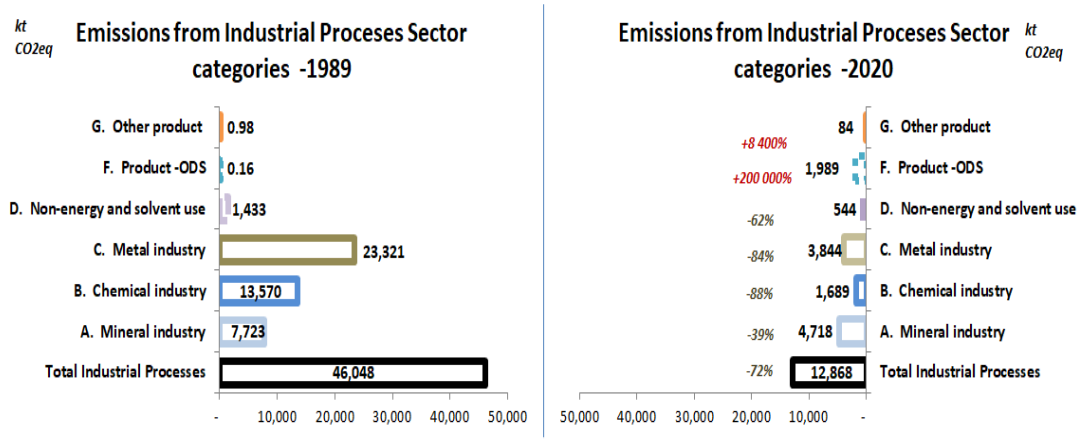


Figure 3-13 Emissions from Industry sector by category

Agriculture

This chapter includes GHG emissions description in the Agriculture sector. The following source categories are quantified and reported:

- CH4 emissions from enteric fermentation
- CH4 and N2O emissions from manure management
- CH4 emissions from rice cultivation
- N2O emissions from agricultural soils
- CH4, N2O, NOx and CO emissions from field burning of agricultural residues
- CO2 emissions from Lime application
- CO2 emissions from Urea application.

The direct GHGs reported within this sector are CH4, N2O and CO2 while indirect gases include NOx and CO. Domestic livestock are the major source of CH4 emissions from agriculture, both from enteric fermentation and manure management. Manure management also generates N2O emissions.

The Agriculture Sector accounted for 17 % of the total GHG emissions in 2020, reaching 18,316 kt CO2 eq. In 2020, emissions from the Agriculture sector have decreased by 52%, compared to 217,441.87 kt CO2 equivalent in 1989 (Figure 3-14), due to a reduction in the number of animals, regardless of the species and type of operation. After a slight recovery of national livestock situation, another dramatic regression occurred, result of economic situation extremely difficult Romania passed in the period 1997-2000. After the period 2001-2002 and in present, for the livestock species of interest there are recorded fluctuations in the livestock number influenced by the economic context, the emergence of various associative forms that have acquired economic power and by the interest shown by farmers for increasing the genetic value of the animals. After 1989 the livestock from most Agricultural Production Cooperatives (C.A.P.) were attributed to rural population they being sacrificed in large numbers for meat. On the other hand, in most rural areas, a significant number of farmers have lost the interest in animal husbandry.

In the general context of the transition of the economy to a market based approach, the activity data level decreased substantially in the last years of the characterized period in comparison to the base year. The livestock number decreased in the last years of the characterized period in comparison to 1989 mainly due to: the import of animals, the draught which affected the crop production levels and the crop production prices, state incentives in some periods, closing of the old/opening new facilities due to the restructuration of the economy. The crop productions level decreased in the late years of the analysed period in comparison to 1989 mainly due to the change in agricultural land property regime and to the transition to the market economy. Reasons for the inter-annual changes in crop production levels include: the existence of draught periods, state incentives for some periods, changes in the land property regime, including the disaggregation of large farms before 1990 and crystallization of new large farms in the late years.

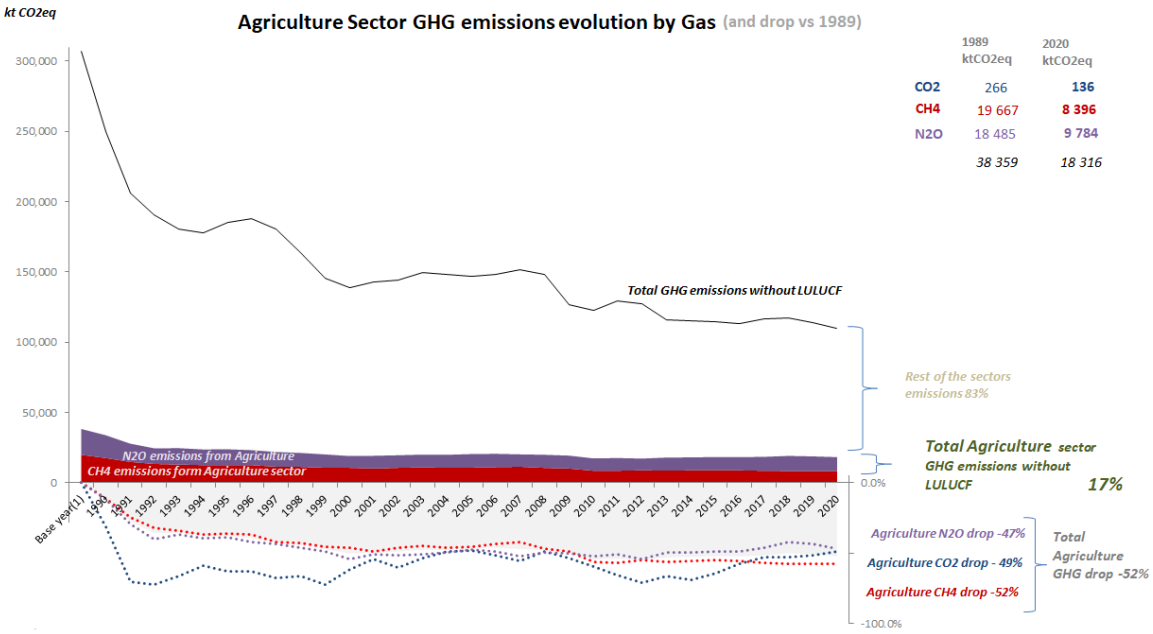


Figure 3-14 Agriculture sector GHG emissions evolution by gas

Within the GHG emissions from the Agriculture sector, the CH_4 and N_2O emissions have the largest contribution. In terms of evolution from base year, the most significant reduction was observed for CH_4 emissions (52%), followed by CO_2 (49%) and N_2O (47%), illustrated in Figure 3-14.

Figure 3-15 depicts the share of each emission within the Agriculture sector, from the total emissions, by gas. Therefore, in 2020, CH_4 emissions contribution from Agriculture sector account for 8% from the total CO_2 equivalent emissions in all sectors, N_2O emissions represent 9% and CO_2 emissions 0.12%.

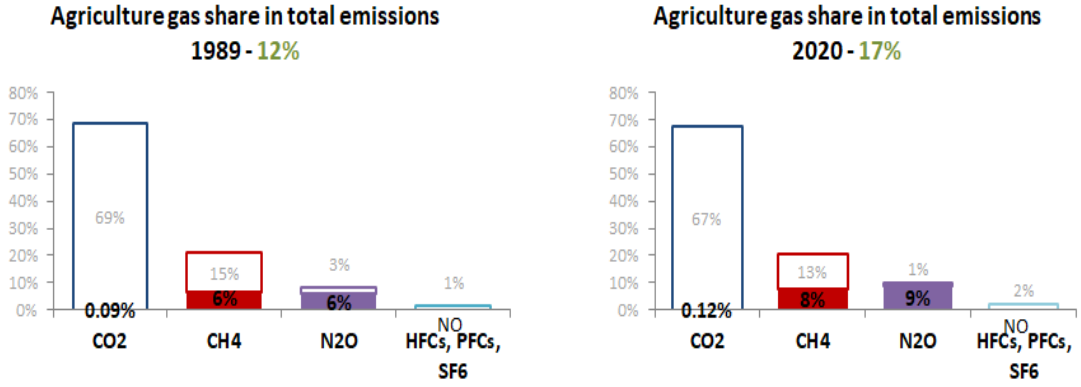


Figure 3-15 Agriculture sector gas share in total emissions

In 2020, the Agriculture sector contributes with 17 % to the total GHG emissions. The total emissions of this sector showed a decrease by 52.3% compared to base year, illustrated in Figure 3-16. Within this category, the main contributing sub-sectors are Agricultural soils (47 %), Enteric Fermentation (39 %), Manure Management (11 %)

and Field Burning of Agricultural Residues (4 %). Other categories (Liming, Rice Cultivation, Urea application) account for the rest of 1% of total emissions from the Agriculture sector.

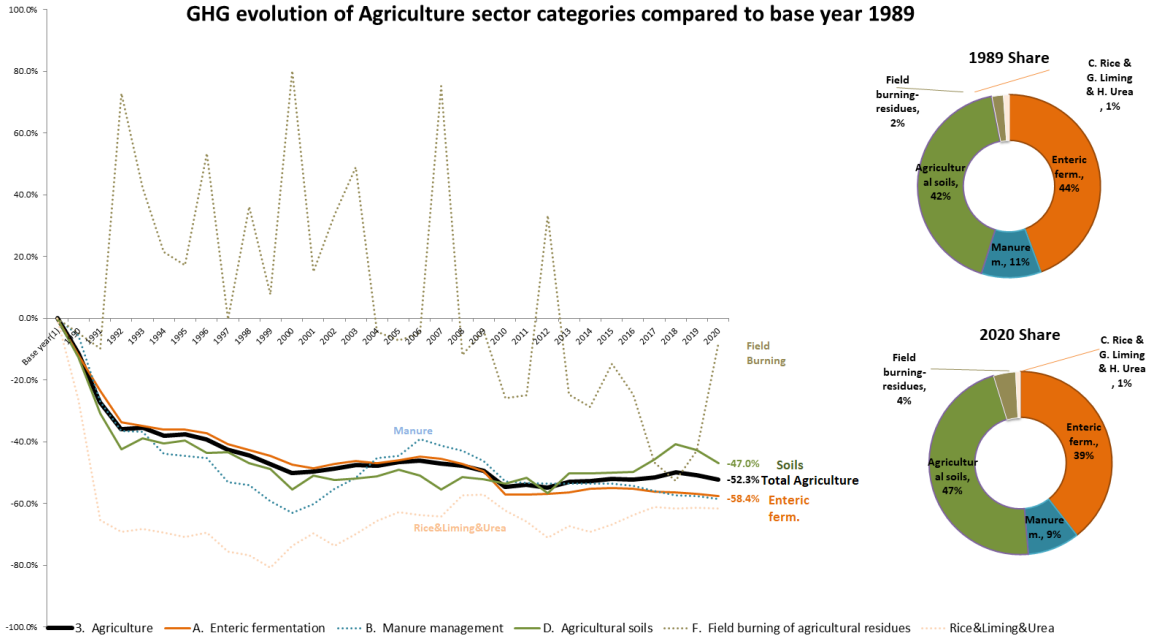


Figure 3-16 GHG evolution of Agriculture sector categories compared to base year (1989)

As depicted in Figures 3-16 and 3-17, the trend of GHG emissions between 1989 and 2020 was defined by a substantial decrease of emissions from Rice Cultivation (85 %), Liming (65 %), Manure Management (58 %), Enteric Fermentation (58 %), Agricultural soils (47 %), Urea application (30 %) and Field Burning of Agricultural Residues (8 %). In case of emissions resulted from enteric fermentation and manure management, the descending trend reflects the decrease in animal population over the period. The number of all cattle categories decreased in the analyzed period, the animals being privately owned both in subsistence farms and individual households. The lack of interest for these species is also due to the lack of associated governmental incentives.

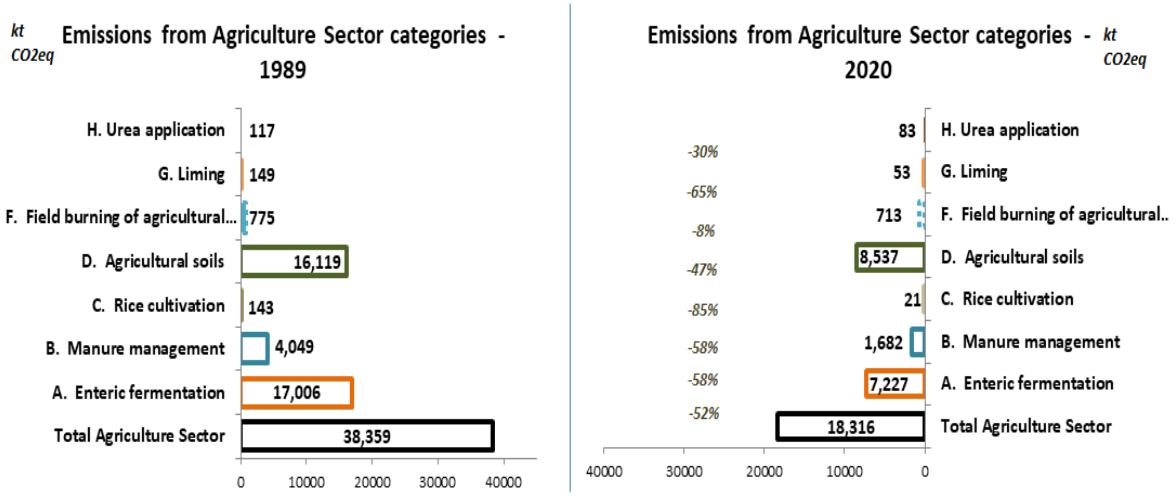


Figure 3-17 Emissions from Agriculture sector by category

Compared to 1989, total GHG emissions from Enteric Fermentation category decreased by 58% in 2020. The decreasing trend is in direct correlation with the dynamics of livestock. The livestock number for all species of economic interest declined.

Emissions from Manure Management category are declining since 1989 (by 58 %) due to the decrease of the animal population and to the switchover from traditional systems to economically organized farms, in which is practiced different waste management systems. The dynamic of emission of GHG from manure management reflects the livestock situation in Romania.

Rice Cultivation category is the smallest source of GHG emissions in the Agriculture sector. The rice cultivation generated in 2020 a significantly reduced emission compared to the base year 1989 (85 %). Emissions from this sub-sector are declining since 1989 due to the reduction of rice cultivated areas, privatization process and concession of the land from state patrimony, which ended in 2004.

Agricultural soils category registered a declining of livestock population and the crop productions, and a diminishment of the synthetic fertilizer amount applied determining a 47% decrease of emissions in 2020 comparing to 1989. The decrease of crops, for example in 1992, was caused by unfavorable weather conditions, while the situation was completely opposite in 2004. In 2007, the crop was reduced from 2006 due to drought. Cultivated areas were maintained crop except soybeans which recorded significant decreases.

Emissions from *Field burning of agricultural residues* are lower in 2020 than emissions in 1989, due to the lower agricultural yields. The lowest emissions are found in the years 2012, 2015 and 2019.

The trend of GHG emissions from *Liming* showed a decrease until 1993 then begins to fluctuate in accordance with the decreasing and increasing of annual amount of calcic limestone CaCO3.

The GHG emissions from Urea application are lower in 2020, with 30 % comparing with 1989; the emissions were decreased until 1992 then begin to fluctuate in according with the decreasing and increasing of annual amount of urea fertilization.

Land Use, Land Use Change and Forestry

The LULUCF sector has become more influential, in terms of the level of removals from the total GHG emissions generated by the different sectors, following the trend of the EU/EC policies to increase/maximize the potential of this sink sector into detriment of other source sectors, in an attempt to mitigate the impact/effect generated by climate changes.

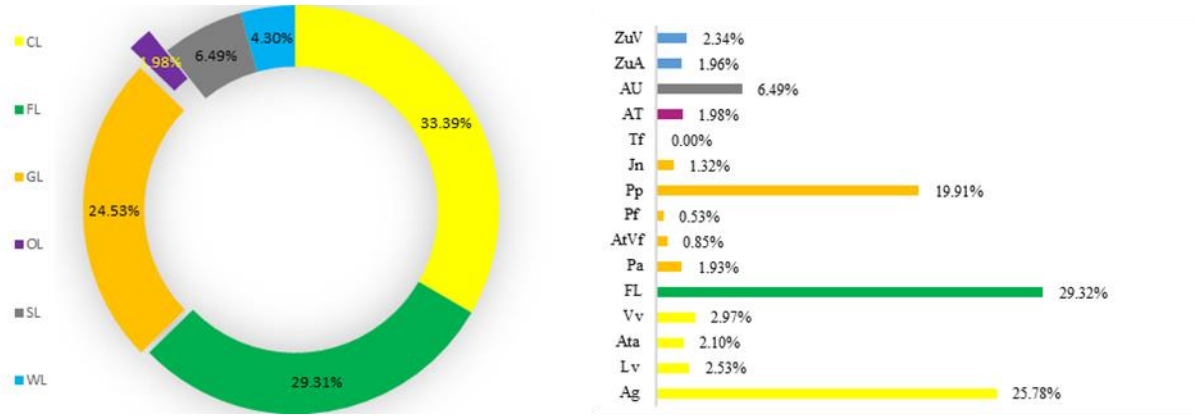


Figure 3-18 LULUCF Sector's land use categories structure

Romania is characterized as a country with a complex geographical composition, which is also reflected in the LULUCF land use categories structure, Figure 3-18.

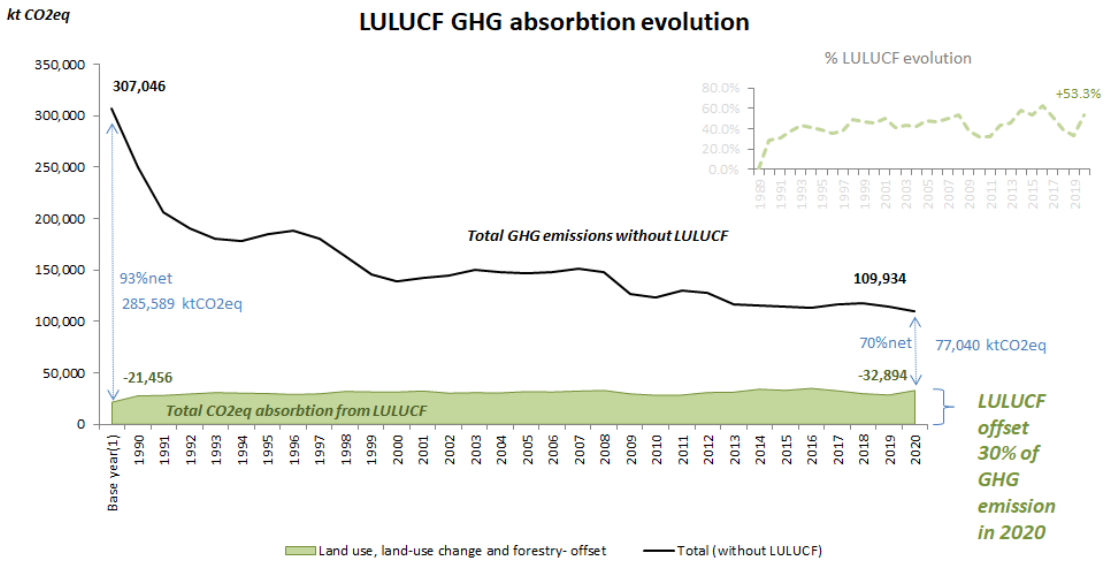


Figure 3-19 LULUCF GHG removal evolution

In 2020, LULUCF sector accounted for an offset of 30% in GHG emissions (32,894 kt CO2 eq. from 109,934.33 kt CO_2 eq. in total). In 1989, the total CO2 equivalents absorption from LULUCF sector comprised of 21,456 kt CO_2 eq. from 307,046 kt CO_2 eq., representing 7% (Figure 3-19). The net GHG removals-emissions level is higher in 2020 in comparison with the base year level due to the decrease trend of emissions from all other sectors. The Romanian land use sector acts as a net sink, at an average uptake of 20,531.11 kt CO2/year, being relatively stable over the last 31 years. For this, data-information developed by different technologies, LPIS-IACS [maps for use and

land use change; farmers declarations for data-information validation], CLCreference years [1990; 2000; 2006; 2012; 2018], LiDAR and aero-photogrammetry [the land use and land use change validation; to cover the gaps] were used. Also, the emissions level is in a slightly upward trend compared to the 1989-2006, time segment characterized by the hybrid methodology uses, respectively through a mix of Tier 1 and Tier 2 emission factors (EF), respectively through activity data developed through type 1 and 3 approaches, AD (kha). To capture the dynamics and trend of GHG emissions-removals characteristic of the LULUCF Sector, NGHGI 2022, priority was given to the development and use of explicit geospatial maps up to year 2007, LPIS-IACS reference year, to avoid the time series inconsistency (TSC).

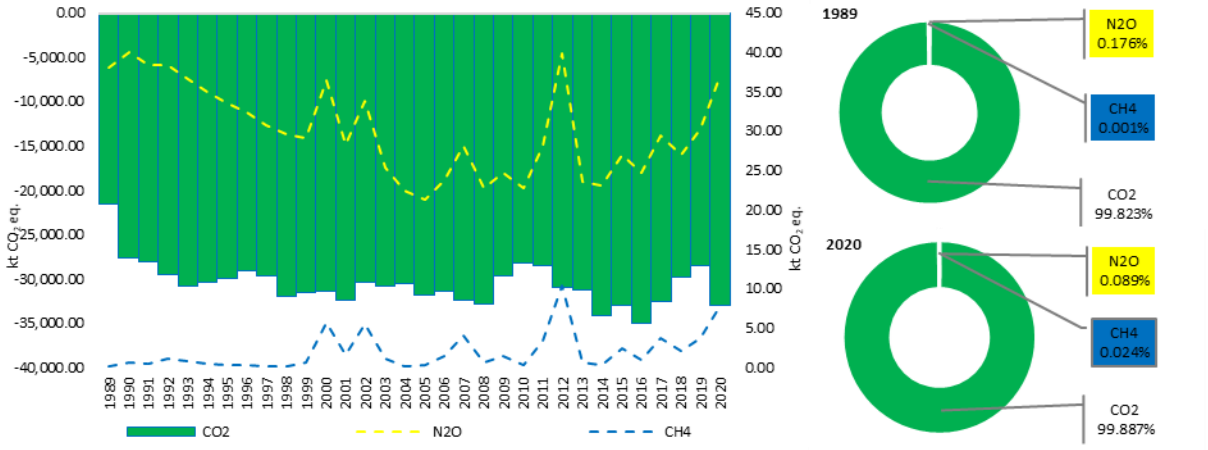


Figure 3-20 LULUCF's Sector trends by gas

Also, the experts involved in GHG emissions-removals monitoring, estimating, and reporting, generated by the specific activities related to LULUCF Sector, developed country-specific (CS) parameters and re-evaluated the values of C stocks in all carbon pools: LB, DOM and Soil. Over time, in the LULUCF Sector, the largest contributor to the GHG budget was occupied by CO2 and non-CO2 GHG, such as CH4 and N2O, respectively, with insignificant contributions, according to Figure 3-20.

Trends in GHG emissions-removals for Forestland. Is defined as areas covered by woody vegetation larger than 0.25 hectares with a minimum tree height of 5 meters at maturity and a canopy cover over 10 percent and wider than 20 m which also includes lands partially or entirely, but temporarily, without tree cover, as well as areas under regeneration but are expected to reach them in the future. The category covers approximately 29% of the country area, Figure 3-18, and is a net sink for the 1989-2020. The category generates the most GHG-negative emissions (removals) in LULUCF Sector, Figure 3-21. The AD is stratified among five group species (conifers, beech, oaks, other softwoods, and other hardwoods), nine age-class structures, and five production classes interpolated between three forest inventory measurements (1984, 2012, 2017). The highest contribution to the FL (4.A.) category emissions is due to the FL-FL category, an average 1989-2020 period of 93%, Figure 3-21. The annual carbon stock change in DOM and SOC for the 4.A.1 category is assumed to be in equilibrium and thus equal to zero meaning the LB pool is the primary source of E/R in the FL category. The estimation methodology of annual GHG emissions outcomes of the GHG emissions-removals from the FL category is characterized by using the same methods for estimating both the activity data (AD-kha) and emission factors (EF's) for the all-time series, Table 3-2.

Table 3-2 Parameter values (LB, DOM, SOC) - FL

Carbon pool	Land use subcategory	Value	EF NGHGI	Parameter type	Tier	References
LB	FL-FL	5.81 m^3/ha	Iv	CS	Tier 2	Giurgiu et al., 2004
	FL-FL	0.5 t d.m./m^3	DW	CS	Tier 2	Giurgiu et al., 2004
	FL-FL	0.2 dimensioless	R	CS	Tier 2	Giurgiu et al., 2004
	FL-FL	0.5 t C/ t d.m	CF	D	Tier 1	IPCC 2006 GL (Table 4.3)
	L-FL	a.v 3 t C/ha/ yr	Annual C gain	CS	Tier 2	Join Implementation project
DOM	FL-FL	0 t C/ha	Annual C gain	Default	Tier 1	IPCC 2006, V4, Ch. 4, 4.2.2.1
	L-FL	0.08 t C/ha	Annual C gain	CS	Tier 2	Join Implementation project
SOC	FL-FL	0 t C/ha	Annual C gain	Default	Tier 1	IPCC 2006, V4, Ch. 4, 4.3.3.3
	CL-FL	1.84 t C/ha	Annual C gain	CS	Tier 2	INCDS, ICPA
	GL-FL	1.84 t C/ha	Annual C gain	CS	Tier 2	INCDS, ICPA

The trend analysis in the 4.A. category shows a constant decrease in CO2 eq. removals starting at 29362 kt CO2 eq. intercept at a rate of 130 kt CO2 eq. a year with a coefficient of determination of r2=0.46. Although the L-FL category constantly increases its contribution in the annual removal of the FL category with a rate (slope) of 14 kt/yr (r2=0.61), it contributes only 7% to the total removal of the 4.A. category. The historical emissions in the 4.A. and 4.G. categories are shown in Figure 3-21:

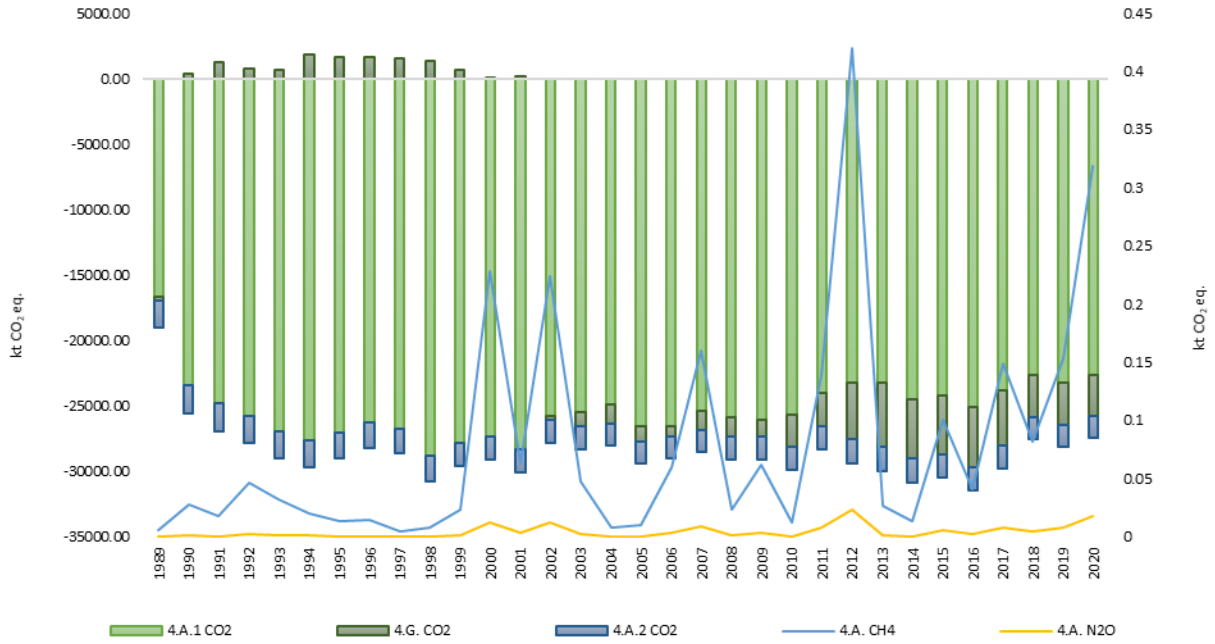


Figure 3-21 The cumulated 4A1, 4A2, 4G category historical GHG emissions-removals

The main reason for the annual decrease in trend is the annual harvest rates, characterized by an abrupt reduction in the period 1990-2000 following the communist years and a constant increase since. The correlation analysis between forest area, species composition, or mean annual forest age indicates a lack of relation between

mentioned EF or AD and the annual removal values of the 4.A.1 category. Nevertheless, strong Pearson correlation values (p = 0.95) are shown between emissions in the 4.A.1 category and annual harvest rates.

Trends in GHG emissions-removals for non-forestlands. Cropland includes arable land (Ag), orchards (Lv), vineyards (Vv), shrub crops (Ata) and in the total share of LULUCF Sector, represents about 33.39% of the area AD (kha), Figure 3-18. Direct and main reasons associated with the evolution of the GHG emissions-removals levels trend for CL are related to following driving forces-variables: (i) AD (kha) developed using the type 3 approach. The CL use category used data-information for the 2007-2020 period, developed through a hybrid methodology, respectively explicit geospatial analysis + mathematical modelling. Geospatial data sources come from the querying of LPIS-IACS and CLC [reference years - 1990; 2006; 2012; 2018] technologies; (ii) revised C stock values for all carbon pools: LB, DOM, and Soil. Romania considered it necessary to revise the parameters of the carbon pools, adapted morpho-climate and morpho-geography, to estimate GHG emissions-removals levels more accurate, Table 3-3 and Table 3-4:

Table 3-3 Parameter values (LB, DOM) - CL

Carbon pool	Land use subcategory	NGHGI 2022	Parameter type	Tier	References
LB	CLa [Ag]	5 tC/ha Gain/Loss	Default	Tier 1	IPCC 2006, V4, Ch. 5, Table 5.9
	CLp [Lv; Vv; Ata]	6.4 tC/ha/y - Loss 8.5 tC/ha/20 years [0.425 tC/ha/y accumulation rate] - Gain	Default	Tier 1	IPCC 2019 Refinement, V4, Ch. 5, Table 5.3
DOM	CLa [Ag]	0 tC/ha	Default	Tier 1	IPCC 2006, V4, Ch. 5, 5.2.2.1
	CLp [Lv; Vv; Ata]	0 tC/ha	Default	Tier 1	IPCC 2006, V4, Ch. 5, 5.2.2.1

Table 3-4 Parameter values (Soil) - CL

	SOC_{ref} tC/ha	F_{LU}	F_{MG}	F_I	SOC tC/ha
1990	45	0.69	1.02	0.95	30.85
1990 assumption	Country Specific (under native vegetation) stocks of organic soil C (SOCref) for mineral soils (tC/ha^{-1} in 0-30 cm depth)	Default, IPCC 2006 Long temp cultivated - temperate	Default, IPCC 2006 Reduced tillage – temperate dry	Default, IPCC 2006 temperate dry - low	$SOCref*F_{LU}-F_{MG}*F_I$
2013	45	0.71	1.02	0.95	32.33
2013 assumption	Country Specific (under native vegetation) stocks of organic soil C (SOCref) for mineral soils (tC/ha^{-1} in 0-30 cm depth)	Default, IPCC inland wetland mineral soils 2013, relative stock change factors for land-use (FLU) for long term cultivation on cropland, table 5.3, V4, Ch. 5 default	Default, IPCC 2006 Reduced tillage – temperate dry	Default, IPCC 2006 temperate dry - low	$SOCref*F_{LU}-F_{MG}*F_I$
2019	45	0.76	1.04	0.95	32.72

2019 assumption	Country Specific (under native vegetation) stocks of organic soil C (SOCref) for mineral soils (tC/ha^{-1} in 0-30 cm depth)	Country Specific	Country Specific	Default, IPCC 2006 temperate dry - low	SOCref*F_{LU}-F_{MG}*F_I
2020	45	0.76	1.04	1.16	
2020 assumption	Country Specific (under native vegetation) stocks of organic soil C (SOCref) for mineral soils (tC/ha^{-1} in 0-30 cm depth)	Country Specific	Country Specific	Country Specific	SOCref*F_{LU}-F_{MG}*F_I

CL maintains his historical sink behavior of the GHG emissions, in accordance with the new parameters specific to carbon pools, T1/T2, respectively Explicit Geospatial Map (EGM) developed-approach 3, for NGHGI 2022. The present trend, according to Figure 7, reveals a strengthening of the sink behavior of the CL use category in 2020 in relation to the base year, 1989, respectively by 208.01% of the removals levels (kt CO2 eq.). The trend per gas, (i) for CO2 removals, an increase of 207.73%; (ii) a decrease of -52.17%, for N2O emissions; (iii) respectively for CH4, no specific activities.

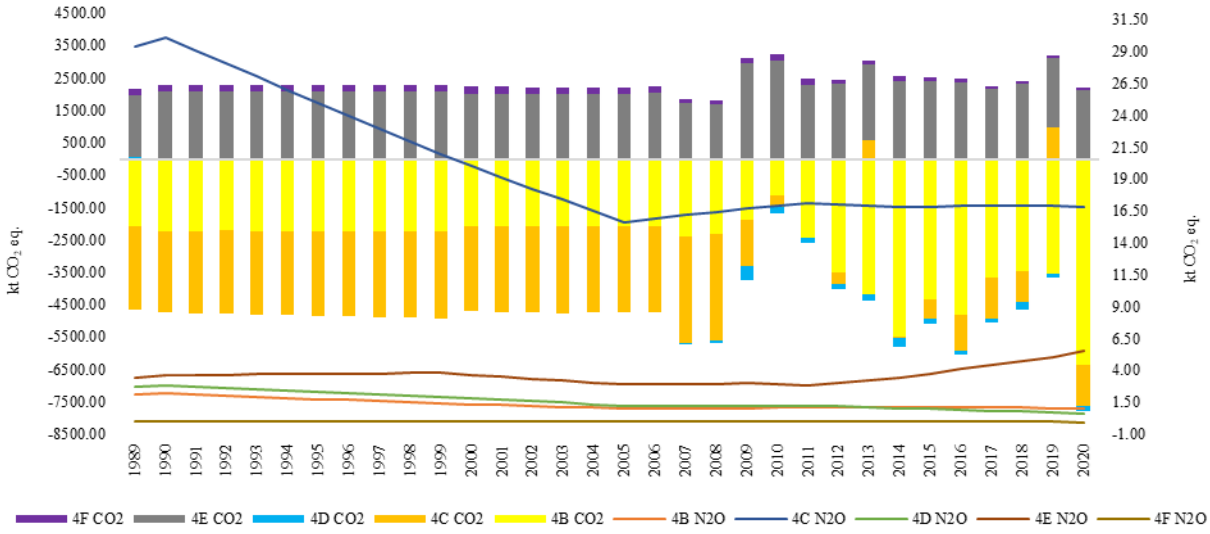


Figure 3-22 Non-forestlands, specific GHG emissions-removals distribution

Grassland is characterized by the following structure, pasture (Pp), hayfields (Pa), pasture with spare trees (Pf), juniper trees (Jn), scrubs (Tf) and other lands with forest vegetation (AtVf), representing 24.53% of the LULUCF Sector total area, Figure 3-18. Direct and main reasons, associated with GHG emissions-removals levels evolution trend for GL are related to following driving forces-variables: (i) EGM, AD (kha) developed using type 3 approach; (ii) revised C stock values for all carbon pools: LB, DOM and Soil. The country considered it necessary to revise the parameters of the carbon pools, corresponding to the climatic and geographical area, to estimate GHG emissions-removals levels more accurate, Table 3-5 and Table 3-6:

Table 3-5 Parameter values (LB, DOM) – GL

Carbon pool	Land use subcategory	NGHGI 2022	Parameter type	Tier	References
LB	GLg [Pp; Pf; Pa]	2.87 [6.1*0.47] tC/ha Gain/Loss Method	Default	Tier 1 Tier 2	IPCC 2006, V4, Ch. 6, Table 6.4, 6.3.1.4 (total non-woody biomass (aboveground and underground) Warm Temperate - Dry
	GLw [AtVf; Jn; Tf]	6.4 tC/ha/y - Loss 8.5 tC/ha/20 years [0.425 tC/ha/y] - Gain	Default	Tier 1	IPCC 2019 Refinement, V4, Ch. 5, Tabel 5.3
DOM	GLg [Pp; Pf; Pa]	0 tC/ha	Default	Tier 1	IPCC 2006, V4, Ch. 6
	GLw [AtVf; Jn; Tf]	0 tC/ha	Default	Tier 1	IPCC 2006, V4, Ch. 6

Table 3-6 Parameter values (Soil) - GL

	SOC_{ref} tC/ha	F_{LU}	F_{MG}	F_I	SOC tC/ha
1990	45	0.70	0.95	0.92	27.53
1990 assumption	Country Specific (under native vegetation) stocks of organic soil C (SOCref) for mineral soils (tC/ha^{-1} in 0-30 cm depth)	Country Specific	Default, IPCC 2006 table 6.2 moderately degraded grassland - temperate	Country Specific	$SOCref*F_{LU}-F_{MG}*F_I$
2020	45	1.00	0.80	0.88	31.68
2020 assumption	Country Specific (under native vegetation) stocks of organic soil C (SOCref) for mineral soils (tC/ha^{-1} in 0-30 cm depth)	Default, IPCC 2006, V4, Ch. 6, Table 6.2, All permanent grassland	Country Specific	Country Specific	$SOCref*F_{LU}-F_{MG}*F_I$

Grassland changes its historical behavior from source to sink of GHG emissions according to the new parameters specific to carbon pools, T1-T2, respectively EGM developed-approach 3. It is also noted the cancellation of the time series inconsistency, by comparison with previous submission. The present trend, according to Figure 3-22, reveals a maintenance of the sink behavior in 2020 in relation to the base year, 1989, in a slight decrease of GHG removals levels, respectively by -49.86% (kt CO2 eq.). The trend per gas, (i) for CO2 removals, a decrease of -49.78%; (ii) respectively a decrease of -42.62%, for N2O emissions. There are also spike years, 1990, 2011, 2013, 2019, related to EF's from the Soil carbon pool, FLU, FMG, FI and SOCref which are in the process of review for the next submissions.

Wetlands, shows the following structure, wet areas with vegetation (ZuV) and waters-ponds (ZuA), representing 4.30% of the LULUCF Sector total area, Figure 3-18. Settlements and Other lands, represents the construction and road sector, respectively OL, characterized by sand dunes, beaches, rocks. SL represents 6.49% from the LULUCF total area, respectively 1.98% are associated with OL surfaces AD (kha). The GHG emissions-removals levels evolution trend for WL, SL and OL are related to following driving forces-variables: (i) AD (kha) developed using the type 3 approach; (ii) revised C stock values for all carbon pools: LB, DOM and Soil. The country considered it necessary to revise the parameters of the carbon pools, corresponding to the climatic and geographical area, in order to estimate GHG emissions-removals levels more accurate, Table 3-7:

Table 3-7 Parameter values (LB, DOM, Soil) - WL, SL, OL

Land use categories	Carbon pool	Land use subcategory	NGHGI 2022	Parameter Type	Tier	References
WL	LB	ZuV	2.87 tC/ha Gain/Loss	Default	Tier 1 Tier 2	IPCC 2006, V5, Ch. 6
		ZuA	0 tC/ha Gain/Loss	Default	Tier 1	IPCC 2006, V4, Ch. 7, 7.3.2.1
	DOM	ZuV	0 tC/ha	Default	Tier 1	IPCC 2006, V4, Ch. 2, 2.3.2.2
		ZuA	0 tC/ha	Default	Tier 1	IPCC 2006, V4, Ch. 2, 2.3.2.2
	Soil	ZuV/ZuA	SOC_{ref}: 40 tC/ha	Country Specific	Tier 2	Soil Quality Monitoring in Romania, ICPA, 2006. National reference C stocks in mineral soils, assuming 20 years transition period
SL	LB	AU	0 tC/ha Gain/Loss	Default	Tier 1	IPCC 2006, V4, Ch. 8, 8.3.1.1
	DOM	AU	0	Default	Tier 1	IPCC 2006, V4, Ch. 2, 2.3.2.2
	Soil	AU	SOC_{ref}: 32 tC/ha	Country Specific	Tier 2	Soil Quality Monitoring in Romania, ICPA, 2006. National reference C stocks in mineral soils, assuming 20 years transition period
OL	LB	AT	0 tC/ha Gain/Loss	Default	Tier 1	IPCC 2006, V4, Ch. 9, 9.3.1.1
	DOM	AT	0	Default	Tier 1 Tier 2	IPCC 2006, V4, Ch. 9, 9.3.2
	Soil	AT	SOC_{ref}: 41 tC/ha	Country Specific	Tier 2	Soil Quality Monitoring in Romania, ICPA, 2006. National reference C stocks in mineral soils, assuming 20 years transition period

Wetland changes its historical source behavior to the GHG emissions sink, according to the new parameters specific to carbon pools, T1/T2, respectively EGM developed approach 3. It is also noted the cancellation of the time series inconsistency, by comparison with previous submission. The present trend, according to Figure 3-22, reveals a change of behavior, from source to sink, and corresponds to the input of explicit geospatial data-information, respectively with the year of 2007. In 2020, the WL use category, in relation to the base year 1989, shows a decrease in generated emissions, respectively by -342.06% (kt CO2 eq.). The trend per gas, (i) for CO2 emissions, a decrease of -354.47%; (ii) respectively a decrease of -75.50%, for N2O emissions. Following the use of the new parameters specific to carbon pools, T1-T2, respectively developed EGM-approach 3, by comparison with the previous report, both SL and OL retain their historical source behavior, but with an obvious tendency to decrease emissions levels, Figure 3-22. It is also worth noting the cancellation of the time series inconsistency, compared to the previous submission.

The present trend, according to Figure 3-22 (SL), reveals the same behavior of emissions source. In 2020, the SL use category, in relation to the base year 1989, shows an increase in generated emissions, respectively by 12.27% (kt CO2 eq.). The trend per gas, (i) for CO2 emissions, an increase of 12.18%; (ii) respectively a decrease of 60.44%, for N2O emissions.

The present trend, according to Figure 3-22 (OL), reveals the same behavior of emissions source. In 2020, the OL use category, in relation to the base year 1989, shows a decrease in generated emissions, respectively by -61.72%

(kt CO2 eq.). The trend per gas, (i) for CO2 emissions, a decrease of -61.72%; (ii) respectively a decrease of -49.49%, for N2O emissions.

Waste

This chapter provides information about GHG emissions from the Waste sector. The following direct GHG emissions and source categories are quantified and reported:

- CH4 and CO2 emissions from Solid Waste Disposal
- CH4 and N2O emissions from Biological Treatment – Composting
- CH4 emissions from Biological Treatment- Anaerobic Digestion at Biogas Facilities
- CH4 and N2O emissions from Wastewater Treatment and Discharge
- CO2, CH4 and N2O emissions from Waste Incineration.

In 2020 GHG emissions from the Waste sector accounted for 5,916.18 kt CO2 equivalent, which represent 5.35 % of the total national GHG emissions. Over the period 1989 - 2020, GHG emissions resulted from Waste sector increased by 15 %, due to population consumption growth, to the increase of waste managed sites number and also to the increase of population connected to sewerage (Figure 3-19). In the base year (1989), the total GHG emissions from the waste sector amounted to 5197.85 kt CO2 equivalent, which accounted for 1.69% of the total national GHG emissions in this year. Compared with the other sectors, emissions from the waste sector showed a significant increase from the base year due to increasing of incineration activities and waste generation rate in parallel with increasing of living standards.

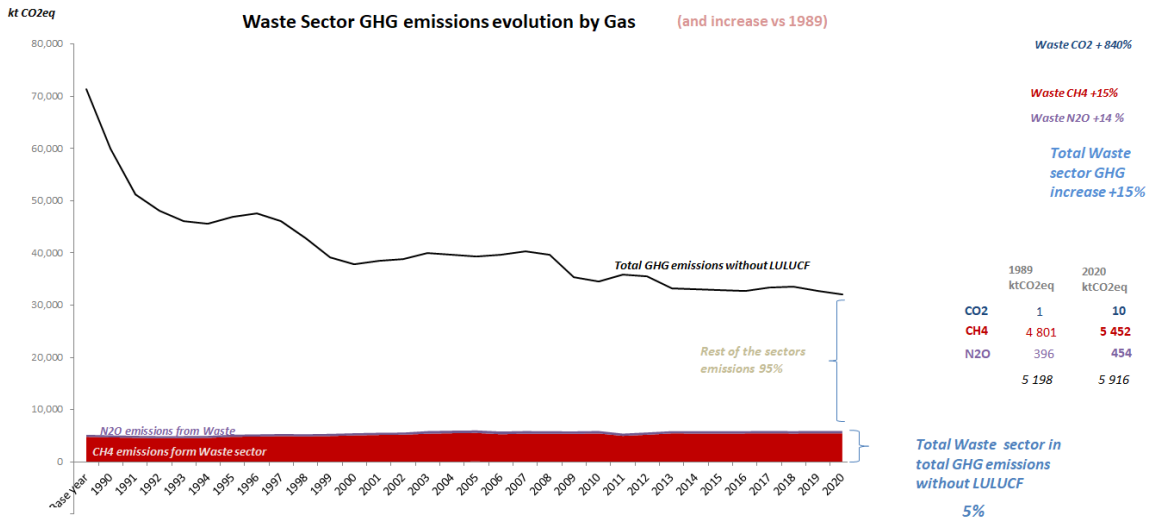


Figure 3-23 Waste sector GHG emissions evolution by gas

Methane represents the major greenhouse gas from Waste sector with a contribution of 23.96% to the total methane emissions in Romania, in 2020. In the same year, nitrous protoxide contributes of 4.15% to the total N_2O emissions in our country. Only CO_2 emissions from Waste Incineration category are reported, these representing 0.01 % of total net CO_2 emissions in Romania, depicted in Figure 3-20. In terms of evolution of emissions of each gas from base year, N_2O increased by 14%, CH_4 by 15% and CO_2 by 840% (Figure 3-23).

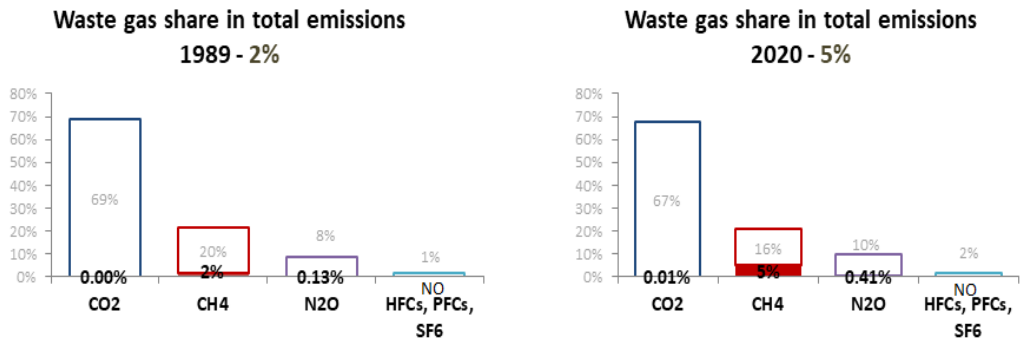


Figure 3-24 Waste sector gas share in total emissions

In 2020, the Waste sector contributes with 5 % to the total GHG emissions. The most important contribution to GHG emissions from Waste Sector has Solid Waste Disposal Subsector, contributing with 65.45% in the total (Figure 3-25), Biological treatment accounts for 1.41 %; Incineration and Open Burning of Waste Subsector accounts for only 0.20% and Wastewater Treatment and Discharge Subsector contribute with 32.94%. Wastewater Treatment and Discharge and Solid Waste Disposal Subsectors are key category sources both by level and trend. After 2000, Romania began to comply with EU standards, implementing European legislation both in waste and wastewater treatment management. However, the GHG emissions trend is different for the three subsectors of Waste Sector due to improvement of living standards which is reflected differently in the evolution of these subsectors.

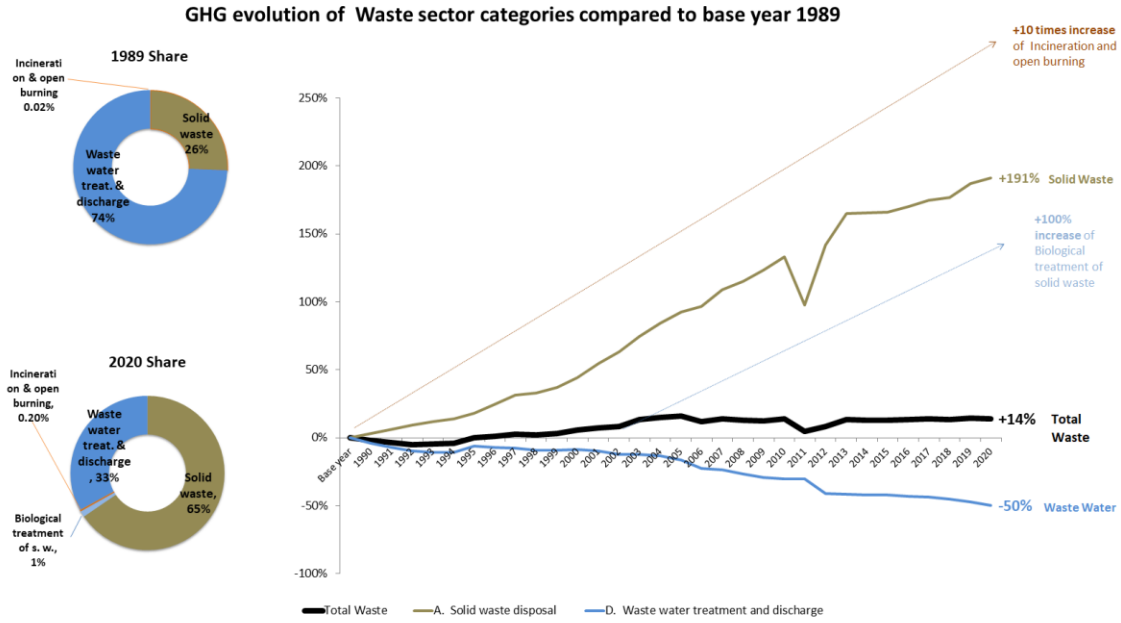


Figure 3-25 GHG evolution of Waste sector categories compared to base year (1989)

The trend of GHG emissions between 1989 and 2020 was defined by a significant increase of emissions from Solid Waste Disposal on Land (191%), from Biological treatment of solid waste (100%) and from Incineration and open burning of waste (1200%), as well of a decrease of emissions from Waste Water Handling (50 %), illustrated in Figure 3-25.

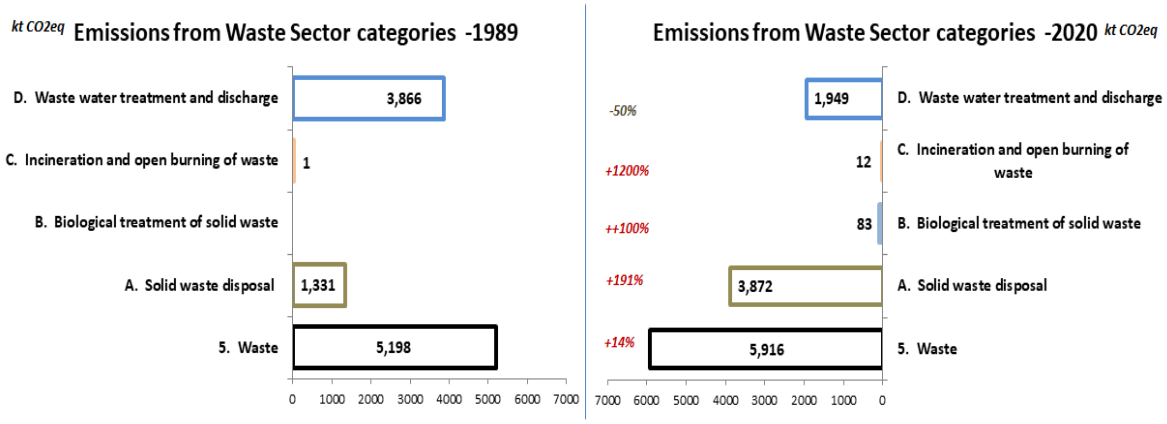


Figure 3-26 Emissions from Waste sector by category

GHG emissions trend from Solid Waste Disposal on Land category increased significantly in 2020 compared with the level in the base year, due to the increasing trend of waste generation rate following the increasing trend of population consumption. Emissions from Wastewater treatment and discharge decreased with 49.59 % in 2020 compared to 1989. This decrease is due to the decreasing number of population and the increased number of inhabitants connected to sewerage, and to the decreasing level of industrial production.

C. National inventory arrangements

C.1. Name and contact information of national entity with overall responsibility

According to the legal provisions in place, the single national entity with overall responsibility for the national inventory, including with the responsibility of administrating the National Inventory Arrangements and the Romanian National System is the National Environmental Protection Agency.

Address: Splaiul Independenţei no. 294, Sector 6, Bucharest; telephone: +40-21-2071101; fax: +40-21-207.11.03.
Designated representative with overall responsibility:
Name: Sorin Deaconu;
Telephone: +40-21-2071101; fax: +40-21-2071103.
E-mail: sorin.deaconu@anpm.ro.

C.2. Roles and responsibilities: Institutional, legal and procedural arrangements (supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol)

The institutional, legal and procedural aspects for supporting the Romanian authorities to estimate the greenhouse gas emissions/removals levels, to report and to archive the National Greenhouse Gas Inventory (NGHGI) information, including supplementary information required under Article 7, paragraph 1, of the Kyoto Protocol are established through the following legislation acts:

- GD (Government Decision) no. 1570 establishing the National System to estimate the anthropogenic greenhouse gas emissions from sources and removals by sinks, adopted in 2007 and modified and completed by the GD no. 668/20012, GD no. 120/2014, GD no. 1022/2016 and GD no. 600/2022.

- GD no. 1000/2012 regarding the reorganization and functioning of the National Environmental Protection Agency and of the subordinated public institutions,
- GD no. 38/2015 regarding the organization and functioning of the Ministry of Environment, Waters and Forests,
- GEO (Governance Emergency Ordinance) no. 9/2016 for the amendment and completion of GEO no. 195/2005 on environmental protection, as well as for the amendment of art. 3 of GEO no. 32/2015 regarding the establishment of Forest Guards
- GD no. 284/2016 for the amendment and completion of GD no. 38/2015 regarding the organization and functioning of the Ministry of Environment, Water and Forests, as well as other normative acts;
- Ministry of the Environment order no. 1376/2008 regarding the approval of the INEGES Reporting Procedure, as well as the method of responding to the observations and questions arising from the INEGES review process
- Ministry of the Environment order no. 1474/2008 regarding the approval of the procedure regarding the processing, archiving and storage of INEGES specific data
- Ministry of the Environment order no. 1442/2014 regarding the approval of the selection procedure of emission estimation methods and emission factors necessary to estimate the level of GHG emissions
- Ministry of the Environment order no. 1602/2014 for the approval of the NGHGI QA/QC Quality Assurance and Control Procedure
- Collaboration protocol no. 3136/MMP/9.07.2012 between the Ministry of the Environment and Forests, NEPA, the Romanian Auto Registry and the Directorate of Driving Permits and Vehicle Registration within the Ministry of Internal Affairs, for the estimation of emissions related to the road transport category, based on the COPERT 4 model.
- GD no. 590/2019 for defining the obligations on the administration of the LULUCF subdomain, part of the Climate change domain, and the subsequent ministerial orders,

The main objective of the GD no. 1570/2007, as ulteriorly modified and completed, is to ensure the fulfillment of the relevant provisions and the obligations of Romania under the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol and the European Union legislation.

The National Inventory Arrangements (NIA), including the National System, is based on the provisions provided by the Decision 24/CP. 19 on the Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention and on Article 5 of the Kyoto Protocol, and complies with the provisions of the subsequent decisions of the CMPs of the Kyoto Protocol. It also complies with the provisions of the Regulation (EU) no. 525/2013 of the European Parliament and of the Council on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision no. 280/2004/EC, as well as with the Commission Implementing Regulation (EU) no. 749/2014 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) no. 525/2013.

In accordance with the Government Urgency Ordinance no. 9/2016 and in the GD no. 284/2016, the competent authority, responsible for administrating the National Inventory Arrangements and National System, is the National Environmental Protection Agency starting with 4 July 2016.

The Ministry of Environment, Waters and Forests officially considers and approves the National GHGI; NEPA submits the National GHGI to the UNFCCC Secretariat, the European Commission and the European Environment Agency considering the specific deadlines.

National Inventory Arrangements including Romanian National System for the estimation of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol (NS) is designed and operated to:

- ensure the transparency, consistency, comparability, completeness, and accuracy of inventories
- ensure the quality of inventories through the planning, preparation and management of inventory
- includes all institutional, legal, and procedural arrangements made as a Party included in Annex I for estimating anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, and for reporting and archiving inventory information
- represents a system for the collection, processing and adequate presentation of data and information or the elaboration of the NGHGI
- is designed and operated to ensure the transparency, consistency, comparability, completeness and accuracy of inventories as defined in the guidelines for the preparation of inventories by Parties included in Annex I, in accordance with relevant decisions of the COP and/or COP/MOP
- is designed and operated to ensure the quality of the NGHGI through planning, preparation and management of inventory activities
- is designed and operated to support compliance with the Kyoto Protocol and with the European Union legislation commitments related to the estimation of anthropogenic GHG emissions by sources and removals by sink
- is designed and operated to consistently estimate anthropogenic emissions by all sources and removals by all sinks of all GHGs, as covered by the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, by the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol and by the 2013 Supplement to the 2006 Guidelines for National Greenhouse Gas Inventories: Wetlands, in accordance with relevant decisions of the COP and/or COP/MOP.

The current institutional arrangements functioning in Romania are presented in the Figure 3-27 - Current national inventory system description and are characterized by:

- centralized approach – NEPA maintain a large degree of control and decision-making authority over the inventory preparation process
- in-sourced approach – a significant part of the inventory is prepared by NEPA (governmental agency)
- single agency – the single national entity is housed within a single governmental organization
- separate approach – the NGHGI related work is not integrated with the air pollutant inventories; however, cross checking activities are periodically implemented.

Under the National Inventory Arrangements and National System, the following activities are performed:

- the central and territorial public authorities, research and development institutes and other public organizations under the authority, in the subordination or in the coordination of central public authorities, owners and professional associations, economic operators and other relevant organizations have the obligation of providing to NEPA the necessary activity data, emission factors and the associated uncertainty data

- the main activity data supplier is the National Institute for Statistics through the yearly-published documents as the National Statistical Yearbook and the Energy Balance and other documents
- the preparation of Road transport category estimates based on COPERT 4 model is administered also based on the Protocol of collaboration no. 3136/MMP/9.07.2012 between Ministry of Environment and Forests, NEPA, Romanian Automobile Register and Directorate on Driving Licenses and Vehicles Registration in the Ministry of Administration and Interior
- development of country-specific values associated to several NGHGI sectors has been also supported by the Institute for Studies and Power Engineering (ISPE), activity that has been continued by NEPA's experts

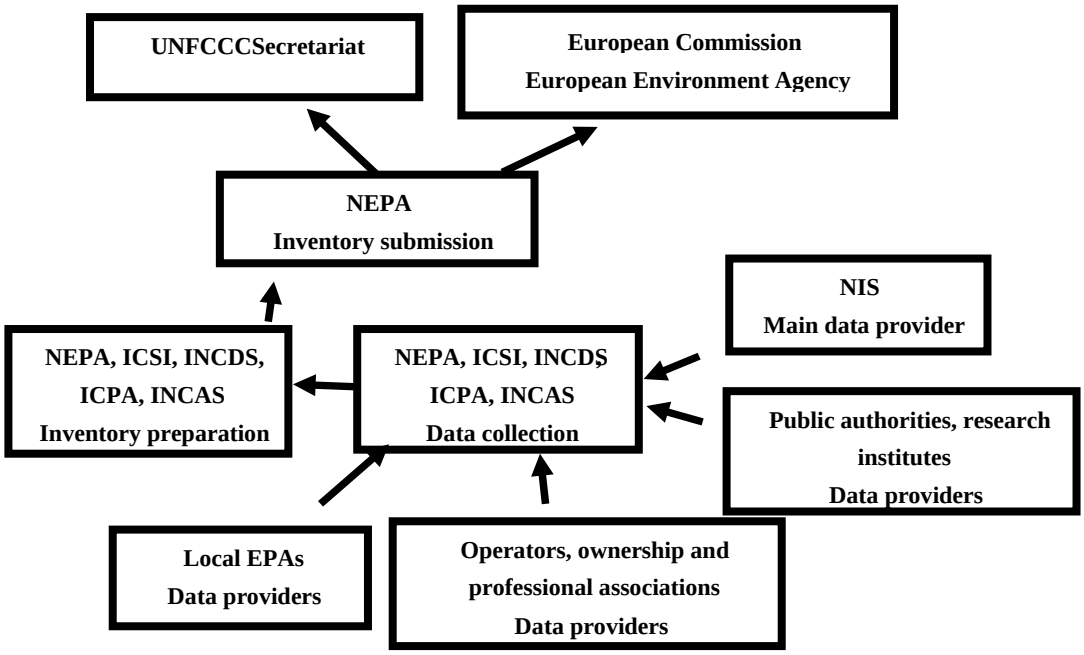


Figure 3-27 Current national inventory system description

- *LULUCF Sector arrangements* - starting with August 2019 the LULUCF Sector administration, in accordance with the GD no. 590/2019, is in the responsibility of the following institutions:
  - National Research and Development Institute for Cryogenic and Isotopic Technologies Rm. Valcea is in charge with monitoring and estimating/reporting the GHG emissions/removals associated to the Cropland, Grassland, Wetlands, Settlements and Other Land categories, excepting the emissions/removals in soils; this institution is the technical coordinator of the LULUCF Sector activities
  - National Institute for Research and Development in Forestry "Marin Dracea" is in charge with monitoring and estimating/reporting the GHG emissions/removals associated to the Forest Land category
  - National Research and Development Institute for Soil Science, Agrochemistry and Environment Bucharest is in charge with monitoring and estimating/reporting the GHG emissions/removals associated to the soils in Cropland, Grassland, Wetlands, Settlements and Other Land categories

- National Institute for Aerospace Research "Elie Carafoli" is in charge with the land use and land-use change in a spatial-explicit system, using aero photogrammetry and aerial surveillance technologies, at national level

The National Environmental Protection Agency is implementing a series of technical activities following the receipt of the deliverables from the above institutes and administrative activities to allow for a continuous implementation of the specific activities.

The implementation of activities by the four institutes previously mentioned is based also on the allocation of adequate financial resources through the Environment Fund Administration based on individual contracts with this latest institution.

Ministry of Environment, Waters and Forests has to analyze and approve the consolidated version of the LULUCF inventory, ensuring the participation and cooperation with the expert review team members within the inventory review cycles, together with NEPA and institutes representatives. Below can be seen how the institutional arrangements are functioning for the LULUCF sector administration.

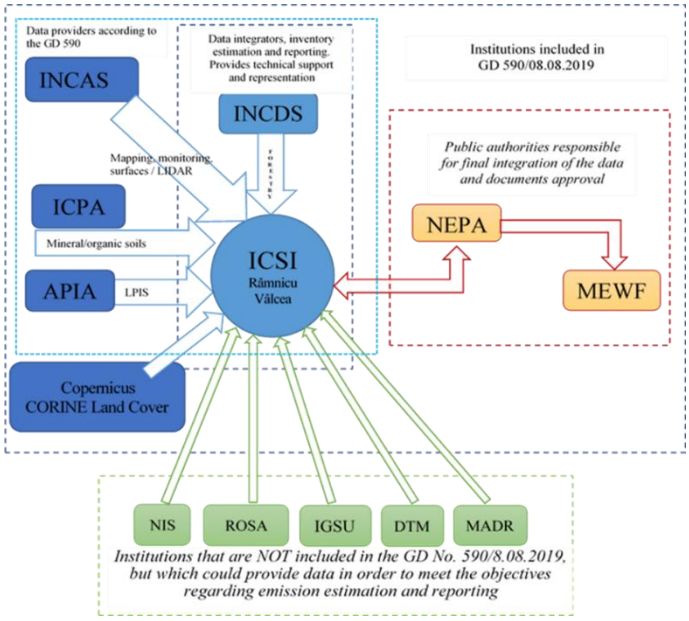


Figure 3-28 National LULUCFsector inventoy arrangements

C.3. Process of inventory preparation

Implementation of the NIA and NS specific functions for the inventory preparation are described below:

- *Collect sufficient activity data, process information and emission factors as necessary to support the selected methods for estimating anthropogenic GHG emissions by sources and removals by sinks, as follows*:
  - identification of data requirements
  - identification of potential data suppliers
  - preparation of specific templates
  - submitting the requests and templates to the potential suppliers of data
  - data collection, data verification

The main activity data provider is the National Institute for Statistics. The sources of the used emission factors are national studies, 2006 IPCC Guidelines, national research institutes performed studies and in a limited number provided by companies.

Data processing is performed according to the GD no. 1570/2007, as ulteriorly amended, and completed by MoEO (Ministry of Environment Order) no. 1474/2008 for approving the Procedure on processing, archiving and storage of the NGHGI specific data or other relevant legal provisions in place (as previously presented). Primary data processing is mostly carried out by NEPA, ICSI, INCDS, ICPA and INCAS.

The selection of emission factors (EFs) is performed according to the provisions in the MoEO no. 1442/2014 on approving the Procedure on selection of the estimation methods and of the emission factors needed for the estimation of the GHG levels and other relevant legal provisions in place (as previously presented). As a result of the activity carried out by NEPA/MEWF for the implementation of the results of the studies developed in the period 2011-2014 for several sectors (Energy, Industrial Processes, Agriculture, LULUCF and Waste), as well as the Collaboration Protocols (for the LULUCF sector and the Road Transport category), a significant amount of activity data and emission factors were collected/processed/developed allowing the use of higher approach levels and a significant decrease of the number of categories characterized by the notation key NE (not estimted).

Also, data collection flows from operators within the Energy sector (Energy Industry and Manufacturing and Construction Industry) respectively the Waste sector (Solid waste disposal and Wastewater Treatment) have been optimized because of the implementation of the integrated IT system developed by NEPA with an extenal IT company. The main sources for activity data are presented in the following table.

Table 3-8 Activity data sources

Sector	Data sources
Energy	National Institute for Statistics (Energy Balance) Energy producers The Ministry of Economy Romanian Civil Aeronautical Authority Transgaz SA National Energy Regulatory Authority National Agency for Mineral Resources
Industrial processes and product use	National Institute of Statistics (Statistical Yearbook, other data sources) Industrial operators, through the 42 Local Environmental Protection Agencies Information collected directly from industrial operators
Agriculture	National Institute for Statistics
LULUCF	National Institute for Statistics (Statistical Yearbook) Ministry of Agriculture, Forests and Rural Development (MADR) - General Directorate of Forests (2007-2008); Ministry of the Environment and Forests - General Directorate of Forests (2009-2011) National Forest Administration
Waste	National Institute for Statistics National Agency for Environmental Protection Institute of Public Health National Administration of Romanian Waters Food and Agriculture Organization (FAO) The waste deposit operators through the 42 Local Environmental Protection Agencies

The sources used for the emission factors are: studies developed at national level, IPCC 2006, national research institutes.

- *Quantitative estimation of the uncertainty for each source category and for the total inventory, by implementing the IPCC good practice guidance*

Specific elements regarding the implementation of the NGHGI uncertainty analysis are, as follows:

- based on Approach 1 in accordance with 2006 IPCC Guidelines provisions, Vol. 1 Ch. 3
- performed for 1989 and 2020, for both excluding and including the LULUCF sector
- based on national studies, data provided by institutions or default AD and EFs uncertainty sources

The uncertainty analysis resulted in the following figures for the base year and 2020 of the 2022 NGHGI submission and the Tier 1 method approach.

Table 3-9 Uncertainty analysis results for years 1989 and 2020

Uncertainty of NGHGI 2022 Submission	1989-without LULUCF	1989-with LULUCF	2020-without LULUCF	2020-with LULUCF
Total [%]	14.6%	15.9%	21.48%	32.71%;
Trend [%]			1.89%	2.09%,

More elements regarding the uncertainty analysis are provided in the NIR-NGHGI, May 2022, Section 1.6.

- *Compilation of the national inventory in accordance with the relevant provisions of UNFCCC and KP Decisions adopted by the Conference of Parties (COP, COP/MOP)*

NGHGI is compiled based on Guidelines for the preparation of national communications by Parties included in Annex 1 to the Convention, Part I: UNFCCC reporting guidelines on annual greenhouse gas inventories (FCCC/CP/2013/10/Add. 3; UNFCCC Reporting Guidelines).

Starting with the 2010 submission, the NIR is compiled according to the recommendations for inventories set out in the Annotated outline of the National Inventory Report including reporting elements under the Kyoto Protocol.

- *Prepare national annual inventories and supplementary information in a timely manner in accordance with Article 5 and Article 7, paragraphs 1 and 2, and relevant decisions of the COP and/or COP/MOP*

Romania submits the NGHGI within the established deadlines: 15 January and 15 March, to the European Commission and to the European Environment Agency, and 15 April, to the UNFCCC Secretariat. The NGHGI is prepared in accordance with Article 5 and Article 7, paragraphs 1 and 2, of the Kyoto Protocol, and with corresponding COP and/or COP/MOP decisions.

Romania reports supplementary information required under Article 7, paragraph 1, of the KP within the NGHGI, as follows:

- information on anthropogenic greenhouse gas emissions by sources and removals by sinks from LULUCF activities under KP's Article 3, paragraphs 3 and 4, in accordance with the provisions in Section I.D of the Annex to Decision 15-CMP. 1
- information on Kyoto units (emission reduction units (ERUs), certified emission reductions (CERs), temporary certified emission reductions (tCERs), long-term certified emission reductions (lCERs),

assigned amount units (AAUs) and removal units (RMUs)), as set out in Section I.E of the Annex to Decision 15/CMP. 1
- changes in national systems in accordance with Article 5, paragraph 1, of the Kyoto Protocol, as set out in Section I.F of the Annex to Decision 15/CMP. 1
- changes in national registries as set out in Section I.G of the Annex to Decision 15/CMP.1
- minimization of adverse impacts in accordance with Article 3, paragraph 14, of the Kyoto Protocol, as set out in Section I.H of the Annex to Decision 15/CMP.

C.4. Key category analysis

Identification of the key source categories following the methods described in the IPCC good practice guidance, as follows:

- key category analysis (KCA) is performed according to the provisions of 2006 IPCC GL, Vol. 1, Chapter 4, following the Approach 1
- KCA was conducted both, considering the exclusion and inclusion of the LULUCF sector and by level and trend criteria
- all IPCC sectors and categories, sources and sinks and gases were analyzed (as provided in Table 4.1 of 2006 IPCC GL Vol. 1)
- KCA was conducted for each year of the time series
- KCA has been performed in the context of the CRF Reporter application; results are presented in NIR, Chapter 1 and Annex 1 to the NIR.
- in the context of using the CRF Reporter application, the results of the key category analysis are reported in CRF tables 7 for each year of the reported period (1989-2020)
- KCA is used for prioritizing the necessary efforts to improve the quality of the NGHGI – developing the relevant studies allowing the implementation of higher tier methods for analyzing the key categories.

More details on the performed KCA are presented in Section 1.5 of the NIR-NGHGI, May 2022.

CRF Table 7, Summary overview for key categories, NGHG inventory 2020, submission 2022 v7 is presented in Annex 3.

Prepare estimates in accordance with the agreed methods under UNFCCC and KP, and ensure that appropriate methods are used to estimate emissions from key source categories, as follows:

- emission estimations from the sectors included in the Annex A of the Kyoto Protocol are estimated following the 2006 IPCC GL provisions
- emissions/removals from the LULUCF Sector are estimated following the 2006 IPCC Wetlands Supplement and KP Supplement
- estimation methods selection is in accordance with the provisions included in the MoEO no. 1442/2014 on approving the Procedure on selection of the estimation methods and of the emission factors needed for the estimation of the GHG levels

More details can be found in Sections 1.3 and 1.4. of the NIR-NGHGI, May 2022.

C.5. Recalculation of data

Any recalculations of previously submitted estimates of anthropogenic GHG emissions by sources and removals by sinks are prepared in accordance with the IPCC good practice guidance and relevant decisions of the COP and/or COP/MOP.

The implementation of recalculations is based on 2006 IPCC GL (before 2015 submissions the recalculations were based on IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000) and on IPCC GPG LULUCF (2003) provisions). During the inventory reporting period, Romania implemented significant recalculations to improve its NGHGI by using the best available AD and/or EFs, mainly based on the implemented studies and NEPA's/ MEWF's work. The recalculations resulted in a significant increase of accuracy, completeness and consistency of data series and are indicated in the NIR to the sectoral recalculation chapters and within Chapter 10 of the NIR - *Recalculations*.

More details on recalculations are presented in the NIR-NGHGI, May 2022.

C.6. Quality assurance and quality control (QA/QC) and verification plans

The QA/QC Program and the QA/QC Procedure provide information regarding to:

- the national authority responsible for the coordination of QA/QC activities
- the objectives envisaged within the QA/QC framework
- the QA/QC Plan
- the QC procedures
- the QA procedures.

According to the GD no. 1570/2007 as modified and completed ulteriorly, establishing the national inventory arrangements and the national system, the MoEO no. 1602/2014 on approving the Quality Assurance and Quality Control Plan associated to the National Greenhouse Gas Inventory and other legal provisions in place (as previously presented), NEPA is the competent authority responsible with the implementation of the QA/QC activities; the QA/QC coordinator is designated by NEPA; additionally, based on the specific provisions in the GD no. 590/2019, ICSI and INCDS are implementing QA/QC and verification activities related to the LULUCF Sector data and are documenting them.

QC activities were implemented:

- by every sectoral expert during all phases of inventory preparation
- by contractors developing studies for the NGHGI improvement
- QC are documented within sectoral QC lists consistently used across the dedicated NIA and NS by the NGHGI dedicated team; increased attention was dedicated to the key categories.

QA activities:

- NGHGI was subject to the annual European Union internal review under EU-Monitoring Mechanism: in 2012, 2016, 2017, 2018, 2019, 2020 and 2021, the NGHGI was reviewed under the Decision no. 406/2009/EC of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020; additionally, in 2020, the NGHGI was reviewed under the Regulation (EU) 2018/842 of the European Parliament and of the Council on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013;
- involvement of third-party reviewers in the context of developing studies for NGHGI quality improvement
- based on previous bilateral cooperation

- based on annual review process under UNFCCC and KP
- performed by national experts
- verification, national versus international datasets are compared, where available (e.g., comparison of national with Food and Agriculture Organization data)

The NGHGI improvement plan is annually updated by the QA/QC coordinator based on the results of the previously mentioned checks; the NGHGI improvement plan is linked with the NGHGI preparation plan administered by the NGHGI coordinator. Significant efforts were undertaken to implement sector-specific QC, QA and verification activities. Further relevant information is presented under Section 1.2.3 of the NIR-NGHGI, May 2022.

Elements characterizing the implementation of the NIA and NS inventory management functions are described below:

- Archive inventory information for each year in accordance with relevant decisions of the COP and/or COP/MOP. Specific details related to the archiving of NGHGI data/information include:
  - the activities are implemented based on the GD no. 1570/2007, as modified and completed ulteriorly, on the MoEO no. 1474/2008 for approving the Procedure on processing, archiving and storage of data specific to the NGHGI and on other relevant provisions in place (as previously presented); additionally, based on the specific legal provisions in the GD no. 590/2019, ICSI, INCDS, ICPA and INCAS archive all documents corresponding related to the administration of the LULUCF Sector and provide them to NEPA for a central archiving
  - electronic and paper documentation, as far as needed to reconstruct and interpret the inventory data and to describe the national inventory arrangements and national system and their functions, is archived
  - the archive is managed by NEPA, ICSI, INCDS, ICPA and INCAS; at the single national entity level, the archive is accessible at a single location at the NEPA's headquarters in Bucharest
  - all information officially submitted is available in English, while not all background information is available in English
  - security of databases and confidentiality of the background data, both in electronic and paper format, are ensured through implementation of restricted access conditions
  - NEPA designated the manager of the archiving system.

C.7. Procedures for official consideration and approval of the inventory

There is in place an established process for the official consideration and approval of the inventory, including any recalculations prior to its submission, and to respond to any issues raised during the inventory review process. Specific elements for the official consideration and approval of the inventory, including any recalculations, prior to its submission, are as follows:

- the process is defined within the GD no. 1570/2007 as ulteriorly modified and completed, within the GD no. 1020/2012 and within the MoEO no. 1376/2008
- the verification and evaluation of the NGHGI is performed at MEWF level
- NEPA personnel consider the observations and comments received and, as appropriate, update the NGHGI, aiming to its improvement as soon as possible and considering the relevant reporting guidelines.

The framework assuring the prompt responding to any issues raised during the inventory review process, includes the followings:

- based on legal provisions in place, NEPA ensures the availability of human and financial resources for the implementation of review activities
- NEPA ensures an efficient collaboration with the review teams under the coordination of the UNFCCC Secretariat, through the provision of all information and responses to the associated observations and questions, according to the relevant legal provisions
- ICSI, INCDS, ICPA and INCAS participate with technical experts during the review of the LULUCF Sector to respond in a timely manner to the questions raised regarding this sector under UNFCCC and KP provisions, together with NEPA representatives.

C.8. Changes to the national inventory arrangements since the previous submission

Since the submission of the 7th National Communication the National Inventory Arrangements and National System were modified, as follows:

- GD 590/2019 approved the new institutional arrangements for a better and efficient administration of the LULUCF sector (see above).
- GD 1570/2007 was modified by GD no. 600/2022 regarding the establishment of measures for the implementation of the provisions of art. 26 para. (2) of Regulation (EU) 2018/1999 of the European Parliament and of the Council, of 11 December 2018, on estimation of the annual proxy inventory of GHG emissions. This GD provides that NEPA prepares and submit to the European Commission by 31 July 2021, and annually thereafter, the Romanian approximate GHG emissions inventory, which characterize at a more general level the GHG emissions in the year X-1, that will be detailed in the following reporting year, through the National Inventory of Greenhouse Gas Emissions (INEGES), according to the rules in place.

D. National registry

General information, Recent changes, Status of Romania's national registry

(a) Name and contact details for the registry administrator designated by Romania to administer the national registry

In accordance with art. 24, paragraph (1) of GD 780/2006, of June 14, 2006, regarding the establishment GHG certificates commercialization scheme with subsequent amendments and additions, NEPA is the national administrator of the accounts in the European Union Register of GHG emissions.

According to NEPA President Decision no. 764/07.07.2017, the GHG Registry of European Union under the jurisdiction of the Romanian state is administered by:

- Mr. Catalin Dulgheru, national administrator of the GHG European Union Registry, Department of the GHG European Union Registry within the Climate Change Directorate
- Mrs. Adriana Cristea, adviser to the GHG European Union Registry Department within the Climate Change Directorate
- Mrs. Izabela-Georgiana Franga, advisor to the GHG European Union Registry Department within the Climate Change Directorate

- Mr. Alin-Daniel Şerban, adviser to the GHG European Union Registry Department within the Climate Change Directorate.

b) The names of the Parties with which the Romania cooperates for the administration of national registers in a consolidated system.

Directive 2009/29/EC adopted in 2009 provides for the centralization of EU ETS operations in a single register of the European Union, administered by the European Commission, as well as for the inclusion of the aviation sector. To increase the efficiency of the operations of the respective national registers, the EU member states that are also parties to the Kyoto Protocol (26), plus Iceland, Liechtenstein, Norway, have decided to operate their registers in a system consolidated in accordance with all relevant decisions applicable to the establishment of Party registers - in particular Decision 13/CMP.1 and Decision 24/CP.8.

(c) Description of the structure of the database and the capacity of the national register

The consolidated platform implementing the national registries (including the EU registry) in a consolidated manner is called the Union Registry and was developed together with the new EU registry based on the following modalities:

- each Party retains its designated registry administrator organization to maintain that party's national registry and remains responsible for all obligations of the parties to be fulfilled through the registries
- each Kyoto unit issued by the parties in such a consolidated system is issued by one of the component parties and continues to bear the identifier of the party of origin in its unique sequence number
- each Party keeps its own set of national accounts in accordance with point 21 of the annex to Decision 15/CMP.1. Each account within a national register keeps a unique account number that includes the identifier of the party and a unique number within the party in which the account is maintained
- Kyoto transactions continue to be transmitted and verified by the UNFCCC's Independent Transaction Registry (ITL), which remains responsible for verifying the accuracy and validity of those transactions
- the transaction log and ledgers continue to reconcile their data with each other to ensure data consistency and facilitate automatic ITL verification.

In 2016, new tables were added to the database to implement CP2 functionality. Versions of the Union register developed after version 6.1.6 (the production version at the time of the last NC submission) introduced other minor changes to the structure of the database.

These changes were limited and affected the functionality of the EU ETS. No changes were required to the backup plan for the database and application plans or to the disaster recovery plan.

(d) Description of the way of compliance of the national registry with DES between systems between national registries, clean development mechanisms and transaction log

All registries are on a consolidated IT platform that shares the same infrastructure technologies. The chosen architecture implements ways to ensure that consolidated national registries are identifiable, protected and distinct from each other, in particular:

- in terms of data exchange, each national registry connects directly to the ITL and establishes a secure communication link through a consolidated communication channel (VPN tunnel);

- ITL remains responsible for authenticating national registers and fully and definitively records all transactions involving Kyoto Protocol units and other administrative processes, so that these actions cannot be challenged or rejected
- With regards to the data storage, the consolidated platform continues to guarantee that data is kept confidential and protected against unauthorized manipulation
- The data storage architecture also ensures that the data pertaining to a national registry are distinguishable and uniquely identifiable from the data pertaining to other consolidated national registries
- In addition, each consolidated national registry keeps a distinct user access entry point (URL) and a distinct set of authorization and configuration rules.

Following the successful implementation of the Union Registry, the 28 national registries concerned were re-certified in June 2012 and switched over to their new national registry on 20 June 2012. Croatia was migrated and consolidated as of 1 March 2013. During the go-live process, all relevant transactions and holdings, data were migrated to the Union Registry platform and the individual connections to and from the ITL were re-established for each Party.

(e) A description of the procedures employed in the national registry to minimize discrepancies in the issuance, transfer, acquisition, cancellation and retirement of emission reduction units (ERUs), certified emission reductions (CERs), temporary certified emissions reductions (tCERs), long-term certified emission reductions (lCERs), assigned amount units (AAUs) and/or removal units (RMUs), and replacement of tCERS and lCERs, and of the steps taken to terminate transactions where a discrepancy is notified and to correct problems in the event of a failure to terminate the transactions

The consolidated platform which implements the national registries in a consolidated manner (including the registry of the EU) is called the Union Registry and was developed together with the new EU Registry on the basis the following modalities:

- Each Party retains its organization designated as its registry administrator to maintain the national registry of that Party and remains responsible for all the obligations of Parties that are to be fulfilled through registries
- Each Kyoto unit issued by the Parties in such a consolidated system is issued by one of the constituent Parties and continues to carry the Party of origin identifier in its unique serial number
- Each Party retains its own set of national accounts as required by paragraph 21 of the Annex to Decision 15/CMP.1. Each account within a national registry keeps a unique account number comprising the identifier of the Party and a unique number within the Party where the account is maintained
- Kyoto transactions continue to be forwarded to and checked by the UNFCCC Independent Transaction Log (ITL), which remains responsible for verifying the accuracy and validity of those transactions
- The transaction log and registries continue to reconcile their data with each other to ensure data consistency and facilitate the automated checks of the ITL.

(f) An overview of security measures employed in the national registry to prevent unauthorized manipulations and to prevent operator error and of how these measures are kept up to date

The mandatory use of hardware tokens for authentication and signature was introduced for registry administrators.

(g) A list of the information publicly accessible by means of the user interface to the national registry

Publicly available information is provided via the Union registry homepage for each registry[17].

In accordance with the Regulation no. 389/2013, Annex XIV, the publicly available information (except confidential data) are posted on the above website and are as follows:

- Persons holding accounts (PHA and TA)
- Operators holding accounts – industrial installations and aircraft operators (OHA and AOHA)
- Verifiers holding accounts
- National accounts administrator contact data
- Number of units (ERUs, CERs and AAUs) cancelled and retired.

(h) The Internet address of the interface to its national registry

The internet address of the Romanian registry is:

https://ets-registry.webgate.ec.europa.eu/euregistry/RO/index.xhtml

(i) A description of measures taken to safeguard, maintain and recover data to ensure the integrity of data storage and the recovery of registry services in the event of a disaster Network errors Disaster Recovery Plan – EU Registry Procedure –confidential (SIAR)- Anex II E, 32 (B) -15/CMP 1

The overall change to a consolidated system of EU Registries also triggered changes to data integrity measures, as reflected in the updated disaster recovery plan. The complete description of the consolidated registry was provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries.

(j) The results of any test procedures that might be available or developed with the aim of testing the performance, procedures and security measures of the national registry undertaken pursuant to the provisions of decision 19/CP.7 relating to the technical standards for data exchange between registry systems.

Each version of the Registry is subject to both regression testing and tests related to the new functionality. These tests also include thorough testing against the DES and were successfully carried out prior to each release of a new version in Production. The test is performed every year. The tests are carried out by the quality assurance consultants on behalf of and assisted by the European Commission.

Table 3-10 Total quantities of CP1 Kyoto Protocol units in Romanian's national registry by account type at the end of 2021

Account type	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Party holding accounts	NO	NO	NO	NO	NO	NO
Entity holding accounts	NO	NO	NO	NO	NO	NO
Article 3.3/3.4 net source cancellation accounts	NO	NO	10,992,158	NO		
Non-compliance cancellation account	NO	NO	NO	NO		

[17] Union Registry for Emissions Trading. Website: https://ets-registry.webgate.ec.europa.eu/euregistry/XX/public/reports/publicReports.xhtml

Other cancellation accounts	897	73,192	NO	16,353	NO	NO
Retirement account	584,842,690	4,479,948	17,988,730	8,618,591	NO	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	
lCER replacement account for expiry	NO	NO	NO	NO		
lCER replacement account for reversal of storage	NO	NO	NO	NO		NO
lCER replacement account for non-submission of certification report	NO	NO	NO	NO		NO
Total	584,843,587	4,553,140	28,980,888	8,634,944	NO	NO

Table 3-11 Total quantities of CP2 Kyoto Protocol units in Romanian's national registry by account type at the end of 2021

Account type	Unit type					
	AAUs	ERUs	RMUs	CERs	tCERs	lCERs
Party holding accounts	656,059,490	17,860,750	NO	8,578,507	NO	NO
Entity holding accounts	NO	7,943	NO	73,621	NO	NO
Retirement account	NO	NO	NO	NO	NO	NO
Previous period surplus reserve account	532,594,270	-	-	-	-	-
Article 3.3/3.4 net source cancellation accounts	NO	NO	NO	NO	-	-
Non-compliance cancellation account	NO	NO	NO	NO	-	-
Voluntary cancellation account	NO	2,032	NO	40,784	NO	NO
Cancellation account for remaining units after carry-over	NO	NO	NO	NO	NO	NO
Article 3.1 ter and quater ambition increase cancellation account	NO	-	-	-	-	-
Article 3.7 ter cancellation account	NO	-	-	-	-	-
tCER cancellation account for expiry	-	-	-	-	NO	-
lCER cancellation account for expiry	-	-	-	-	-	NO
lCER cancellation account for reversal of storage	-	-	-	-	-	NO
lCER cancellation account for non-submission of certification report	-	-	-	-	-	NO
tCER replacement account for expiry	NO	NO	NO	NO	NO	-
lCER replacement account for expiry	NO	NO	NO	NO	-	-
lCER replacement account for reversal of storage	NO	NO	NO	NO	-	NO
lCER replacement account for non-submission of certification report	NO	NO	NO	NO	-	NO
Total	1,188,653,760	17,870,725	NO	8,692,912	NO	NO

4. POLICIES AND MEASURES

A. Policymaking process

A.1. Overall policy context, including any national targets for GHG mitigation

The most important part of the policymaking process for GHG mitigation is part of the EU process. The mitigation and adaptation policies are designed to bring benefits to citizens, businesses, and other stakeholders. Before proposing new policies, the European Commission describes the initiative in a roadmap, examining the potential economic, social, and environmental consequences in an impact assessment and requesting input from the public and from stakeholders. At the same time, citizens can suggest new EU policies or laws through the European Citizens' Initiative. Impact assessment reports are published with the proposals or with acts adopted by the European Commission. They are also sent to the EU lawmakers, the Parliament and Council, to consider as they decide on whether to adopt the proposed law. Current polices and laws are regularly evaluated so as to improve them, so that they achieve their objectives in the most efficient and effective way possible. More details on the EU policymaking process are provided in section 4.2 of the EU 8th National Communication.

The EU adopted policies are integrated for implementation at national level, being monitored evaluated and reported against their impact on GHG emission level and target achievement. At the same time national policies are elaborated, discussed, adopted and implemented with impact in GHG emissions reduction.

In this way the European Union and its Member States have a comprehensive system in place which helps them fulfil their climate change mitigation commitments under the Convention, under the Kyoto Protocol and under the Paris Agreement. In addition, since 2020, the European Green Deal, a comprehensive and holistic plan to become the first carbon neutral continent by 2050 has been adopted. More information regarding the EU climate policies, current or under adoption process, are provided in Section 4.3 of the EU's 8th National Communication.

In Romania the right for any citizen to live in a healthy environment is recognized by Constitution. As consequence each entity has the right and duty to protect and improve the environment conditions.

There are some overarching Strategies in Romania that were recently developed to respond to the need of the economic sectors and the entire society to follow an agreed development path to a green growth and sustainable development.

✓ Romania has completed its 2030 National Strategy for Sustainable Development[18] (2030 NSSD) adopted by the GD no. 877/2018 by adopting in June 2022 the GD no. 754/2022 – National Action Plan implementing the Strategy. Through its 2030 NSSD Romania establishes its national framework for supporting the achievement of 2030 Agenda goals and implementing the set of 17 SDGs. The strategy supports Romania's development on three main pillars, economic, social and environment.

The governance of Strategy implementation is provided by the GD no. 313/2017 regarding the establishment, organization and functioning of the Department for Sustainable Development within the Romanian Government, ulteriorly completed, and amended. The Department is in charge of developing a strong legislative and inter-institutional framework to coordinate the implementation of the 2030 Agenda. It defines the priorities for action

[18] https://dezvoltaredurabila.gov.ro/files/public/10000001/Romania-Sustainable-Development-Strategy-2030-en.pdf

and oversee implementation and monitoring of progress with the intention to make sustainability assessments part of decision-making and policy evaluation processes.

One of the main actions of the implementation plan was developing the regulation framework and inter-institutional cooperation for the implementation of the 2030 NSSD.

At the management level was constituted in 2019 - the Interdepartmental Committee for Sustainable Development, an inter-institutional body having as members the ministers of the Romanian Government. This Body analysis the reports on SDGs implementation elaborated and submitted by the Sustainable Development Department.

At the implementation level an occupational standard was created in Romania that is the basis for the training of experts in sustainable development. The occupation "sustainable development expert" was introduced in the Classification of Occupations in Romania (COR242232). Thus, it was enhanced the role of the sustainable development hubs established at the level of public authorities having responsibilities in the field of sustainable development and envisaged to operate as a national network to ensure the connection between the institutions.

One of the most important overarching objectives of the 2030 National Strategy for Sustainable Development is related to incorporation of the sustainable development principle into the activities of the government to combat global warming and achieving of the SDG 13 - climate action. By ratifying the UNFCCC in 1994, the Kyoto Protocol in 2001, the Doha Amendment to the Kyoto Protocol in 2016 and the Paris Agreement in 2017, Romania committed to contribute individual and jointly at the EU level to the stabilization of greenhouse gas emissions at a level that prevents dangerous anthropogenic interference with the climate system. The Long-Term Strategy of Romania is under developing process, and it will strive to establish the most ambitious goal for 2050 and the path to achieve it, in line with the new ambitious EU 2030 adopted legislation package and the 2050 established neutrality goal. The strategy will present the climate goals and emission pathways for the energy, buildings, industry, transport, agricultural, and waste sectors. The CO2 removals and the new energy technologies will have an important role to balance the GHG un-avoided emissions.

Continuing the good practices within implemented within the sustainable development area, in April 2022 it was established the Inter-ministerial Committee on Climate Change by adoption of Government Decision 563/2022. The members of this Body are the ministers of different Ministries of the Romanian Government, and it is led by three vice-presidents, the president being the Prime Minister of the Romanian Government. The three vice-presidents are, as follows:

- the head of the Chancellery of the Prime Minister (who can replace the president)
- the head of the Climate and Sustainability Department within the Presidential Administration
- the Minister of the Environment, Waters and Forests
- the President of Romania can also be invited

This Committee has the role to analyze the climate actions at national and sectoral level to ensure:

- the coherence of the implemented mitigation sectoral policies with the national climate commitments and the appropriate contribution to achieving the EU and its Member States joint targets
- monitoring progress towards the fulfilment of these commitments
- proposes annual priority policies consistent with existing commitments
- analyses the implementation of the National Integrated Energy Climate Plan and the objectives of the Long-Term Strategy for the GHG emissions reduction (LTS – Long Term Strategy)

- analyses the budgeting of the climate actions
- analyses and proposes indicators to monitor the implementation of the climate policies and targets achievement
- proposes the communication of a unified and coherent message on the topic of climate change.

✓ The Romanian Government adopted the National Strategy regarding the Circular Economy, developed under the coordination of the Department for Sustainable Development – GD no. 1172/2022. The document provides an overview of 14 economic sectors in terms of their circularity potential, setting a direction to accelerate the transition from a linear to a circular economic model. The success indicator of this transition is the decoupling of economic development from the use of natural resources and environmental degradation.

✓ It was launched in October 2022 the public debate of the National Competitiveness Strategy 2021-2027. This Strategy proposes a redefinition of the national policy in the field of economic competitiveness through an inclusive approach, based on a synthesis of documents and public policies, especially in the fields of economics, research and development, education, the labor market, public institutions, and regulation. The main strategic objective is to develop an economy based on a competitive economic environment, to implement the digital transformation process in companies and to have a stable institutional framework.

✓ The National Long-term Renovation Strategy supporting the renovation of the national residential and non-residential building stock, public and private, into a highly efficient and decarbonized building stock by 2030 – it was adopted by the GD 1034/2020. The Strategy establishes indicative milestones for 2030, 2040 and 2050 and the envisaged contribution to the overall EU energy efficiency target for 2030. It considers policies and actions to incentivize cost-effective renovation of buildings, address energy poverty, promote smart technologies and well-connected buildings and communities, education in the construction and energy efficiency areas.

✓ Romania's Energy Strategy for 2019 - 2030 period, with the perspective of 2050, updating the previous strategy, considered the demand and international obligations of Romania, but also the achievement of the optimal scenario for the development of the national energy system.

✓ The National Waste Management Plan, approved by GD no. 942/2017, includes clear and coherent measures to achieve the objectives of preparation for reuse and recycling of waste by 2020.

A.2. Institutional arrangements for monitoring over time the policies and measures and evaluating the progress for GHG emissions mitigation

According to Governmental Decision (GD) no. 43/2020 regarding the organization of the Ministry of Environment, Water and Forests (MEWF), MEWF is the competent authority ensuring the fulfilment of Romania's reporting obligations in the climate area.

In 2022, further to GD no. 43/2020 modifications, as provided by the GDs no. 369, 677 and 1534, the structure of the MEWF was modified and the climate activities were integrated under the General Directorate on Impact Assessment, Pollution Control and Climate Change and are accomplished by two departments: the Climate Strategies and Reporting Department and the Climate Regulation and Implementation Department.

MEWF has the following attributions, in accordance with *Regulation (EU) No. 2018/1999 regarding the governance of the energy union and climate actions*:

- Ensuring the management of the National System for policies and measures and projections of GHG emissions, in line with Article 39 provisions of the *Regulation (EU) No. 2018/1999*

- Ensuring the coordination of elaboration and submission of the Report on policies and measures to mitigate the GHG emissions and the Report on projections of the GHG emissions, in accordance with *art. 17 and 18 of the Regulation (EU) 2018/1999*
- Ensuring the coordination of elaboration and submission of the Biennial Report and National Communication, in accordance with article 12 of the Convention and the relevant COP decisions (i.e., Decisions 2/CP.17 and 6/CP.25).

To fulfil the above obligations, MEWF develops public acquisitions and engages contract research services as well as consulting services to achieve the necessary studies providing as results the elaboration of the above reports.

In order to meet Romania's reporting obligations in accordance with Article 17 and 18 of the Regulation (EU) 2018/1999, as well as with COP decisions 2/CP.17, 6/CP.25 and the corresponding CMP decisions providing guidelines to report in accordance with Article 7.2 of the Kyoto Protocol, the Ministry of Environment, Waters and Forests deployed a public acquisition procedure to engage Consultancy Services to elaborate the study regarding to "*Elaboration of Biennial Reports and National Communications, as well as Reports on policies and measures and projections on greenhouse gas emissions mitigation, according to the provisions of art. 17, respectively art. 18 of Regulation (EU) 2018/1999*". The public acquisition contract was awarded to a consortium with technical expertise in National Greenhouse Gas Inventory (NGHGI) sectors and is coordinated by BEIA Consult International.

Data and information flow for drawing up the 5th Biennial Report and the 8th National Communication, and the associated reports on PaMs and Projections is presented in the figure below:

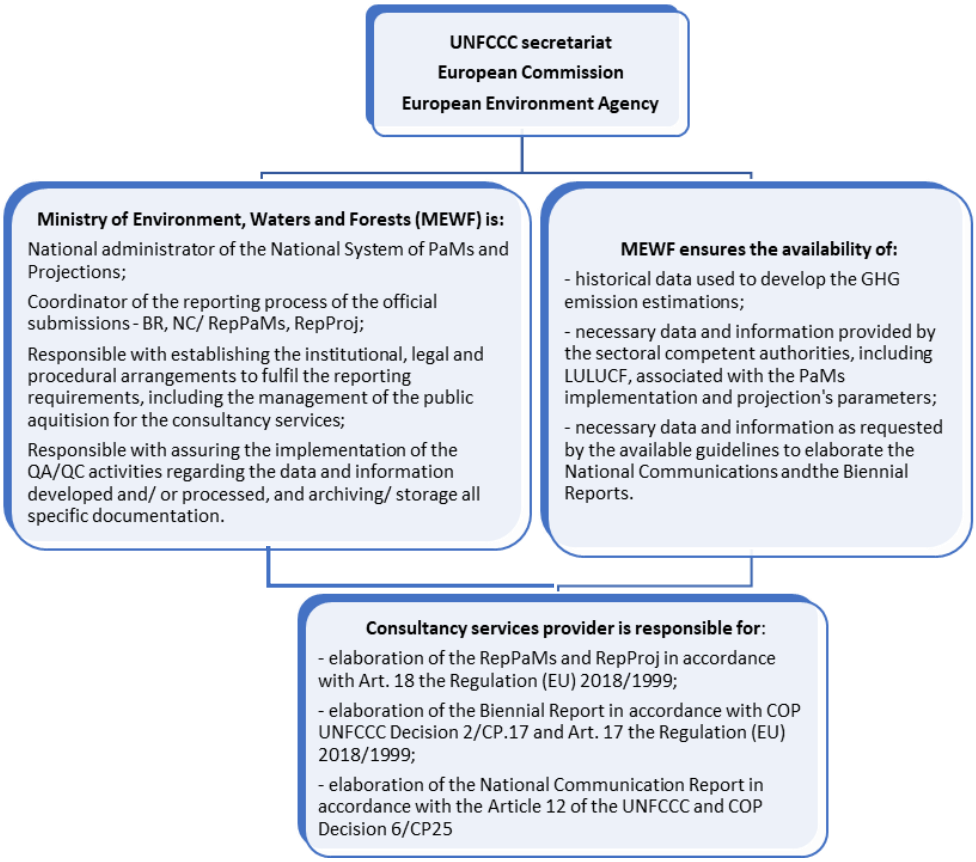


Figure 4-1 RepPaMs and RepProj data and information flow

In Romania the Ministry of Environment, Waters and Forests is the national entity responsible for administration of the National System for policies and measures and projections of the GHG emissions, as provides the *GD no. 267/2019 on the establishment of the National System for Reporting on Policies and Measures and Projections of anthropogenic GHG emissions by sources and removals by sinks* (NSPMPGHG). This GD establishes the legal, institutional, and procedural framework for collecting the necessary data to fulfil the reporting obligations assumed by Romania at European and international level, as follows:

- MEWF, as competent authority, is responsible for the development and submission of the Report on Policies and Measures (RepPaMs) and the Report on Projections (RepProj) of anthropogenic GHG emissions by sources and removals by sinks
- MEWF, as competent authority, is responsible for the development and submission of the Biennial Report and National Communication
- The central public authorities and public institutions provide the necessary data and information to elaborate the RepPaMs and RepProj, including the macro-economic parameters
- MEWF ensures the completeness of the data and information related to PaMs and projections, which shall include all GHG emissions and removals for all years, all gases and all considered projection scenarios
- MEWF ensures the implementation of the quality assurance and quality control (QA / QC) of data and information developed and / or processed and the archiving and storage of all specific documentation related to RepPaMs and RepProj or to Biennial Reports or National Communications
- The central public authorities and the public institutions responsible for providing the necessary data and information for elaboration of the reports are implementing the quality control procedures regarding the provided data, in accordance with their competences.

A.3. Domestic and regional programmes and/or legislative arrangements and enforcement and administrative procedures in accordance with Article 7.2 of the Kyoto Protocol

Information on domestic and regional legislative arrangements and enforcement and administrative procedures to meet the commitments under the Kyoto Protocol.

Romania ratified Kyoto Protocol in 2001 and Doha Amendment to the Kyoto Protocol in 2016. As such, these institutional arrangements provided the overall context to achieve the targets under the KP commitments.

After the first commitment period Romania achieved its individual target and the joint target as the EU MSs. The total greenhouse gas emissions in the first commitment period is 615 929 959 tCO2 eq. The assigned amount established in accordance with Article 3, paragraphs 7 and 8, of the Kyoto Protocol was 1 279 835 099 t CO2 eq. The base year greenhouse gas emissions accounted 278 225 022 tCO2 eq. Quantified emission limitation or reduction commitment for the first commitment period as provided by the Annex B of the Kyoto Protocol was 92.0 % of base year level.

For the second commitment period of the Kyoto Protocol (2013-2020), the Effort Sharing Decision (cf. section 4.2.2 of the EU's 5th Biennial Report) established emission reduction targets for the non-ETS sectors for each Member State individually and for each year of the period and included an annual compliance mechanism. The institutional arrangements to coordinate activities relating to participation in the Kyoto Protocol mechanisms are

laid out in the Effort Sharing Decision, the ETS Directive[19] and the Monitoring Mechanism Regulation[20]. These legal acts are publicly accessible, and the progress towards the 2020 targets has been published annually in the 'Trends and Projections in Europe' reports[21].

Further to the last NGHGI 2022 submission under the second commitment period, Romania achieved for the base year 307,326,206.5 tonnes CO_2 eq in comparison with the calculated base year of 304 920 568 t CO2 eq. The assigned amount of Romania calculated for the second commitment period of the Kyoto Protocol (2013-2020) was 656 059 490 t CO2 eq. The analysis of the NGHGI 2022 submission is still ongoing, but after the preliminary estimations Romania overachieved its individual KP2 target and also contributed to the joint EU target achievement for the period 2013-2020 compared to the joint assigned amount for EU-27, the UK and Iceland.

Information on the institutional arrangements and decision-making procedures that are in place to coordinate activities relating to participation in the mechanisms under Articles 6, 12 and 17, including the participation of legal entities.

The Kyoto Protocol provided for three mechanisms, supplemental to domestic action, which supported the Parties in the achievement of their emission limitation and reduction targets: under Article 6 - Joint Implementation, which made use of emission reductions or the enhancement of greenhouse gas removals by sinks in other developed countries; under Article 17 - the emissions trading between developed countries; under Article 12 - the Clean Development Mechanism, which allowed accounting for emission reduction projects in developing countries.

For Romania the Kyoto Protocol mechanisms constituted a supplemental element, and domestic action constituted the key element allowing the GHG emission reductions.

For both, the first commitment period (2008-2012) and the second commitment period (2013-2020), Romania encountered substantial decreases in domestic GHG emissions and the both targets of the two Kyoto Protocol periods have been largely achieved through domestic emission reductions.

Romania has in place the institutional arrangements that allowed the implementation of the Joint Implementation projects of the Kyoto Protocol, under its Article 6[22], mostly on the first commitment period implementation. As explained in chapter [BR5] 4 of the Fifth Biennial Report, these emission reductions can be attributed to various key EU policies such as the EU ETS and the effort sharing decision. Hence it can be concluded that domestic action was the key driver for meeting the Kyoto protocol targets of the EU, and the Kyoto Protocol mechanisms played a supplemental role only.

[19] Directive 2003/87/EC Of The European Parliament And Of The Council of 13 October 2003. Available at: https://eur-lex.europa.eu/eli/dir/2003/87/2021-01-01.
[20] Regulation (EU) No 525/2013 Of The European Parliament And Of The Council. Available at: https://eur-lex.europa.eu/eli/reg/2013/525/oj.
[21] Trends and projections in Europe, https://www.eea.europa.eu/themes/climate/trends-and-projections-in-europe.
[22] JI: Parties Involved in JI Projects (unfccc.int)

Information on national legislative arrangements and administrative procedures that seek to ensure that the implementation of activities under Article 3, paragraph 3, forest management under Article 3, paragraph 4, and any elected activities under Article 3, paragraph 4, also contribute to the conservation of biodiversity and sustainable use of natural resources.

The EU has specific arrangements in place to ensure that the implementation of policies and measures also contribute to the conservation of biodiversity and sustainable use of natural resources. As an example, under the Renewable Energy Directive, biofuels need to fulfil a set of sustainability criteria including minimum emission reduction, biodiversity aspects, and requirements for various land types. Several related initiatives were recently adopted by the European Commission: A new EU Forestry Strategy, a biodiversity strategy, a communication in sustainable carbon cycles, a carbon farming initiative and an EU soil strategy.

In 5 October 2022 the Romanian Government approved the legislative proposal of the Ministry of Environment, Water and Forests, the National Forestry Strategy for 2030. This Decision transposes the Forestry Strategy of the European Union to the forestry sector in Romania. The adoption of the National Forestry Strategy represents a milestone in the implementation of the National Recovery and Resilience Program, C2 Component - *Forests and biodiversity protection*.

The National Forestry Strategy is a strategic document whose general objectives are ensuring the balanced integration of social, ecological and economic functions in the management of forests.

Romania implements activities under Article 3, paragraph 3, forest management under Article 3, paragraph 4, and any elected activities under Article 3, paragraph 4, that also contribute to the conservation of biodiversity and sustainable use of natural resources. As the NIR 2022 of Romania explains in Chapter 11.7 - Information relating to Article 6, pg. 815, Romania implemented an AR activity project as a Joint Implementation project within the framework of the flexible mechanism under Article 3.3 of the Kyoto Protocol. The project lasted from 2002 to 2017.

B. Policies and measures and their effects

Romania, as an EU Member State has implemented mitigation policies and measures for many years which has already contributed successfully to the reduction of greenhouse gas emissions in recent years. These include the European Union Emissions Trading System (EU ETS) and a wide range of policies and measures addressing all sectors of the economy. At EU level the climate policies are already extended as such to achieve in 2030 the NDC target communicated by the EU and its Member States, which is an economy-wide net domestic emission reduction of at least 55 % by 2030 compared to 1990. The European Union and its Member States have a comprehensive system in place which helps them fulfil their climate change mitigation commitments under the Convention, under the Kyoto Protocol and under the Paris Agreement. In addition, since 2020, the European Green Deal, a comprehensive and holistic plan to become the first carbon neutral continent by 2050 has been adopted. It acts as a catalyst for more ambitious targets.

This report is focused on the key policies and measures that are currently in place at EU level and are implemented by each Member State. More details on the EU policymaking processes are provided in Chapter 4.2 of the EU's 8th National Communication Report[23].

[23] https://unfccc.int/documents/624694

In this section, an overview of the climate change mitigation policies and measures is provided. More detailed information can be found in the CTF tables annexed to the Romanian's 5th Biennial Report, which are submitted together with this National Communication. The 5th Biennial Report and its annexed CTF tables include information on the sector or sectors affected, the greenhouse gases affected, objectives/activities, whether the policy or measure makes use of economic, fiscal, regulatory or other instruments, the start year and status of implementation, responsibilities and – as far as available – information on the mitigation impact.

The Policies and measures are selected and reported being prioritized in accordance with their most significant impact on the GHG emissions mitigation and removals enhancing. The distinction of the PaMs was made by considering their status as implemented, adopted, and planned, definitions applicable to PaMs.

The report was organized by sector implementing the PaMs and by affected gases. In terms of the quantitative impact on GHG mitigation, this was estimated considering the sectoral collection of policies and measures. It was not possible to estimate the individual impact of each PaM since the necessary data were not provided in detail by the implementing responsible institutions.

B.1. Description of the significant policies and measures

This section provides information on adopted and planned policies and measures, which contribute to achieve the GHG emissions mitigation goals at EU level and of the Convention taking into consideration the Kyoto Protocol.

The adopted and planned policies and measures took into consideration the GHG emissions of each sector, the reduction potential, and the national priorities for economic development.

The adopted and planned policies and measures at the national level, applying on several activity categories representing GHG emissions sources are the following:

Adopted Policies and measures

- *GD no. 877/2018 approving Romania's Sustainable Development Strategy 2030*, defining the national framework for implementing the 2030 Agenda for Sustainable Development and promoting the development of Romania by focusing on three dimensions – economic, social and environmental; the specific dimensions where additional efforts and resources are needed to achieve the convergence objectives with the EU on the main indicators of sustainable development are presented in the following sections, at sectoral level
- *Law no. 278/2013 on industrial emissions*, including common provisions related to integrated pollution prevention and control for industrial activities (large combustion plants, waste incineration/co-incineration plants, installations and activities using organic solvents and installation producing titanium dioxide)
- *Decisions establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU* of the European Parliament and of the Council
- *GD no. 780/2006 establishing the greenhouse gas emission allowance trading scheme* (ETS), with further amendments and supplements, applicable for the 2007÷2020 period.

For the 2021-2030 period, the national emissions reduction commitment is part of the EU's commitment to reduce GHG emissions related to ETS sector (43.9% lower than in 2005).

- *Regulation (EU) 2018/842 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement*, establishing the Member States obligations related to their minimum contribution for the 2021-2030 period to fulfil

the Union's target of reducing its GHG emissions by 30% below 2005 levels in 2030 in the sectors covered by article 2 of Regulation

For non-ETS sector, Romania GHG emissions reduction in 2030, in relation with 2005 level, is -2%.

In accordance with Commission Implementing Decision (EU) 2020/2126, the annual emission allocation for Romania under Regulation (EU) 2018/842, calculated by applying the global warming potentials set out in the IPCC's 5th Assessment Report (listed in Commission Delegated Regulation (EU) 2020/1044), are the following:

Table 4-1 Annual adjusted emission allocation for Romania, 2021÷2030 period

Annual allocated emission level ESR (t CO_2)									
2021	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
87878093	76914871	76884391	76853912	76823433	76792954	76762474	76731995	76701516	76671037

- *Law no. 220/2008 on establishing the promotion system for the production of the energy from renewable energy*, with further amendments
- *Law no.121/2014 on energy efficiency*, with further amendments, ensuring the legal framework and policy measures for energy efficiency for the whole chain (primary resources, manufacturing, distribution, supply, transport, and final consumption) with the purpose of meeting the strategic objective of the national energy policy to improve energy efficiency. The national indicative contribution regarding energy efficiency for 2030 is established through PNIESC 2021-2030.
- GD no. 203/2019 on the approval of the National Action Plan for energy efficiency IV (NEEAP IV), establishing significant measures to increase energy efficiency, evaluating the energy savings achieved and establishing the energy savings expected to be achieved by 2020, considering NEEAP III as reference.
- The 2021-2030 Integrated National Energy and Climate Plan, adopted by GD no. 1076/2021, establishing the national targets and shares in the achievement of the 2030 EU climate change targets, as presented below:
    - *ETS emissions*: the national emissions reduction commitment is part of the EU's commitment to reduce GHG emissions related to ETS sector (43.9 % lower comparing with 2005)
    - Non-ETS emissions: according with *Regulation (EU) 2018/842 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement*; Romania GHG emissions reduction in 2030, in relation to the 2005 level, is -2%
    - *Renewable energy*: Romania contribution for achieving the EU target (32% renewable energy consumption in 2030) consists in reaching an overall share of renewable energy in gross final energy consumption of 30.7% in 2030 (of which: RES-E share: 49.4%; RES-T share: 14.2%; RES-H&C share: 33.09%)
    - *Improvement in energy efficiency*: Romania contribution for achieving the EU target (32.5% for improvements in energy efficiency in 2030), consists in the reduction of primary energy consumption (45.1% compared to the PRIMES 2007 projection for 2030, meaning 32.3 Mtoe in 2030) and the reduction of final energy consumption (40.4% compared to the PRIMES 2007 projection for 2030, meaning 25.7 Mtoe in 2030).
- *National Recovery and Resilience Plan (PNRR)*, ensuring an optimal balance between EU priorities and Romania's development needs, in the context of recovery after the COVID-19 crisis, and containing

interventions designed to support the implementation of the PNIESC 2021-2030; PNRR includes several components that shall directly contribute to the reduction of GHG pollutant emissions: C1 Water Management, C3 Waste Management, C4 Sustainable Transport, C5 Renovation Wave, C6 Energy.

- *National programs for local and regional development*, e.g., the programs managed by MDLPA (e.g. Anghel Saligny National Investment Program) or MMAP through AFM ("Rabla Clasic", "Rabla Plus", "Realization of cycle tracks", "Recharging stations with normal power", "Photovoltaic Green House").

Planned policies and measures

- *The Sustainable Development Operational Program (PODD) 2021 -2027*[24], with the following policy objectives relevant to climate change, the GHG emission reduction component:
  - Promoting energy efficiency measures, developing smart energy systems and GHG emissions reduction, by financing the thermal energy supply systems in centralized system, respectively the heating networks, including thermal points
  - Promoting the use of renewable energy sources, by financing investments in new capacities or in the modernization of existing capacities to produce electricity/thermal energy from biomass/biogas and in new capacities or in the modernization of capacities to produce thermal energy from geothermal water
  - Input of gases from renewable sources and gases with low carbon emissions into the system
  - Improving energy efficiency at the industrial consumer's level
  - Increasing the degree of collection and purification of urban wastewater
  - Efficient waste management to accelerate the transition to the circular economy
- *The Regional Operational Programs (POR) 2021-2027*[25], developed for the sustainable and balanced development of the 8 development regions of Romania, having the following policy objectives relevant to the climate change, the GHG emissions reduction component:
  - Improving energy performance in the buildings sector for achieving the PNIESC 2021÷2030 objectives
  - Increasing regional connectivity and ensuring access to mobility for all areas, including the rural areas
  - The construction/expansion/modernization of urban public transport and urban/suburban electric public transport routes, the infrastructure intended for the bicycles use and investments intended for the purchase of rolling stock (trams) to reduce the degree of use of personal vehicles
- The *Just Transition Operational Program (POTJ) 2021-2027*[26] , responding to the investment needs defined at the territorial plans level developed for 6 counties (Gorj, Hunedoara, Dolj, Galați, Prahova and Mureș);
- *P and M planned to be implemented at EU level*, respectively the EU package of proposals "Fit for 55", revising and updating the EU legislation in the field of climate, energy and transport and including the following EC proposals, currently in the negotiation process with the European Parliament:
  - *The proposal on the revision of the EU Emissions trading system (ETS)*, which should lead to a global reduction of GHG emissions in the targeted sectors by 61% by 2030, compared to 2005, by:

[24] The Sustainable Development Operational Program 2021 -2027, version submitted to EC on 8 July 2022, https://mfe.gov.ro/minister/perioade-de-programare/perioada-2021-2027/

[25] The Regional Operational Programs 2021-2027, submitted version to EC: PO București- Ilfov, 23 July 2022; POR Vest, 18 May 2022; POR Sud Muntenia, 25 May 2022; POR Sud-Vest Oltenia, 25 May 2022; POR Nord-Vest, 26 May 2022; POR Nord-Est, 30 May 2022; POR Sud-Est, 30 May 2022; PO Centru, 30 May 2022, https://mfe.gov.ro/minister/perioade-de-programare/perioada-2021-2027/

[26] The Just Transition Operational Program, https://mfe.gov.ro/minister/perioade-de-programare/perioada-2021-2027/

- Expanding the EU ETS scope, by including maritime transport within the scope of the EU ETS; phasing out the free allocation for the aviation sector and for sectors to be subject to the carbon border adjustment mechanism; implementation of the global carbon offsetting and reduction scheme for international aviation; increasing funding available from the modernisation fund and the innovation fund;
- A new, self-standing emissions trading system for the buildings and road transport, which would lead to a reduction of emissions associated with these sectors of 43% by 2030, compared to 2005

- *The Proposal on the revision of the Effort Sharing Regulation (ESR),* which increases the objective of reducing GHG emissions at the EU level from 29% to 40%, compared to 2005, and updates the objectives at the MS level; for Romania, the reduction commitment proposed for the non-ETS sector in 2030 is -12.7% compared to 2005
- *The Proposal for a Directive amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and of the Directive 98/70/EC as regards the promotion of energy from renewable sources,* which sets as a mandatory objective at EU level, a share of energy from renewable sources in the global energy mix of 40% by 2030, compared to the current level of 32%; MS will need to increase their national contributions set out in their integrated national energy and climate plans, due to be updated in 2023 and 2024, to collectively reach the new target;

The Directive proposal establishes the following objectives at the sectoral level:

Transport sector:

- Reduction of GHG intensity in the transport sector of at least 13% by 2030 or a binding target of at least 29% renewable energy within the final energy consumption in the transport sector by 2030
- Increasing the share of advanced biofuels used in the transport sector, at least 0.2% in 2022, 1% in 2025 and 4.4% in 2030
- Increasing the share of fuels from renewable sources of non-biological origin used in transport (mainly hydrogen from renewable sources and synthetic hydrogen-based fuels) - 2.6%
- Establishing a cap to the amount of final energy consumption in the maritime sector

Heating and cooling sector:

- The mandatory increase of the share of energy from renewable sources in this sector, of 0.8% per year at the national level until 2026 and 1.1% in the period 2026-2030; the minimum average annual rate applicable to all MS is supplemented with additional indicative increases calculated specifically for each MS - for Romania, the additional indicative increases are at least 0.6% for the period 2021-2025 and at least 0.3% for the period 2026 -2030. The weight resulting from the additions, without residual heat and cooling, is 1.4%

Industrial sector:

- MS are making efforts to increase the share of energy from renewable sources in the amount of energy used for final energy and non-energy purposes - average annual increase of 1.1 percentage points until 2030

- MS ensures that by 2030, 35% of the hydrogen used in industry should come from renewable fuels of non-biological origin; the percentage should increase to 50% by 2035

Buildings sector:

- Indicative EU target of at least a 49% renewable energy share in buildings in 2030

- *The Proposal for a recast of Energy Efficiency Directive*, which establishes the reduction of energy consumption at EU level by 36% for final energy consumption and by 39% for primary energy consumption until 2030; the MS contribution to the EU target will be set out in the integrated national energy and climate plans to be updated in 2023 and 2024

In order to meet the energy savings target for final energy consumption, the MS would ensure savings of 1.1% of annual final energy consumption from 1 January 2024; 1.3% from 1 January 2026 and 1.5% from 1 January 1 2028 and 31 December 2030, with the possibility to carry over a maximum of 10% of excess savings in the following period.

For the public sector, annual energy consumption reduction of 1.7% (or alternatively at least 1.9% each year if public transport or the armed forces are excluded) and annual renovation of at least 3% of the total floor area of buildings owned by public administration.

- *The Proposal for a Regulation on the deployment of alternative fuels infrastructure,* for ensuring a sufficient infrastructure network for recharging of light electric vehicles, electric heavy-duty vehicles and hydrogen refueling and for the power supply of ships at the quayside in ports; for each type of vehicle, specific requirements are established for MS to ensure refueling with alternative fuels and electricity supply, respectively:
  - Light electric vehicles: power requirements to be provided based on the size of the registered vehicle fleet and TEN-T network coverage requirements in 2025 and 2030
  - Heavy duty vehicles and hydrogen refueling requirements for TEN-T network coverage by 2030, starting in 2025 for electric heavy-duty vehicles
  - Electricity supply to ships at the quayside in ports: requirements applicable from 2030
- *The Proposal on CO2 emission performance standards for cars and vans*, establishing CO2 emission reduction targets of 55% for cars and 50% for vans by 2030; by 2035, for new cars and vans, the CO2 emission reduction target is 100%, by banning the introduction of internal combustion cars and vans on the EU market
- *The proposal for the revision of the Directive on the taxation of energy products and electricity*, aiming to move from a taxation based on volume to a taxation based on energy content, establishing a ranking of rates according to environmental performance, as well as by limiting the incentives for the fossil fuels use
- *The Proposal for a Regulation on the carbon border adjustment mechanism*, aiming to prevent the relocation of carbon emissions through imports from non-EU countries (excepting Iceland, Liechtenstein, Norway, and Switzerland) of products with high CO2 emissions from the cement, aluminum, fertilizer, electricity, cast iron, iron and steel sectors and encouraging carbon pricing policies to combat climate change
- *The Proposal for a Regulation on ensuring a level playing field for sustainable air transport* (ReFuelEU in the aviation field), aiming to reduce the environmental footprint of the aviation sector, through fuel suppliers obligation to ensure that all fuels made available to operators of aircrafts at EU airports contain a minimum share of sustainable aviation fuels (SAF) from 2025

and, from 2030, a minimum share of synthetic fuels, with a progressive increase of these shares until 2050; the general approach also foresees an increase in the minimum share for 2030 from 5 to 6%;

- *The Proposal for a Regulation on the use of fuels from renewable sources and with low carbon dioxide emissions in maritime transport* (FuelEU in the maritime field), aiming to reduce the intensity of GHG emissions generated by the energy used on board ships by up to 75% by in 2050, by promoting the use of greener fuels by ships and the obligation to use shore power sources or zero-emission technologies in ports under the jurisdiction of an MS; according to the proposed Regulation, starting from 1 January 2030, post-container ships and passenger ships at the quayside in ports under the jurisdiction of an MS, connect to a source of electricity supply from the shore and use it to ensure the necessary their electricity;
- *The Proposal for a Regulation establishing the Fund to mitigate the social impact of climate actions*, aiming to support vulnerable consumers (households, micro-enterprises and transport users) through temporary direct income support and through measures and investments aimed at increasing energy efficiency of buildings, the decarbonization of heating and cooling of buildings, including the integration of energy from renewable sources and the provision of improved access to zero and low emission mobility and transport;

  Each MS will submit to the EC a Plan for mitigating the social impact of climate actions, together with the update of the Integrated National Energy and Climate Plan which will include national projects for:

  - Financing measures and investments aimed at increasing the energy efficiency of buildings, implementing measures to improve energy efficiency, renovating buildings and decarbonizing the heating and cooling of buildings, including the integration of energy production from renewable energy sources
  - The financing of measures and investments aimed at increasing the use of mobility and transport with zero and low emissions.

The framework policies, developed in accordance with the legislation at the EU level, establishing the development directions by activity sectors for certain time periods, are presented in the following sections.

Energy Sector

The Government of Romania has a strategic objective for the energy sector to meet the energy demand, both now and in the medium and long term at a lower price, appropriate to a modern market economy and a civilized standard of living, food safety, respecting the principles of sustainable development.

Considering the role of energy for the economy and society, the development of this sector is carried out under state supervision, through the development and implementation of a sectoral strategy, and in the short term by implementing a policy related to the strategic field.

Romania has transposed all EU Directives with implications for primary energy consumption at national level.

Energy industry

The national energy regulation framework includes norms specific to the electricity and/or heating generation sector, as well as norms regarding the improvement of consumer energy efficiency.

Adopted Policies and measures

- *Romania's Sustainable Development Strategy 2030*, approved by GD no. 877/2018, within the Objective 7 Affordable and clean energy, establishes the following 2030 national targets that directly influence the GHG emissions related to the Energy sector:
    - Expand electricity and gas distribution networks for ensuring household consumer, industrial and commercial access to safe sources of energy at acceptable prices
    - Decouple the economic growth from the process of resource depletion and environmental degradation by substantially boosting of the energy efficiency (by a minimum of 27% compared with the status quo) and the extensive use of the ETS in stable and predictable market conditions
    - Increase the share of renewable energy and low-carbon fuel used in the transport sector (electric vehicles), including the use of alternative fuels
    - Ensure a stable and transparent regulatory framework in the field of energy efficiency to attract investments
    - Strategically support the share of electricity in total household, industrial and transport consumption by establishing performance standards for facilities and equipment.
- *Romania's Energy Strategy for 2019 - 2030 period, with the perspective of 2050*, updating the previous strategy, considering the demand and international obligations of Romania, but also the achievement of the optimal scenario for the development of the national energy system. The national strategic investments presented by the Romania's Energy Strategy for 2019 - 2030, with the perspective of 2050, are the following:
    - Completion of groups 3 and 4 from NPP Cernavoda, with an installed capacity of 720 MW each (one group to be put into operation by 2030); by investment and implementation, an additional energy input in the energy system of about 11 TWh, as well as an increase in installed capacity by 1,440 MW, shall be ensured
    - New 600 MW group on lignite, with supercritical parameters, to enter in production after 2020; the group will be provided starting with 2035 with technology of capture, transport, and geological storage of CO2 (CSC)
    - Construction of the Tarnița-Lăpuștești Pumped Hydropower Plant, with a capacity of 1,000 MW that could balance the electrical power system for durations between 4-6 hours
    - Construction of the Turnu Măgurele-Nicopole Hydrotechnical Complex of approx. 2,200 GWh/year, by the Danube River arrangement on the downstream sector between Portile de Fier I and II and the confluence with the Olt River, within the cooperation between the governments of Romania, Bulgaria, and Serbia
- *The 2021-2030 Integrated National Energy and Climate Plan (PNIESC)*, approved by GD no. 1076/2021, involving the implementation of the following measures to achieve the targets established at national level, with direct implication for the energy sector:
    - Decarbonization dimension:
        - Decarbonization of energy sector through promotion of investments in new low-carbon power generation capacities (replacement of existing conventional power generation capacities with new low carbon capacities on natural gases, nuclear energy, and RES) and promotion of RES and energy efficiency projects
        - Decarbonization of industrial sector, through implementation of the best available technologies (BAT), to reduce GHG emissions and to increase energy efficiency in the industrial sector

        - Promotion of circular economy (recycling) for achieving the energy efficiency target by reducing consumption of energy used in the industry, in the processing of raw materials
    - Energy efficiency dimension:
        - Increasing energy efficiency in the industrial sectors regulated by ETS
    - Energy security dimension:
        - Assuring the flexibility of the energy system, through encouraging the development of energy storage capacities and high-efficiency cogeneration
        - Implementation of the Decarbonization Plan of CE Oltenia, involving the development of new solar energy and micro-hydro- power capacities which will contribute to the achievement of RES-E target and will ensure the diversification of energy sources
- *PNRR - Component 6 Energy*, addressing the main challenges of the energy sector in Romania in terms of decarbonization and air pollution, ensuring the green transition and digitalization of the energy sector by promoting the production of electricity from renewable sources, energy efficiency and future technologies. By PNRR, is envisaged:
    - Replacement of coal in the energy mix, by: decommissioning the installed coal-based electricity production capacities (in 2025: 3,780 MW compared to the 2021 reference value of 1,695 MW); partial replacement with a gas-based electricity production or a combined electricity and gas thermal energy production, allowing the use of renewable and low-carbon gases of 1,300 MW; additional energy capacity from renewable sources (wind and solar) of at least 3,000 MW, commissioned and connected to the grid;
    - New capacities for electricity production from renewable sources (in 2024, additional 950 MW capacity of energy from renewable sources - wind and solar energy);
    - Gas distribution infrastructure from renewable sources (natural gas in combination with green hydrogen, as a transitional measure), as well as green hydrogen production capacities and/or its use for electricity storage;
    - Flexible and highly efficient gas cogeneration capacities for the district heating sector (in 2025, 300 MW);
    - Ensuring energy efficiency in the industrial sector.
- *GEO no. 53/2019* on the approval of the multi-annual investment financing program for the modernisation, rehabilitation, expansion or establishment of centralised thermal energy supply systems - the Heating Program 2019-2027, financing new investment and ongoing projects. Currently, funding for 7 UATs (Arad – 3 investment objectives, Giurgiu, Gheorgheni, Iași, Brad, Vatra Dornei, Suceava) has been requested.

Planned policies and measures

- *PODD 2021÷2027*, *Priority 4 Promoting energy efficiency, intelligent energy systems and networks and reducing GHG emissions, Action 4.1 Improving energy efficiency*, aiming to increase the energy efficiency in SMEs and large enterprises and the share of energy from renewable sources, through the development of electricity production facilities by industrial consumers (with a consumption greater than 1,000 toe/year)

  Expected results in the target year 2029: reduction of annual primary energy consumption from the 2018 reference value of 32,989,123 MWh/year to the 2029 target value of 31,447,974 MWh/year; total budget 135,294,118 Euro (ERDF and national contribution)

- *PODD 2021÷2027*, *Priority 4 Promoting energy efficiency, intelligent energy systems and networks and reducing GHG emissions, Action 4.2 Reducing GHG emissions and increasing energy efficiency in thermal energy production systems*, aiming to replace the thermal energy production plant based on coal and fuel oil with a high efficiency cogeneration plant based on natural gas in the Motru municipality
  Expected results in the target year 2029: annual primary energy consumption 31,447,974 MWh/year, compared to the 2018 reference value of 32,989,123 MWh/year; total budget 11,764,706 Euro (ERDF and national contribution).
- *PODD 2021÷2027, Priority 4 Promoting energy efficiency, intelligent energy systems and networks and reducing GHG emissions, Action 4.3 Reducing GHG emissions and increasing energy efficiency in thermal energy distribution and transport systems*, aiming to finance centralized thermal energy supply systems, respectively heating networks, including thermal points, with priority for the completion of projects started in programming period 2014÷2020
  Expected results in the target year 2029: new or modernized heating networks: 135 km; energy losses on the heat transport and distribution networks: 22.70%, compared to the reference value of 2018 (29.8%); total budget 355,647,059 Euro (CF and national contribution)
- *PODD 2021÷2027, Priority 4 Promoting energy efficiency, intelligent energy systems and networks and reducing GHG emissions, Action 4.4 Promoting the use of renewable energy sources*, aiming to finance investments for new capacities or for modernization of existing electricity/thermal capacities on biomass/biogas and for new or modernized geothermal capacities
  Expected results in target year 2029: new capacity on renewable sources of 14 MW; increasing the energy produced from RES from the 2022 reference value of 22 MWh/year to the 2029 target value of 256,832 MWh/year; total budget 58,823,530 Euro (ERDF and national contribution).
- *PODD 2021÷2027, Priority 4 Promoting energy efficiency, intelligent energy systems and networks and reducing GHG emissions, Action 4.5*, financing intelligent energy systems and networks, total budget 176,470,588 Euro (ERDF and national contribution)
- *POTJ 2021-2027*, aiming to ensure the investment needs defined at the level of territorial plans developed for 6 counties (Gorj, Hunedoara, Dolj, Galați, Prahova and Mureș), by supporting the installation of photovoltaic/photothermal panels at household level and through investments in the development of small capacities for production, transport and storage of renewable energy (photovoltaic, wind or geothermal, including heat pumps) necessary for public buildings (schools, hospitals, homes for the elderly, nurseries, social services, vocational training centres)

  The budget from EU funds (FTJ) is 397,023,048 Euro (without national contribution of 15%).

Transport

The transport activity holds an important role in the support of the economic and social development of Romania, in close correlation with the energy/fuel consumption and the GHG emissions.

The evolution of this economic activity sector indicates a significant increase of the number of vehicles registered in Romania. Therefore, it is necessary to adopt adequate measures leading to the decoupling of GHG emissions in the transport sector in relation to the economic growth, aiming to ensure sustainable development.

The objective in the Transport area is the development of a sustainable system improving social cohesion, access in peripheral areas, the reduction of environmental impact, including the reduction of GHG emissions, promoting economic competitiveness through the improvement of the infrastructure, ensuring an optimal fuel mix, as well

as the use of biofuels from renewable plants and the use of information and communication technology to increase the efficiency of the sector.

The reduction of the CO2 emissions generated by transport shall be carried out through an integrated, cost-efficient approach, combining innovation in the automobile propulsion technology area and the use of biofuels with the efforts made by the decisional factors and consumers on taking a new attitude in terms of the development of the economic sector.

The technical and financial options, competitiveness and, not lastly, social impact shall be considered in establishing the balance between the demand for mobility and the environmental protection requirements.

Adopted Policies and measures

- *Romania's Sustainable Development Strategy 2030*, approved by GD no. 877/2018, within the Objective 9 Industry, innovation and infrastructure establishes the following 2030 national targets that directly influence the GHG emissions related to the Transport sector:
    - Modernize and develop quality, viable, sustainable, and powerful regional and cross-border infrastructure, in order to support economic development and human well-being, with a focus on fair and equitable access by all
    - Improve road safety
- **The 2021-2030 Integrated National Energy and Climate Plan**, approved by GD no. 1076/2021, involves implementation of the following measures to achieve the targets established at national level, with direct implications for the transport sector:
    - Decarbonization dimension:
        - Decarbonization of the transport sector, through Priority development and fostering the use of rail transport for transportation of passengers (to the detriment of road transport) and its intermodal integration with other modes of transport
        - Promotion of use of renewable energy in transport (RES-T)
    - Energy Efficiency dimension:
        - Developing and promoting alternative mobility and renewing the vehicle stock.

  For the 2021-2030 period, according with the 2021-2030 Integrated National Energy and Climate Plan, the Transport sector could contribute together with Industry and the Residential sectors to the achievement of the energy efficiency target (cumulative value of energy savings in the period of 10.12 Mtoe), in approximately equal shares (each with a percentage of 29%), by renewing the fleet, modernization of urban and rail public transport, encouraging alternative mobility and promoting the use of electric vehicles.
- The *General Transport Master Plan (GTMP)*, approved by GD no. 666/2016, as a planning strategic instrument for major investments in the transport sector, aiming to develop a modern transport infrastructure considering the environmental effects, defines the following specific environmental objectives:
    - Promotion of transport investment projects that contribute to the sustainable transport system performance, with measures to avoid and reduce negative effects, such as: air pollution emissions; noise pollution in urban areas and, on heavy traffic routes; water and soil pollution due to diffuse sources; impact on landscape and cultural heritage
    - Reduction GHG emissions from the transport sector
    - Protection the population's health by improving environmental and transport safety conditions

  - Decrease the impact on biodiversity by ensuring measures for protection and preservation of biodiversity and ensuring the coherence of the national network of natural protected areas.
- *The Investment Program for the Development of Transport Infrastructure for the period 2021-2030*, approved by GD no. 1312/2021, updating the GTMP implementation strategy and specifying the needs for the development of the transport infrastructure in Romania (6,624.1 km of road network -highways, expressways, transregions, bypasses, of which 2,900.5 km primary network and 3,723.6 km secondary network). For the railway network, the program envisages the construction of 3,274.8 km primary network and 1,228 km secondary railway network. The Program develops the strategy to ensure the necessary financing for the 10 years of implementation, starting from the correlation of the main sources of financing available to Romania: PNRR, POT 2021-2027, Connecting Europe Facility (CEF 2.0) and national budget.
- *The Action Program for the development of railway infrastructure and the modal transfer to the railway of passenger and freight transport flows*, approved by GD no. 1302/2021, including for the reference period 2021-2026:
  - Measures to increase the railway freight traffic, by at least 25% until 2026 compared to 2020
  - Specific measures to achieve the objective of increasing the number of passengers in railway transport, by an average of 25% compared to the reference level of 2021
  - Measures to increase the use of newly purchased rolling stock
  - Passenger transfer measures from bus/minibus transport to railway transport.
- *PNRR, Component 4 Transport*, aiming to develop the transport infrastructure to optimize travel speed, avoid traffic jams, improve the quality of services, reduce the impact on the environment and human health, as well as drastically reduce the number of road accidents. The implementation of the measures aims to discourage the use of polluting vehicles and to transfer the road traffic (passengers and goods) to railway transport until 2026, compared to 2020.
- *PNRR, Component 10 Local Fund*, aiming to increase access to sustainable and safe mobility solutions in urban and rural areas, through new zero-emission public transport vehicles, construction of 13,200 additional charging stations for electric vehicles and 1,091 km of cycle tracks at local / metropolitan level. The implementation of the measures aims to discourage the use of polluting vehicles and the transfer of road traffic (passengers and goods) to rail transport until 2026, compared to 2020.
- *Strategy for the development of railway infrastructure 2021-2025*, approved by GD no. 985/2020, detailing the general strategy presented through the GTMP for the railway field. The Strategy identifies a series of strategic actions and priority measures for the modal balancing of the national transport system and for the reduction of the total costs supported by the national economy for ensuring mobility of people and goods.
- *GEO no. 80/2018 related the conditions for gasoline and diesel on the market*, establishing the obligation for suppliers to sell gasoline and diesel with a minimum biofuel content of 8% and, respectively, 6.5% in the total sold volume to the final consumer in a calendar year.
- *Regulation CE/EU for vehicles*, namely:
  - Regulation (EC) no. 595/2009 on type-approval of motor vehicles and engines with respect to emissions from heavy duty vehicles (Euro VI)
  - Regulation (EC) no. 715/2007 on type approval of motor vehicles with respect to emissions from light passenger and commercial vehicles (Euro 5 and Euro 6)
  - Regulation (EU) no. 168/2013 on the approval and market surveillance of two- or three-wheel vehicles and quadricycles

- *Regulation (EU) 2019/631* setting CO2 emission performance standards for new passenger cars and for new light commercial vehicles, and repealing Regulations (EC) no. 443/2009 and (EU) no. 510/2011 (recast).

Planned policies and measures

- *POT 2021÷2027*, aiming to improve primary and secondary road connectivity, increase the efficiency of Romanian railways, increase the attractiveness of rail passenger transport, develop sustainable mobility in urban nodes and develop naval and multimodal transport. The requested budget to finance the investments included in the POT 2021-2027 is 7,312,358,178 Euro (European funds and national contribution).
- *POR 2021÷2027*, priority an accessible region, aiming to promote the increase of connectivity at the regional level and to ensure the access to mobility, including the rural areas, by modernization of road infrastructure of regional importance for ensuring connectivity to the TEN-T network and solutions for decongestion and streamlining of traffic at the level of county seat municipalities. The requested budget to finance the investments included in this priority is 1,465,119,467 Euro (ERDF and national contribution).
- *POR 2021÷2027*, priority A region with sustainable multimodal urban mobility, aiming to promote the construction/expansion/modernization of urban public transport and urban/suburban electric public transport routes, the infrastructure for the bicycles use and investments for the purchase of rolling stock (tram) in order to reduce the degree of using personal vehicles. The requested budget to finance the investments included in this priority is 1,377,048,518 Euro (ERDF and national contribution).
- *POTJ 2021-2027*, aiming to ensure the investment needs defined at the level of territorial plans developed for 6 counties (Gorj, Hunedoara, Dolj, Galați, Prahova and Mureș), by supporting the development of green public transport (the purchase of non-polluting vehicles and charging stations necessary for public transport services) which facilitate access to vocational training and employment opportunities. The requested budget to finance the investments is 63,502,310 Euro, to which is added the national co-financing of 15%.
- *The national program for scrapping used vehicles*[27], managed by the Ministry of Environment, Water and Forests through AFM, to be launched in 2023. Through this program, the individuals receive an incentive of 3,000 lei for scrapping a vehicle older than 15 years. The budget allocated for the financing session is 50,000,000 lei.

Other sectors (commercial/ institutional/ residential/ agriculture, forestry, fishery)

Land use is an important instrument for the evolution of society, as it is practically the spatial expression of its economic, social, and ecological policies.

Adopted Policies and measures

- *The National Long-term Renovation Strategy to support the renovation of the national residential and non-residential building stock, public and private, into a highly efficient and decarbonized building stock by 2030*, approved by GD no. 1034/2020, forecasting an increase rate of renovations of the national building stock to improve energy efficiency, reduce GHG emissions and increase the share of renewable energy in total energy consumption.

[27] Program casarea autovehiculelor uzate, https://www.afm.ro/casare_auto_uzate.php

According to the scenario recommended by the Strategy (scenario 2), the annual renovation rate shall register in the period 2021-2030 a gradual increase from 0.69% to 3.39%; the annual renovation rate in 2031-2040 period shall be 3.79% and in the 2041-2050 period shall be 4.33%.

- *PNRR, Component 5 Renovation Wave*, aiming to accelerate the rate of renovation by financing moderate or deep energy renovation investments of multi-family residential buildings and public buildings, respectively the integrated renovation of multi-family residential buildings and public buildings (energy efficiency and seismic strengthening).
  The PNRR 2021-2027 will finance the renovation of at least 4.3 million m² of residential buildings and 2.3 million m² of public buildings. By implementing the energy renovation measures, the following total primary energy savings are expected to be achieved: residential buildings of at least 0.15 Mtoe; public buildings of at least 0.0215 Mtoe.
- *PNRR, Component 10 Local fund*, aiming to improve the provision of local public services through the moderate renovation of public buildings (area of 1,306,818 m2) belonging to cities and communes.
- *GD no. 55/2011* on the establishment of eco-design requirements for energy related products, including the EU Regulation related to eco-design requirements for space heaters, domestic local space heaters, solid fuel boilers, solid fuel local space heaters, namely:
  - Commission Regulation (EU) No 813/2013 regarding eco-design requirements for space heaters and combination heaters, establishing eco-design requirements for the placing on the market and/or putting into service of space heaters and combination heaters with a rated heat output ≤ 400 kW
  - Commission Regulation (EU) 2015/1188 regarding eco-design requirements for local space heaters, establishing eco-design requirements for the placing on the market and putting into service of domestic local space heaters with a nominal heat output of 50 kW or less and commercial local space heaters with a nominal heat output of the product or of a single segment of 120 kW or less
  - Commission Regulation (EU) 2015/1189 regarding eco-design requirements for solid fuel boilers, establishing eco-design requirements for placing on the market and putting into service solid fuel boilers with a rated heat output of 500 kilowatt, applicable starting with 1 January 2020
  - Commission Regulation (EU) 2015/1185 regarding eco-design requirements for solid fuel local space, establishing eco-design requirements for the placing on the market and putting into service of solid fuel local space heaters with a nominal heat output of 50 kW or less, applicable starting with 1 January 2022.

Planned policies and measures

- *POR 2021÷2027, Priority An environmentally friendly region*, specific objective Promoting energy efficiency and reducing GHG emissions, aiming to finance investments in residential and public buildings. The total budget is 1,420,013,100 Euro (ERDF and national contribution).
- *PODD 2021÷2027, Priority 4, Action 4.6 Conversion, modernization and expansion of gas transmission and distribution networks to add gas from renewable sources and low-carbon gases to the system*, aiming to adapt the existing natural gas transmission and distribution system for green gases (e.g. hydrogen).
  Expected results in the target year 2029: new or modernized gas transmission and distribution networks: 1,437 km; users connected to smart grids: 137,612 end users/year, compared to the reference value of the year 2020 ("0"); total budget 380,545,520 Euro (CF and national contribution).

For this sector, in addition with the planned policies and measures mentioned above, the following measures are envisaged:

- Support schemes to promote the use of renewable energy sources (solar panels, heat pumps)
- Support schemes to equip residential buildings with high energy performance equipment (household appliances, lighting systems, etc.)

IPPU Sector

The reduction of emissions from Industrial Processes shall mainly be carried out through the enforcement of measures to increase energy efficiency, by optimizing the technological flows and promoting green technologies. Measures on the reduction of energy intensity for the industry sector include:

- Energy audits and efficient energy management
- Improving energy efficiency by supporting financing from European union funds
- Information campaigns
- Long term volunteer agreements in various sectors of the processing industry.

Adopted Policies and measures

- *Romania's Sustainable Development Strategy 2030*, approved by GD no. 877/2018, within the Objective 9 Industry, innovation and infrastructure establishes the following 2030 national targets that directly influence the GHG emissions:
    - Rehabilitate the industrial sector to make it sustainable through a more efficient use of resources and increased adoption of clean and ecological industrial technologies and processes
    - Boost the scientific research and modernize the technological capacity of the industrial sectors
    - Promote inclusive and sustainable industrialization and increase the rate of employment.

  By implementing adequate economic policy instruments between 2008 and 2030, the productivity of the used material and energy resources shall increase by a 3÷4% annual average rate, by reducing the shares of the energy-intensive sub-sectors, through the upgrade of technologies and management development.

  Considering that Europe requires a strong, competitive, and innovative industry to be internationally competitive, based on excellence, clusters and cluster networks were promoted, as key factors of innovation and economic growth, through the development of a collaborative and multi-sectoral approach and through the stimulation of interactions between innovative participants.

  Through public funds, the Romanian Government shall support the increase of competitiveness in industrial enterprises, the production of high added value products, the production of exported products, and respecting the environmental operating permits.

  The industrial policy aims to implement the best technologies to increase energy efficiency and provide quality products for competitive prices, in accordance with environmental permits. The result is that the industrial processes require re-engineering operations and the use of new technologies for the efficient processing of raw material and energy resources, leading to the reduction of GHG emissions.

- *Regulation no. 517/2014* on fluorinated greenhouse gases (F-gases) which repeal Regulation No. 842/2006 are applying since 1 January 2015 and aim to reduce these emissions by two thirds in 2030 compared to 2015 levels.

  Regulation lays down rules on the containment, use, recovery and destruction of F gases and prohibits the sale of certain products containing F-gases. Also, sets an annual limit on the overall climate impact of HFC which will be phased out between 2015 and 2030.

  The Regulation establishes the following obligations:

  - Prohibits the deliberate release of F gases if it is not technically necessary for the intended use of a product; manufacturers must strive to limit emissions during production, transport and storage of F gases
  - Operators of equipment containing F gases must take every precaution possible to prevent any leakage and must ensure that equipment are regularly checked for leakage; requirements vary depending on the potential impact on the climate or how hermetically sealed they are
  - National authorities are responsible for establishing training and certification programs for businesses and individuals involved in the installation, providing the service, maintenance, repair or decommissioning of equipment containing F gases, and recovery
  - From 2015 until 2025, are phased ban on the sale of new items, such as certain types of refrigerators and freezers, air conditioning systems, foams and aerosols containing F gases, where safer and less polluting alternatives exist;
  - Annual limit for HCF quantities placed on the market in 2030 represent 21% of 2009-2012 levels; to ensure the compliance with the limits the Commission allocates producers and importers annual quotas which must not be exceeded
  - Manufacturers, importers, exporters, users and businesses that destroy F gases must report annually to the Commission; importers of equipment containing F gases must do the same and, from 2017 must present evidence on accounting of the quantities of HFCs contained in imported equipment.
- *Directive 40/2006/EC* (MAC Directive) on emissions from air conditioning systems of the motor vehicles provides the gradual replacement of air-conditioning systems using HFC-134a. It also limit the possibility of retrofitting motor vehicles with air conditioning systems designed to contain fluorinated greenhouse gases with a global warming potential higher than 150 and prohibit the charging of the air conditioning systems with such gases.

  Automotive manufacturers must provide the competent authority all relevant technical information regarding the installed air conditioning systems and the gases used in the respective systems. If air conditioning systems designed to contain fluorinated greenhouse gases with a global warming potential higher than 150, the manufacturer must make available the leakage rate of these systems. The measures provided for in this Directive are expected to take effect from 2011.

  Romania has adopted the Montreal Protocol Amendment on substances that deplete the ozone layer (Kigali Amendment, 2016) by Law no. 30/2020 published in the Official Gazette. no. 275/2 Apr. 2020. The Kigali Amendment sets emission limits for substances in category F (HFCs and HCFCs) by 2045.

Planned policies and measures

- *National Competitiveness Strategy 2021-2027*. Enables the development of a coherent action plan regarding the implementation and evaluation of public policies that it coordinates at the level of the institution, with the aim of increasing Romania's economic competitiveness, mainly targeting economic fields, research and development, education, labor market, public institutions, and regulation. Thus, the strategic target of the SNC 2021-2027 consists in encouraging an economy based on a competitive economic environment, the adoption of digitization in enterprises and a stable institutional framework. The objectives of the strategy aim at the industrial modernization of enterprises, including by supporting the mechanisms of the circular economy and the collaborative economy and supporting the digital transformation process (Industry 4.0) to increase the degree of competitiveness of enterprises. At the same time, it also aims to increase the institutional capacity for the implementation of national public policies with an impact on competitiveness.

- *Strategy for Circular Economy 2030*. The general objective of the National Strategy on Circular Economy in Romania is to provide the framework to guide the country in its efforts to transition to Circular economy through the implementation of the Action Plan. The success indicator of this transition is the decoupling of economic development from the use of natural resources and environmental degradation. The overall objective of the strategy is closely linked to the Sustainable Development Goals (SDGs) of the UN 2030 Agenda and the global climate goals, as well as the new EU goals of the Circular Economy Action Plan (PAEC), in line with the principles and actions promoted within the EU Green Deal. The transition to circular economy must take place in such a way that it does not affect quality, productivity, competitiveness, and performance. This is important since the business environment in Romania is characterized by small and medium-sized enterprises, with a significant presence of micro-enterprises, which have a relatively important contribution in terms of added value and jobs.

Agriculture Sector

Adopted policies and measures

- *The National Strategy for Sustainable Development of Romania - Horizon 2013 - 2020 - 2030* (HG no. 1460/2008) focuses on the field of agriculture and food production on ensuring food security and food safety. Agriculture continues to play an important role in ensuring the income of a significant part of the active population. It will have to promote a sustainable production model with the protection of ecosystems and ensure the sustainability of food production, the reduction and elimination of imbalances on the agricultural market generated by the way natural resources are used, ensuring better capitalization of the advantages available to Romanian agriculture.

  Within the National Strategy for Sustainable Development of Romania for agriculture and forestry, the following national objectives are considered:

  - Horizon 2020. Consolidation of structures in the agri-food and forestry field simultaneously with the economic and social development of rural areas to further reduce the gaps and reach the current average level of performance of EU member countries; the affirmation of Romania as an element of food security stability in South-Eastern Europe

- Horizon 2030. Full adoption of Community policies and practices in agriculture, forestry, and fisheries; completing the restructuring and modernization of these sectors and the rural area.

- By *GD 529/July 24, 2013*, the National Strategy on climate change and economic growth based on low carbon emissions, for the period 2016-2020, is approved. In the field of animal husbandry, the objectives of the Strategy are the following:

  a) improving animal feed to improve digestive processes
  b) improved practices for livestock management
  c) ensuring and supporting local animal breeds with high potential for adaptation to climate change and climate risks
  d) genetic improvement, maintenance of permanent meadows, avoiding excessive grazing or by mowing them at least once a year
  e) prohibition of the act of setting fire to permanent meadows.

  In the sector of management of organic waste from animals:

  a) improving the management of zootechnical residues using technical solutions of storage adapted to different types of residues and their incorporation into the soil
  b) processing residues to produce biogas and compost.

- *The National Rural Development Program 2014-2020* was approved according to the European Commission's Implementation Decision no C (2015)3508 of 26 May 2015, as amended. This program continues the efforts necessary for the development of the rural area made through the previous program (2007-2013) through the strategic approach of the following objectives:
  - restructuring and increasing the viability of agricultural holdings
  - sustainable management of natural resources and combating climate change
  - diversifying economic activities, creating jobs, improving infrastructure and services to improve the quality of life in rural areas

  These objectives comply with the provisions of the Partnership Agreement and agree with the Common Agricultural Policy and the Europe 2020 Strategy.
  The fulfillment of these objectives is achieved in the period 2014-2020 through the six EU priorities established in the framework of the Rural Development Regulation (1305/2013):
  - encouraging knowledge transfer and innovation in agriculture, forestry, and rural areas (P1)
  - increasing the viability of holdings and the competitiveness of all types of agriculture in all regions and the promotion of innovative agricultural technologies and sustainable forest management (P2)
  - promoting the organization of the food chain, including the processing and marketing of agricultural products, animal welfare and risk management in agriculture (P3)
  - restoring, conserving, and strengthening ecosystems that are linked to agriculture and
  - forestry (P4)
  - promoting the efficient use of resources and supporting the transition to an economy with low carbon emissions and resilience to climate change in the agricultural, food and forestry sectors (P5)
  - promoting social inclusion, poverty reduction and economic development in rural areas (P6).

All these priorities have been transposed through areas of intervention and facilitate the achievement of objectives related to innovation, environmental protection and mitigating the effects of climate change and adapting to them.

- By *GD no 226 of April 2, 2015* regarding the establishment of the general framework for the implementation of the measures of the national rural development program co-financed from the European Agricultural Fund for Rural Development and from the state budget established the general framework regarding the submission, evaluation, selection, contracting, public procurement, payment, control and monitoring, related to the projects provided for in PNDR 2014-2020.
- In 2015, it was issued to the *Order of the Minister of Agriculture and Rural Development, the Minister of Environment, Water and Forests and the president of the National Veterinary Sanitary and Food Safety Authority no. 352/636/54/2015* for the approval of the rules regarding eco-conditionality within the schemes and support measures for farmers in Romania, with subsequent amendments. The rules in the annex to the Order are drawn up pursuant to art. 93 and 94, respectively annex II of Regulation (EU) no. 1306/2013 of the European Parliament and of the Council of 17 December 2013 on the financing, management and monitoring of the common agricultural policy and repealing Regulations (EEC) no 352/78, (EC) no 165/94, (EC) no 2.799/98, (EC) no 814/2000, (EC) no 1,290/2005 and (EC) no 485/2008 of the Council.
- The Government of Romania, by GD no. 932/2016 approved the "*National Program for the Rehabilitation of the Main Irrigation Infrastructure in Romania*". From MADR Order no. 5/2017 for establishing the implementation method of the National Program for the rehabilitation of the main irrigation infrastructure in Romania, it follows that the program is carried out in three successive stages, as follows:
  - stage I, in which several 40 irrigation systems are rehabilitated
  - stage II, in which several 37 irrigation systems are rehabilitated
  - stage III, in which several 9 irrigation systems are rehabilitated
- The strategy regarding the organization of the activity of improvement and exploitation of meadows at the national level in the medium and long term approved by the joint Order 226/2003 of the Ministry of Agriculture, Food and Forests and the Ministry of Public Administration has as its fundamental objective to increase the total production of green mass and its quality, in line with the increase in the economic efficiency of animal farms, especially cows and sheep herds.

Directive 91/676/EEC on the protection of waters against nitrite pollution from agricultural sources was transposed into Romanian legislation by GD no. 964/2004 approving the Action Plan for the protection of waters against nitrite pollution from agricultural sources. GD no 964/2000 provides that Romania re-examines, revises or completes at least once every 4 years, the list of designated nitrite vulnerable areas to take into account changes and factors that have occurred since the previous designation. Thus, in the joint Order 1552/2008 of the Ministry of the Environment and Sustainable Development and the Ministry of Agriculture and Rural Development, the list of localities by county where there are sources of nitrites from agricultural activities is approved. As a result of this approved list, the Interministerial Commission for the application of the Action Plan for the protection of waters against nitrite pollution from agricultural sources approved the Action Program for nitrite-vulnerable areas by Decision 21130/DC/14.10.2010. In accordance with this program, the provisions of the Code of Good Agricultural Practices for the protection of waters against nitrate pollution from agricultural sources approved by joint Order 1182/1270/2005 of the MMDD and MADR are mandatory in areas declared vulnerable to nitrate pollution. The nutrient

management plan is carried out under the guidance of the Pedological, and Agrochemical Studies Offices based on the nutrient management framework plan drawn up and made available by MADR.

In Romania, there is a national system for integrated soil monitoring, supervision, control and decisions to reduce the input of pollutants from agricultural sources and for the management of organic residues from animal husbandry in vulnerable and potentially vulnerable areas to nitrite pollution, within the structures of the National Integrated Monitoring System of Water Resources and Protected Areas, managed by the National Research - Development Institute for Pedology, Agrochemistry and Environmental Protection.

- On February 20, 2020, a guide was published on facilities for the intensive breeding of farm animals, including meat birds, egg-laying birds, pigs and sows, approved by ORDER no 269 of February 20, 2020, published in the Official Gazette, Part I, no. 211 of March 16, 2020.

  The conclusions on the best available techniques (BAT) concern the following activities provided for in section 6.6 of Annex I to Directive 2010/75/EU, "6.6. Intensive breeding of poultry and pigs", with capacities of over:

  (a) 40 000 places for poultry
  (b) 2 000 places for production pigs (over 30 kg)
  (c) 750 places for sows

  These BAT conclusions cover the following on-farm processes and activities:

  — nutritional management of poultry and pig feed administration
  — feed preparation (grinding, mixing and storage)
  — raising (housing) poultry and pigs
  — collection and storage of animal manure
  — animal manure processing
  — the spreading of animal droppings on the ground (https://eur-lex.europa.eu)

- *Appendix no 1 to MADR Order no. 49/2021*, brings additions regarding Agro-environment and climate measures in the field of animal husbandry, allocating subsidies for raising animals from local breeds at risk of abandonment. Breeding of animals from local breeds in danger of abandonment is done in Romania in a semi-intensive system and/or in an extensive system. The extensive breeding system is practiced in the family household where animals are raised for own consumption and only a small amount of products is capitalized on the organized market. The animals are raised in simple shelters, without special technical equipment and with the practice of foraging on pasture or, in some species, to a large extent, with household scraps, to which are added bran, corn, barley, oats, root crops, legumes, potatoes, alfalfa, green mass. In this system, livestock performances are not special, production having a pronounced seasonal character, especially to cover own consumption. The semi-intensive breeding system defines the holding with a larger herd of animals. The acceptance of this animal rearing system requires modernized shelters and an appropriate endowment with feeding equipment, watering and ensuring microclimate conditions. Local animal breeds have a low production potential, but they stand out for their high degree of adaptation to the conditions of exploitation in extensive and semi-intensive systems, as well as for their

high resistance to diseases. Breeders' interest in a certain breed decrease if the level of production does not ensure efficiency in exploitation. As a result, the herd is reduced to extinction.

Planned policies and measures

- The national strategy for the sustainable development of Romania 2030 - Objective 2 - Zero hunger, the agricultural production sector and ecological agriculture and traditional products can lead to a decrease in greenhouse gas emissions from the agriculture sector through a better use of nutrients or manure treatment can change the way of agricultural production, for the transition to a functional circular economy.
- National strategy on climate change and low-carbon economic growth. The effects of the strategy in the field of animal husbandry will be seen in the target years because it targets more sensitive sectors of husbandry technologies (changes in animal rations to reduce GHG emissions, or in manure management, by modernizing manure management technologies).

Waste Sector

Waste Management

Based on the continuous decrease and degradation of natural resources, as well as on the need to conserve them (mainly biological resources), the re-assessment of the anthropogenic origin waste management options is required, concerning the increase of the recovery level thereof and the drastic reduction of the quantities requiring disposal.

Judicious waste management is a means to identify, totalize and assess eco-systemic services, to adopt the best decisions on environmental preservation, conservation, and management, and, therefore, a means of GHG emission reduction.

Adopted Policies and measures

- *Romania's Sustainable Development Strategy 2030*, approved by GD no. 877/2018, within the Objective 12 Responsible consumption and production establishes the following 2030 national targets that directly influence the GHG emissions for this sector:
    - Halving per capita the food waste at the level of retail and consumption and reduce food waste throughout the production and supply chain, including post-harvest losses
    - Recycle 55% of municipal waste by 2025 and 60% by 2030
    - Recycle 65% of packaging waste by 2025 (plastic materials 50%, wood 25%, ferrous metals 70%, aluminum 50%, glass 70%, paper and cardboard 75%) and 70% by 2030 (plastic materials 55%, wood 30%, ferrous metals 80%, aluminum 60%, glass 75%, paper and cardboard 85%)
    - Implement the separate collection of household hazardous waste by 2022 of biological waste by 2023 and of textile waste by 2025
    - Establish extended producer responsibility schemes for all types of packaging by 2024.
- The *National Waste Management Plan*, approved by GD no. 942/2017, including clear and coherent measures to achieve the objectives of preparation for reuse and recycling of waste by 2020, in accordance with Article 11 (2) of Directive 2008/98/EC; the measures considered are mainly based on the existence and use of key economic instruments such as:

- Adequate storage rates (and / or prohibitions on the storage of recyclable waste)
- Incineration pricing policy able to favor recycling / reuse
- Other economic instruments identified during the elaboration of the plan, in accordance with the specific national situation
- Additional capacities for collection, treatment, recycling, if applicable
- In 2020 - gradual increase of the readiness degree for reuse and recycling of municipal waste - target of 50% of the total amount of recyclable waste generated, calculated by Method 2 of Annex I of Decision 2011/753 / EU, ensuring compliance current legal provisions
- In 2025 - gradual increase of the readiness degree for reuse and recycling of municipal waste - target in 2025 - 50% calculated by Method 4 of Annex I of Decision 2011/753 / EU, correlated with the provisions of the proposed amendment to the Directive framework of the Circular Economy Package, published in December 2015

- *PNRR, Component 1 Water management*, aiming to increase the degree of access of the population, especially in rural areas, to a public water and sewerage service in accordance with the requirements of European directives, accessible to all social categories.
- *PNRR, Component C3 Waste Management*, aiming to accelerate the process of expansion and modernization of waste management systems in Romania based on separate collection, prevention measures, reduction, reuse and recycle to comply with the applicable directives and the transition to the circular economy. This component includes the adoption of the National Strategy for Circular Economy and the Action Plan (Q3 2022).
- The *Circular Economy package*, adopted by the European Commission in December 2015, aiming to stimulate the transition to a circular economy at European level. The package includes legislative proposals on waste, as well as a related action plan. Waste proposals set long-term goals to reduce waste disposal and increase recycling and reuse.

  The adoption of the circular economy package entails the revision of the following Directives:
  - Directive 2008/98/EC on waste and repealing certain Directives
  - Directive 2006/66/EC on batteries and accumulators and waste batteries and accumulators and repealing Directive 91/157 / EEC
  - Directive 2011/65/EC on restrictions on the use of certain hazardous substances in electrical and electronic equipment
  - Directive 2012/19/EU on waste electrical and electronic equipment
  - Directive 2000/53/EC on end-of-life vehicles
  - Directive 94/62/EC on packaging and packaging waste

  Adopted in May 2018, following the inter-institutional negotiations between Parliament and the Council, the four Directives (Directive 2018/849 amending Directive 2000/53/EC on end-of life vehicles, Directive 2006/66/EC on batteries and accumulators and waste batteries and accumulators and Directive 2012/19/EU on waste electrical and electronic equipment, Directive 2018/850 amending Directive 1999/31/EC on the landfill of waste, Directive 2018/851 amending Directive 2008/98/EC on waste and Directive 2018/852 amending Directive 94/62/EC on packaging and packaging waste), include the following main elements:
  - Reuse and recycling of 65% of the mass of municipal waste by 2035 (with an intermediate target of 55% by 2025 and 60% by 2030). To achieve this goal, Romania can benefit from an additional period of five years, provided that by 2025 and 2030, respectively, the preparation rate for reuse and recycling of municipal waste reaches a minimum of 50% and 60% by weight

- Reuse and recycling of 65% of the weight of all packaging waste by 2025 and at least 70% by 2030. Minimum targets are also set for the preparation for reuse and recycling of specific materials contained in packaging waste for both 2025 and for the year 2030
- Storage of a maximum of 10% of municipal waste by 2035. Romania may benefit from an additional period of five years provided that by 2030 the amount of municipal waste stored is reduced to 20% of the total amount of waste generated
- Prohibition of the storage of separately collected waste, which requires the separate collection of biological waste until 2023 and textiles and hazardous waste from households until 2025
- Promoting economic instruments to discourage storage
- Simplified and improved definitions and harmonized methods for calculating recycling rates at EU level
- Promoting reuse and stimulating industrial symbiosis - transforming a by-product of one industry into a raw material for another industry
- Economic incentives for manufacturers to market greener products and support recycling and recovery schemes (e.g., for packaging, batteries, electrical and electronic equipment, vehicles)
- Reducing the generation of food waste in primary production, processing, and processing, in wholesale and retail trade, in restaurants and food services, as well as in households.

The action plan provides for measures aimed at closing the loop of the circular economy, following all stages of the life cycle of a product: from production and consumption, to waste management and the secondary raw materials market.

Planned policies and measures

- *PODD 2021÷2027, Priority 1 Development of water and waste water infrastructure and the transition to a circular economy, Action 1.2 Efficient waste management for accelerate the transition to the circular economy, for meeting the requirements of environmental directives*, aiming to: expand the separate waste collection recyclables system; implementation/expansion of separate collection of bio-waste; implementation/expansion of separate collection of bulky, hazardous and textile waste by 2025; centres prepared for reuse; new transfer stations and modernisation/expansion of the existing ones; facilities/integrated facilities for the treatment of separately collected waste, and of residual waste; modernisation of existing facilities (sorting, composting and mechanical-biological treatment); closing non-compliant landfills and ensuring the necessary storage capacities.

Expected results in the target year 2029: additional capacity for waste recycling: 370,000 t/year; investments in separate waste collection facilities: 73,312,500 Euro; investments for the closure of non-compliant landfills: 11,250,000 Euro; recycled waste: 290,000 t/year, compared to the reference value of 2021 ("0" value); separately collected waste: 330,000t/year, compared to the 2020 reference value ("0" value); recycled waste from residual waste: 30,000 t/year, compared to the reference value ("0" value); non-compliant landfills closed: 6 landfills, compared to the reference value of 2020 (value "0").

The total budget required for this action is 480,000,000 Euro (CF and national co-financing).

Wastewater treatment

The legislation in force shall be observed to prevent the pollution of surface water sources with waste waters resulting from anthropogenic sources. The legislation mainly refers to the quality indicators of the waste waters discharged in tributary streams.

The basis of the European Union legislation on waste waters is Directive 91/271/EEC of May 21st, 1991, on the treatment of urban waste waters, amended and supplemented by Commission Directive 98/15/EC of February 27th, 1998. Directive 91/271/EEC was fully transposed in the Romanian legislation by Romanian Government Decision no. 188/2002 approving certain norms on the conditions for the aquatic discharge conditions of wastewater, amended and supplemented by Romanian Government Decision no. 352/2005. GD no. 188/2002 contains the following capital importance annexes in the collection, transport, treatment, and discharge of waste waters:

- Annex 1. Technical norms on the collection, treatment, and discharge of municipal waste waters, NTPA – 011
- Annex 2. Norm on the conditions on the discharge of waste waters in the sewage systems of localities and directly in treatment stations, NTPA – 002
- Annex 3. Norm on establishing the pollutant loading limits of industrial and municipal waste waters, on discharge in natural receptors, NTPA – 001.

The main objective of Directive 91/271/EEC is to protect the environment from the negative impacts of the discharges of urban waste waters and of waste waters from certain industrial sectors (mainly food industry product processing and manufacturing).

In Romania, the European legislation on the treatment of wastewater and discharge in the aquatic environment was transposed between 2002 and 2005. However, implementation stages for full conformity with the Directive requirements are still required.

Considering both Romania's location in the hydrographic basin of the Danube River and in the Black Sea basin, as well as the need for environmental protection in such areas, Romania declared its entire territory as a sensitive area. The decision materializes through the fact that agglomerations with over 10000 equivalent inhabitants shall ensure an infrastructure for the treatment of urban waste waters enabling advanced treatment, particularly in terms of the nitrogen and phosphor nutrients. Secondary treatment (the biological step) is a general rule for agglomerations under 10000 equivalent inhabitants.

The Directive implementation terms vary and depend on the size of the agglomeration and the impact thereof on the receptor waters. The final transition term for the implementation of the Directive was set for December 31st, 2018, with interim terms for the collection and treatment of urban waste waters.

Measures for the limitation and/or reduction of GHG emissions resulting from the treatment of household waste waters are as follows:

- Increasing the connection level to wastewater sewage and treatment services
- Construction and commissioning new wastewater treatment stations
- The rehabilitation and upgrade of the existing wastewater treatment stations
- Using modern, low power technologies
- The automation of the wastewater treatment facility operation, with positive implications on the optimum operation thereof, respectively the avoidance of methane gas emissions

- Collecting household sludges per geographic areas, the processing thereof through anaerobic fermentation in modern and safe biogas production facilities.

Adopted Policies and measures

- Romania's Sustainable Development Strategy 2030, approved by GD no. 877/2018, within the Objective 6 Clean water and sanitation establishes for 2030 the following national targets that directly influence the GHG emissions for this sector:
  - Substantially increase the efficiency of water use in industrial, commercial, and agricultural activities; expand the rational reuse of treated and recycled water to meet the requirements of a circular economy
  - Connect at least 90% of households in towns, communes and compact villages to the drinking water and sewerage network
  - Improve water quality by reducing pollution, eliminating waste disposal and reducing to a minimum the number of chemical products and dangerous substances, thereby reducing the proportion of untreated wastewater and significantly increasing recycling and safe reuse.

LULUCF Sector

Policies which lead to a mitigation of GHG emissions date back to the early 1990ies, as Romania's early National Communications under the UNFCCC have illustrated. The previous chapters show that emissions among the LULUCF Sector have clearly decreased due to implemented measures. In comparison with other sectors, the LULUCF Sector is unique in that it constitutes a net carbon sink. The main effect of the policies and measures set out in this section is to reduce CO2 emissions or to contribute to carbon storage through CO2 removal, Figure 4-2.

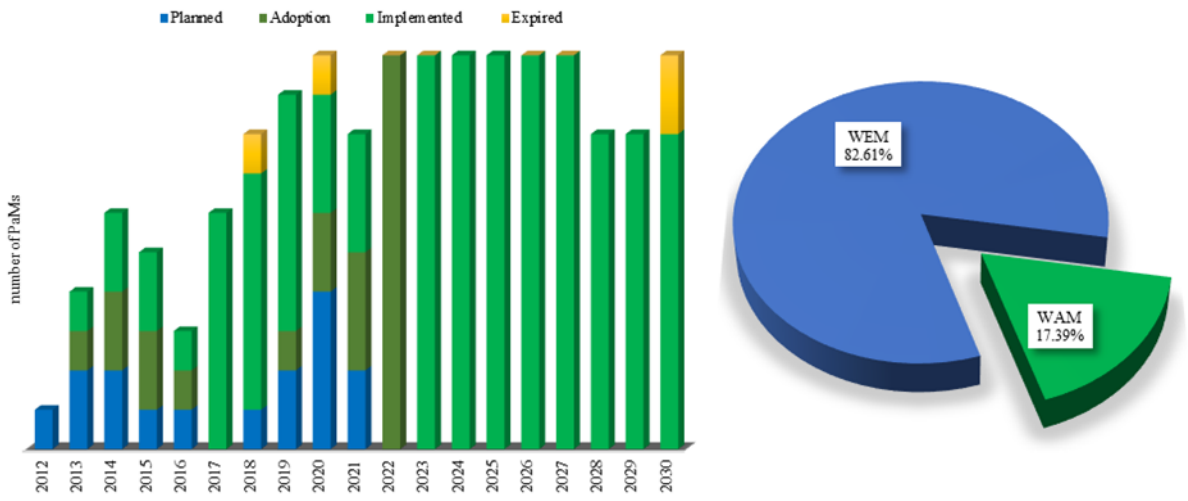


Figure 4-2 PaMs analysis. LULUCF Sector

Some policies and measures specific to other sectors influence the LULUCF Sector's sources and sinks. Within the LULUCF Sector, forest land (CRF 4.A) has by far the largest share of total emissions/removals from this sector. The Romanian Program for Rural Development 2014-2022 also provides for support measures, e.g., for preventive

action to protect forests from forest fires and natural disasters as well as to restore forest ecosystems after those events, and for increasing the resilience of forest ecosystems. Government of Romania has committed to reducing emissions and increasing removals through actions in three key areas: (i) increasing stored carbon and advancing innovative practices; (ii) increasing the use of wood for construction; and (iii) generating bioenergy and advanced bioproducts. Selected measures that have a significant mitigation effect are described in this section, with estimates of the expected reductions. These measures aim to maintain or even increase carbon sequestration in subcategories, through them it directly affects CO2 emission reduction targets.

- Government Decision no. 739/2016[28] for the approval of the Romania's national strategy regarding climate change and economic growth based on low carbon emissions (NSCCE)[29]

  GHG affected: CO2; CH4; N2O
  Type of policy: regulatory
  Implementing entity: MARD; MEWF
  Interlinkages with projection-scenario: WEM
  Covering: national
  Quantified mitigation impact: (i) carbon conservation in existing forests, increase production in existing forests, increase the pool of harvested timber products, improve forest management, prevent deforestation, strengthen protection against natural disturbances, replace raw materials and GHG-intensive materials with harvested timber products; (ii) reduction of GHG emission levels

  (A) promoting the transfer of knowledge and advisory services on climate change issues between farmers: (A1) providing services for farmers to acquire knowledge on methods to reduce GHG concentrations in the air generated by activities key, animal husbandry and fertilizer use; (A2) promoting carbon sequestration technologies and practices, insulation of buildings, use of energy from renewable sources. (B) investment support for farm modernization; this objective can be achieved by: (B1) encouraging investment in the creation of facilities and the purchase of high-performance equipment for the storage and use of manure; (B2) encouraging investment for increased energy efficiency of buildings / farms; (B3) encouraging the generation and use of energy from renewable sources on a small scale. (C) promoting good agricultural practice: (C1) avoiding the use of mechanized machinery; (C2) prohibition/limitation of the use of chemical and organic fertilizers; (C3) reduction of the number of animals on pastures; (C4) use of crops with a high capacity to fix nitrogen in the soil; (C5) encouraging organic farming. (D) promoting carbon sequestration in agriculture: (D1) incorporating plant matter into soil on agricultural land where green crops are grown.

- National Rural Development Program (NRDP)[30]

  GHG affected: CO2; CH4; N2O
  Type of policy: regulatory
  Implementing entity: MARD
  Interlinkages with projection-scenario: WEM

[28] The national strategy on climate change and economic growth based on low carbon emissions for the period 2016-2020. Available at: https://legeaz.net/monitorul-oficial-831-2016/hg-739-2016-strategii-nationale-schimbari-climatice
[29] http://www.mmediu.ro/categorie/strategia-cresc
[30] The National Rural Development Program. Available at: https://www.pndr.ro

Covering: national
Quantified mitigation impact: (i) carbon conservation in existing forests, increase production in existing forests, increase the pool of harvested timber products, improve forest management, prevent deforestation, strengthen protection against natural disturbances, replace raw materials and GHG-intensive materials with harvested timber products; (ii) reduction of GHG emission levels

It is a non-reimbursable EU financial instrument to support rural development and to unlock the rural economy and life. It contributes to the implementation of rural development priorities in order to meet national strategic objectives and EU CAP objectives. A large number of measures and sub-measures contained in the NRDP have an implicit potential to support LULUCF GHG reduction and adaptation actions. The scale of application of the measures differs depending on the specific, from the small farm to the large farms. Specific support measures range from better management of soil and land resources to promoting renewable energy production and use, from avoiding land abandonment and addressing emissions from the application of nitrogen fertilizers to green measures. The environmental and climate measures of NRDP 2014-2022, both in the case of permanent natural and semi-natural meadows, and in the case of traditional orchards used extensively or arable land, promote the practice of agriculture which involves avoiding or limiting the use of heavy machinery and avoiding chemicalization application of traditional agricultural techniques used, which are basically reduced to non-intensive grazing and the establishment of data and methods of mowing. They will promote the maintenance of priority habitats and important species, the traditional cultural background, as well as the rational use of natural resources. Efforts to date to achieve ambitious environmental protection targets are further supported by the NRDP 2014-2022, the allocation of environmental and climate measures in the current programming period, exceeding 30% of total EAFRD allocations. For the 2014-2022 programming period, special emphasis was placed on promoting the efficient use of resources, as well as on smart, sustainable and inclusive growth in agriculture and rural areas, in line with the objectives set by the Europe 2020 Strategy made available to Member States to achieve these objectives is the new package of environmental and climate measures of the NRDP 2020, addressed to agri-environment and climate practices - Measure 10, organic farming - Measure 11 of areas facing natural constraints - Measure 13, they being implemented in Romania since 2015. The allocations of these Measures are consistent, with farmers being able to access the commitments in which amounts of approximately 2.623 billion euros are available, as follows: (i) Measure 10 - 1.069 billion euros, agri - environment and climate. Measure to encourage the application of sustainable agricultural practices in relevant areas, in areas of high natural value and in areas important for wild bird and butterfly species, Natura 2000 areas, with the aim of conserving biodiversity on agricultural land, protecting water and soil and reducing GHG emissions. It is also envisaged to increase the number of adult breeding animals from traditional local breeds in danger of abandonment. (ii) Measure 11- 235.72 million euros, organic farming. The measure promotes the application of organic farming practices by providing financial support both for the conversion to organic farming methods and in maintaining organic farming practices. (iii) Measure 13- 1.318 billion euros, payments for areas facing natural or other specific constraints. Aims to encourage the continuation of agricultural activities in areas facing natural or specific constraints.

- Joint Order no. 352/636/54/2015 on cross-compliance in support schemes and measures for farmers in Romania[31]

[31] https://legeaz.net/monitorul-oficial-363-2015/ordinul-madr-mmap-ansvsa-352-2015/anexa-norme

GHG affected: CO2; CH4; N2O
Type of policy: regulatory
Implementing entity: MARD; NVSFSA; MEWF
Interlinkages with projection-scenario: WEM
Covering: national
Quantified mitigation impact: (i) increasing the cropland and grassland quality through is SOC increases in mineral soils; (ii) reduction of GHG emission levels

Romania has established a set of rules that all beneficiaries are obliged to observe on all agricultural plots within the holding, including those for which they do not request support and those that are not used for production purposes. The cross-compliance norms refer to a series of standards constituted by the Good Agricultural and Environmental Conditions (GAEC) and the Legal Requirements in Management Matters (SMR), grouped by domains: Soil and carbon stock: (i) minimum soil cover; (ii) minimum land management that reflects specific local conditions to limit erosion, (iii) maintaining soil organic matter levels, including a ban on burning arable stubble. Landscape, minimum level of maintenance: (i) the preservation of landscape elements, including isolated trees and existing terraces on agricultural land, (ii) taking appropriate measures to prevent the installation of unwanted vegetation and to ensure a minimum level of maintenance of agricultural land.

- National Support Program in the Wine Sector (NSPWS)[32]. In the context of the continuous development of the Agricultural Sector, it was decided to continue the national support programs in the wine sector for the next programming period, respectively for the period 2019-2023.

  GHG affected: CO2
  Type of policy: regulatory
  Implementing entity: MARD
  Interlinkages with projection-scenario: WEM
  Covering: national
  Quantified mitigation impact: (i) prevention of soil erosion; (ii) maintain organic matter and soil structure; (iii) protecting biodiversity; (iv) reduction of GHG emission levels

  Is based on the evaluation of the results obtained because of the implementation of previous national programs, namely the National Support Program 2009-2013 and the National Support Program of Romania in the wine sector 2014-2018 and on conducting an analysis of the needs of the Romanian wine sector. Through the National Support Program in the Wine Sector 2019-2023, Romania aims to restructure, annually, an area of vines of approx. 1000-1800 ha, which would represent an annual percentage of 0.5-1% of the total vineyard area. The important activities provided for in the "National Support Program for Vineyards and Wine Producers for 2019-2023", in the context of climate change, refer to the conversion of varieties, including grafting, relocation of vineyards, replanting due to compulsory deforestation, sanitary or phytosanitary products, as well as the modernization of vineyards by: (i) designing, (ii) installing/replacing a management and palisade support system, (iii) modernizing vine management through the transition from low to semi-high cultivation, and (iv) modernization of the support system by replacing the wires and installing 3 rows of wires, of which at least two doubles, to the management and fencing system to support the hubs, (v) installation of drip irrigation systems eligible for

[32] https://www.madr.ro/comunicare/4724-sprijin-european-acordat-sectorului-vitivinicol-in-perioada-2019-2023

funding, including for winegrowers who have accessed restructuring programs - previous conversion of vineyards.

- GD on the organization, management, and use of permanent pastureland in support of the implementation of GEO 34/2013[33], in accordance with Regulation 1234/2007 EC [34]

  GHG affected: CO2
  Type of policy: regulatory
  Implementing entity: MARD; MEWF
  Interlinkages with projection-scenario: WEM
  Covering: national
  Quantified mitigation impact: (i) increasing the grassland quality through is SOC increases in mineral soils; (ii) reduction of GHG emission levels

  It focuses on improving the management of grazing land and conserving its total area as of 1 January 2007, although without land conversion restrictions. It also established the obligation of the owners to develop a pastoral management plan and establish a register of grazing lands, organized by the local municipality. The decision is meant to fill a historical institutional gap regarding the management of grazing lands by allocating specific tasks to different local and county institutions.

- Law no. 220 of October 27, 2008, for the establishment of the system for the promotion of energy production from renewable energy sources [35]

  GHG affected: CO2; CH4; N2O
  Type of policy: Regulatory, Support
  Implementing entity: Ministry of Energy
  Interlinkages with projection scenario: WEM
  Covering: national
  Quantified mitigation impact: reducing GHG emissions produced from instant oxidation of wood used for energy uses and reducing the pressure on the annual harvest

  The mentioned law foresees to promote of the use of renewable resources for energy production and seeks to extend the renewable grid across Romania. Producers of energy from renewable sources benefit from several green certificates for the electricity produced and delivered according to the provisions; one or more green certificates are given for every 1 MWh based on specific guidelines.

- Order No. 68 of March 22, 2022, for the amendment of the annex to the Order of the Minister of Agriculture and Rural Development no. 857/2016 on the approval of the state aid scheme "Support for the first afforestation and the creation of forested areas" [36]

  GHG affected: CO2
  Type of policy: Regulatory

[33] Emergency Ordinance No. 34 of April 23, 2013. Available at: https://legislatie.just.ro/Public/DetaliiDocument/147761
[34] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32007R1234
[35] Law no. 220 of October 27, 2008, for the establishment of the system for the promotion of energy production from renewable energy sources. Available at: https://www.engie.ro/wp-content/uploads/2021/07/Legea-nr-220-din-2008-actualizata.pdf
[36] https://legislatie.just.ro/Public/DetaliiDocument/253202

Implementing entity: MARD, MEWF
Interlinkages with projection scenario: WEM
Covering: national
Quantified mitigation impact: reducing GHG emissions

The budget of the state aid scheme at the end of the period (2020) was 21.786.653,33 Euros from a total of 46.786.653,35 Euros. Thus, no quantitative data regarding afforestation or the creation of forested areas are available, yet almost half of the budget was indirectly used to reduce GHG emissions. Through the mentioned Order No. 68, the remaining amount from the budget will be relocated to the state budget and probably transferred towards the Resilience and Recovery plan.

- Romania's National Strategy for Sustainable Development 2030[37] (GD 754/2022; GD 877/2018)[38]

GHG affected: CO2
Type of policy: regulatory
Implementing entity: MARD; MEWF
Interlinkages with projection-scenario: WAM
Covering: national
Quantified mitigation impact: reduction of GHG emission levels until climate neutrality

Through this strategy, Romania establishes its national framework for supporting the 2030 Agenda and implementing the 17 SDG set. The strategy supports the development of Romania on three main pillars, namely economic, social, and environmental. The strategy aims to strengthen Romania's capacity to adapt and resilience to combat the dangers of climate change and natural disasters by integrating measures to mitigate and adapt to climate change and natural disasters in both national strategies and policies and in planning and increasing the level of climate change education and awareness.

- National Recovery and Resilience Plan (NRRP), 2021-2026[39]

GHG affected: CO2; CH4; N2O
Type of policy: regulatory
Implementing entity: MEIP; MARD; MEWF
Interlinkages with projection-scenario: WAM
Covering: national
Quantified mitigation impact: afforestation and reforestation, including urban forests

Developed under the Recovery and Resilience Mechanism under Article 16 of the Regulation of the European Commission and the European Parliament, it presents a multiannual budget for 12 priority areas. Romania benefits of a budget in the EU's multiannual financial framework, from the total budget in the EU. NRRP Romania is structured on 3 pillars of interest: (i) transport and climate change; (ii) public services, urban development, capitalization; (iii) economic competitiveness, digitization, resilience. Of the three major pillars set for the NRPP, the Transport and Climate Change pillar presents 5 areas of intervention: (i) sustainable transport; (ii) climate change; (iii) environmental; (iv) energy and green

[37] https://gov.ro/fisiere/NF_HG_754-2022
[38] https://legislatie.just.ro
[39] Romania's National Recovery and Resilience Plan (Planul Național de Redresare și Reziliență al României). Available at: https://mfe.gov.ro/pnrr

transition; (v) energy and thermal efficiency. Area of intervention - Climate change: reforms and investments in Romania, the challenges launched by climate change have led to multi-annual studies, developing maps of high-risk areas, respectively: (i) desertification; (ii) swamping; (iii) soil erosion and (iv) occurrence of extreme weather events. The concept pursued in NRRP was to strengthen Romania's resilience to combat the risk of climate change. Specific investments will focus on the following areas: (i) irrigation arrangements; (ii) drainage arrangements; (iii) arrangements for combating soil erosion; (iv) anti-hail systems; (v) forest fund management, torrent collection.

- EU Farm to Consumer Strategy[40]

  GHG affected: CO2; CH4; N2O
  Type of policy: regulatory
  Implementing entity: MARD; EC
  Interlinkages with projection-scenario: WAM
  Covering: EU level
  Quantified mitigation impact: achieving climate neutrality by 2050

  Is one of the key actions in the European Green Deal, helping to achieve the goal of achieving climate neutrality by 2050, a strategy that considers the evolution of the current EU food system towards a sustainable model. The strategy has the following main objectives: (i) to ensure a sufficient supply of affordable, nutritious food within the planetary limits; (ii) halving the use of pesticides, fertilizers, and the sale of antimicrobials; (iii) increasing the area of land intended for organic farming; (iv) promoting more sustainable food consumption and healthy diets; (v) reducing food loss and waste; (vi) combating food fraud along the food supply chain; (vii) improving animal welfare.

- EU Biodiversity Strategy for 2030[41]

  GHG affected: CO2; CH4; N2O
  Type of policy: regulatory
  Implementing entity: MARD; EC
  Interlinkages with projection-scenario: WAM
  Covering: EU level
  Quantified mitigation impact: mitigate of climate change impact

  It is the cornerstone of biodiversity protection in the EU. The main actions to be taken by 2030 include: (i) the creation of protected areas covering at least 30% of the EU's land and sea area, extending the coverage of existing Natura 2000 areas; (ii) restoring degraded ecosystems across the EU by 2030 through a number of specific commitments and measures, including a 50% reduction in pesticide use and associated risk by 2030 and the planting of 3 billion trees across the EU; (iii) allocating EUR 20 billion per year to protect and promote biodiversity through EU funds and by mobilizing national and private sources of funding; (iv) creating an ambitious global biodiversity framework. The EU aims to lead by example worldwide in this regard.

[40] Farm to Fork strategy for a fair, healthy and environmentally friendly food system. Available at: https://food.ec.europa.eu/horizontal-topics/farm-fork-strategy_en
[41] Biodiversity Strategy for 2030. Available at: https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_ro#obiective

- Government Decision no. 1076 for the approval of the National Integrated Plan in the field of energy and climate change 2021-2030

  GHG affected: CO2; CH4; N2O
  Type of policy: regulatory
  Interlinkages with projection-scenario: WAM
  Covering: national
  Implementing entity: MARD; MAWF; Ministry of Energy
  Quantified mitigation impact: reduction of GHG emission levels

  Following the EU's accession to the Paris Agreement and with the publication of the Energy Union Strategy, the Union assumed an important role in combating climate change, through the 5 main dimensions: energy security, decarbonization, energy efficiency, the internal energy market and research, innovation and competitiveness. Thus, the European Union is committed to leading the energy transition at a global level, by fulfilling the objectives set out in the Paris Agreement on climate change, which aims to provide clean energy throughout the European Union. To fulfill this commitment, the European Union has set energy and climate objectives for 2030 as follows: (i) the objective of reducing domestic greenhouse gas emissions by at least 40% by 2030, compared to 1990; (ii) the objective regarding energy consumption from renewable sources of 32% in 2030; (iii) the objective of improving energy efficiency by 32.5% in 2030; (iv) the objective of interconnecting the electricity market at a level of 15% by 2030. In this sense, the main elements considered in the strategic approach of the Plan were the following: (i) the holistic approach to energy, economy, environment and climate change should take place in close correlation with the economic reality of the Member States, so that the internal macroeconomic and social balance is not affected; (ii) the restructuring of the market framework, in the context of the costs induced by the transition and the capacity of the Member States to support these costs, in terms of accessibility and competitiveness; (iii) economic growth and income per household (on the horizon of 2030); (iv) reduction of energy poverty.

- Decision No. 933 of July 20, 2022. National Strategy of 20 July 2022 for research, innovation, and smart specialization 2022-2027[42]

  GHG affected: CO2; CH4; N2O
  Type of policy: regulatory
  Implementing entity: MCD
  Interlinkages with projection scenario: WAM
  Covering: national
  Quantified mitigation impact: reducing GHG emission levels in all sectors through innovation programs

  The strategy foresees the concept of bioeconomy through seeds and genotypes improvement as well as advanced technologies, which contributes to the development of the forest sector, agroforestry, hunting management, and cropland ecology.

- Decision no. 195 of February 10, 2022, for the approval of the State Aid Scheme regarding the support of investments intended to promote the production of energy from less exploited renewable sources,

[42] https://legislatie.just.ro/Public/DetaliiDocument/257796

namely biomass, biogas, geothermal energy, and the State Aid Scheme regarding the support of investments in high-efficiency cogeneration[43]

GHG affected: CO2
Type of policy: regulatory, support
Implementing entity: MMAP, MARD
Interlinkages with projection scenario: WAM
Covering: national
Quantified mitigation impact: reducing GHG emissions through more efficient use of resources

It is designed as an aid scheme regarding investments promoting energy production from less exploited renewable sources, such as biomass, biogas, and geothermal energy, and acquisitions in high-efficiency cogeneration energy-producing installations. In principle, the goal is targeted towards a more efficient economy regarding resources. Moreover, it stresses the achievement of EU objectives regarding the use of energy from renewable sources, the increase in production, the share of energy from renewable sources, and the reduction of carbon emissions in the atmosphere. There is an estimated increase of 60 MW in the installed capacity to produce electric and thermal energy from biomass, biogas, and thermal energy through Annex 1 and an increase of 50 Mwe in power installed in high-efficiency cogeneration.

- Law no. 254 of July 20, 2022, for the amendment and completion of the Land Fund Law no. 18/1991 and other normative acts[44]

  GHG affected: CO2; CH4; N2O
  Type of policy: Regulatory
  Implementing entity: All ministries
  Interlinkages with projection scenario: WAM
  Covering: national
  Quantified mitigation impact: Efficient land and resources use, reducing GHG emissions

  The land fund law is updated with the possibility of placing investment objects on quality class III, IV, and V agricultural lands. The specific investment must be the production of electric energy from renewable sources: production capacity of solar energy, wind energy, energy from biomass, bioliquids, and biogas on agricultural land located outside the village with a maximum area of 50 ha.

- Law no. 248 of July 20, 2022, regarding the approval of the Government's Emergency Ordinance no. 143/2021 for the amendment and completion of the Electricity and Natural Gas Law no. 123/2012, as well as for the modification of some normative acts[45]

  GHG affected: CO2; CH4; N2O
  Type of policy: Regulatory
  Implementing entity: All ministries
  Interlinkages with projection scenario: WAM
  Covering: national

[43] https://legislatie.just.ro/Public/DetaliiDocument/251619
[44] https://legislatie.just.ro/Public/DetaliiDocumentAfis/257727
[45] https://legislatie.just.ro/Public/DetaliiDocumentAfis/257741

Quantified mitigation impact: reducing GHG emissions from fossil fuels filled power plants; efficient use of resources; communities' economic growth and development

The amendment and completion of the Electricity and Natural Gas Law no. 123/2012 encourages the production of electrical energy from renewable sources. It guarantees that the produced energy is received into the national grid. Participation in energy sector activities of local energy communities is ensured. At the same time, prosumers are exempted from the obligation to purchase annual and quarterly green certificates provided in Law no. 220/2008 for electricity produced from renewable sources and used at the place of production for their own final consumption. At the same time, the same producers can conclude directly negotiated contracts only with the final consumer suppliers for the sale of green certificates issued for the electricity produced and delivered.

- Decision No. 1.172 of September 21, 2022, for the approval of the National Strategy regarding the circular economy[46]

  GHG affected: CO2; CH4; N2O
  Type of policy: Regulatory, Informational, Economic
  Implementing entity: All ministries
  Interlinkages with projection scenario: WAM
  Covering: national
  Quantified mitigation impact: reducing GHG emissions, sequestrating CO2, maximizing reuse

  The strategy will provide the necessary tools for implementing decisions regarding reducing generated waste, dependence on primary resources, and harmful emissions, simultaneously changing the economic model and creating the premises for increasing the number of new jobs. Moreover, it foresees the cascading use of biomass, increasing the use of bio-fertilizers, and compost, supporting initiatives on alternative protein sources, regulating water/wastewater reuse in agriculture, optimizing water extraction, and maximizing its reuse/recycling. It also adopts circular design principles, reducing synthetic materials, increasing the degree of separate collection, and investing in furniture return infrastructure and recycling technologies. In the agriculture and forest domain, the decision-makers state that the owners should be rewarded, either through the CAP or other public or private initiatives, to ensure implementation. In the case of Romania, a regulatory framework will be developed for the certification of carbon emissions according to the EU Action Plan.

- Emergency Ordinance No. 35 of April 6, 2022, for the approval of the necessary measures to carry out the national afforestation and reforestation campaign provided for in the National Recovery and Resilience Plan[47]

  GHG affected: CO2; CH4; N2O
  Type of policy: Regulatory, Financial, Informational
  Implementing entity: All ministries, MMAP
  Interlinkages with projection scenario: WAM
  Covering: national

[46] https://legislatie.just.ro/Public/DetaliiDocument/259668
[47] https://legislatie.just.ro/Public/DetaliiDocumentAfis/253712

Quantified mitigation impact: reducing GHG emissions, improving soil fertility, intersectoral coordination, and efficient land use

The follow-up intervention implemented financial aid schemes according to specific guidelines elaborated by The Environment, Water, and Forest Ministry. Considering the low rate of afforestation of lands outside the national forest fund, i.e., less than 200 ha in 2020, and the need to increase the areas covered with forest vegetation to achieve the objectives of the National Recovery and Resilience Plan, the decision-makers have found mandatory to carry out some interventions legislation to simplify the procedures for afforestation of lands outside the national forest fund. Thus, the approved funds are used for the financing of the following: developing projects, as well as carrying out afforestation and plantation maintenance works carried out on agricultural land in the use categories of arable land, permanent meadows, and permanent crops; technical-economic documentation, as well as carrying out afforestation and plantation maintenance works on degraded land suitable for afforestation, established in improvement perimeters; restoration of forest potential by afforestation of lands located in the national forest fund, which have been affected by forest fires, unfavorable meteorological phenomena that can be assimilated to a natural calamity, plant infestations with harmful organisms and catastrophic events, as well as the maintenance of plantations; technical-economic documentation, as well as carrying out the installation works of forest protection curtains and maintenance of the plantations.

- Decision No. 1.227 of October 5, 2022, regarding the approval of the National Strategy for Forests 2030[48]

GHG affected: CO2; CH4; N2O
Type of policy: Regulatory, Support, Informational
Implementing entity: MMAP
Interlinkages with projection scenario: WAM
Covering: national
Quantified mitigation impact: reducing GHG emissions through the diversity of measures in policy reforms

The National Strategy for Forests (SNP30) is sought to ensure a good governance approach based on the coherence of legislation in the forestry field, the assumption of responsibility and transparency, and capitalizing more effectively on the principles of sustainable management of forests that has to ensure productivity, the multifunctional role, stability and the biodiversity of Romania's forests. The strategy is built upon the principles of sustainable forest management, from which five thematic areas emerged following the strategic regions provided by the European Forest Strategy 2030. The main thematic areas that affect LULUCF consist of supporting the forests' socio-economic functions and stimulating the forest bioeconomy within the limits of sustainability and Protecting, Restoring, and Expanding forests in Romania. The strategy is acknowledged as a novelty as a shift towards descriptive directions rather than prescriptive. Even though the quantitative ambitions of the strategy are not high (15.000 hectares of new forests in the period of 2026-2030 and 350 hectares of urban forests until 2026), the plan focuses on easing out the bureaucracy and increasing transparency through the diversity of measures.

The LULUCF Sector GHG emissions-removals level is undoubtedly influenced by the implementation of the national and/or European Policies and Measures. The proof of the direct relationship between the PaMs and the

[48] https://legislatie.just.ro/Public/DetaliiDocument/260277

levels of emissions-removals in the LULUCF Sector is the last submission of NGHGI report, were all the annual average values, without exception, were within the national proposed target that should be achieved in 2030, in compliance with the new LULUCF Regulation (Annex II.a), in the amount of - 25665 kt CO2 eq. It should be mentioned that this proposed target to the LULUCF Sector in compliance with the new LULUCF Regulation - Fit for 55 - is the effect of an average of GHG emissions-removals levels over the 2016–2018-time segment, related to the NIR 2020, Figure 4-3. Romania, from the perspective of the AFOLU Sector [non-CO2 Agriculture + LULUCF], respectively of the neutrality proposed target, related to 2035, in compliance with the new LULUCF Regulation, presents a historical series as a sink behavior.

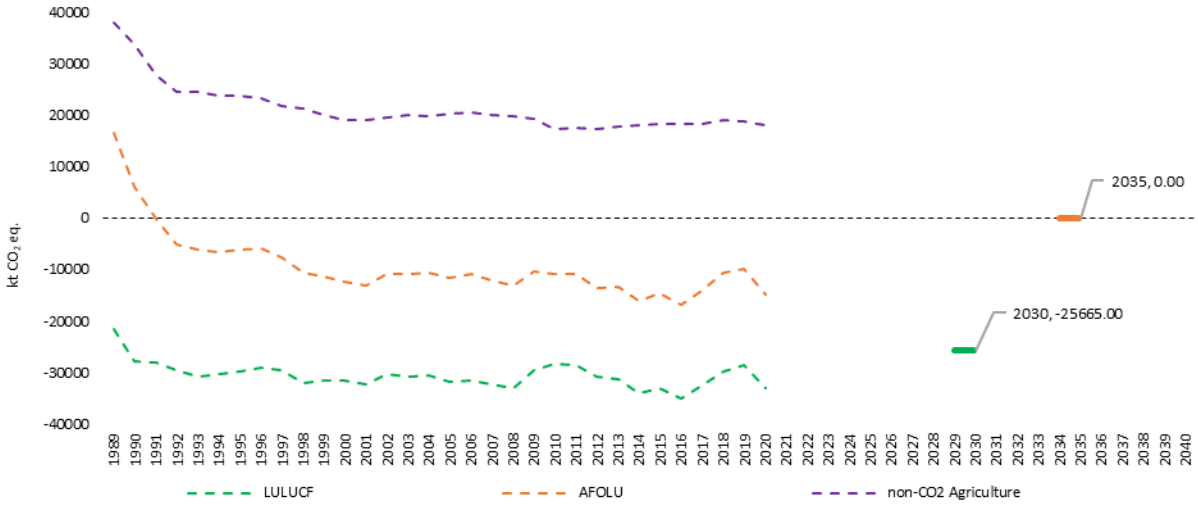


Figure 4-3 GHG emissions-removals levels related to NGHGI 2022 vs. the targets proposed by the LULUCF Regulation

Cross-cutting Policies and Measures

An overview of all cross-cutting policies and measures, including the affected sectors, is presented in Table 4-2.

Table 4-2 Cross-sectoral policies and measures

Policies and Measures	Affected sector					
	Energy Supply	Energy Consumption	Industry	Transport	Agriculture and forests	Waste
Adopted policies and measures						
GD no. 877/2018 aproving Romania's Sustainable Development Strategy 2030	YES		YES	YES		YES
Law no. 278/2013 on industrial emissions	YES		YES			
Decisions establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU	YES		YES		YES	YES
GD no. 780/2006 establishing the scheme for greenhouse gas emission allowance trading, with subsequent amendments (including GD no. 393/2020)	YES		YES			

Regulation (EU) 2018/842 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement	YES	YES	YES	YES	YES	YES
Law no. 220/2008 on establishing the promotion system for the production of energy from renewable energy sources, with further amendments	YES	YES			YES	
Law no. 121/2014 on energy efficiency	YES	YES	YES	YES	YES	
GD no. 203/2019 on the approval of the National Action Plan for energy efficiency IV (NEEAP IV)	YES	YES	YES	YES	YES	
GD 1076/2021 for approval of the 2021-2030 Integrated National Energy and Climate Plan (PNIESC)	YES			YES		
Romania's National Recovery and Resilience Plan (PNRR)	YES	YES		YES		YES
National programs for local and regional development		YES		YES		
Planned policies and measures						
The Sustainable Development Operational Program (PODD) 2021 -2027	YES	YES				YES
The Regional Operational Programs (POR) 2021-2027		YES		YES		
The Just Transition Operational Program (POTJ) 2021-2027	YES			YES		
National programs foreseen for local and regional development		YES		YES		

The policies and measures considered in the WEM and WAM scenario are presented in BR5, CTF Table 3.

B.2. Policies and measures in accordance with Article 2 of the Kyoto Protocol

- ***Information policies and measures implemented and/or further elaborated as well as cooperation with other such Parties in achieving its quantified emission limitation and reduction commitment under Article 3, in order to promote sustainable development.***

Of the policies and measures listed above, many promote sustainable development in the EU and its Member States. As an example, under the Renewable Energy Directive, biofuels need to fulfil a set of sustainability criteria including minimum emission reduction, biodiversity aspects, and requirements for various land types. See more information on promoting sustainable development in the section regarding assessment of the economic and social consequences of response measures.

- ***Information on the steps taken to promote and/or implement any decisions by the International Civil Aviation Organization and the International Maritime Organization in order to limit or reduce emissions of greenhouse gases not controlled by the Montreal Protocol from aviation and marine bunker fuels.***

As an instrument to limit GHG emissions from international aviation, ICAO adopted in 2016 the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), with the aim to avoid or offset CO_2 emission growth from international aviation from 2020 onwards. The first voluntary phase of this scheme started in 2021, and all EU Member States are implementing CORSIA[49] in this first phase.

For international maritime transport, the IMO[50] established a data collection system which started in 2019 and requires large ships to report fuel consumption data. Large ships calling into EU ports report on their fuel consumption both under the IMO system and under the EU-internal Monitoring, Reporting and Verification Regulation[51]. While there is currently no carbon market instrument in place for international shipping under the IMO, the EU is planning to include GHG emissions from international shipping in the EU ETS from 2023 onwards[52].

- ***Information on implementing policies and measures under Article 2 of the Kyoto Protocol in such a way as to minimize adverse effects, including the adverse effects of climate change, effects on international trade, and social, environmental and economic impacts on other Parties, especially developing country Parties and in particular those identified in Article 4, paragraphs 8 and 9, of the Convention, taking into account Article 3 of the Convention.***

All policies and measures listed in this chapter of the Romania's 8th NC aim at reducing greenhouse gas emissions and/or increasing the capacity of sinks and thereby contribute to minimising the adverse effects of climate change. As far as international trade is concerned, the EU aims at contributing to the economic ecovery after the COVID-19 pandemic through support for the green and digital transformations, as well as a renewed focus on strengthening multilateralism and reforming global trade rules to ensure that they are fair and sustainable. This approach is laid out in the European Commission's 2021 trade strategy[53]. Social, environmental and economic impacts of policies and measures on other countries are assessed in the course of the impact assessment (see also section above). In addition, the EU and its Member States have committed to Policy Coherence for Development (PCD)[54]. Through PCD, they seek to take account of development objectives in policies that are likely to have an impact in developing countries. A specific process is available in the Better Regulation Toolbox for analysing the potential impact of EU policy initiatives on developing countries[55]

[49] https://www.icao.int/environmentalprotection/CORSIA/Documents/CORSIA_States_for_Chapter3_State_Pairs_Jul2020.pdf.

[50] https://www.imo.org/en/OurWork/Environment/Pages/DataCollection-System.aspx.

[51] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32015R0757

[52] Regulation (EU) 2015/757 of the European Parliament and of the Council of 29 April 2015 on the monitoring, reporting and verification of carbon dioxide emissions from maritime transport, https://ec.europa.eu/clima/eu-action/transport-emissions/reducingemissions-shipping-sector_en.

[53] Trade Policy Review - An Open, Sustainable and Assertive Trade Policy, COM(2021) 66 final, https://eurlex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52021DC0066.

[54] Policy coherence for development, https://ec.europa.eu/international-partnerships/policy-coherence-development_en.

[55] Better regulation toolbox, Tool 35, https://ec.europa.eu/info/law/law-making-process/planning-and-proposinglaw/better-regulation-why-and-how/better-regulation-guidelines-and-toolbox_en.

B.3. Information on the assessment of the economic and social consequences of response measures

According to the Article 3.14 of the Kyoto Protocol, Annex I countries will take mitigation measures in such a way as to minimize adverse social, environmental and economic impacts on developing countries.

The UNFCCC biennial reporting guidelines encourage Parties to provide, to the extent possible, detailed information on the assessment of the economic and social consequences of response measures. Romania, as EU member state strives to implement policies and measures under Article 2 of the Kyoto Protocol in such a way to minimize adverse effects on other Parties.

The implemented policies and measures can have positive and negative social and economic consequences. To ensure that all relevant possible impacts are considered, the EU has established processes that assess the economic and social consequences of climate policy measures. The key instrument in the EU policymaking process used to assess such consequences is the impact assessment. Information on impact assessments can be found in sections 2.2 and 4.2 of the EU's 8th National Comunication Report, as well as in the section 4.5 of the 5th EU's Biennial Report. provides more information on how the economic and social consequences (both in the EU and in developing countries) of policies and measures are assessed.

Also, information on the approach of the EU on the assessment of the economic and social consequences of response measures are also provided in Section 4.3.4.3 of the EU's 6th NC, chapter 15 of the EU NIR 2020, and section 4.4. of EU's 4th BR.

Romania has a comprehensive approach of climate change mitigation policy development, addressing all sources as well as sinks, to minimize adverse effects of climate policies and measures on the national economy. The purpose is to promote sustainable development for the benefit of the individual, society, and future generations. The vulnerability due to climate change is included in Strategic Environmental Assessments of the national strategies and programs.

On a large period (1989-2000) the reduction of emissions in Romania was mainly a consequence of the decline of the economic activities. After that, the emission reductions are also in tight connection with the upgrading of technologies and energy efficiency measures promoted including as result of European Union acquis.

The achieved reductions of the GHG emissions are also due to Romania's participation from the early stage to implementation of the Joint Implementation mechanism resulting in upgrading and refurbishing of the old technologies, improving at the same time the energy efficiency.

Starting with 2007, an important role to reduce emissions has been the implementation of the EU Emission Trading Scheme. Therefore, the national policies developed so far in response to climate change to reduce GHG emissions has no impact abroad and especially on developing countries.

Romania considers the technical and financial assistance for developing countries as very important to develop policies on climate change at international level and it is willing to join the European Union initiative to provide a "fast start financing" for developing countries. Under the fast start financing Romania decided to focus its contribution for the benefit of developing countries associated to the Copenhagen Accord (see Section 4.1.3 of the Romania 2BR). In 2010 was signed between the Governments of Romania and Republic of Moldova the Accord on implementation of the technical and financial assistance based on 100 million euros granted by the Romanian Government. In this context 15 million Euros represents Romanian contribution planned for the fast start financing mechanism that will be used for energy efficiency and transport infrastructure projects with a view to develop climate change mitigation policy and efficiency of natural resources use in the Republic Moldova.

Romania is member of IRENA (International Renewable Energy Agency) since 22 July 2010. This international organization develops renewable energy policies and promotes its wider utilization worldwide. One of the main functions of IRENA is to offer advice to its member states regarding selection and adaptation of energy sources, technologies, business models, organizational and regulatory frameworks. The cooperation within IRENA contributes to increase sectoral administrative capacity (Romanian authorities could learn more about experiences of sectoral policy implementation and provide advice to other members on developing the renewable energy sector). Romania has valuable experiences regarding the renewable energy and joint implementation projects developed under article 6 of Kyoto Protocol.

Romania contributes to the EU Eastern Europe Energy Efficiency and Environment Partnership (E5P) Fund (270,000 RON in 2016) which supports energy efficiency and environmental sustainability projects. The E5P Fund activities started first in Ukraine, but since 2013 it has been extended to Georgia, Moldova, and Armenia. As part of bilateral cooperation Romania also offered support to Georgia for disaster prevention and preparedness as part of adaptation measures.

C. Policies and measures no longer in place

The climate change mitigation policies and measures are revised and updated regularly, at national and EU level, which is imperative in light of the urgent need to step up climate action in all sectors of the economy. In general, where possible the scope and ambition of current policies and measures are enhanced. Alternative, new climate policies and measures are adopted. The climate change mitigation policies or measures are not abandoned, hence there are no 'policies and measures no longer in place'. During the reporting period no policies and measures have expired or were abrogated, which may influence the GHG emissions trends.

In 2016, the National Strategy on Climate Change and Low-carbon Economic Growth for 2016-2020 was approved by GD no. 739/2016 and the National Action Plan for the Implementation of the National Strategy on Climate Change and Economic Growth Based on Low Carbon Emissions for the period 2016-2020.

The main objective of the national strategy on climate change and low carbon growth is to mobilize and enable private and public actors to reduce greenhouse gas emissions, GHGs from economic activities in line with EU targets and adapt to the impacts of climate change, both current and future. As regards the GHG emission reduction process, this strategy adopts quantifiable targets in line with the EU's 2030 commitments. As far as adaptation to climate change is concerned, the aim is to support and promote the protection of the environment, people and the environment. economic activities to the effects of climate change, especially extreme events. The strategy will guide Romania's climate change and low carbon development actions by 2030, representing an update and extension of the National Climate Change Strategy 2013-2020 in the light of current events.

Policy in the LULUCF sector

By comparison with previous reporting, Romania presents a series of PaMs that have completed their mission, but which continue their impact, respectively, Table 4-3:

Table 4-3 Completed policies and measures

Nr. crt.	Policy-measure	Period of development /implementation	Conclusion/impact
1.	GD on the organization, management and use of permanent pasture land in support of the implementation of GEO 34/2013	2013-2020	*increasing the grassland quality through is SOC increases over the years in mineral soils due to improved management practices which include, among others, balanced fertilization according to fertilization plans (based on agrochemical studies), controlled grazing etc.*
2.	National Rural Development Plan (NRDP)	2014-2022	*- biodiversity conservation, water and soil protection* *- GHG emissions reducing* *- long term carbon sequestration in biomass*
3.	National Support Program in the Wine Sector (NSPWS)	2014-2018	*- increased the new varieties area adapted to the challenges of climate change* *- soil erosion reducing* *- GHG emissions reducing*
4.	Romania's national strategy regarding climate change and economic growth based on low carbon emissions (NSCCE)	2015-2020	*- maintenance and increasing of the organic matter in the soil, especially in carbon-rich soils like swamps, peatlands* *- increasing the forest area, by stopping illegal cuts, ecological forest reconstruction*
5.	BIO4ECO-Sustainable regional bioenergy policies: a new approach	2016-2020	*- reducing carbon emissions and transitioning to a low-carbon economy* *- use of renewable energy, energy efficiency of buildings and forest and agricultural biomass* *- increasing the share of renewable energy in the general energy mix*
6.	GO no. 225/2020 regarding the modification of some normative acts and the establishment of some measures in the field agriculture	2020-2022	*increasing the grassland quality through is SOC increases over the years in mineral soils due to improved management practices which include, among others, balanced fertilization according to fertilization plans (based on agrochemical studies), controlled grazing etc.*

5. PROJECTIONS AND TOTAL EFFECT OF POLICIES AND MEASURES

A. Projections

A.1. Background and scenarios

The most recent GHG emission projections were elaborated in 2022, considering the trends of key macro-economic, technological, demographical, and other indicators related to the social-economic development of Romania.

The projections of GHG emissions were considered the following:

- The Seventh National Communication of Romania
- The 2021-2030 Integrated National Energy and Climate Plan
- Romania's Sustainable Development Strategy for 2030
- National Allocation Plan for participation at EU ETS
- The data and information related to GHG trend during the 1989 - 2020 period, included in the National inventories submitted by Romania to the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC)
- The development and planning strategies at national and sectoral level
- The forecasts of the macroeconomic indicators elaborated by the National Prognosis Commission in 2017 year.

The GHG projections for 2025, 2030, 2035 and 2040 considered different scenarios related to the economic-social, demographic, and technological evolution, to allow the highlight of the measures undertaken by Romania to achieve the GHG emissions mitigation goals at EU level and of the Convention considering the Kyoto Protocol.

The GHG emission projections are carried out for 3 scenarios, respectively:

- A "business as usual" reference scenario – **the scenario without measures (WOM)**, reference year - 2005
- A mitigation scenario, similar to the reference scenario in terms of the evolution of the economic-social and demographic indicators, containing mitigation policies and programs - **the scenario with measures (WEM)**, reference year - 2020
- A mitigation scenario with additional measures, similar to the mitigation scenario, containing additional emission mitigation measures - **the scenario with additional measures (WAM),** reference year - 2020.

The reference scenario, in terms of the evolution of the economic-social and demographic indicators, considered the impact of current economic crisis on the development of Romania. The considered scenarios are based on the key social-economic assumptions, presented in subchapter V.A.3.

Considering that the projection horizon is 2025 - 2040, the reference year is 2020, for which the National Inventory of Greenhouse Gas Emissions is realized and submitted to the UNFCCC, according with Romania's obligations.

The achievement of GHG emission projections is based on assumptions about high-uncertainty macroeconomic indicators on the forecast horizon until 2040 due to the national and global economic crisis due to the COVID19 pandemic and the lack of strategies for the 2030-2040 horizon on industry, agriculture, transport, etc.

To analyze the sensitivity of projections of GHG emissions in the given assumptions there are developed scenarios on the minimum and maximum economic recovery, compared to baseline scenario for which projections were made. In the chapter 5.D are presented the sensitivity of underlying assumption and uncertainty made for GHG emission projections to changes in economic and social development of Romania and sensitivity analysis for LULUCF sector.

A.2. Total GHG emissions projections

The total GHG emissions projections are presented in the Tables 5-1 – 5-3 for scenario WOM scenario, WEM scenario and WAM scenario, for each sector (Energy – CRF1, Industrial Processes - CRF2, Agriculture - CRF3, Land Use, Land – Use Change and Forestry LULUCF – CRF4, Waste – CRF5).

In Figure 5-1 is presented the GHG emissions evolution in the period 1990-2040 for all scenarios (WOM, WEM, WAM). Romania achieved the joint quantified economy-wide greenhouse gas emission reduction target of 20 per cent below the 1990 level by 2020 ("the Cancun pledge") under the UNFCCC.

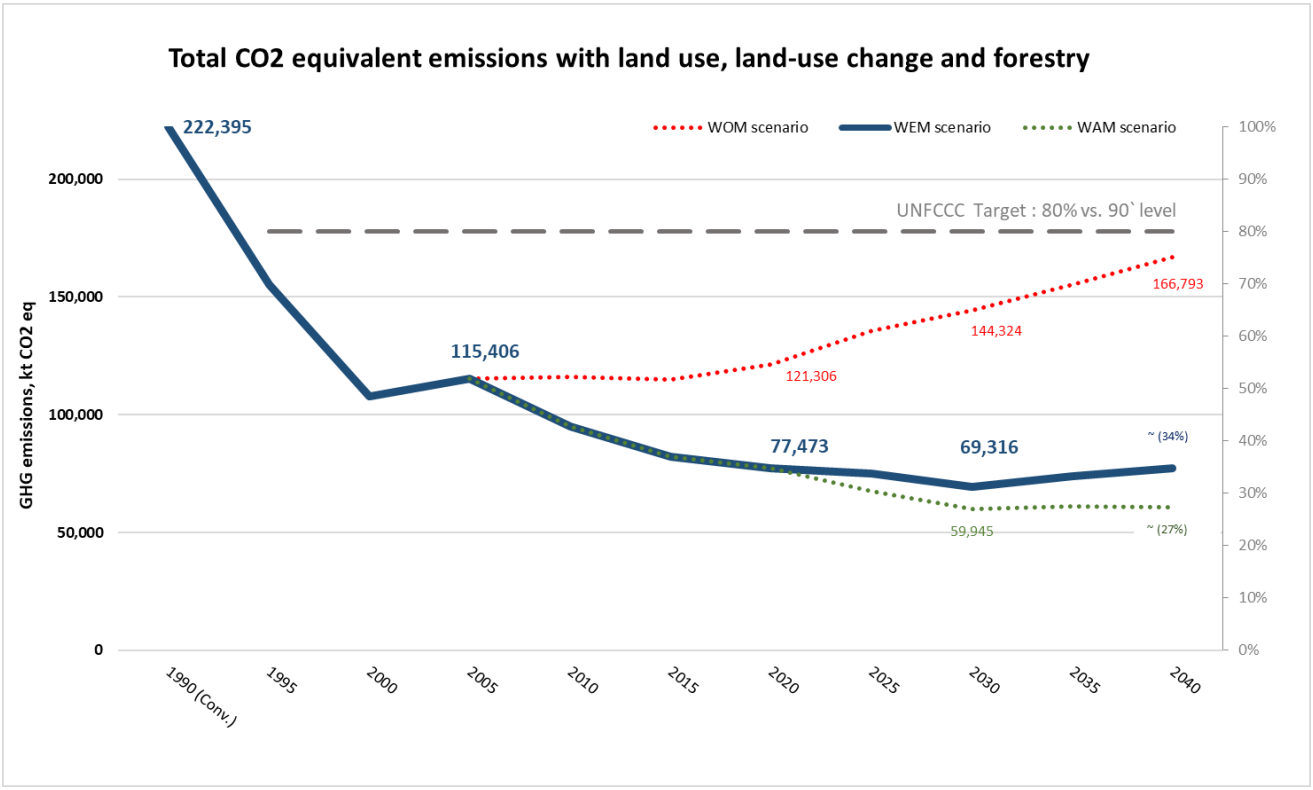


Figure 5-1 Evolution of the GHG emissions

Table 5-1 shows that in the WOM scenario, the GHG emissions increased increase in 2005-2020 from 115,405.87 kt CO2 eq. to 121,305.66 kt CO2 eq. and are higher by about 56 % in comparison with the value determined by National Inventory of Greenhouse Gas Emissions for 2020.

Table 5-2 shows that in the WEM scenario, GHG emissions are expected to decrease between 2020 and 2025 with about 3.1%. GHG emissions in 2025 will be lower by about 45% compared to the emissions from WOM scenario.

Table 5-3 shows that in the WAM scenario, GHG emissions are expected to decrease between 2020 and 2025 with about 12.7 %. GHG emissions in 2025 will be lower by 51% compared to the emissions from WOM scenario.

Table 5-1 The GHG emissions (kt CO2 eq) in the WOM scenario, 2005-2040

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2005	2020	2025	2030	2035	2040
Total national emissions and removals	**115405.87**	**121305.67**	**135542.44**	**144323.95**	**155134.15**	**166793.19**
1. Energy	**98520.26**	**105009.96**	**109757.05**	**114315.23**	**119945.16**	**126163.07**
A. Fuel combustion	82146.83	88659.10	93406.19	97964.38	103594.31	109812.21
1. Energy industries	40984.23	39663.03	39232.17	39393.30	39549.45	39718.27
2. Manufacturing industries and construction	16028.83	16028.33	16028.17	16028.17	16028.17	16028.17
3. Transport	12598.15	18401.03	22719.64	26138.42	30533.77	35395.87
4. Other sectors	11299.15	13827.42	14792.63	15738.74	16783.37	17934.52
5. Other	1236.46	739.29	633.58	665.75	699.55	735.38
B. Fugitive emissions from fuels	16373.43	16350.85	16350.85	16350.85	16350.85	16350.85
1. Solid fuels	11417.49	11396.24	11396.24	11396.24	11396.24	11396.24
2. Oil and natural gas and other emissions from energy production	4955.95	4954.62	4954.62	4954.62	4954.62	4954.62
C. CO_2 Transport and storage	NO	NO	NO	NO	NO	NO
2. Industrial processes and product use	**21853.25**	**16520.66**	**14993.21**	**14623.97**	**15231.99**	**15652.63**
A. Mineral industry	4170.07	5340.53	5289.60	5464.14	5682.70	5796.36
B. Chemical industry	6593.18	3462.22	2225.36	2457.86	2605.20	2735.49
C. Metal industry	9435.32	4422.69	3667.49	2772.19	2997.49	3181.28
D. Non-energy products from fuels and solvent use	1262.17	560.60	456.89	392.47	354.79	337.41
E. Electronic industry	NO	NO	NO	NO	NO	NO
F. Product uses as substitutes for ODS	374.57	2648.30	3304.00	3506.96	3562.34	3573.41
G. Other product manufacture and use	17.93	86.31	49.87	30.35	29.47	28.68
H. Other[3]	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
3. Agriculture	**20803.51**	**24595.75**	**26252.50**	**28042.99**	**29707.15**	**31783.95**
A. Enteric fermentation	9495.95	10811.78	11510.65	12374.85	13111.00	14224.34
B. Manure management	2240.08	2635.24	2879.89	3092.96	3307.74	3557.98
C. Rice cultivation	13.63	13.63	13.63	13.63	13.63	13.63
D. Agricultural soils	8195.15	10247.39	10950.94	11654.48	12358.03	13061.57
E. Prescribed burning of savannas	NO	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	720.15	720.15	720.15	720.15	720.15	720.15
G. Liming	85.79	98.99	103.39	107.79	112.19	116.60
H. Urea application	52.75	68.58	73.86	79.13	84.41	89.68
I. Other carbon-contining fertilizers	NA	NA	NA	NA	NA	NA
J. Other	NO	NO	NO	NO	NO	NO
4. Land use, land-use change and forestry [4]	**-31810.41**	**-31028.46**	**-21602.01**	**-18743.04**	**-15773.32**	**-12777.60**
A. Forest land [4]	-28211.87	-22356.01	-21488.60	-20049.19	-18655.33	-17286.99
B. Cropland [4]	-2043.92	-6342.64	-2234.90	-2208.29	-2155.00	-2095.42
C. Grassland [4]	-2667.00	-1264.38	912.18	1902.23	3017.42	4239.96
D. Wetlands [4]	40.30	-149.96	769.96	765.83	764.95	764.69
E. Settlements [4]	1988.29	2164.16	2719.47	2860.13	2990.84	3118.51
F. Other land [4]	210.91	73.46	246.88	245.83	279.76	280.01
G. Harvested wood products	-1127.12	-3153.10	-2527.00	-2259.58	-2015.97	-1798.37
H. Other [4]	NA	NA	NA	NA	NA	NA
5. Waste	**6039.25**	**6207.77**	**6141.69**	**6084.80**	**6023.16**	**5971.14**
A. Solid waste disposal [5]	2565.06	2691.24	2610.68	2539.55	2477.91	2425.88
B. Biological treatment of solid waste [5]	138.78	138.87	138.87	138.87	138.87	138.87
C. Incineration and open burning of waste [5]	98.35	98.22	98.47	98.47	98.47	98.47
D. Wastewater treatment and discharge	3237.06	3279.44	3293.67	3307.92	3307.92	3307.92
E. Other [5]	NA	NA	NA	NA	NA	NA
6. Other *(please specify)* [6]						
Total CO2 equivalent emissions without land use, land-use change and forestry	**147216.28**	**152334.13**	**157144.45**	**163066.99**	**170907.46**	**179570.79**
Total CO2 equivalent emissions with land use, land-use change and forestry	**115405.87**	**121305.67**	**135542.44**	**144323.95**	**155134.15**	**166793.19**

Table 5-2 The GHG emissions (kt CO2 eq) in the WEM scenario, 2020-2040

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2020	2025	2030	2035	2040
Total national emissions and removals	**77472.87**	**75067.84**	**69315.68**	**73904.46**	**77414.30**
1. Energy	**72834.34**	**71142.56**	**67336.34**	**71441.95**	**74915.52**
A. Fuel combustion Reference approach(2)	64249.65	62896.19	59407.17	63591.06	67514.62
1. Energy industries	18339.29	12232.61	5619.25	6058.73	6498.94
2. Manufacturing industries and construction	14781.93	15437.72	16261.96	17402.24	18230.18
3. Transport	18401.03	22363.48	24442.09	26718.87	29006.32
4. Other sectors	12077.33	12228.80	12418.13	12711.67	13043.81
5. Other	650.08	633.58	665.75	699.55	735.38
B. Fugitive emissions from fuels	8584.68	8246.37	7929.17	7850.89	7400.90
1. Solid fuels	5461.94	5199.79	4947.41	4861.12	4512.46
2. Oil and natural gas and other emissions from energy production	3122.75	3046.58	2981.76	2989.77	2888.44
C. CO_2 Transport and storage	NO	NO	NO	NO	NO
2. Industrial processes and product use	**12867.96**	**11034.81**	**9012.18**	**9153.01**	**9201.70**
A. Mineral industry	4718.38	4692.31	4829.72	4933.01	4946.93
B. Chemical industry	1689.24	776.66	838.60	888.82	933.50
C. Metal industry	3843.69	3182.39	1172.54	1250.21	1310.87
D. Non-energy products from fuels and solvent use	544.27	443.58	381.04	344.46	327.58
E. Electronic industry	NO	NO	NO	NO	NO
F. Product uses as substitutes for ODS	1988.58	1891.45	1760.82	1707.91	1654.99
G. Other product manufacture and use	83.80	48.42	29.47	28.61	27.85
H. Other(3)	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
3. Agriculture	**18748.36**	**21187.47**	**21944.09**	**22019.56**	**22561.00**
A. Enteric fermentation	7659.16	10792.29	10718.83	10615.81	10599.06
B. Manure management	1682.40	1862.02	1826.07	1810.53	1777.18
C. Rice cultivation	21.24	27.50	27.50	27.50	27.50
D. Agricultural soils	8536.60	7877.21	8734.16	8925.22	9513.79
E. Prescribed burning of savannas	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	713.40	509.58	509.58	509.58	509.58
G. Liming	52.88	55.80	58.57	59.97	61.36
H. Urea application	82.67	63.07	69.38	70.96	72.53
I. Other carbon-contining fertilizers	NA	NA	NA	NA	NA
J. Other	NO	NO	NO	NO	NO
4. Land use, land-use change and forestry (4)	**-32893.96**	**-31316.32**	**-31680.39**	**-31163.94**	**-31519.17**
A. Forest land (4)	-24222.19	-22422.94	-21844.51	-20472.86	-19991.01
B. Cropland (4)	-6343.42	-5948.30	-6761.55	-7587.26	-8440.23
C. Grassland (4)	-1270.41	-2223.86	-2531.30	-2690.58	-2773.72
D. Wetlands (4)	-149.96	-208.19	-231.06	-249.06	-265.43
E. Settlements (4)	2161.24	2083.84	2004.84	1925.55	1848.71
F. Other land (4)	73.37	25.01	-19.05	-63.11	-107.17
G. Harvested wood products	-3142.60	-2621.87	-2297.75	-2026.63	-1790.32
H. Other (4)	NA	NA	NA	NA	NA
5. Waste	**5916.18**	**3019.32**	**2703.44**	**2453.90**	**2255.24**
A. Solid waste disposal (5)	3871.98	964.30	715.88	528.59	386.97
B. Biological treatment of solid waste (5)	83.40	183.91	206.57	227.94	251.53
C. Incineration and open burning of waste (5)	11.91	11.85	11.85	11.85	11.85
D. Wastewater treatment and discharge	1948.89	1859.26	1769.15	1685.52	1604.89
E. Other (5)	NA	NA	NA	NA	NA
6. Other *(please specify)* (6)					
Total CO2 eq emissions without land use, land-use change and forestry	**110366.83**	**106384.16**	**100996.06**	**105068.41**	**108933.47**
Total CO2 eq emissions with land use, land-use change and forestry	**77472.87**	**75067.84**	**69315.68**	**73904.46**	**77414.30**

Table 5-3 The GHG emissions (kt CO2 eq) in the WAM scenario, 2020-2040

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	2020	2025	2030	2035	2040
Total national emissions and removals	**77472.87**	**67623.31**	**59945.19**	**61274.77**	**60948.22**
1. Energy	**72834.34**	**69853.52**	**65895.08**	**68989.86**	**70154.66**
A. Fuel combustion Reference approach(2)	64249.65	61607.15	57965.91	61138.97	62753.76
1. Energy industries	18339.29	12232.61	5619.25	6058.73	5055.40
2. Manufacturing industries and construction	14781.93	15052.72	15839.25	16814.49	17181.48
3. Transport	18401.03	21627.49	23578.50	25237.64	27479.12
4. Other sectors	12077.33	12060.75	12263.17	12328.56	12302.38
5. Other	650.08	633.58	665.75	699.55	735.38
B. Fugitive emissions from fuels	8584.68	8246.37	7929.17	7850.89	7400.90
1. Solid fuels	5461.94	5199.79	4947.41	4861.12	4512.46
2. Oil and natural gas and other emissions from energy production	3122.75	3046.58	2981.76	2989.77	2888.44
C. CO_2 Transport and storage	NO	NO	NO	NO	NO
2. Industrial processes and product use	**12867.96**	**11034.42**	**8884.79**	**9017.86**	**9060.76**
A. Mineral industry	4718.38	4692.31	4730.86	4828.02	4837.57
B. Chemical industry	1689.24	776.44	811.92	860.53	903.78
C. Metal industry	3843.69	3182.22	1170.69	1248.34	1309.00
D. Non-energy products from fuels and solvent use	544.27	443.58	381.04	344.46	327.58
E. Electronic industry	NO	NO	NO	NO	NO
F. Product uses as substitutes for ODS	1988.58	1891.45	1760.82	1707.91	1654.99
G. Other product manufacture and use	83.80	48.42	29.47	28.61	27.85
H. Other(3)	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
3. Agriculture	**18748.36**	**21016.66**	**21582.52**	**21531.56**	**21856.56**
A. Enteric fermentation	7659.16	10656.10	10425.76	10209.43	9993.02
B. Manure management	1682.40	1827.40	1757.58	1728.91	1678.78
C. Rice cultivation	21.24	27.50	27.50	27.50	27.50
D. Agricultural soils	8536.60	7877.21	8734.16	8925.22	9513.79
E. Prescribed burning of savannas	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	713.40	509.58	509.58	509.58	509.58
G. Liming	52.88	55.80	58.57	59.97	61.36
H. Urea application	82.67	63.07	69.38	70.96	72.53
I. Other carbon-contining fertilizers	NA	NA	NA	NA	NA
J. Other	NO	NO	NO	NO	NO
4. Land use, land-use change and forestry (4)	**-32893.96**	**-37041.89**	**-38793.48**	**-40394.78**	**-42087.06**
A. Forest land (4)	-24222.19	-25252.78	-26095.37	-26778.54	-27450.28
B. Cropland (4)	-6343.42	-8550.78	-10572.56	-12616.05	-14693.33
C. Grassland (4)	-1270.41	-1687.48	-863.96	-22.93	816.90
D. Wetlands (4)	-149.96	-142.67	-129.85	-113.85	-97.06
E. Settlements (4)	2161.24	1569.91	1519.59	1452.78	1378.41
F. Other land (4)	73.37	124.34	114.99	105.64	96.29
G. Harvested wood products	-3142.60	-3102.43	-2766.32	-2421.83	-2137.98
H. Other (4)	NA	NA	NA	NA	NA
5. Waste	**5916.18**	**2760.60**	**2376.28**	**2130.27**	**1963.30**
A. Solid waste disposal (5)	3871.98	708.52	401.54	225.37	124.14
B. Biological treatment of solid waste (5)	83.40	180.97	193.74	207.53	222.43
C. Incineration and open burning of waste (5)	11.91	11.85	11.85	11.85	11.85
D. Wastewater treatment and discharge	1948.89	1859.26	1769.15	1685.52	1604.89
E. Other (5)	NA	NA	NA	NA	NA
6. Other *(please specify)* (6)					
Total CO2 eq. emissions without land use, land-use change and forestry	**110366.83**	**104665.20**	**98738.68**	**101669.55**	**103035.28**
Total CO2 eq emissions with land use, land-use change and forestry	**77472.87**	**67623.31**	**59945.19**	**61274.77**	**60948.22**

The contribution of different sectors from total GHG emissions, in 2005/2020, 2030 and 2040, for WOM scenario and WEM scenario, are presented in Figure 5-2.

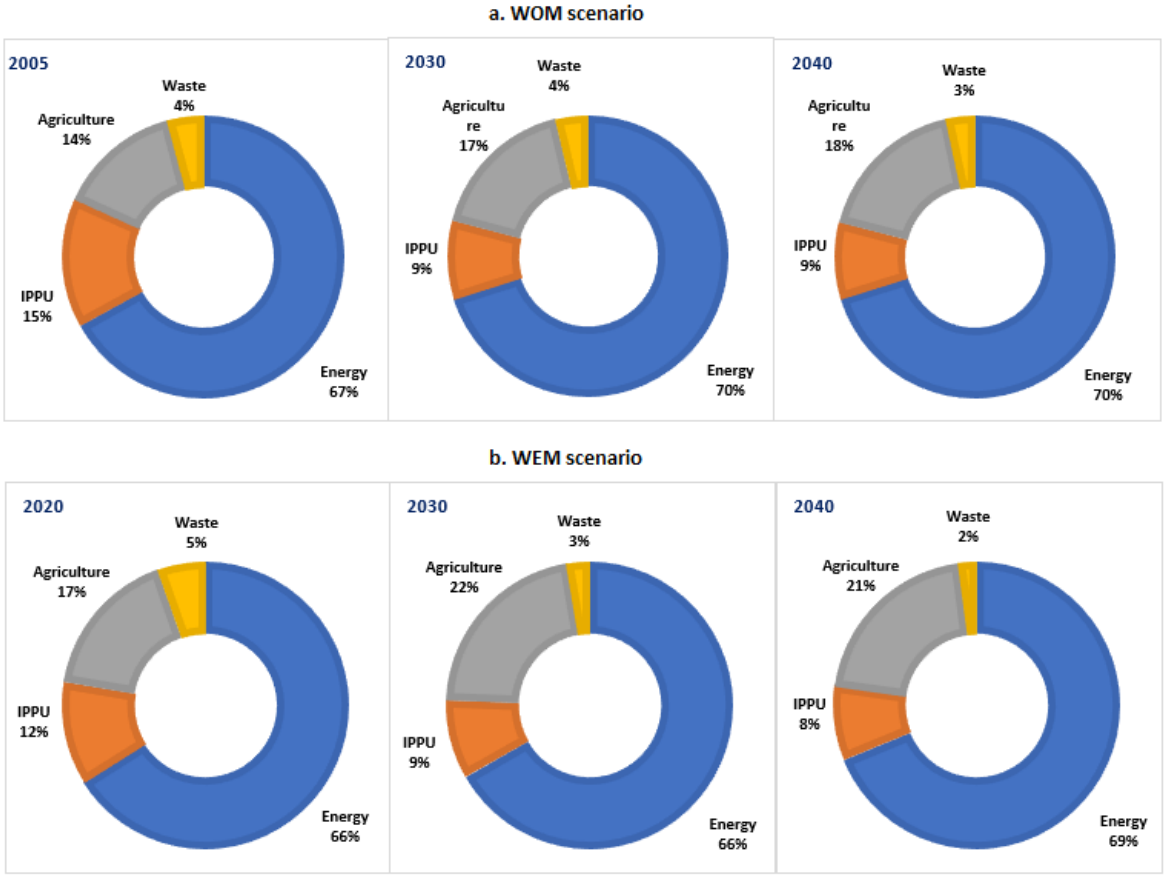


Figure 5-2 The contribution of the sectors at the GHG emissions

In all years and scenario, the contribution of energy sector from total GHG emissions is the highest (about 66÷70%), followed by contribution of agriculture sector (about 14÷22%).

In Figure 5-3 are presented the contributions of different gases (CO2, CH4, N2O, HFC, PFC, SF6) to total GHG emissions.
In all periods and in all scenarios, the contribution of CO2 emissions is highest in total GHG emissions (around 66-68%), followed by CH4 emissions (around 19-22%).

In the energy sector, in 2020, the combustion of the fuels (CRF1.A) generated the biggest quantities of GHG emissions, about 88% of total GHG emissions and the fugitive emissions from fuel processing (CRF1.B) generated only about 12% of total GHG emissions. The contribution of the various subsectors to the GHG emissions due to the combustion of the fuels in 2020 and 2040, in WEM scenario, is presented in Figure 5-4.

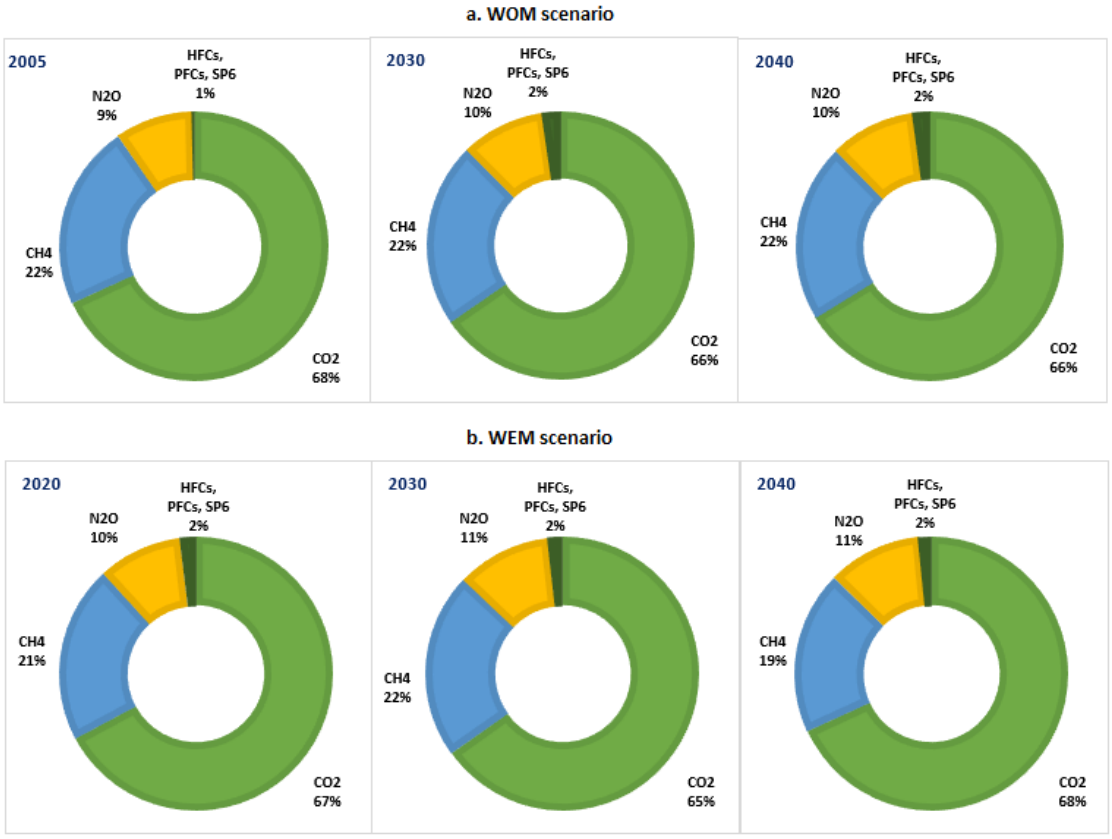


Figure 5-3 The contribution of various gases at total GHG emissions

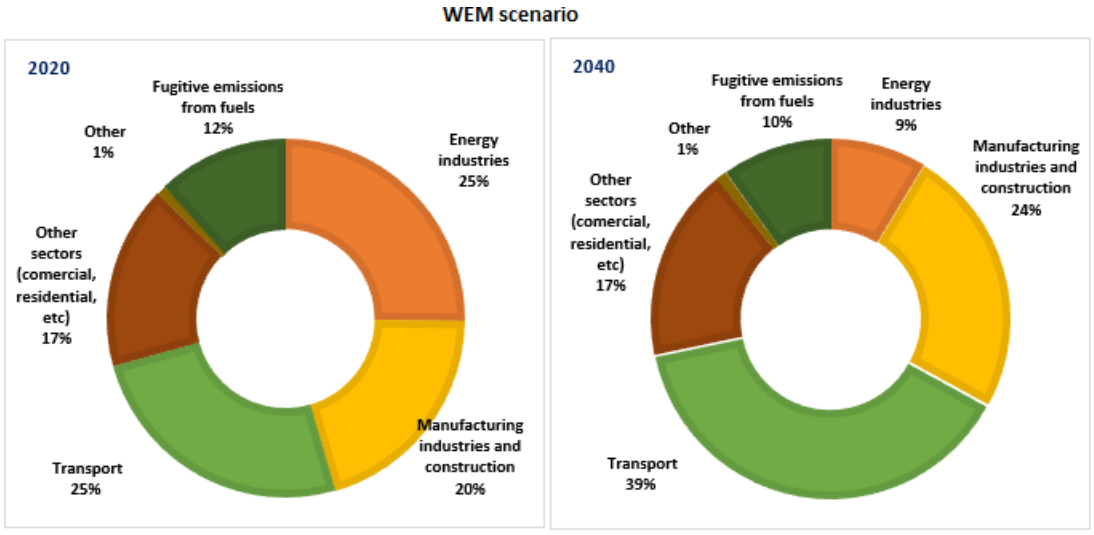


Figure 5-4 The contribution of different subsectors at GHG emissions due to the combustion of the fuels

The projections of CO2 emissions for WOM scenario, WEM scenario and WAM scenario, during the period 2005/2015 ÷ 2035, are presented in the Tables 5-4 ÷ 5-6.

Table 5-4 The CO2 emissions (kt) projections in the WOM scenario, 2005-2040

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Inventory	Projection			
	2005	2025	2030	2035	2040
Total national emissions and removals	**68409.98**	**81241.14**	**87789.06**	**96666.45**	**106007.57**
1. Energy	**81712.18**	**92537.99**	**96934.54**	**102388.36**	**108410.84**
A. Fuel combustion Reference approach(2)	80569.50	91395.30	95791.85	101245.67	107268.15
1. Energy industries	40842.00	39097.92	39255.82	39411.97	39580.54
2. Manufacturing industries and construction	15961.20	15961.20	15961.20	15961.20	15961.20
3. Transport	12376.60	22325.19	25679.02	30003.19	34781.92
4. Other sectors	10225.38	13380.39	14233.04	15172.74	16212.39
5. Other	1164.31	630.60	662.77	696.57	732.10
B. Fugitive emissions from fuels	1142.69	1142.69	1142.69	1142.69	1142.69
1. Solid fuels	NA,NO	NO,NA	NO,NA	NO,NA	NO,NA
2. Oil and natural gas and other emissions from energy production	1142.69	1142.69	1142.69	1142.69	1142.69
C. CO_2 Transport and storage	NO	NO	NO	NO	NO
2. Industrial processes and product use	**18301.20**	**10076.99**	**9366.57**	**9818.33**	**10138.93**
A. Mineral industry	4170.07	5289.603	5464.140	5682.704	5796.361
B. Chemical industry	3540.47	733.936	810.330	858.950	901.898
C. Metal industry	9328.49	3596.565	2699.632	2921.886	3103.268
D. Non-energy products from fuels and solvent use	1262.17	456.887	392.466	354.790	337.405
E. Electronic industry					
F. Product uses as substitutes for ODS					
G. Other product manufacture and use	NO	NO	NO	NO	NO
H. Other[3]	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
3. Agriculture	**138.54**	**177.24**	**186.92**	**196.60**	**206.28**
A. Enteric fermentation					
B. Manure management					
C. Rice cultivation					
D. Agricultural soils					
E. Prescribed burning of savannas					
F. Field burning of agricultural residues					
G. Liming	85.79	103.39	107.79	112.19	116.60
H. Urea application	52.75	73.86	79.13	84.41	89.68
I. Other carbon-contining fertilizers	NO	NA	NA	NA	NA
J. Other	NO	NO	NO	NO	NO
4. Land use, land-use change and forestry [4]	**-31831.81**	**-21640.95**	**-18788.83**	**-15826.70**	**-12838.34**
A. Forest land [4]	-28212.29	-21,498.07	-20,060.00	-18,667.48	-17,300.48
B. Cropland [4]	-2044.96	-2,235.51	-2,208.71	-2,155.41	-2,095.89
C. Grassland [4]	-2682.67	893.40	1,881.56	2,993.35	4,212.36
D. Wetlands [4]	39.00	769.59	765.76	764.95	764.69
E. Settlements [4]	1985.35	2,709.76	2,846.29	2,974.09	3,099.33
F. Other land [4]	210.89	246.88	245.83	279.76	280.01
G. Harvested wood products	-1127.12	-2,527.00	-2,259.58	-2,015.97	-1,798.37
H. Other [4]	NA	NA	NA	NA	NA
5. Waste	89.87	89.87	89.87	89.87	89.87
A. Solid waste disposal [5]	NA	NA	NA	NA	NA
B. Biological treatment of solid waste [5]					
C. Incineration and open burning of waste [5]	89.87	89.87	89.87	89.87	89.87
D. Wastewater treatment and discharge					
E. Other [5]	NA	NA	NA	NA	NA
Total CO2 emissions without land use, land-use change and forestry	**100241.79**	**102882.09**	**106577.90**	**112493.16**	**118845.92**
Total CO2 emissions with land use, land-use change and forestry	**68409.98**	**81241.14**	**87789.06**	**96666.45**	**106007.57**

Table 5-5 The CO2 emissions (kt) projections in the WEM scenario, 2020-2040

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Inventory	Projection			
	2020	2025	2030	2035	2040
Total national emissions and removals	**41206.70**	**39775.48**	**34092.57**	**38985.52**	**42665.84**
1. Energy	**63302.19**	**61994.60**	**58547.79**	**62736.14**	**66675.10**
A. Fuel combustion Reference approach(2)	62508.31	61160.23	57670.87	61814.50	65706.45
1. Energy industries	18262.98	12189.22	5606.32	6045.32	6485.05
2. Manufacturing industries and construction	14714.29	15379.71	16213.91	17354.69	18186.61
3. Transport	18122.95	22015.35	24046.50	26281.68	28523.53
4. Other sectors	10760.06	10945.35	11141.36	11436.24	11779.15
5. Other	648.03	630.60	662.77	696.57	732.10
B. Fugitive emissions from fuels	793.88	834.37	876.92	921.64	968.65
1. Solid fuels	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
2. Oil and natural gas and other emissions from energy production	793.88	834.37	876.92	921.64	968.65
C. CO_2 Transport and storage	NO	NO	NO	NO	NO
2. Industrial processes and product use	**10689.99**	**9000.59**	**7121.55**	**7310.30**	**7407.21**
A. Mineral industry	4718.38	4692.31	4829.72	4933.01	4946.93
B. Chemical industry	1591.25	688.96	741.74	786.24	825.55
C. Metal industry	3836.09	3175.73	1169.06	1246.59	1307.15
D. Non-energy products from fuels and solvent use	544.27	443.58	381.04	344.46	327.58
E. Electronic industry					
F. Product uses as substitutes for ODS					
G. Other product manufacture and use	NO	NO	NO	NO	NO
H. Other(3)	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
3. Agriculture	**135.56**	**118.87**	**127.95**	**130.92**	**133.89**
A. Enteric fermentation					
B. Manure management					
C. Rice cultivation					
D. Agricultural soils					
E. Prescribed burning of savannas					
F. Field burning of agricultural residues					
G. Liming	52.88	55.80	58.57	59.97	61.36
H. Urea application	82.67	63.07	69.38	70.96	72.53
I. Other carbon-contining fertilizers	NA	NA	NA	NA	NA
J. Other	NO	NO	NO	NO	NO
4. Land use, land-use change and forestry (4)	**-32931.31**	**-31348.85**	**-31714.99**	**-31202.12**	**-31560.63**
A. Forest land (4)	-24235.39	-22429.21	-21850.52	-20479.11	-19997.22
B. Cropland (4)	-6344.47	-5949.19	-6762.29	-7588.07	-8441.15
C. Grassland (4)	-1287.28	-2240.60	-2548.01	-2708.93	-2793.99
D. Wetlands (4)	-150.64	-208.56	-231.13	-249.06	-265.43
E. Settlements (4)	2155.71	2075.57	1993.76	1912.79	1834.64
F. Other land (4)	73.36	25.01	-19.05	-63.11	-107.17
G. Harvested wood products	-3142.60	-2621.87356	-2297.75304	-2026.62606	-1790.32096
H. Other (4)	NA	NA	NA	NA	NA
5. Waste	10.27	10.27	10.27	10.27	10.27
A. Solid waste disposal (5)	NA	NA	NA	NA	NA
B. Biological treatment of solid waste (5)					
C. Incineration and open burning of waste (5)	10.27	10.27	10.27	10.27	10.27
D. Wastewater treatment and discharge					
E. Other (5)	NA	NA	NA	NA	NA
Total CO2 emissions without land use, land-use change and forestry	**74138.01**	**71124.32**	**65807.56**	**70187.63**	**74226.46**
Total CO2 emissions with land use, land-use change and forestry	**41206.70**	**39775.48**	**34092.57**	**38985.52**	**42665.84**

Table 5-6 The CO2 emissions (kt) projections in the WAM scenario, 2020-2040

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Inventory	Projection			
	2020	2025	2030	2035	2040
Total national emissions and removals	**41206.70**	**32816.35**	**25485.07**	**27279.45**	**27330.20**
1. Energy	**63302.19**	**60761.30**	**57180.50**	**60395.77**	**62047.97**
A. Fuel combustion Reference approach(2)	62508.31	59926.93	56303.58	59474.13	61079.32
1. Energy industries	18262.98	12189.22	5606.32	6045.32	5042.94
2. Manufacturing industries and construction	14714.29	15005.53	15792.82	16775.51	17146.63
3. Transport	18122.95	21323.79	23254.84	24891.42	27099.49
4. Other sectors	10760.06	10777.80	10986.84	11065.31	11058.16
5. Other	648.03	630.60	662.77	696.57	732.10
B. Fugitive emissions from fuels	793.88	834.37	876.92	921.64	968.65
1. Solid fuels	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
2. Oil and natural gas and other emissions from energy production	793.88	834.37	876.92	921.64	968.65
C. CO_2 Transport and storage	NO	NO	NO	NO	NO
2. Industrial processes and product use	**10689.99**	**9000.33**	**6994.44**	**7175.45**	**7266.58**
A. Mineral industry	4718.38	4692.31	4730.86	4828.02	4837.57
B. Chemical industry	1591.25	688.87	715.33	758.25	796.16
C. Metal industry	3836.09	3175.56	1167.22	1244.73	1305.27
D. Non-energy products from fuels and solvent use	544.27	443.58	381.04	344.46	327.58
E. Electronic industry					
F. Product uses as substitutes for ODS					
G. Other product manufacture and use	NO	NO	NO	NO	NO
H. Other(3)	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
3. Agriculture	**135.56**	**118.87**	**127.95**	**130.92**	**133.89**
A. Enteric fermentation					
B. Manure management					
C. Rice cultivation					
D. Agricultural soils					
E. Prescribed burning of savannas					
F. Field burning of agricultural residues					
G. Liming	52.88	55.80	58.57	59.97	61.36
H. Urea application	82.67	63.07	69.38	70.96	72.53
I. Other carbon-contining fertilizers	NA	NA	NA	NA	NA
J. Other	NO	NO	NO	NO	NO
4. Land use, land-use change and forestry (4)	**-32931.31**	**-37074.42**	**-38828.09**	**-40432.96**	**-42128.52**
A. Forest land (4)	-24235.39	-25259.05	-26101.38	-26784.79	-27456.49
B. Cropland (4)	-6344.47	-8551.66	-10573.30	-12616.85	-14694.24
C. Grassland (4)	-1287.28	-1704.21	-880.68	-41.29	796.64
D. Wetlands (4)	-150.64	-143.04	-129.91	-113.85	-97.06
E. Settlements (4)	2155.71	1561.64	1508.51	1440.02	1364.34
F. Other land (4)	73.36	124.34	114.99	105.64	96.29
G. Harvested wood products	-3142.60	-3102.42792	-2766.3232	-2421.82878	-2137.97847
H. Other (4)	NA	NA	NA	NA	NA
5. Waste	10.27	10.27	10.27	10.27	10.27
A. Solid waste disposal (5)	NA	NA	NA	NA	NA
B. Biological treatment of solid waste (5)					
C. Incineration and open burning of waste (5)	10.27	10.27	10.27	10.27	10.27
D. Wastewater treatment and discharge					
E. Other (5)	NA	NA	NA	NA	NA
Total CO2 emissions without land use, land-use change and forestry	**74138.01**	**69890.77**	**64313.16**	**67712.41**	**69458.72**
Total CO2 emissions with land use, land-use change and forestry	**41206.70**	**32816.35**	**25485.07**	**27279.45**	**27330.20**

The projections of CH4 emissions for WOM scenario, WEM scenario and WAM scenario, during the period 2005/2020 ÷ 2040 are presented in the Tables 5-7 ÷ 5-9.

Table 5-7 The CH4 emissions (kt) projections in the WOM scenario, 2005-2040

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Inventory	Projection			
	2005	2025	2030	2035	2040
Total national emissions and removals	**1312.31**	**1414.57**	**1454.45**	**1489.13**	**1540.68**
1. Energy	**651.66**	**658.95**	**662.11**	**665.54**	**669.25**
A. Fuel combustion Reference approach(2)	42.48	50.63	53.79	57.22	60.93
1. Energy industries	0.72	0.64	0.65	0.65	0.66
2. Manufacturing industries and construction	1.01	1.01	1.01	1.01	1.01
3. Transport	2.80	5.05	5.86	6.80	7.87
4. Other sectors	35.56	43.93	46.27	48.76	51.39
5. Other	2.40	0.00	0.00	0.00	0.00
B. Fugitive emissions from fuels	609.18	608.33	608.33	608.33	608.33
1. Solid fuels	456.70	455.85	455.85	455.85	455.85
2. Oil and natural gas and other emissions from energy production	152.48	152.48	152.48	152.48	152.48
C. CO_2 Transport and storage					
2. Industrial processes and product use	**3.38**	**0.41**	**0.38**	**0.40**	**0.43**
A. Mineral industry					
B. Chemical industry	2.92	0.22	0.25	0.26	0.27
C. Metal industry	0.46	0.18	0.13	0.14	0.15
D. Non-energy products from fuels and solvent use	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
E. Electronic industry					
F. Product uses as substitutes for ODS					
G. Other product manufacture and use	NO	NO	NO	NO	NO
H. Other(3)	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
3. Agriculture	**439.41**	**533.04**	**572.03**	**605.69**	**655.55**
A. Enteric fermentation	379.84	460.43	494.99	524.44	568.97
B. Manure management	37.91	50.95	55.38	59.59	64.92
C. Rice cultivation	0.55	0.55	0.55	0.55	0.55
D. Agricultural soils	NE	NE	NE	NE	NE
E. Prescribed burning of savannas	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	21.12	21.12	21.12	21.12	21.12
G. Liming					
H. Urea application					
I. Other carbon-contining fertilizers					
J. Other	NO	NO	NO	NO	NO
4. Land use, land-use change and forestry (4)	**0.01**	**0.23**	**0.26**	**0.29**	**0.33**
A. Forest land (4)	0.01	0.23	0.26	0.29	0.33
B. Cropland (4)	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
C. Grassland (4)	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
D. Wetlands (4)	NO	NO	NO	NO	NO
E. Settlements (4)	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE
F. Other land (4)	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
G. Harvested wood products					
H. Other (4)	NA	NA	NA	NA	NA
5. Waste	**217.85**	**221.95**	**219.67**	**217.21**	**215.13**
A. Solid waste disposal (5)	102.60	104.43	101.58	99.12	97.04
B. Biological treatment of solid waste (5)	3.24	3.24	3.24	3.24	3.24
C. Incineration and open burning of waste (5)	0.01	0.01	0.01	0.01	0.01
D. Wastewater treatment and discharge	112.01	114.27	114.84	114.84	114.84
E. Other (5)	NA	NA	NA	NA	NA
6. Other *(please specify)* (6)					
Total CH4 emissions without land use, land-use change and forestry	**1312.30**	**1414.35**	**1454.19**	**1488.84**	**1540.36**
Total CH4 emissions with land use, land-use change and forestry	**1312.31**	**1414.57**	**1454.45**	**1489.13**	**1540.68**

Table 5-8 The CH4 emissions (kt) projections in the WEM scenario, 2020-2040

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Inventory	Projections			
	2020	2025	2030	2035	2040
Total national emissions and removals	**927.91**	**916.49**	**886.28**	**867.53**	**838.16**
1. Energy	**355.97**	**339.31**	**324.54**	**319.65**	**299.48**
A. Fuel combustion Reference approach(2)	44.37	42.83	42.45	42.48	42.19
1. Energy industries	0.46	0.27	0.20	0.21	0.22
2. Manufacturing industries and construction	1.04	0.89	0.73	0.71	0.67
3. Transport	1.28	1.55	1.77	1.94	2.10
4. Other sectors	41.57	40.11	39.74	39.62	39.20
5. Other	0.02	0.00	0.00	0.00	0.00
B. Fugitive emissions from fuels	311.60	296.48	282.09	277.17	257.29
1. Solid fuels	218.48	207.99	197.90	194.44	180.50
2. Oil and natural gas and other emissions from energy production	93.12	88.49	84.19	82.73	76.79
C. CO_2 Transport and storage					
2. Industrial processes and product use	**0.40**	**0.34**	**0.23**	**0.24**	**0.25**
A. Mineral industry					
B. Chemical industry	0.23	0.21	0.23	0.24	0.25
C. Metal industry	0.16	0.13	0.00	0.00	0.00
D. Non-energy products from fuels and solvent use	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
E. Electronic industry					
F. Product uses as substitutes for ODS					
G. Other product manufacture and use	NO	NO	NO	NO	NO
H. Other(3)	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
3. Agriculture	**353.14**	**475.38**	**472.15**	**467.84**	**466.20**
A. Enteric fermentation	306.37	431.69	428.75	424.63	423.96
B. Manure management	25.00	27.69	27.40	27.21	26.24
C. Rice cultivation	0.85	1.10	1.10	1.10	1.10
D. Agricultural soils	NE	NE	NE	NE	NE
E. Prescribed burning of savannas	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	20.92	14.90	14.90	14.90	14.90
G. Liming					
H. Urea application					
I. Other carbon-contining fertilizers					
J. Other	NO	NO	NO	NO	NO
4. Land use, land-use change and forestry (4)	**0.32**	**0.15**	**0.14**	**0.15**	**0.15**
A. Forest land (4)	0.32	0.15	0.14	0.15	0.15
B. Cropland (4)	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
C. Grassland (4)	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
D. Wetlands (4)	NO	NO	NO	NO	NO
E. Settlements (4)	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE
F. Other land (4)	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
G. Harvested wood products					
H. Other (4)	NA	NA	NA	NA	NA
5. Waste	**218.09**	**101.30**	**89.22**	**79.65**	**72.08**
A. Solid waste disposal (5)	154.88	38.57	28.64	21.14	15.48
B. Biological treatment of solid waste (5)	2.26	4.69	5.32	5.87	6.47
C. Incineration and open burning of waste (5)	0.00	0.00	0.00	0.00	0.00
D. Wastewater treatment and discharge	60.95	58.04	55.27	52.64	50.13
E. Other (5)	NA	NA	NA	NA	NA
Total CH4 emissions without land use, land-use change and forestry	**927.60**	**916.34**	**886.14**	**867.38**	**838.01**
Total CH4 emissions with land use, land-use change and forestry	**927.91**	**916.49**	**886.28**	**867.53**	**838.16**

Table 5-9 The CH4 emissions (kt) projections in the WAM scenario, 2020-2040

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Inventory	Projections			
	2020	2025	2030	2035	2040
Total national emissions and removals	**927.91**	**899.05**	**858.50**	**834.66**	**797.93**
1. Energy	**355.97**	**339.07**	**324.31**	**319.25**	**299.11**
A. Fuel combustion Reference approach(2)	44.37	42.59	42.22	42.08	41.82
1. Energy industries	0.46	0.27	0.20	0.21	0.19
2. Manufacturing industries and construction	1.04	0.74	0.72	0.60	0.54
3. Transport	1.28	1.48	1.57	1.84	2.26
4. Other sectors	41.57	40.10	39.73	39.43	38.83
5. Other	0.02	0.00	0.00	0.00	0.00
B. Fugitive emissions from fuels	311.60	296.48	282.09	277.17	257.29
1. Solid fuels	218.48	207.99	197.90	194.44	180.50
2. Oil and natural gas and other emissions from energy production	93.12	88.49	84.19	82.73	76.79
C. CO_2 Transport and storage					
2. Industrial processes and product use	**0.40**	**0.33**	**0.22**	**0.23**	**0.24**
A. Mineral industry					
B. Chemical industry	0.23	0.20	0.22	0.23	0.24
C. Metal industry	0.16	0.13	0.00	0.00	0.00
D. Non-energy products from fuels and solvent use	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
E. Electronic industry					
F. Product uses as substitutes for ODS					
G. Other product manufacture and use	NO	NO	NO	NO	NO
H. Other(3)	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
3. Agriculture	**353.14**	**468.55**	**457.69**	**448.32**	**438.03**
A. Enteric fermentation	306.37	426.24	417.03	408.38	399.72
B. Manure management	25.00	26.31	24.66	23.94	22.31
C. Rice cultivation	0.85	1.10	1.10	1.10	1.10
D. Agricultural soils	NE	NE	NE	NE	NE
E. Prescribed burning of savannas	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	20.92	14.90	14.90	14.90	14.90
G. Liming					
H. Urea application					
I. Other carbon-contining fertilizers					
J. Other	NO	NO	NO	NO	NO
4. Land use, land-use change and forestry (4)	**0.32**	**0.15**	**0.14**	**0.15**	**0.15**
A. Forest land (4)	0.32	0.15	0.14	0.15	0.15
B. Cropland (4)	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
C. Grassland (4)	NO,IE	NO,IE	NO,IE	NO,IE	NO,IE
D. Wetlands (4)	NO	NO	NO	NO	NO
E. Settlements (4)	NO,NE	NO,NE	NO,NE	NO,NE	NO,NE
F. Other land (4)	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
G. Harvested wood products					
H. Other (4)	NA	NA	NA	NA	NA
5. Waste	**218.09**	**90.95**	**76.14**	**66.71**	**60.40**
A. Solid waste disposal (5)	154.88	28.34	16.06	9.01	4.97
B. Biological treatment of solid waste (5)	2.26	4.57	4.81	5.05	5.31
C. Incineration and open burning of waste (5)	0.00	0.00	0.00	0.00	0.00
D. Wastewater treatment and discharge	60.95	58.04	55.27	52.64	50.13
E. Other (5)	NA	NA	NA	NA	NA
Total CH4 emissions without land use, land-use change and forestry	**927.60**	**898.90**	**858.36**	**834.51**	**797.78**
Total CH4 emissions with land use, land-use change and forestry	**927.91**	**899.05**	**858.50**	**834.66**	**797.93**

The projections of N2O emissions for WOM scenario, WEM scenario and WAM scenario, during the period 2005/2020 ÷ 2040 are presented in the Tables 5-10 ÷ 5-12.

Table 5-10 The N2O emissions (kt) projections in the WOM scenario, 2005-2040

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Inventory	Projections			
	2005	2025	2030	2035	2040
Total national emissions and removals	**45.98**	**52.08**	**55.60**	**58.99**	**62.40**
1. Energy	**1.73**	**2.50**	**2.78**	**3.08**	**3.43**
A. Fuel combustion Reference approach(2)	1.73	2.50	2.78	3.08	3.43
1. Energy industries	0.42	0.40	0.41	0.41	0.41
2. Manufacturing industries and construction	0.14	0.14	0.14	0.14	0.14
3. Transport	0.51	0.90	1.05	1.21	1.40
4. Other sectors	0.62	1.05	1.17	1.31	1.47
5. Other	0.04	0.01	0.01	0.01	0.01
B. Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00
1. Solid fuels	NA,NO	NO,NA	NO,NA	NO,NA	NO,NA
2. Oil and natural gas and other emissions from energy production	0.00	0.00	0.00	0.00	0.00
C. CO_2 Transport and storage					
2. Industrial processes and product use	**10.01**	**4.99**	**5.52**	**5.85**	**6.14**
A. Mineral industry					
B. Chemical industry	10.00	4.99	5.51	5.84	6.13
C. Metal industry	NO	NO	NO	NO	NO
D. Non-energy products from fuels and solvent use	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
E. Electronic industry					
F. Product uses as substitutes for ODS					
G. Other product manufacture and use	0.01	0.01	0.01	0.01	0.01
H. Other(3)	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
3. Agriculture	**32.48**	**42.78**	**45.49**	**48.22**	**50.97**
A. Enteric fermentation					
B. Manure management	4.34	5.39	5.73	6.10	6.49
C. Rice cultivation					
D. Agricultural soils	27.50	36.75	39.11	41.47	43.83
E. Prescribed burning of savannas	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	0.65	0.65	0.65	0.65	0.65
G. Liming					
H. Urea application					
I. Other carbon-contining fertilizers					
J. Other	NO	NO	NO	NO	NO
4. Land use, land-use change and forestry (4)	**0.07**	**0.11**	**0.13**	**0.15**	**0.18**
A. Forest land (4)	0.00	0.01	0.01	0.02	0.02
B. Cropland (4)	0.00	0.00	0.00	0.00	0.00
C. Grassland (4)	0.05	0.06	0.07	0.08	0.09
D. Wetlands (4)	0.00	0.00	0.00	0.00	0.00
E. Settlements (4)	0.01	0.03	0.05	0.06	0.06
F. Other land (4)	0.00	0.00	0.00	0.00	0.00
G. Harvested wood products					
H. Other (4)	NA	NA	NA	NA	NA
5. Waste	**1.69**	**1.69**	**1.69**	**1.69**	**1.69**
A. Solid waste disposal (5)					
B. Biological treatment of solid waste (5)	0.19	0.19	0.19	0.19	0.19
C. Incineration and open burning of waste (5)	0.03	0.03	0.03	0.03	0.03
D. Wastewater treatment and discharge	1.47	1.47	1.47	1.47	1.47
E. Other (5)	NA	NA	NA	NA	NA
Total N2O emissions without land use, land-use change and forestry	**45.91**	**51.97**	**55.47**	**58.83**	**62.22**
Total N2O emissions with land use, land-use change and forestry	**45.98**	**52.08**	**55.60**	**58.99**	**62.40**

Table 5-11 The N2O emissions (kt) projections in the WEM scenario, 2020-2040

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Inventory	Projections			
	2020	2025	2030	2035	2040
Total national emissions and removals	**36.89**	**35.03**	**37.83**	**38.57**	**40.64**
1. Energy	**2.12**	**2.23**	**2.27**	**2.40**	**2.53**
A. Fuel combustion Reference approach(2)	2.12	2.23	2.27	2.40	2.53
1. Energy industries	0.22	0.12	0.03	0.03	0.03
2. Manufacturing industries and construction	0.14	0.12	0.10	0.10	0.09
3. Transport	0.83	1.04	1.18	1.30	1.44
4. Other sectors	0.93	0.94	0.95	0.96	0.96
5. Other	0.00	0.01	0.01	0.01	0.01
B. Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00
1. Solid fuels	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
2. Oil and natural gas and other emissions from energy production	0.00	0.00	0.00	0.00	0.00
C. CO_2 Transport and storage					
2. Industrial processes and product use	**0.32**	**0.28**	**0.31**	**0.33**	**0.35**
A. Mineral industry					
B. Chemical industry	0.31	0.28	0.31	0.32	0.34
C. Metal industry	NO	NO	NO	NO	NO
D. Non-energy products from fuels and solvent use	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
E. Electronic industry					
F. Product uses as substitutes for ODS					
G. Other product manufacture and use	0.01	0.01	0.01	0.01	0.01
H. Other(3)	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
3. Agriculture	**32.83**	**30.82**	**33.60**	**34.20**	**36.15**
A. Enteric fermentation					
B. Manure management	3.55	3.93	3.83	3.79	3.76
C. Rice cultivation					
D. Agricultural soils	28.65	26.43	29.31	29.95	31.93
E. Prescribed burning of savannas	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	0.64	0.46	0.46	0.46	0.46
G. Liming					
H. Urea application					
I. Other carbon-contining fertilizers					
J. Other	NO	NO	NO	NO	NO
4. Land use, land-use change and forestry (4)	**0.10**	**0.10**	**0.10**	**0.12**	**0.13**
A. Forest land (4)	0.02	0.01	0.01	0.01	0.01
B. Cropland (4)	0.00	0.00	0.00	0.00	0.00
C. Grassland (4)	0.06	0.06	0.06	0.06	0.07
D. Wetlands (4)	0.00	0.00	0.00	0.00	0.00
E. Settlements (4)	0.02	0.03	0.04	0.04	0.05
F. Other land (4)	0.00	0.00	0.00	0.00	0.00
G. Harvested wood products					
H. Other (4)	NA	NA	NA	NA	NA
5. Waste	**1.52**	**1.60**	**1.55**	**1.52**	**1.49**
A. Solid waste disposal (5)					
B. Biological treatment of solid waste (5)	0.09	0.22	0.25	0.27	0.30
C. Incineration and open burning of waste (5)	0.01	0.01	0.01	0.01	0.01
D. Wastewater treatment and discharge	1.43	1.37	1.30	1.24	1.18
E. Other (5)	NA	NA	NA	NA	NA
Total N2O emissions without land use, land-use change and forestry	**36.80**	**34.93**	**37.73**	**38.45**	**40.51**
Total N2O emissions with land use, land-use change and forestry	**36.89**	**35.03**	**37.83**	**38.57**	**40.64**

Table 5-12 The N2O emissions (kt) projections in the WAM scenario, 2020-2040

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Inventory	Projections			
	2020	2025	2030	2035	2040
Total national emissions and removals	**36.89**	**34.86**	**37.60**	**38.23**	**40.22**
1. Energy	**2.12**	**2.07**	**2.04**	**2.06**	**2.11**
A. Fuel combustion Reference approach(2)	2.12	2.07	2.04	2.06	2.11
1. Energy industries	0.22	0.12	0.03	0.03	0.03
2. Manufacturing industries and construction	0.14	0.10	0.10	0.08	0.07
3. Transport	0.83	0.90	0.95	1.01	1.08
4. Other sectors	0.93	0.94	0.95	0.93	0.92
5. Other	0.00	0.01	0.01	0.01	0.01
B. Fugitive emissions from fuels	0.00	0.00	0.00	0.00	0.00
1. Solid fuels	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
2. Oil and natural gas and other emissions from energy production	0.00	0.00	0.00	0.00	0.00
C. CO_2 Transport and storage					
2. Industrial processes and product use	**0.32**	**0.28**	**0.31**	**0.33**	**0.35**
A. Mineral industry					
B. Chemical industry	0.31	0.28	0.31	0.32	0.34
C. Metal industry	NO	NO	NO	NO	NO
D. Non-energy products from fuels and solvent use	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
E. Electronic industry					
F. Product uses as substitutes for ODS					
G. Other product manufacture and use	0.01	0.01	0.01	0.01	0.01
H. Other(3)	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
3. Agriculture	**32.83**	**30.82**	**33.60**	**34.20**	**36.15**
A. Enteric fermentation					
B. Manure management	3.55	3.93	3.83	3.79	3.76
C. Rice cultivation					
D. Agricultural soils	28.65	26.43	29.31	29.95	31.93
E. Prescribed burning of savannas	NO	NO	NO	NO	NO
F. Field burning of agricultural residues	0.64	0.46	0.46	0.46	0.46
G. Liming					
H. Urea application					
I. Other carbon-contining fertilizers					
J. Other	NO	NO	NO	NO	NO
4. Land use, land-use change and forestry (4)	**0.10**	**0.10**	**0.10**	**0.12**	**0.13**
A. Forest land (4)	0.02	0.01	0.01	0.01	0.01
B. Cropland (4)	0.00	0.00	0.00	0.00	0.00
C. Grassland (4)	0.06	0.06	0.06	0.06	0.07
D. Wetlands (4)	0.00	0.00	0.00	0.00	0.00
E. Settlements (4)	0.02	0.03	0.04	0.04	0.05
F. Other land (4)	0.00	0.00	0.00	0.00	0.00
G. Harvested wood products					
H. Other (4)	NA	NA	NA	NA	NA
5. Waste	**1.52**	**1.60**	**1.55**	**1.52**	**1.49**
A. Solid waste disposal (5)					
B. Biological treatment of solid waste (5)	0.09	0.22	0.25	0.27	0.30
C. Incineration and open burning of waste (5)	0.01	0.01	0.01	0.01	0.01
D. Wastewater treatment and discharge	1.43	1.37	1.30	1.24	1.18
E. Other (5)	NA	NA	NA	NA	NA
Total N2O emissions without land use, land-use change and forestry	**36.80**	**34.77**	**37.50**	**38.11**	**40.10**
Total N2O emissions with land use, land-use change and forestry	**36.89**	**34.86**	**37.60**	**38.23**	**40.22**

The projections of HFCs, PFCs and SF_6 emissions for WOM scenario, WEM scenario and WAM scenario, during the period 2005/2020 ÷ 2040 are presented in the tables 5-13 ÷ 5-15.

Table 5-13 The HFCs, PFCs and SF_6 emissions (kt CO2eq) projections in the WOM scenario, 2005-2040

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Inventory	Projections				
	2005	2020	2025	2030	2035	2040
Total national emissions (kt CO2 eq)	**485.52**	**2809.27**	**3418.03**	**3604.23**	**3661.30**	**3673.48**
Emissions of HFCs	**374.57**	**2648.28**	**3303.95**	**3506.91**	**3562.29**	**3573.37**
2. Industrial processes and product use	**374.57**	**2648.28**	**3303.95**	**3506.91**	**3562.29**	**3573.37**
A. Mineral industry						
B. Chemical industry	NO	NO	NO	NO	NO	NO
C. Metal industry	NO	NO	NO	NO	NO	NO
D. Non-energy products from fuels and solvent use						
E. Electronic industry	NO	NO	NO	NO	NO	NO
F. Product uses as substitutes for ODS	374.57	2648.28	3303.95	3506.91	3562.29	3573.37
G. Other product manufacture and use	NO	NO	NO	NO	NO	NO
H. Other(3)	NO	NO	NO	NO	NO	NO
Emissions of PFCs	**95.28**	**76.81**	**66.45**	**69.35**	**72.13**	**74.29**
2. Industrial processes and product use	**95.28**	**76.81**	**66.45**	**69.35**	**72.13**	**74.29**
A. Mineral industry						
B. Chemical industry	NO	NO	NO	NO	NO	NO
C. Metal industry	95.28	76.79	66.40	69.31	72.08	74.24
D. Non-energy products from fuels and solvent use						
E. Electronic industry	NO	NO	NO	NO	NO	NO
F. Product uses as substitutes for ODS	NO	0.026	0.043	0.045	0.046	0.046
G. Other product manufacture and use	NO	NO	NO	NO	NO	NO
H. Other(3)	NO	NO	NO	NO	NO	NO
Emissions of PFCs	**15.67**	**84.18**	**47.63**	**27.97**	**26.89**	**25.83**
2. Industrial processes and product use	**15.67**	**84.18**	**47.63**	**27.97**	**26.89**	**25.83**
A. Mineral industry						
B. Chemical industry	NO	NO	NO	NO	NO	NO
C. Metal industry	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
D. Non-energy products from fuels and solvent use						
E. Electronic industry	NO	NO	NO	NO	NO	NO
F. Product uses as substitutes for ODS	NO	NO	NO	NO	NO	NO
G. Other product manufacture and use	15.67	84.18	47.63	27.97	26.89	25.83
H. Other(3)	NO	NO	NO	NO	NO	NO

Table 5-14 The HFCs, PFCs and SF6 emissions (kt CO2eq) projections in the WEM scenario, 2020-2040

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Inventory	Projections			
	2020	2025	2030	2035	2040
Total national emissions and removals, kt CO2 eq	**2073.83**	**1941.02**	**1791.45**	**1737.62**	**1683.79**
Emissions of HFCs	**1988.55**	**1891.43**	**1760.80**	**1707.88**	**1654.97**
2. Industrial processes and product use	**1988.55**	**1891.43**	**1760.80**	**1707.88**	**1654.97**
A. Mineral industry					
B. Chemical industry	NO	NO	NO	NO	NO
C. Metal industry	NO	NO	NO	NO	NO
D. Non-energy products from fuels and solvent use					
E. Electronic industry	NO	NO	NO	NO	NO
F. Product uses as substitutes for ODS	1988.55	1891.43	1760.80	1707.88	1654.97
G. Other product manufacture and use	NO	NO	NO	NO	NO
H. Other(3)	NO	NO	NO	NO	NO
Emissions of PFCs	**3.55**	**3.35**	**3.50**	**3.64**	**3.74**
2. Industrial processes and product use	**3.55**	**3.35**	**3.50**	**3.64**	**3.74**
A. Mineral industry					
B. Chemical industry	NO	NO	NO	NO	NO
C. Metal industry	3.52	3.33	3.47	3.61	3.72
D. Non-energy products from fuels and solvent use					
E. Electronic industry	NO	NO	NO	NO	NO
F. Product uses as substitutes for ODS	0.03	0.024	0.023	0.022	0.021
G. Other product manufacture and use	NO	NO	NO	NO	NO
H. Other(3)	NO	NO	NO	NO	NO
Emissions of SF6	**81.73**	**46.24**	**27.15**	**26.11**	**25.08**
2. Industrial processes and product use	**81.73**	**46.24**	**27.15**	**26.11**	**25.08**
A. Mineral industry					
B. Chemical industry	NO	NO	NO	NO	NO
C. Metal industry	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
D. Non-energy products from fuels and solvent use					
E. Electronic industry	NO	NO	NO	NO	NO
F. Product uses as substitutes for ODS	NO	NO	NO	NO	NO
G. Other product manufacture and use	81.73	46.24	27.15	26.11	25.08
H. Other(3)	NO	NO	NO	NO	NO

Table 5-15 The HFCs, PFCs and SF_6 emissions (kt CO2eq) projections in the WAM scenario, 2020-2040

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Inventory	Projections			
	2020	2025	2030	2035	2040
Total national emissions and removals, kt CO2 eq	**2073.83**	**1941.02**	**1791.45**	**1737.62**	**1683.79**
Emissions of HFCs	**1988.55**	**1891.43**	**1760.80**	**1707.88**	**1654.97**
2. Industrial processes and product use	**1988.55**	**1891.43**	**1760.80**	**1707.88**	**1654.97**
A. Mineral industry					
B. Chemical industry	NO	NO	NO	NO	NO
C. Metal industry	NO	NO	NO	NO	NO
D. Non-energy products from fuels and solvent use					
E. Electronic industry	NO	NO	NO	NO	NO
F. Product uses as substitutes for ODS	1988.55	1891.43	1760.80	1707.88	1654.97
G. Other product manufacture and use	NO	NO	NO	NO	NO
H. Other(3)	NO	NO	NO	NO	NO
Emissions of PFCs	**3.55**	**3.35**	**3.50**	**3.64**	**3.74**
2. Industrial processes and product use	**3.55**	**3.35**	**3.50**	**3.64**	**3.74**
A. Mineral industry					
B. Chemical industry	NO	NO	NO	NO	NO
C. Metal industry	3.52	3.33	3.47	3.61	3.72
D. Non-energy products from fuels and solvent use					
E. Electronic industry	NO	NO	NO	NO	NO
F. Product uses as substitutes for ODS	0.03	0.024	0.023	0.022	0.021
G. Other product manufacture and use	NO	NO	NO	NO	NO
H. Other(3)	NO	NO	NO	NO	NO
Emissions of SF6	**81.73**	**46.24**	**27.15**	**26.11**	**25.08**
2. Industrial processes and product use	**81.73**	**46.24**	**27.15**	**26.11**	**25.08**
A. Mineral industry					
B. Chemical industry	NO	NO	NO	NO	NO
C. Metal industry	NO,NA	NO,NA	NO,NA	NO,NA	NO,NA
D. Non-energy products from fuels and solvent use					
E. Electronic industry	NO	NO	NO	NO	NO
F. Product uses as substitutes for ODS	NO	NO	NO	NO	NO
G. Other product manufacture and use	81.73	46.24	27.15	26.11	25.08
H. Other(3)	NO	NO	NO	NO	NO

A.3. Assumptions regarding Romania's key macroeconomic indicators

To define the assumptions concerning the evolution of Romania in the period 2020÷2040, a SWOT analysis was made for the period 1989÷2020 targeting:

- economic growth
- demographic development
- social development
- structural adjustment of the economy
- structural adjustment of the industry
- technological modernization and reduction of energy intensity in industry, agriculture, construction
- transport sector development and modernization

- services sector development and modernization
- development and modernization of living conditions.

To estimate the forecast for 2018÷2040 period it should be considered the average annual GDP growth rate indicated by the National Commission for Strategy and Prognosis in the Report Projection of the main macroeconomic indicators (from October 2022) for period 2019÷2030 and years 2035 (1.71%), 2040 (1.17%) and by the European Commission in the greenhouse gas projections made for the year 2023 (Table 5-16).

Table 5-16 Average annual GDP growth rate 2005÷2040 (%)

Year	2005	2018	2019	2020	2021-2025	2026-2030	2031-2035	2036-2040
	Inventory				Projections			
National Commission for Strategy and Prognosis (September 2020)	4.7	4.4	4.1	-3.75	5.05	3.52	-	-
Parameters recommended by the European Commission (year 2022)	-	-	-	-3.75	3.63	3.04	2.16	1.27

Table 5-17 shows the GDP growth rates for 2020÷2040 period provided by the National Commission for Strategy and Prognosis, which were considered in the implementation of GHG forecasts.

Table 5-17 Average annual GDP growth rate during 2005÷2040 (%)

Year	2005	2018	2019	2020	2021-2025	2026-2030	2031-2035	2036-2040
	Inventory				Projections			
Growth rate	4.7	4.4	4.1	-3.75	5.05	3.52	2.16	1.27

The positive evolution of the Romanian economy in the period 2000÷2018 led to a 2.32-fold increase in the gross domestic product per capita (9,814 $Euro_{2016}$/capita at 2018 level). In the period 2007÷2016 the gross domestic product per capita increased by almost 20% compared to the European Union average. So, if in 2007 it stood at 40% of the average, in 2016 the value of this indicator reached 60% of the average. It follows that Romania must make important progress in economic development.

Table 5-18 shows the structure of the GVA (Gross Value Added) by economic branches in the period 2017÷2040 provided by the National Commission for Strategy and Prognosis.

Table 5-18 GVA structure by branches (%)

Year	2020	2021	2022	2025	2030	2035	2040
	History			Projections			
TOTAL GVA (%), of which:	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Industry	22.42	22.28	22.01	21.90	21.32	20.17	19.87
Agriculture	4.38	4.72	4.79	4.50	4.02	3.16	3.23
Construction	7.25	6.72	6.97	7.87	8.41	8.04	7.24
Services	65.95	66.28	66.23	65.73	66.25	68.30	69.06

Table 5-19 shows the evolution of the main macroeconomic indicators used in the methodologies for determining GHG emission forecasts.

Table 5-19 Macroeconomic indicators in the period 2005÷2040

Specification / Year	2005	2019	2020	2021	2025	2030	2035	2040
	History				Projections			
Population (mill. inhabitants)	21.62	19.375	19.269	19.167	18.662	17.96	17.17	16.58
GDP (billion Euro$_{2020}$)	122.13	227.4	218.9	231.8	280.0	333.0	363.8	398.8
GDP per capita (Euro$_{2020}$/ capita)	5649.11	11736.7	11360.2	12093.7	15003.8	18541.2	21188.1	24053.0
TOTAL GVA (billion Euro $_{2020}$)	108.17	205.6	198.5	231.8	246.3	292.6	329.7	361.9
Industry	30.64	46.6	44.5	46.7	52.2	60.4	66.5	71.9
Agriculture	7.35	10.2	8.7	9.9	10.5	11.1	11.5	11.7
Construction	7.37	13.1	14.4	14.1	18.8	23.9	26.5	28.4
Services	62.80	135.7	130.9	138.9	164.8	197.2	225.2	249.9

A.4. Projections of GHG emissions by sector and by gas

The projected GHG emissions per sector and type of gas (as CO2 eq) for two scenarios (WEM and WAM) for the years 2030 and 2040 are presented below.

Sector Energy (CRF Source Category 1)

In Table 5-20 is presented the projected GHG emissions for Energy sector, by gas, for two scenarios (WEM, WAM).

Table 5-20 The projections of GHG emissions for Energy sector, by gas

	Inventory	WEM scenario		WAM scenario	
	2020	2030	2040	2030	2040
CO2	63302.19	58547.79	66675.10	57180.50	62047.97
CH4	8899.26	8113.39	7486.92	8107.86	7477.71
N2O	632.89	675.16	753.51	606.72	628.98
Total	**72834.34**	**67336.34**	**74915.52**	**65895.08**	**70154.66**

Sector IPPU (CRF Source Category 2)

In Table 5-21 is presented the projected GHG emissions for IPPU sector, by gas, for two scenarios (WEM, WAM).

Table 5-21 The projections of GHG emissions for IPPU sector, by gas

	Inventory	WEM scenario		WAM scenario	
	2020	2030	2040	2030	2040
CO2	10689.99	7121.55	7407.21	6994.44	7266.58
CH4	9.88	5.68	6.33	5.40	6.00
N2O	94.26	93.50	104.38	93.50	104.38
HFCs	1988.55	1760.80	1654.97	1760.80	1654.97
PFCs	3.55	3.50	3.74	3.50	3.74
SF6	81.73	27.15	25.08	27.15	25.08
Total	**12867.96**	**9012.18**	**9201.70**	**8884.79**	**9060.76**

Agriculture Sector (CRF Source Category 3)

In Table 5-22 are presented the projected GHG emissions for Agriculture sector, by gas, for two scenarios (WEM, WAM).

Table 5-22 The projections of GHG emissions for Agriculture sector, by gas

	Inventory	WEM scenario		WAM scenario	
	2020	2030	2040	2030	2040
CO2	135.56	127.95	133.89	127.95	133.89
CH4	8828.39	11803.79	11655.09	11442.22	10950.65
N2O	9784.41	10012.36	10772.02	10012.36	10772.02
Total	**18748.36**	**21944.09**	**22561.00**	**21582.52**	**21856.56**

Sector LULUCF (CRF Source Category 4)

In Table 5-23 is presented the projected GHG emissions for LULUCF sector, by gas, for two scenarios (WEM, WAM).

Table 5-23 The projections of GHG emissions for LULUCF sector, by gas

	Inventory	WEM scenario		WAM scenario	
	2020	2030	2040	2030	2040
CO2	-32931.31	-31714.99	-31560.63	-38828.09	-42128.52
CH4	7.96	3.62	3.74	3.62	3.74
N2O	29.39	30.99	37.72	30.99	37.72
Total	**-32893.96**	**-31680.39**	**-31519.17**	**-38793.48**	**-42087.06**

Sector WASTE (CRF Source Category 5)

In Table V_18 is presented the projected GHG emissions for Waste sector, by gas, for two scenarios (WEM, WAM).

Table 5-24 The projections of GHG emissions for Waste sector, by gas

	Inventory	WEM scenario		WAM scenario	
	2020	2030	2040	2030	2040
CO2	10.27	10.27	10.27	10.27	10.27
CH4	5452.35	2230.59	1802.03	1903.43	1510.10
N2O	453.56	462.58	442.94	462.58	442.94
Total	**5916.18**	**2703.44**	**2255.24**	**2376.28**	**1963.30**

A.4.1 Energy

A.4.1.1. Introduction

According to the National Energy Efficiency Action Plan NEEAP IV in 2015 Romania had the following characteristics:

- final energy consumption per capita of 1.102 toe, being 1.93 times lower than the EU28 average
- the share of final energy consumption in primary domestic energy consumption was close to the EU28 average (1.02 higher than the EU28 average)

- the primary energy intensity was 0.227 toe/1000Euro, 1.89 times higher than the value of this indicator for the EU28 average
- the structure of primary internal energy consumption has changed between 2005 and 2015, the natural gas having the highest share, followed by oil and coal
- the final consumption of electricity per capita was 2,171 kWh/capita, being about 2.6 times lower than the average value of the EU28 (5,380 kWh/capita); the share of electricity consumption in the final energy consumption increased between 2005 and 2015, reaching 16.9% which still shows the low level of electricity penetration in social and economic activities.

The National Commission for Strategy and Prognosis presented in October 2022 the Energy Balance Forecast for 2019÷2023 period, in correlation with the projection of macroeconomic indicators and Romania's national targets for energy efficiency, greenhouse gas emissions, the use of renewable energy resources, etc. A forecast for the years 2035 and 2040 was also presented.

Table 5-25 shows the achievements of 2019, 2020, 2021 years and the forecasts for the other years. It results that Romania's domestic primary energy consumption in 2020 was about 32.171 million toe, representing about 75% of the national target of 42.99 million toe indicated in PNAEE IV.

Table 5-25 Forecast of primary energy consumption and final energy consumption [thou toe]

Specification / year	2019	2020	2021	2025	2030	2035	2040
	History			Projections			
Internal primary energy consumption	**33015**	**32171**	**32909**	**33693**	**35637**	**36979**	**39822**
Consumption in the energy sector	3023	3050	2926	2810	2782	2754	2730
Losses	895	870	872	844	810	780	750
Available for the final consumption	**25102**	**25127**	**25795**	**26784**	**28388**	**30082**	**32660**
Non-energy consumption	1135	1295	1286	1326	1346	1358	1370
Final energy consumption, of which:	**23874**	**23513**	**24509**	**25458**	**27042**	**28724**	**31290**
- Population consumption	7754	8008	8089	7482	7512	7564	7625
- Consumption in economy, of which:	**16120**	**15505**	**16410**	**18363**	**19530**	**21160**	**23665**
- Industry	6281	6009	6412	6621	6808	7130	7640
- Construction	378	416	398	484	525	603	675
- Transport and telecommunications	537	531	571	554	562	572	583
- Agriculture. forestry and fishing	6713	6514	6907	8346	9177	10250	11980
- other economy branches	2191	2035	2131	2357	2458	2605	2787

Source: National Commission for Strategy and Prognosis For the period 2019÷2023; *National Institute of Statistics for* 2019÷2021

Romania's final energy consumption in 2020 was about 25.127 million toe, representing about 82.8% of the national target of 30.32 million toe.

The National Commission for Strategy and Prognosis considered the assumptions (production and imports) shown in Table 5-25. After analyzing the forecasts in this table, the following conclusions can be drawn:

1. Crude oil production is declining (e.g., due to lack of new fields)
2. Natural gas production is increasing due to new investments in the exploitation of Black Sea deposits
3. The increase in renewable electricity generation accompanies the increase in renewable generation capacity described in the NECP

4. The increase in power generation from nuclear power plants because of Romania's Energy Strategy 2022-2030 with a view to 2050

A.4.1.2. Electricity and heat production in cogeneration

To establish the power plants development program in the 2018÷2040 period, are taken into consideration the forecast of the evolution of electricity and heat consumption in cogeneration, the diversification of primary energy resources, the retrofitting and modernization of the sector, modern technologies for the electricity and heat generation, environmental requirements.

Establishing the electricity generation structure in the period 2022÷2040 is particularly difficult due to the high degree of uncertainty regarding:

- the evolution of electricity demand and fuel prices on international markets
- compliance of existing power units with environmental requirements
- the ability of investors to carry out the investment programs provided in the National Investment Plan; in the National Renewable Energy Action Plan (NREAP).

Therefore, different scenarios for the electricity generation structure are analyzed in the period 2022÷2040 to take into account different hypotheses regarding the variations in key parameters influencing this structure.

Key assumptions for defining scenarios are related to:

- forecasts of electricity consumption
- diversification of primary energy resources used
- modern technologies for the cogeneration of electricity and heat
- environmental requirements
- the situation of existing power units in the National Power System (NPS)
- investment programs of the different companies (domestic or foreign).

Table 5-26 shows the forecast of fuel prices for the 2022÷2040 period according to EC recommendations.

Table 5-26 Hypotheses regarding the evolution of import fuel prices in the 2022÷2040 period. according to EC recommendation

Fuel type	Price (€2020/toe)				
	2022	2025	2030	2035	2040
Crude oil	643	643	643	643	680
Natural gas	1391	554	473	473	473
Coal	220	128	130	131	139
	Price (€2020/GJ)				
	2022	2025	2030	2035	2040
Crude oil	15.4	15.4	15.4	15.4	16.3
Natural gas	33.2	13.2	11.3	11.3	11.3
Coal	5.3	3.1	3.1	3.1	3.3

Table 5-27 shows the trajectory of the trading price of green certificates (carbon price (€2020 /tCO2) period 2022÷2040, according to EC recommendations.

Table 5-27 Price of green certificates over the period 2022÷2040

Year	The trajectory of the trading price of green certificates until 2030 ($€_{2020}/tCO_2$)	
2022	75	
2023	77	
2024	78	
2025	80	
2030	80	
	WEM	WAM
2035	82	120
2040	85	250

Table 5-28 shows the evolution of electricity production in the 2005÷2040 period, which was envisaged for the determination of the production capacities structure within NPS.

Table 5-28 Development of domestic consumption and production of electricity over the period 2005÷2040

Indicators	2005	2018	2019	2020	2025	2030	2035	2040
	Inventory				Projections			
Gross internal consumption of electricity [**TWh**]	56.51	57.40	56.67	54.68	58.25	60.79	62.76	64.63
Total gross production [**TWh**]	59.41	64.88	59.62	55.94	61.25	63.16	64.18	66.85

In 2020 the installed capacity in Romanian power plants was 20584 MW as shown in Table 5-29.

Table 5-29 Installed capacity in Romanian power plants in 2020

Power Plant Type	Installed capacity (MW)
Thermal PP	
- on coal	4786.969
- on liquid hydrocarbons	87.494
- on gaseous hydrocarbons	3340.142
Nuclear power Plants	1414.000
Hydro Power Plants	6560.797
Wind Power Plants	3012.53
Photovoltaic Power Plants	1382.539
TOTAL INSTALLED CAPACITY	20584.461

The power plants development program for the period 2018÷2030 is presented considering the provisions of the Romanian Energy Strategy 2019÷2030 with perspective up to 2050 and the NECP 2021÷2030, version April 2020.

The measures program shall consider the provisions of NECP 2021÷2030, regarding the evolution of installed capacities for 2020÷2030 period compared to installed capacities in 2020 in view of the policies and measures foreseen and the increasing of electricity demand trend.

According to NECP, by 2030, the installed capacity in wind power plants (WPP) is expected to increase to a power of 5255 MW and in photovoltaic power plants (PVPP) to 5054 MW.

To meet the trajectory of RES shares assumed by Romania, the new net energy production capacities necessary to be installed in RES are:

- Wind Power Plants (WPP)
  - 822 MW additional installed capacity in 2022 compared to 2020
  - 559 MW additional installed capacity in 2025 compared to 2022
  - 556 MW additional installed capacity in 2027 compared to 2025
  - 365 MW additional installed capacity in 2030 compared to 2027.
- Photovoltaic Power Plants (PVPP)
  - 994 MW additional installed capacity in 2022 compared to 2020
  - 1,037 MW additional installed capacity in 2025 compared to 2022
  - 528 MW additional installed capacity in 2027 compared to 2025
  - 1,133 MW additional installed capacity in 2030 compared to 2027.

In the 2027-2030 horizon, in order to preserve the existing capacity, it will be necessary to take measures to rehabilitate about 3000 MW in WPP and 1250 MW in PVPP.

The NECP provides the development and decarbonization plan for Oltenia Energy Complex in the period 2020÷2030. In this respect, the following actions are envisaged, which will be implemented by 2030:

- Construction of 3 (three) photovoltaic parks, with a total installed capacity of about 300 MW installed on closed slag and ash deposits (related to Rovinari, Turceni and Işalnița TPPs). Construction works will begin in 2023, commissioning will be carried out in 2024 (150 MW), respectively 2025 (additional 150 MW)
- Construction of a new cogeneration unit (200 MW) on natural gas at Craiova CHPP, which will replace from 2024 the current lignite capacities (2x150 MW)
- Construction of a 400 MW unit on natural gas at Turceni TPP, which will replace an existing capacity of 330 MW on lignite from 2026
- Construction of 2x400 MW units (total installed additional capacity of 800MW) on natural gas at Işalnița TPP, which will replace unit 8 (315 MW) on lignite from 2024 and from 2025 unit 7 (315 MW) on lignite.

From 2024 onwards, a sustainable transition is foreseen by developing new natural gas units with a total installed capacity of 1400 MW. This fuel has the advantage of allowing units operation flexibility, which will allow greater integration of RES in the NPS, whereas natural gas can ensure the system balance, considering the intermittent nature of the RES.

The NECP states that nuclear energy is an important element for Romania's energy security. According to this plan, extending the operating life time for Units 1 and 2 at Cernavoda NPP is an efficient solution, since the extension with another life cycle is made at around 40% lower costs then a new objective of the same capacity. Thus, the supply of electricity free of greenhouse gas emissions can be ensured, with minimal impact on the environment, at competitive costs, contributing sustainably to the decarbonization of the energy sector and the achievement of Romania's energy and environmental targets for 2030, in line with the objectives assumed at European and even global level (Paris Agreement). Unit 1 will be retrofitted in 2027-2028 and Unit 2 will be retrofitted after 2037.

According to the NECP, Units 3 and 4 in Cernavoda NPP are expected to be put into operation in 2030 and 2031.

Additionally, the NECP provides the development of high-efficiency cogeneration capacities and integration of RES into heat production for the centralized heating systems. According to the plan, the implementation of

cogeneration units or the rehabilitation of existing ones is underlined as a priority for several local communities in Romania:

- Implementation of a combined cycle cogeneration unit in Grozavesti Combined Heat and Power Plant CHPP, which involves the construction of a new high energy efficient cogeneration unit (Combined Cycle Gas Turbine - CCGT technology), operating on natural gas
- Implementation of a combined cycle cogeneration unit in Bucuresti Sud CHPP, which involves the construction of a new high efficiency cogeneration unit (CCGT technology) of about 200 MWe and about 200 MWt
- Implementation of a new high efficiency cogeneration capacity, on natural gas, in Progresu CHPP
- Rehabilitation of the combined cycle in Bucuresti Vest CHPP, to extending the lifetime period; implementation of new combined cycle unit of approx.186 MWe and approx. 170 Gcal/h
- Implementation of a new cogeneration power plant (CHPP), operating on natural gas, at Govora CHPP
- Implementation of a new cogeneration unit at Midia CHPP (around 70 MW)
- In the scenario with additional measures, it is designed to increase the amount of renewable energy used in district heating systems (DHS), with geothermal energy, from 31 ktoe in 2016 to 45 ktoe at 2030 level.

This above planning is envisaged in the case of the scenario with measures for 2020-2040 period.

In the WAM scenario, it is expected that the installed capacity in wind and photovoltaic power plants to be supplemented by about 2000 MW in 2030÷2040 period. Table 5-30 shows the structure of electricity generation in the 2020÷2040 period for the WEM and WAM scenarios.

Table 5-30 Structure of electricity generation in the 2005÷2040 period

Specification/Scenario/Year	Scenario	2005	2020	2025	2030	2035	2040
		Inventory		Projections			
Total electricity generation (GWh), of which based on:	**WEM**	**59412**	**55934**	**61252**	**63163**	**64210**	**65182**
• Liquid fuel		1816	17	0	0	0	0
• Solid fuel		21915	9360	5530	0	0	0
• Gaseous fuel		9612	10005	14700	11960	5379	5055
• Renewable resources		20207	24380	28921	38041	39718	42009
• Uranium		5555	11354	11400	12400	18319	17319
• Biomass		307	818	701	762	794	799
Total electricity generation (GWh), of which based on:	**WAM**	**59412**	**55934**	**61252**	**63163**	**64210**	**65182**
• Liquid fuel		1816	17	0	0	0	0
• Solid fuel		21915	9360	5530	0	0	0
• Gaseous fuel		9612	10005	14700	11816	4950	2157
• Renewable resources		20207	24380	28921	38185	40147	42226
• Uranium		5555	11354	11400	12400	18319	20000
• Biomass		307	818	701	762	794	799

In accordance with the structure of the electricity generation, the total demand for energy resources (fuel) is resulting and is presented in Table 5-31.

Table 5-31 Energy resources (Fuel) demand structure in 2020÷2040

Specification/Scenario/Year	Scenario	2020	2025	2030	2035	2040
		Inventory	Projections			
Total demand for energy resources in PJ, of which based on:	**WEM**	**222.20**	**128.69**	**49.49**	**54.57**	**59.45**
• Liquid fuel		4.510	0	0	0	0
• Solid fuel		114.445	63.16	0	0	0
• Gaseous fuel		97.762	62.92	46.65	51.73	56.60
• Biomass		5.483	2.61	2.84	2.84	2.85
Total demand for energy resources in PJ, of which based on:	**WAM**	**222.20**	**128.69**	**49.49**	**54.57**	**33.55**
• Liquid fuel		4.510	0	0	0	0
• Solid fuel		114.445	63.16	0	0	0
• Gaseous fuel		97.762	62.92	46.65	51.73	30.70
• Biomass		5.483	2.61	2.84	2.84	2.85

In tables 5-32, 5-33, 5-34 are presented the GHG emissions evolution in the 2018÷2040 period in the scenario without measures (WOM), in the scenario with measures (WEM) and the one with additional measures (WAM).

Table 5-32 Evolution of CO2 emissions from 2005 to 2040, in the analyzed scenarios

Scenario	Total emissions (kt CO_2)						
	2005	2019	2020	2025	2030	2035	2040
	Inventory			Projections			
WOM	33280.61	22320.59	15213.04	33280.61	33280.61	33280.61	33280.1
WEM				8717.88	2597.47	2880.33	3151.49
WAM				8717.88	2597.47	2880.33	1709.38

Table 5-33 Evolution of CH4 emissions from 2005 to 2040, in the analyzed scenarios

Scenario	Total emissions (kt CH_4)						
	2005	2019	2020	2025	2030	2035	2040
	Inventory			Projections			
WOM	0.50	0.43	0.38	0.50	0.50	0.50	0.50
WEM				0.20	0.13	0.14	0.14
WAM				0.20	0.13	0.14	0.11

Table 5-34 Evolution of N2O emissions from 2005 to 2040, in the analyzed scenarios

Scenario	Total emissions (kt N_2O)						
	2005	2019	2020	2025	2030	2035	2040
	Inventory			Projections			
WOM	0.38	0.30	0.20	0.38	0.38	0.38	038
WEM				0.11	0.02	0.02	0.02
WAM				0.11	0.02	0.02	0.01

A.4.1.3. Refineries

The refining sector in Romania consists of four operational refineries: Petrobrazi (owned by OMV Petrom), Petromidia and Vega (owned by Rompetrol), Petrotel (owned by Lukoil), which have a total operating capacity of approximately 12 million tons per year.

Romanian refineries purchase domestic crude oil production and import about two-thirds of what is needed, currently having an operating capacity of 12 million t /year.

In 2017, refineries in Romania processed 11.2 million tons of crude oil and additives (gross domestic deliveries were 11.17 million tons of crude oil and additives, out of which 3.52 million tons from domestic production), resulting: 5.47 million tons of diesel; 1.55 million tons of gasoline and kerosene; 0.56 million tons of coke oil; 0.7 million tons of LPG; 0.38 million tons of fuel oil; 0.2 million tons of naphtha; 0.5 million tons of refinery gas and 0.81 million tons of other refinery products. The total consumption of petroleum products was 9.45 million tons.

In 2018, the net import of crude oil was 8.265 million tons, mainly from Kazakhstan and the Russian Federation, but also from Azerbaijan, Iraq, Libya, and Turkmenistan, while imports of petroleum products were about 3.290 million tons. Romania is an exporter of petroleum products - according to statistics. In 2018, Romania exported petroleum fuels and lubricants worth 2285.3 million euros (of which 943.4 million euros for engines fuels).

According to the Order no. 1401/2020 or the Ministry of Environment, Waters and Forests (MMAP) for the approval of the number of GHG emission certificates allocated free of charge, related to the year 2020, for each installation in the stationary sector in which one or more activities provided in Annex 1 to GD no. 780/2006, 4 refineries are operational at national level; the fuels used in the combustion processes in the refineries falling under the EU-ETS, according to the GHG Emissions Authorizations issued for the period 2013÷2020, are presented in Table 5-35.

Table 5-35 Fuels used in combustion processes in refineries

Name of the company	Fuels used
SC Rompetrol Rafinăria SA VEGA - Workstation Rafinăria Vega Ploieşti	Natural gas, fuel oil, torch gas
SC OMV SA - Petrobrazi	Refinery gas, natural gas, fuel oil, torch gas, diesel
SC Rompetrol Rafinare - Workstation Petromidia	Refinery gas, natural gas, torch gas
SC Petrotel – Lukoil SA	Refinery gas, natural gas

The National Commission for Strategy and Prognosis estimated the forecasts regarding the energy balance of Romania for the period 2020÷2040, resulting the demand for liquid fuel to be used in industry, transport, agriculture, services, etc.

From the Energy Balance forecast prepared by the National Commission for Strategy and Prognosis (CNSP), it appears that between 2022 to 2040, Romania will extract crude oil and import crude oil for processing in refineries. Table 5-36 shows the forecast quantities of crude oil to be processed in the 4 operational refineries.

Table 5-36 Evolution of crude oil processing in Romania (thousand toe)

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2035	2040
Extracted oil	3382	3243	3045	2975	2907	2840	2783	2727	2673	2619	2567	2332	2440
Imported oil	7071	6909	7634	8131	8643	9136	9702	10216	10686	11103	11158	12275	13155
TOTAL	**10453**	**10152**	**10679**	**11106**	**11550**	**11976**	**12485**	**12943**	**13359**	**13722**	**13725**	**14607**	**15595**

To cover domestic liquid fuel demand, the four existing refineries will efficiently use their operational capacity of 12 million t/year. Thus, in the period 2020÷2040, for operating at this capacity, the fuel demand that must be ensured in the refineries is shown in Table 5-37, considering the requirements of NAPEE IV and NECP.

Table 5-37 Energy demand evolution between 2005÷2040

Fuel demand in PJ	2005	2018	2020	2025	2030	2035	2040
	Inventory			Projections			
Liquid fuel	49.305	25.856	24.736	25.92	29.16	30.9	31.95
Solid fuel	-	-	0.081	-	-	-	-
Gaseous fuel	12.549	8.431	5.307	8.594	10.4	11.2	13.0
Biomass	-	0.047	0.001	-	-	-	-
Other fuels	0.919	-	-	-	-	-	-
TOTAL (PJ)	**62.773**	**34.334**	**30.125**	**34.514**	**39.56**	**42.10**	**44.95**

Having in view that no information is available on measures taken by economic operators to increase energy efficiency and reduce GHG emissions, the same GHG emission trends are considered for all refineries in the three scenarios.

In tables 5-38, 5-39, 5-40 are shown the GHG emissions evolution between 2020÷2040 for all the analyzed scenarios.

Table 5-38 Evolution of CO2 emissions during 2020÷2040

Scenario	Total emissions (kt CO_2)					
	2005	2020	2025	2030	2035	2040
	Inventory		Projections			
WOM, WEM, WAM	4033.28	1883.46	2289.20	2447.10	2603.25	2771.82

Table 5-39 Evolution of CH4 emissions during 2020÷2040

Scenario	Total emissions (kt CH_4)					
	2005	2020	2025	2030	2035	2040
	Inventory		Projections			
WOM, WEM, WAM	0.12	0.04	0.04	0.05	0.05	0.06

Table 5-40 Evolution of N2O emissions during 2018÷2040

Scenario	Total emissions (kt N_2O)					
	2018	2020	2025	2030	2035	2040
	Inventory		Projections			
WOM, WEM, WAM	0.02	0.01	0.0	0.01	0.01	0.01

A.4.1.4. Fuel production and other energy industries

According to Romania's Energy Balance, electricity, liquid and gaseous fuels are required for the extraction and handling of coal, oil and natural gas. Table 5-41 shows the evolution of fuel requirements in the years 2005, 2010, 2015, 2018, 2019, 2020 according to the data used in NIGHGE 2020.

Table 5-41 Evolution of fuel demand for fuel preparation in the period 2005÷2020

Fuel type	2005	2010	2015	2018	2019	2020
	Quantity (PJ)					
Liquid fuels	22.805	12.053	8.421	9.962	11.92	12.768
Solid fuels	6.70	0.08	0.007	0.002	0.0003	0.00
Gaseous fuels	28.063	17.015	10.212	9.139	5.03	4.383
Biomass	0.006	0.001	0.001	0.0005	0.004	0.0007
TOTAL	57.575	29.148	18.642	19.103	16.954	17.152

Fossil fuels in Table 5-41 were used in combustion processes resulting the GHG emissions in Table 5-42.

In 2022, according to NIGHGE 2020 these emissions were 3.18% from the total amount of GHS emissions.

Table 5-42 Evolution of GHG emissions from fossil fuel preparation 2005÷2020

Type of GHG	2005	2010	2015	2018	2019	2020
	Quantity (kt)					
CO_2	3528.12	1802.06	11162.76	1212.58	1131.95	1166.48
CH_4	0.1	0.05	003	0.03	0.04	0.04
N_2O	0.02	0.01	0.00	0.01	0.01	0.01

It is difficult to determine the fuel and electricity requirements for fossil fuel production over the period 2020÷2040 given the restructuring of the sector and the changes envisaged with the use of different types of fuels in economic and environmental conditions. According to the NECP it is expected that the use of coal after 2025 will be restricted and more natural gas will be used.

Table 5-43 shows for the three scenarios the evolution of fuel demand for fossil fuel production (extraction and handling of fossil fuels).

For the WOM scenario the amount of fuel needed in 2005 has been kept constant. For the WEM and WAM scenarios, for the period 2020÷2040, the consumption for the year 2020 was extrapolated at an average annual rate of 1% until 2030 and the structure was modified, considering the priority in use of gaseous fuel. After 2030, the fuel quantity is kept constant.

Table 5-43 Evolution of fuel demand for fuel preparation in the period 2020÷2040

Scenario	Fuel demand (PJ)	2020	2025	2030	2035	2040
		Inventory	Projections			
WOM	Liquid fuels	22.805	22.805	22.805	22.805	22.805
	Solid fuels	6.70	6.70	6.70	6.70	6.70
	Gaseous fuels	28.063	28.063	28.063	28.063	28.063
	Biomass	0.007	0.007	0.007	0.007	0.007
	TOTAL, în PJ	**57.575**	**57.575**	**57.575**	**57.575**	**57.575**
WEM WAM	Liquid fuels	12.768	10.768	7.768	7.768	7.768
	Solid fuels	0.00	0.00	0.00	0.00	0.00
	Gaseous fuels	4.383	7.259	11.179	11.179	11.179
	Biomass	0.000	0.00	0.00	0.00	0.00
	TOTAL, in PJ	**17.152**	**18.027**	**7.779**	**7.779**	**7.779**

Table 5-44 shows the GHG emission trends for the period 2020÷2040 for the category fuel production and other energy industries.

Table 5-44 Evolution of GHG emissions from fossil fuel combustion in the period 2020÷2040

Scenario	Type of GHG	2005	2020	2025	2030	2035	2040
		Quantity (kt)					
WOM	CO_2	3528.12	1166.48	3528.12	3528.12	3528.12	3528.12
	CH_4	0.1	0.04	0.1	0.1	0.1	0.1
	N_2O	0.02	0.01	0.02	0.02	0.02	0.02
WAM	CO_2	3528.12	1166.48	1182.14	561.75	561.75	561.75
	CH_4	0.1	0.04	0.04	0.02	0.02	0.02
	N_2O	0.02	0.01	0.01	0.00	0.00	0.00

A.4.1.5. Fugitive emissions from fuels

GHG emissions result from the handling of fossil fuels. The following direct GHG emissions by source categories are quantified and reported in the NIGHGE:

- •CH4 emissions due to handling of the solid fuels
- •CH4, CO2 and N2O emissions due to handling of the oil and natural gas.

In 2020, GHG emissions from the fugitive emissions category from handling of the fossil fuel were 8584.68 kt CO2 equivalent, which represents 7.81% of total GHG emissions in that year. GHG emissions from coal handling account for 63.62% of fugitive emissions and those from oil and gas handling account for 36.38%.

Fuel emissions of CH4 result from coal handling. In 2018, these emissions were about 10.4% of CH4 emissions due to the energy sector, 33% of total CH4 emissions in Romania.

Table 5-45 shows the evolution of fugitive emissions, in 2005 and 2018, in the handling of fossil fuels. It is noted that CH4 emissions in 2018 were reduced by about 45% compared to 2005, in close correlation with the production of fossil fuels used and restructuring actions in these sectors.

Table 5-45 The evolution of fugitive emissions in 2005, 2018 and 2020

Fuels	Activity	CH_4 emissions (thou tons)			CO_2 emissions (thou tons)		
		2005	2018	2020	2005	2018	2020
Coal	**Handling of coals**	**455.85**	**228.33**	**218.48**	-	-	-
	Underground mines	**433.48**	**208.19**	**205.76**	-	-	-
	Mining activity	64.85	5.92	4.78	-	-	-
	Post-mining activity	9.09	0.89	0.72	-	-	-
	Abandoned mines	359.54	201.38	200.26	-	-	-
	Surface mines	**22.37**	**20.14**	**12.72**	-	-	-
	Mining activity	20.65	18.59	11.74	-	-	-
	Post-mining activity	1.72	1.55	0.58	-	-	-
Oil and natural gas							
Oil	**Total**	**15.92**	**9.63**	**9.36**	**876.73**	**696.84**	**635.92**
	Extraction	0.23	0.14	0.13	62.32	37.33	36.39
	Production	15.23	9.13	8.90	1.18	1.11	1.06
	Transport	0.09	0.07	0.07	0.01	0.01	0.01
	Storage	0.37	0.29	0.27	-	-	-

	Other activities	-	-	-	812.59	658.19	598.46
Natural gas	**Total**	**73.96**	**51.20**	**46.87**	**3.50**	**2.81**	**2.48**
	Production	16.24	13.77	11.95	0.58	0.49	0.43
	Processing	7.15	6.06	5.26	2.01	1.71	1.48
	Transport and storage	4.74	3.22	3.02	0.02	0.01	0.01
	Distribution	19.12	12.97	12.16	0.89	0.60	0.56
	Other activities	26.71	15.17	14.48	-	-	-
Open flames at oil and natural gas		**62.60**	**38.05**	**36.89**	**262.46**	**160.87**	**155.48**

Taking into consideration the difficulty to make the forecast regarding the emission sources due to handling of fossil fuels for 2020÷2040, the following assumptions were considered:

- for the WOM scenario - the value of emissions reported in 2005 remains constant
- for the WEM and WAM scenarios - the value of reported emissions in 2018 is reduced with an average annual rate of about 4% during 2018-2020, with an average annual rate of 1% during 2020-2030 (compared to 2020) and with an average annual rate of 1.5% during 2030-2040, given the reduction of coal used, in the process of closing uneconomical deep-sea coal mines and the use of CH4 emissions for preparing the domestic warm water.

Table 5-46 shows the evolutions of CH4 emissions during 2020÷2040, in the three analyzed scenarios: without measures, with measures and with additional measures.

Table 5-46 The evolution of CH4 emissions during 2018÷2040 (kt)

Scenario	Total emissions (kt CH_4)						
	2005	2018	2020	2025	2030	2035	2040
	Inventory			Projections			
WOM	608.33	373.03	311.60	608.33	608.33	608.33	608.33
WEM				296.48	282.09	277.17	257.29
WAM				296.48	282.09	277.17	257.29

The systems corresponding to the oil and natural gas sector cover the entire chain from extraction (crude oil or natural gas) to the final consumer, including transformation processes to meet consumer requirements. The fugitive CO2 emissions also result from these systems. These emissions were in 2020, de 793.88 kt CO2 representing about 1.25% of total CO2 emissions in Romania.

Taking into consideration the difficulty to make forecasts on the evolution of the oil and natural gas sector in the future until 2040 and to make forecasts on fugitive CO2 emissions, the following assumptions were considered for all three scenarios:

- for the WOM scenario, the value of emissions reported in 2005 remains constant
- for the WEM and WAM scenarios, for the period 2020-2040, the value from 2018 is extrapolated with the average rate of 1%.

Table 5-47 shows the forecast of CO2 emissions during 2020-2040.

Table 5-47 The evolution of CO2 emissions during 2020÷2040 (kt)

Scenario	Total emissions (kt C02)						
	2005	2019	2020	2025	2030	2035	2040
	Inventory			Projections			
WOM				1142.69	1142.69	1142.69	1142.69
WEM	1142.69	860.52	793.88	834.37	876.92	921.64	968.65
WAM				834.37	876.92	921.64	968.65

A.4.1.6. Energy consumption in the industry sector

The following types of energy utilization are considered within the industry sector:

- Fuels (gas, diesel)
- Strictly electric uses, without alternative (lighting, electrolysis, electric motors, etc.)
- Heat uses (space heating and domestic hot water, steam, furnace heating and direct heat generation, etc.)
- Special treatments.

Table 5-48 shows the alternative forms of energy by categories of use in the industry sector.

Table 5-48 Alternative forms of energy by end-use categories for the industry sector

Forms of energy	Mining			Processing Industry				
						Thermal use		
	Electrical use	Engines	Thermal use	Power use	Engines	Space and water heating	Steam Production	Furnaces/direct burning
Fossil fuels	X		X			X	X	X
Electricity	X		X	X		X	X	X
Fuels		X			X			
Heat						X	X	
Solar energy			X			X	X	
Traditional fuels (firewood, agricultural waste)			X			X	X	X
Modern biomass (biofuels, bio liquids)			X			X	X	X

The National Forecasting Commission has indicated the evolution of energy consumption in the industry sector for the period 2020÷2040 as shown in Table 5-49.

Table 5-49 Evolution of energy demand in the period 2020÷2040, for the industry and construction sector

Energy demand	2020	2025	2030	2035	2040
	Inventory	Projections			
Total (Mtoe)	6.424	7.017	7.333	7.733	8.315
Total (PJ)	268.991	293.822	307.053	323.802	348.173

Considering the assumptions on the development of the different industrial branches, the policies and measures specified in the NECP 2021-2030 and the NEEAP IV, the evolution of fuel demand is obtained for the period 2020÷2040, in the industry sector, for the two scenarios for which GHG emissions are projected (Table 5-50).

Table 5-50 Evolution of fuel demand over the period 2005÷2040 (PJ)

Fuel demand	2005	2018	2019	2020	2025	2030	2035	2040
WOM	**Inventory**				**Projections**			
Total (PJ), of which	**258.646**	**242.980**	**231.950**	**246.369**	**264.2**	**276.3**	**291.4**	**303.4**
Liquid fuels	49.464	42.766	55.823	49.489	50.8	68.2	80.8	88.4
Solid fuels	34.553	8.147	9.336	9.608	0.0	0.0	0.0	0.0
Other fuels	2.534	7.039	6.288	11.690	10.0	4.0	3.5	2.5
Gaseous fuel	161.006	171.249	147.048	164.299	193.4	194.6	199.1	205.5
Biomass	11.088	13.779	13.455	11.282	10.0	9.5	8.0	7.0
WAM	**Inventory**				**Projections**			
Total (PJ), of which	**258.646**	**242.980**	**231.950**	**246.369**	**260.7**	**271.3**	**285.1**	**291.2**
Liquid fuels	49.464	42.766	55.823	49.489	49.8	60.5	68.9	70.2
Solid fuels	34.553	8.147	9.336	9.608	0.0	0.0	0.0	0.0
Other fuels	2.535	7.039	6.288	11.690	4.9	4.0	1.5	0.0
Gaseous fuel	161.006	171.249	147.048	164.299	196.0	197.3	207.7	215.0
Biomass	11.088	13.779	13.455	11.282	10.0	9.5	7.0	6.0

GHG emission projections in the industrial sector are obtained for each fuel type considering the characteristic emission factors used to produce NIGHGE.

Tables 5-51, 5-52, 5-53 show the evolutions of GHG emissions, in the period 2018 - 2040, in the three analyzed scenarios. In the WOM scenario the 2005 GHG emission values are maintained for the period 2005÷2040.

Table 5-51 Evolution of the CO2 emissions during 2005÷2040

Scenario	Evolution of the CO_2 emissions during (kt CO_2)						
	2005	2018	2020	2025	2030	2035	2040
	Inventory			Projections			
WOM	15961.20	14019.39	14714.29	15961.20	15961.20	15961.20	15961.20
WEM				15379.71	16213.91	17354.69	18186.61
WAM				15005.53	15792.82	16775.51	17146.63

Table 5-52 Evolution of the CH4 emissions during 2005÷2040

Scenario	Total emissions (kt CH_4)						
	2005	2018	2020	2025	2030	2035	2040
	Inventory			Projections			
WOM	1.01	0.96	1.04	1.01	1.01	1.01	1.01
WEM				0.89	0.73	0.71	0.67
WAM				0.74	0.72	0.60	0.54

Table 5-53 Evolution of the N2O emissions during 2005÷2040

Scenario	Evolution of the N_2O emissions during (kt N_2O)						
	2005	2018	2020	2025	2030	2035	2040
	Inventory			Projections			
WOM	0.14	0.13	0.14	0.14	0.14	0.14	0.14
WEM				0.12	0.10	0.10	0.09
WAM				0.10	0.10	0.08	0.07

A.4.1.7. Energy consumption in the Transport sector

Romania has a national transport system (infrastructure, vehicles, etc.) located, to a large extent, both in terms of functional structure, and services provided, at the level of the average standards of conventional transport systems in Europe.

The strategic framework on sustainable transport policy in Romania is in line with the European policy defined in the White Paper on Transport.

In the field of transport, Romania holds a key position at the eastern border of the EU, as a transit area both on the east-west direction (connection with Asia via the Black Sea) and north-south (from the Baltic Sea to the Mediterranean Sea). Three of the TEN-T priority axes cross the Romanian territory.

The development of the Transport sector is conducted in close correlation with the socio-economic development of Romania.

For a coherent and correct analysis of the Transport sector from the energy point of view, two distinct areas are considered, namely: freight transport and passenger transport.

Considering the economic and social development of Romania, the transport sector must efficiently ensure both the freight and passengers transports over different distances.

Table 5-54 presents the evolution of the freight transport during 2015÷2020.

Table 5-54 Freight transport evolution during 2015÷2020

Year	2005	2015	2016	2017	2018	2019	2020
Transported freight				**thou tons**			
Rail transport	69175	55307	52618	50348	55429	58808	49671
Road transport	306994	198638	216085	191486	237132	256616	266523
Inland naval transport	16632	30020	30484	26858	229714	33261	30518
Oil pipeline transport	13378	6663	6825	5625	6459	6856	6410
Freight routes				**mill tons-km**			
TOTAL	75471	66877	75656	80038	685178	89479	82025
Rail transport	16582	13673	13535	12941	13076	13312	12291
Road transport	51531	39022	48175	54026	58761	61041	55026
Inland naval transport	5147	13153	13161	12242	12261	13957	13638
Oil pipeline transport	2211	1029	785	829	1080	1168	1070

It is noted that during the period 2015÷2019 of economic growth, the freight routes increased from 66877 million tons-km to 89479 million tons-km, with an average annual growth rate of about 7.5%.

The freight transport is conducted, mainly, by road.

Table 5-55 presents the evolution of the passenger transport during 2015÷2020.

Table 5-55 Passenger transport evolution during 2015÷2020

Year	2005	2015	2016	2017	2018	2019	2020
Transported passengers				**thou passengers**			
Rail transport	92424	66482	64456	69057	66500	69708	50556
Road transport	238017	275548	302951	325532	361338	355556	273454

Inland naval transport	218	169	153	153	120	111	134
Passenger routes				**mill. passengers-km**			
TOTAL	19820	22630	23740	23850	25520	26465	17300
Rail transport	7985	5149	4988	5664	5577	5906	3720
Road transport	11811	17471	18744	18178	19937	20553	13573
Inland naval transport	24	10	8	8	6	6	7

It is noted that during the period 2015÷2019 of economic growth, the passenger routes with an average annual growth rate of 4%.

The passenger transport is conducted, mainly, by road (78%).

According to NAPEE IV and NECP, for the 2020÷2040 horizon the following measures are going to be adopted in the transport sector:

- Renewal of the fleet of vehicles for all means of transportation
- Development and promotion of alternative mobility
- Limiting the circulation of the conventional vehicles in city centers
- Promoting electric mobility in road transport
- Promoting the use of biofuels in transport
- Promoting the use of renewable energy in rail transport
- Priority development of railway transport and its intermodal integration with other means of transportation
- Electrification and modernization of railway lines
- Modernization of urban and interurban passenger transport in major cities.

The National Commission for Strategy and Prognosis has shown the evolution of energy consumption in the transport sector in the period 2020÷2040 in Table 5-56.

Table 5-56 Evolution of energy demand in 2020÷2040 for the transport sector

Energy demand	2020	2025	2030	2035	2040
	Inventory		Projections		
Total (Mtoe)	6.514	8.103	9.177	10.250	11.980
Total (PJ)	272.749	339.283	384.252	429.179	501.617

In 2020 fuel consumption in the transport sector according to INGES 2022 was 240.124 PJ representing 88% of the sector's final energy consumption.

Considering the policies and measures in the NECP 2021-2030 and the NAPEE IV, the evolution of fuel demand is obtained (Tables 5-57, 5-58) over the period 2020÷2040, in the transport sector for two scenarios for which GHG emissions are projected.

Table 5-57 Evolution of fuel demand between 2018 and 2040 in the WEM scenario

Fuel demand	2005	2018	2019	2020	2025	2030	2035	2040
	Inventory				Projections			
Total in PJ, out of which:	**168.818**	**253.407**	**254.042**	**240.124**	**288.32**	**315.11**	**343.30**	**391.2**
Liquid fuel	167.396	240.959	236.772	219.877	267.72	293.91	322.00	369.9

Solid fuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gaseous fuels	1.393	0.009	0.005	0.013	0.100	0.200	0.300	0.300
Biomass	0.028	12.439	17.265	20.234	20.500	21.000	21.000	21.000
a. Air transport	**2.640**	**2.325**	**2.708**	**1.618**	**2.900**	**3.400**	**3.900**	**4.300**
Gasoline	0.445	0.047	0.074	0.046	0.055	0.045	0.055	0.065
Kerosene	2.195	2.278	2.634	1.572	2.845	3.355	3.845	4.235
b. Road transport	**159.205**	**245.255**	**243.942**	**232.228**	**274.820**	**297.410**	**322.400**	**346.700**
Gasoline	66.490	55.154	53.109	51.556	61.687	70.799	76.345	81.257
Diesel	89.987	173.739	169.439	156.733	186.733	196.611	212.055	248.443
Liquefied petroleum gas	2.311	3.924	4.129	3.705	5.900	9.000	13.000	16.000
Biomass	0.417	12.438	17.265	20.233	20.500	21.000	21.000	21.000
c. Rail transport	**3.335**	**4.004**	**5.439**	**4.499**	**7.500**	**10.500**	**12.500**	**15.000**
Liquid fuels	3.307	4.002	5.437	4.497	7.500	10.500	12.500	15.000
Biomass	0.028	0.002	0.002	0.002	0.0	0.0	0.0	0.0
d. Naval transport	**1.739**	**1.761**	**1.868**	**1.715**	**2.200**	**2.700**	**3.200**	**3.700**
Diesel fuel	1.697	1.721	1.825	1.675	2.175	2.630	3.110	3.600
Gasoline	**168.818**	**253.407**	**254.042**	**240.124**	**288.32**	**315.11**	**343.30**	**391.2**
e. Other types of transport	167.396	240.959	236.772	219.877	267.72	293.91	322.00	369.9
Liquid fuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gaseous fuels	1.393	0.009	0.005	0.013	0.100	0.200	0.300	0.300
Total in PJ, out of which:	0.028	12.439	17.265	20.234	20.500	21.000	21.000	21.000

Table 5-58 The evolution of the fuel demand during 2018÷2040 in the WAM scenario

Fuel demand	2005	2018	2019	2020	2025	2030	2035	2040
	Inventory				Projections			
Total in PJ, out of which:	**168.818**	**253.407**	**254.042**	**240.124**	**271.480**	**299.850**	**330.450**	**352.720**
Liquid fuel	167.396	240.959	236.772	219.877	259.466	296.630	330.435	352.700
Solid fuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gaseous fuels	1.393	0.009	0.005	0.013	0.009	0.010	0.015	0.020
Biomass	0.028	12.439	17.265	20.234	12.005	3.210	0.000	0.000
a. Air transport	**2.640**	**2.325**	**2.708**	**1.618**	**2.500**	**2.900**	**3.400**	**4.300**
Gasoline	0.445	0.047	0.074	0.046	0.100	0.100	0.200	0.300
Kerosene	2.195	2.278	2.634	1.572	2.400	2.800	3.200	4.000
b. Road transport	**159.205**	**245.255**	**243.942**	**232.228**	**262.625**	**275.810**	**292.965**	**321.350**
Gasoline	66.490	55.154	53.109	51.556	63.800	69.300	85.900	110.500
Diesel fuel	89.987	173.739	169.439	156.733	181.825	195.710	197.965	198.950
Liquefied petroleum gas	2.311	3.924	4.129	3.705	5.000	7.600	9.100	11.900
Biomass	0.417	12.438	17.265	20.233	12.000	3.200	0.000	0.000
c. Rail transport	**3.335**	**4.004**	**5.439**	**4.499**	**4.320**	**5.500**	**6.500**	**7.500**
Liquid fuels	3.307	4.002	5.437	4.497	4.315	5.490	6.500	7.500
Biomass	0.028	0.002	0.002	0.002	0.005	0.010	0.000	0.000
d. Naval transport	**1.739**	**1.761**	**1.868**	**1.715**	**1.970**	**2.550**	**3.080**	**3.600**
Diesel fuel	1.697	1.721	1.825	1.675	1.940	2.500	3.000	3.500
Gasoline	0.042	0.040	0.043	0.04	0.030	0.050	0.080	0.100
e. Other types of transport	**1.898**	**0.062**	**0.084**	**0.064**	**0.065**	**0.090**	**0.105**	**0.130**
Liquid fuel	0.505	0.053	0.081	0.052	0.056	0.080	0.090	0.110
Gaseous fuels	1.393	0.009	0.003	0.012	0.009	0.010	0.015	0.020

The forecast of GHG emissions in the transport sector is obtained for each type of fuel considering the specific emission factors used within the NIGHGE.

Tables 5-59, 5-60, 5-61 present the evolutions of GHG emissions, in the period 2018÷2040, in the three analyzed scenarios. In the WOM scenario, the values of emissions achieved in 2005 are extrapolated with an average annual growth rate of 3% for the period 2005÷2040.

Table 5-59 Evolution of the CO2 emissions during 2018÷2040

Scenario	Total emissions (kt CO_2)						
	2005	2019	2020	2025	2030	2035	2040
	Inventory			Projections			
WOM	12376.60	18176.82	18122.950	22325.190	25679.020	30003.190	34781.920
WEM				22015.35	24046.50	26281.68	28523.53
WAM				21323.79	23254.84	24891.42	27099.49

Table 5-60 Evolution of the CH4 emissions during 2018÷2040

Scenario	Total emissions (kt CH_4)						
	2005	2019	2020	2025	2030	2035	2040
	Inventory			Projections			
WOM	2.80	1.36	1.28	5.050	5.860	6.800	7.870
WEM				1.55	1.77	1.94	2.10
WAM				1.48	1.57	1.84	2.26

Table 5-61 Evolution of the N2O emissions during 2018÷2040

Scenario	Total emissions (kt N_2O)						
	2005	2019	2020	2025	2030	2035	40
	Inventory			Projections			
WOM	0.51	0.75	0.83	0.900	1.050	1.210	1.400
WEM				1.04	1.18	1.30	1.44
WAM				0.90	0.95	1.01	1.08

A.4.1.8. Energy consumption in the Services sector

The energy consumption of the services sector is closely related to the economic activity level of the sector characterized by the added value and the working force involved. The service sector includes two main categories, namely: trade and public services.

The service sector requires space heating/cooling, preparation of hot water and food, lighting, operation of electric engines, computer power, etc. For this purpose, the service sector uses fuels, as well as electricity and heat.

Table 5-62 shows the forecast of final energy consumption in the services sector given by the National Commission for Strategy and Prognosis for the period 2020÷2040.

Table 5-62 Evolution of energy demand in 2020÷2040, in for the services sector

Energy demand	Inventory	Projections			
	2020	2025	2030	2035	2040
Total in thou toe	2035	2320	2458	2605	2787
Total in PJ	85.19	97.12	102.89	109.05	114.62

In 2020 fuel consumption in the service sector according to NIGHGE 2022 was 39.365PJ representing 46% of the final energy consumption of the sector.

Considering the policies and measures specified in NECP and in NAPEE IV, an evolution of the fuel demand within the services sector is estimated during the 2020÷2040, in services sector, for the three scenarios for which GHG emissions are forecast.

Table 5-63 shows the fuel demand evolution for the WEM and WAM scenarios.

Table 5-63 Evolution of fuel demand between 2020÷2040

Fuel demand	2005	2018	2019	2020	2025	2030	2035	2040
WEM		**Inventory**			**Projections**			
Total in PJ, of which:	**42.908**	**42.845**	**42.875**	**39.366**	**41.760**	**42.180**	**43.620**	**44.770**
Liquid fuel	10.167	4.305	4.506	3.786	4.500	4.500	4.000	3.500
Solid fuel	0.015	0.026	0.016	0.003	0.0	0.0	0.0	0.0
Gaseous fuels	32.726	34.057	33.926	31.948	37.26	37.68	39.62	41.27
Other fuel	0.0	0.126	0.125	0.102	0.0	0.0	0.0	0.0
Biomass	0.0	4.329	4.301	3.527	0.0	0.0	0.0	0.0
WAM		**Inventory**			**Projections**			
Total in PJ, of which:	**42.908**	**42.845**	**42.875**	**39.366**	**38.800**	**39.400**	**39.500**	**35.500**
Liquid fuel	10.167	4.305	4.506	3.786	4.300	4.500	3.500	3.000
Solid fuel	0.015	0.026	0.016	0.003	0.0	0.0	0.0	0.0
Gaseous fuel	32.726	34.057	33.926	31.948	34.500	34.900	36.000	32.500
Other fuels	0.0	0.126	0.125	0.102	0.0	0.0	0.0	0.0
Biomass	0.0	4.329	4.301	3.527	0.0	0.0	0.0	0.0

Tables 5-64, 5-65, 5-66 present the evolutions of GHG emissions, in the period 2019÷2040 for the three analyzed scenarios. In the WEM scenario, the evolution of GHG emissions was determined by extrapolating the values achieved in 2005 with an average annual rate of 0.5%.

Table 5-64 Evolution of the CO2 emissions during 2019÷2040

Scenario	Total emissions (kt CO_2)						
	2005	2019	2020	2025	2030	2035	2040
	Inventory			Projections			
WOM				2777.04	2847.16	2919.05	2992.76
WEM	2512.24	2207.07	2053.08	2389.23	2412.57	2485.07	2541.44
WAM				2221.67	2258.04	2248.50	2018.61

Table 5-65 Evolution of the CH4 emissions during 2019 - 2040

Scenario	Total emissions (kt CH_4)						
	2005	2019	2020	2025	2030	2035	2040
	Inventory			Projections			
WOM	0.25	1.49	1.26	0.277	0.284	0.291	0.298
WEM				0.22	0.23	0.23	0.24
WAM				0.21	0.21	0.21	0.19

Table 5-66 Evolution of the N2O emissions during 2019 - 2040

Scenario	Total emissions (kt N_2O)						
	2005	2019	2020	2025	2030	2035	2040
	Inventory			Projections			
WOM	0.01	0.02	0.02	0.011	0.0113	0.0116	0.0119
WEM				0.01	0.01	0.01	0.01
WAM				0.01	0.01	0.01	0.00

A.4.1.9. Energy consumption in the residential sector

The energy consumption of the residential sector is closely related to the number of households (dwellings), the level of family wellbeing, the average number of persons per household, climatic and cultural conditions.

The income level per household is an important element for energy consumption. Individuals with a higher income can occupy larger dwellings and consume more energy using air conditioning equipment, multiple TVs, and domestic appliances.

To determine the energy demand evolution in the residential sector it is estimated the average surface evolution of a dwelling, as well as the evolution of indicators used for calculation of the energy demand differentiated between urban and rural area.

Table 5-67 shows the evolution of average surface of dwellings during 2020÷2040.

Table 5-67 Evolution of average surface for a dwelling [m2]

Type of dwelling	2018	2020	2025	2030	2035	2040
Apartment in multifamily building	56.3	58.5	60.0	62.0	64.0	66.0
Single family dwelling placed in the urban area	69.5	74.0	78.0	82.0	84.0	86.0
Individual dwelling placed in the rural area	45.0	48.0	50.0	52.0	54.0	56.0

The National Commission (NFC) has indicated an evolution of the fuel demand for the residential sector during 2020 - 2040 shown in Table 5-68.

Table 5-68 Evolution of energy demand from 2020 to 2040 for the residential sector

Energy demand	2020	2025	2030	2035	2040
	Inventory	Projections			
Total (Mtoe)	8.008	7.467	7.512	7.564	7.625
Total (PJ)	335.308	312.665	314.539	316.719	319.271

In 2020 fuel consumption in the service sector according to INGES 2022 was de 255.138 PJ representing 76% of the final energy consumption of the sector.

Considering the hypotheses and forecasts of the National Commission for Strategy and Prognosis, the policies and measures specified in NECP and in NAPEE IV, an evolution of the fuel demand is estimated for the residential sector, during 2020÷2040, for the two scenarios for which GHG emissions are forecasted. (Table 5-69).

Table 5-69 The evolution of fuel demand for 2018÷2040

Fuel demand	2005	2018	2019	2020	2025	2030	2035	2040
WEM	**Inventory**				**Projections**			
Total in PJ, of which:	**239.690**	**245.532**	**246.957**	**255.138**	**253.200**	**255.600**	**258.500**	**261.300**
Liquid fuel	28.412	12.233	13.105	11.367	15.200	15.900	16.500	17.900
Solid fuel	0.559	1.421	1.578	1.805	0.0	0.0	0.0	0.0
Gaseous fuel	96.324	105.248	104.872	113.819	108.500	110.700	113.500	116.400
Biomass	114.395	126.630	127.402	128.146	129.500	129.000	128.500	127.000
WAM	**Inventory**				**Projections**			
Total in PJ, of which:	**239.690**	**245.532**	**246.957**	**255.138**	**253.200**	**255.600**	**257.000**	**259.500**
Liquid fuel	28.412	12.233	13.105	11.367	15.200	15.900	16.000	17.000
Solid fuel	0.559	1.421	1.578	1.805	0.0	0.0	0.0	0.0
Gaseous fuel	96.324	105.248	104.872	113.819	108.500	110.700	113.000	116.500
Biomass	114.395	126.630	127.402	128.146	129.500	129.000	128.000	126.000

Tables 5-70, 5-71, 5-72 show the evolutions of GHG emissions, in the period 2018÷2040 for the three analyzed scenarios. In the WOM scenario, the evolution of the GHG emissions was determined by extrapolating the values achieved in 2005 with an average annual rate of 1% for the period 2005÷2040.

Table 5-70 Evolution of the CO2 emissions during 2018÷2040

Scenario	Total emissions (kt CO_2)						
	2005	2019	2020	2025	2030	2035	2040
	Inventory			Projections			
WOM	7242.34	6766.68	7218.27	8835.25	9285.93	9759.61	10257.45
WEM				7026.45	7194.58	7389.51	7642.39
WAM				7026.45	7194.58	7328.98	7589.01

Table 5-71 Evolution of the CH4 emissions during 2018÷2040

Scenario	Total emissions (kt CH_4)						
	2005	2019	2020	2025	2030	2035	2040
	Inventory			Projections			
WOM	35.14	39.01	39.62	42.83	45.01	47.31	49.72
WEM				39.47	39.34	39.21	38.78
WAM				39.47	39.34	39.05	38.47

Table 5-72 Evolution of the N2O emissions during 2018÷2040

Scenario	Total emissions (kt N_2O)						
	2005	2019	2020	2025	2030	2035	2040
	Inventory			Projections			
WOM	0.48	0.52	0.53	0.58	0.61	0.65	0.68
WEM				0.53	0.53	0.53	0.52
WAM				0.53	0.53	0.53	0.52

A.4.1.10. Energy consumption in Agriculture and Forestry

Romania has actively participated in the debate on the Common Agricultural Policy (CAP) for the period 2021÷2027. The post-2020 CAP reform package contains three legislative proposals:

- A regulation on strategic plans in the field of the CAP (which addresses direct payments, sectoral interventions, and rural development)
- A regulation on the single common organization of the market (single CMO)
- A horizontal regulation on the financing, management, and monitoring of the CAP.

The common objectives of the CAP are the following:

- to increase competitiveness
- to ensure a fair income to farmers
- to protect food and health quality
- vibrant rural areas
- to support generational renewal
- to preserve landscapes and biodiversity
- environmental care
- climate change action
- to rebalance the power in the food chain.

A total amount of EUR 20.5 billion is proposed by the EC for Romania in the 2021-2027 period, of which EUR 13.3 billion are allocated for direct payments, EUR 363 million are directed to market support measures (EAGF) and EUR 6.7 billion are assigned for rural development (EAFRD).

The implementation of the post-2020 CAP reform package aims to:

- Increase the productivity and competitiveness of the agri-food sector
- Increase the degree of resistance of agricultural holdings to climatic factors and ensuring food security
- Increase the added value of agricultural products
- Diminish the dependence of farmers on the incomes obtained from the agricultural production by achieving integrated productions in the agricultural farms to reduce the variability of the agricultural incomes
- Increase the incomes of farmers and the rural population
- Attract young people to agriculture
- Increase the degree of association

- Increase the role of research in obtaining agricultural production in the context of climate change and the efficient use of agricultural resources
- Increase the quality of life in rural areas.

According to the 2021-2030 NECP, in the agricultural and rural development sector, the following measures will be taken to reduce GHG emissions and pollutants:

- Supporting investments for modernization of farms
- Promoting good agricultural practices
- Promoting carbon sequestration in agriculture
- Rehabilitating and modernizing of irrigation and drainage infrastructure
- Proper management of agricultural lands for adaptation to the effects of climate change.

For the period 2020÷2040 it is estimated the reduction of energy intensity. The specific fuel consumption for agricultural works will have a decreasing trend due to the concentration of agricultural land, but also an increasing effect due to the replacement of animals for agricultural work with cars. Action will be taken to modernize irrigation systems.

National Commission for Strategy and Prognosis has indicated an evolution of the fuel demand for the 2020÷2040 forecast shown in Table 5-73.

Table 5-73 The evolution of fuel demand for 2020 ÷ 2040, for agriculture sector

Energy demand	2020	2025	2030	2035	2040
	Inventory	Projections			
Total (Mtoe)	0.531	0.551	0.562	0.572	0.583
Total (PJ)	22.234	23.071	23.532	23.950	24.411

In 2020 fuel consumption in the agriculture sector according to INGES 2022 was 19.935 PJ representing 98.7% of the final energy consumption of the sector.

Considering the hypotheses and forecasts of the National Commission for Strategy and Prognosis, regarding the development of the agricultural sector, the policies and measures specified in NECP and in NAPEE IV, an evolution of the fuel demand was estimated for the 2020÷2040, for the scenario with measures and additional measures for which GHG emissions are forecasted (table 5-74).

Table 5-74 The evolution of fuel demand for 2020÷2040

Fuel demand	2005	2018	2019	2020	2025	2030	2035	2040
WEM		**Inventory**				**Projections**		
Total in PJ, of which:	**6.764**	**21.624**	**20.845**	**19.936**	**20.833**	**21.063**	**21.437**	**21.969**
Liquid fuel	4.842	15.484	14.892	13.915	14.679	15.108	15.385	15.555
Solid fuel	0.148	0.625	0.615	0.684	0.600	0.000	0.000	0.000
Gaseous fuels	1.518	4.675	4.349	4.237	5.344	5.955	6.052	6.414
Other fuel	0.142	0.621	0.614	0.684	0.000	0.000	0.000	0.000
Biomass	0.114	0.219	0.375	0.416	0.210	0.000	0.000	0.000
WAM		**Inventory**				**Projections**		
Total in PJ, of which:	**6.764**	**21.624**	**20.845**	**19.936**	**20.833**	**21.063**	**20.464**	**19.875**
Liquid fuel	4.842	15.484	14.892	13.915	14.679	15.108	14.564	14.375

Solid fuel	0.148	0.625	0.615	0.684	0.600	0.000	0.000	0.000
Gaseous fuel	1.518	4.675	4.349	4.237	5.344	5.955	5.900	5.500
Other fuels	0.142	0.621	0.614	0.684	0.000	0.000	0.000	0.000
Biomass	0.114	0.219	0.375	0.416	0.210	0.000	0.000	0.000

Tables 5-75, 5-76, 5-77 show the evolutions of GHG emissions, in the period 2020÷2040, in the three analyzed scenarios. In the WOM scenario, the evolution of GHG emissions was not determined by extrapolating the values achieved in 2005, given that the restructuring that took place in agriculture led to an increase in fuel consumption in the sector of 3.1 times between 2005÷2020. In view of this increase, to determine the CO2 emissions, the values obtained in 2020 will be extrapolated with an average annual rate of 3.5% for the period 2020÷2040. To determine the values of CH4 and N2O emissions, the values obtained in 2020 will be extrapolated at an annual average rate of 3.5% for the period 2020÷2040.

Table 5-75 Evolution of the CO2 emissions during 2018÷2040

Scenario	Total emissions (kt CO_2)						
	2018	2019	2020	2025	2030	2035	2040
	Inventory			Projections			
WOM				1768.10	2099.95	2494.08	2962.18
WEM	1467.21	1447.51	1488.70	1529.67	1534.21	1561.66	1595.32
WAM				1529.67	1534.21	1487.83	1450.54

Table 5-76 Evolution of the CH4 emissions during 2018 – 2040

Scenario	Total emissions (kt CH_4)						
	2018	2019	2020	2025	2030	2035	2040
	Inventory			Projections			
WOM				0.819	0.972	1.154	1.370
WEM	0.61	0.65	0.69	0.41	0.18	0.18	0.19
WAM				0.41	0.18	0.17	0.17

Table 5-77 Evolution of the N2O emissions during 2018 - 2040

Scenario	Total emissions (kt N_2O)						
	2018	2019	2020	2025	2030	2035	2040
	Inventory			Projections			
WOM				0.463	0.550	0.653	0.776
WEM	0.43	0.41	0.39	0.40	0.42	0.42	0.43
WAM				0.40	0.42	0.40	0.39

A.4.2 Industrial Processes and Products Use

For the Industrial Processes and Products Use sector the activity data used for projections in the WEM and WAM scenarios are the same as those used in air pollutants projection.

Mineral industry

Cement Production

The cement industry is highly concentrated in Romania, 7 business units being held by three large international companies. These units are vertically integrated upstream, because they have their own career to ensure raw materials and carry out the processing to the final product - the cement. All these units are included in the EU-ETS, so that emissions from the industrial processes are found entirely under this legislation.

Due to the relatively high transport costs, cement or clinker is not usually transported over long distances (+/- 200 km at most). At the national level, between 2014÷2020 imported or exported quantities of clinker were very small. Thus, it appears that the cement industry in Romania is closely related to the socio-economic development of the country.

Clinker production in Romania had a downward trend from a peak in 1989 (10,571kt) to a minimum of 4,971 kt in 1999 with a slight revival in 2006 when they were produced approx. 6,000 kt clinker. There was a period of 5 years when production was around 5,000 kt clinker. Since 2003, with the economic recovery, production began to increase reaching a maximum value of 7,780 kt in 2008, followed by a decrease of about 25% in 2009 (5,801 kt). In 2015 the production continued to increase compared to 2014, and in 2016 there was a decrease of approx. 4.5% compared to the previous year. In 2017, the registered clinker reached 6322 kt, returning to a level close to that of 2015. In 2018, there was a new increase in production that reaches a value of 6696 kt of clinker. In 2020 the production level reached 7,474 kt clinker.

Cement manufacturing technologies existing in Romania are within the limits set by the BAT-BREF and are expected that by applying the new conclusions regarding the Best Available Technologies from 2010/75/UE Directive regarding Industrial Emissions, supplementary emissions reduction will be reached.

It is difficult to forecast the evolution of clinker production in circumstances where there are the following potential threats:

- competition from imports from non-EU economies that are not subject to the regulations related to carbon
- high costs of energy, particularly electricity costs as an indirect effect of legislation on climate change (higher than for competitors)
- relocation of investments outside the EU.

CO_2 emissions from cement production sector are mainly influenced by the clinker production, emission factor associated with clinker production, the amount of kiln dust not reintroduced into the system, its associated emission factor and correction factor for kiln dust. CO_2 emission factor associated with clinker production is calculated based on the contents of CaO and MgO.

Assumptions considering activity data

In all scenarios, the activity data used in projections are equal and the same as those used in air pollutants projections.

Considering the trend provided by the National Commission for Strategy and Prognosis for the period 2025÷2040, it is estimated that in the 2025 the clinker production will reach a value of 7677 kt and about 8475 kt clinker in 2040.

Assumptions considering emissions factors

For emissions projections in the WOM scenario, the average value of 0.529 tons CO_2/ tons of clinker will be used, which represents the value of the emission factor in 2005.

Considering the effects of the 2010/75/EU Directive and EU-ETS Directive, for the WEM scenarios the assumption is that EF will decrease in the period 2055-2040 to a value of 0.52 tons CO_2/ tons of clinker in 2030 and will continue to decrease to 0.50 tons CO_2/ tons of clinker in 2040.

For the WAM scenario are considered the effects of the 2010/75/EU Directive, EU-ETS Directive and National Strategy of Competitiveness. It is assumed that the EF will reach a value of 0.51 tons CO_2/ tons clinker in 2030 and will continue to decrease to 0.49 tons CO_2/ tons clinker in 2040.

Table 5-78 shows the projected evolution of CO_2 emissions from category 2.A.1.- *Cement production* for the period 2020-2040 in the scenarios considered.

Table 5-78 The CO2 emissions projection for category 2A.1. Cement production, 2025-2040

Scenario	CO_2 emissions, kt					
	2005	2020	2025	2030	2035	2040
	Historic values (estimated for WOM)		Projection			
WOM	3174.81	3953.71	4061.38	4226.18	4395.23	4483.13
WEM	3174.81	3901.03	4007.64	4154.28	4237.37	4237.37
WAM	3174.81	3901.03	4007.64	4074.39	4154.28	4152.62

Lime production

Lime is a material used for a long time and with many applications. In the EU 27 in 2004, 30÷40% of the lime production was used in metallurgy, 30% in environmental applications, agriculture and forests, 15÷20% in construction and soil stabilization and 10÷15% in other applications (chemical industry, food industry, paper making, medicine, etc.).

Lime production declined in the late 1980s because of changes in consumption pattern, mainly because of the largest consumer, the iron and steel industry, which has drastically reduced its specific consumption of lime (from 100 kg/t steel to 40 kg/t steel). Lime production began to rise again in the mid-1990s, mainly due to the new environmental uses.

Lime kilns are a big, long-term investment, making difficult adaptation of this industry to short-term fluctuations in demand or quick compliance to legislative changes related to energy or air emissions.

Lime industry in Romania is quite concentrated, with eight business units, non-captive in terms of production, owned by 4 companies. These units are vertically integrated upstream, because they have their own career to ensure raw materials and carry out the processing to the final products. There are also economic units who own lime factories, resulting products being used in their flows (captive units).

As the activity data are confidential only the emissions will be presented as values. Captive and non-captive lime production (quicklime and dolomite lime) in Romania had a downward trend with a peak value in 1989. The total lime production in 2020 represents 54% of the 2005 production.

Lime manufacturing technologies existing in Romania are within the limits set by the BAT-BREF and are expected that by applying the new conclusions regarding the Best Available Technologies from 2010/75/UE Directive regarding Industrial Emissions, supplementary emissions reduction will be reached.

Possible threats faced by the lime industry are:

- rising energy prices affecting the competitiveness of industry
- imposing unilateral carbon-related constraints on the lime producers which could lead to increased imports of lime from neighboring EU countries
- increased compliance costs with environmental legislation.

Lime is a heavy product and with a relatively low selling price, therefore transport costs have an important share and can determine the distance on which lime it can be viably transported. Therefore, long-distance delivery of lime is limited (<300 km), except for certain special products, or in areas that do not have any natural source of limestone. Only a very small percentage of total production is exported, and this is usually done in neighboring countries. If a large manufacturer has identified potential markets, it usually takes the decision to invest in production capacity in these markets.

Given the current economic situation, it is considered a hypothesis that in the short term no new production capacities will be closed or opened. In all scenarios, the activity data used in projections are equal with those used in air pollutants projections.

Regarding the activity data, the following assumptions are used:

- For the WOM scenario, the production structure will be the same as in 2005 (87% calcium lime, 13% dolomite lime); the calcium lime production will be the same as in the WEM and WAM scenarios.
- For the WEM and WAM scenarios the production structure will consider only calcium lime production. Given the demand of the internal market and considering the trends for activity sector presented by National Commission for Strategy and Prognosis, the production of calcium lime is estimated to decrease with 28% till 2030 compared with 2020 level and will increase with 6% in 2040 compared with estimated values for 2030.

In all scenarios, the activity data used in projections are equal and the same as those used in air pollutants projections.

CO_2 emission factors associated with lime production are estimated based on CaO and MgO contents. For CO_2 emissions projections the following assumptions will be used:

- for the WOM scenario, was used the 2005 implied emission factor
- for WEM and WAM scenario the effects of 2010/75/UE Directive and EU ETS Directive will be considered. Thus, the EF for high calcium lime considered are the average value from the period 2018-2020
- for the WAM scenario, supplementary to the legislation from WEM scenario, will be considered the effects of the National Strategy of Competitiveness. Thus, the EF for high calcium lime considered in 2030 represents 99% of the EF used in WEM scenario and is constant till 2040.

Table 5-79 presents the CO_2 emissions projections for category **2.A.2. - Lime production** for the period 2020-2040, in all three scenarios.

Table 5-79 The CO_2 emissions projection from 2A.2. Lime production, 2025-2040

Scenario	CO_2 emissions, kt					
	2005	2020	2025	2030	2035	2040
	Historic values (estimated for WOM)		Projection			
WOM	908.89	556.64	423.08	400.65	416.67	425.01
WEM	908.89	518.78	393.36	372.50	387.40	395.15
WAM	908.89	518.78	393.36	370.00	384.80	392.50

Glass Production

Glass is a material used to manufacture a wide range of products, for example: flat glass, glass for liquids, glass containers, special glass, glass wool, glass fiber, glass for liquid bottling. The melting process of raw material for production glass is often similar even the fused glass is used for manufacturing different types of products.

Production of flat glass, glass for liquids and glass fiber occurs predominantly in multinational companies, while domestic production of glass (manufacture of tableware and decorative glassware) in most cases occurs in small and medium enterprises. Unlike the production of technical glass, domestic glass production is characterized by a greater diversity of products and processes, including manual glass shaping

As the activity data of the various types of glass are confidential, only the total CO2 emissions will be presented as values. National glass production decreased from a peak in 1989 (1,137 kt) to a value of 286 kt in 1999. It followed a period of 4 years in which the amount of glass produced increased to a maximum of 538 kt (2003). On the economic crisis, quantities of glass products decreased in Romania by about 20% in 2009 compared to 2008. In the period 2014÷2016 the total glass production followed an upward trend, reaching values of 411 kt (in 2016), and in the period 2017÷2019 it will decrease up to 359 kt. The total glass production registered in 2020 was 424 kt.

The main weaknesses of this sector are the high energy intensity of the production process. Also, the production technologies have reached a high level of maturity, and in some areas, the process is highly automated (flat glass production). Thus, the ability to improve energy performance and reduce CO_2 emissions is limited. The high cost of starting production and distribution channels in some sub-sectors may hinder innovation. Moreover, production facilities are capital intensive and require long investment cycles. In some sub-sectors, the product range is very diverse, making it difficult to obtain a sufficiently large production volume to ensure adequate profit margin.

Glass manufacturing technologies existing in Romania are within the limits set by the BAT-BREF and are expected that by applying the new conclusions regarding the Best Available Technologies from 2010/75/UE Directive regarding Industrial Emissions, supplementary emissions reduction will be reached.

Considering the current economic situation, the following assumptions regarding the activity data are considered:

- on the short-term, no new facilities will be closed or opened
- the production structure considered will be that of the period 2018÷2020
- considering the requirement of the internal market and the trend presented by National Commission for Strategy and Prognosis is projected that the glass production will increase up to 426 kt in 2030, to 452 kt in 2040. These activity data will be used in all scenarios.

For the CO_2 emission projections, the following assumptions are considered for the value of the composite emission factor:

- for the WOM scenario, the value registered in the year 2005 will be used
- for the WEM scenario, the effects of 2010/75/UE Directive and EU-ETS Directive will be considered. Thus, the EF representing the average value for the period 2018-2020 will be used and will be constant until 2040.
- for the WAM scenarios, in addition to the policies considered in WEM scenario, the effects of National Strategy of Competitiveness will be considered. Thus, the EF used in 2030 represents 96%, respective 91% of the average value for the period 2018-2020.

Table 5-80 presents the CO_2 emissions projections for category **2.A.3. - Glass Production** for the period 2025-2040, in all three scenarios.

Table 5-80 The CO_2 emissions projection from 2A.3. Glass Production, 2025-2040

Scenario	CO_2 emissions, kt					
	2005	2020	2025	2030	2035	2040
	Historic values (estimated for WOM)		Projection			
WOM	46.90	65.63	63.52	66.03	68.67	70.05
WEM	46.90	55.25	51.64	53.68	55.82	56.94
WAM	46.90	55.25	51.64	51.12	50.95	49.71

Other process uses of carbonates

Carbonates (i.e. limestone, dolomite) are naturally occurring materials, non-processed, with commercial use in many industries such as metallurgy (mainly iron and steel production), glass manufacturing, agriculture, construction and environmental pollution control. CO_2 emissions are generated in industrial processes due to exposure to high temperatures.

According to IPCC 2006 GLs, within this category are considered all uses of carbonates in ceramics manufacturing, soda ash use, non-metallurgical magnesia production and other uses.

In the period 2016-2020, the quantities of dolomite, limestone and other raw materials with carbon content used in the ceramic industry reached a maximum value in 2019 (1536 kt) and the minimum in 2020 (1306 kt).

The evolution of the quantities of caustic soda used in the period 2016-2020 shows a downward trend, from 73 kt in 2017 to 38 kt in 2020.

For the category 2.A.4.d – *Other uses of limestone and dolomite*, the maximum value of the activity data was registered in 2017 (560 kt) while the minimum in the year 2020 (364kt).

In all scenarios are used the same activity data. Considering the trends provided by the National Commission for Strategy and Prognosis the following activity data are used for the projections.

Table 5-81 Projected activity data for category 2.A.4. - Other uses of carbonate category, 2025-2040

2A.4 - Other uses of carbonate	Unit	2025	2030	2035	2040
Limestone and dolomite use - ceramics	kt	1267.126	1317.811	1370.523	1397.933
Soda ash use	kt	37.331	38.824	40.377	41.185
Limestone and dolomite use - others	kt	352.753	366.863	381.538	389.169

For the WOM scenario, the CO_2 EF is used at a constant value of the EFs which are equal with the value registered in 2005.

In the WEM scenario the effects of 2010/75/UE Directive are considered. The EFs used represent the average value of the EFs registered in the period 2018-2020.

For the WAM scenario it is considered the EF for the category 2A.4.a will decrease in 2030 with 16% compared with the 2025 EF value and will be constant till 2040. For the category 2.A.4.b the EF will be the same as that used in the WEM scenario, while for the category 2A.4.d a reduction of 1% of the 2020 EF is considered for the years 2030 and 2040.

Table 5-82 presents the CO_2 emissions projections for category **2.A.4. - Other uses of carbonates,** for the period 2025-2040, in all the scenarios.

Table 5-82 The CO_2 emissions projection for category 2.A.4. - Other uses of carbonates, 2025-2040

Scenario	CO_2 emissions, kt					
	2005	2020	2025	2030	2035	2040
	Historic values (estimated for WOM)		Projection			
WOM	39.47	764.55	741.62	771.28	802.13	818.18
WEM	39.47	243.31	239.68	249.26	252.43	257.47
WAM	39.47	243.31	239.68	235.35	237.99	242.75

Chemical industry

GHG emissions resulting from chemical industry result from production processes of ammonia, nitric acid), carbide and other substances (ethylene, methanol, sulphuric acid, etc.). Thus, ammonia production is highly dependent on the natural gas availability and their price.

Ammonia production

The ammonia production process is based on the reaction between nitrogen (obtained from the atmospheric air) and hydrogen (obtained from the raw material - natural gas). Thus, ammonia production is highly dependent on the natural gas availability and their price.

The average ammonia production in the period 2018-2020 is 618 kt and represents 38% from the production value registered in 2005. For the projections are considered the trend of the chemical production provided by National Commission for Strategy and Prognosis for the period 2025-2040.

Considering the current economic situation, the following assumptions are considered:

- on the short-term, no new facilities will close or open
- the activity data are equal in all scenarios
- for the WOM scenario, the 2005 EFs were used
- for the WEM scenario the effect of Directive 2010/75/EU are considered. The value of the 2025 EF is lower with 2.5% that the average EF for the period 2018-2020, respectively with 5% for the value of the 2030 EF. For 2035 and 2040 the EF are constant and equal with the value from 2030.
- for the WAM scenario the effect of Directive 2010/75/EU and of the National Strategy for Competitiveness are considered. The EF used and the same with those from the WEM scenario for the years 2025 and 2030 and is considered that for the next years the EF will be with 6% lower than the average EF for the period 2018-2020.

Table 5-83 presents the projected evolution of CO2 emissions for category 2.B.1 Ammonia production for the period 2025-2040 in the scenarios considered.

Table 5-83 CO2 emissions for category 2.B.1 Ammonia production, 2025-2040

Scenario	CO2 emissions, kt					
	2005	2020	2025	2030	2035	2040
	Historic values (estimated for WOM)		Projection			
WOM	2900.82	1719.76	730.00	806.00	854.36	897.07
WEM	2900.82	1586.76	685.10	737.49	781.73	820.82
WAM	2900.82	1586.76	685.10	711.29	753.97	791.67

Nitric acid production

As the nitric acid production data are confidential, the report will present only the N_2O emission values.

In 2018-2020, N_2O emissions resulting from nitric acid production decreased, from 0.78 kt N_2O in 2018 to 0.31 kt N_2O in 2020.

Considering the current economic situation, the following assumptions are considered:

- on the short-term, no new facilities will close or open
- the activity data are equal in all scenarios
- for the WOM scenario, the 2005 EFs were used
- for the WEM and WAM scenarios, the 2020 EF will be used for the entire projection period

Table 5-84 presents the projected evolution of N_2O emissions for category 2.B.2 Nitric acid production for the period 2025-2040 in the scenarios considered.

Table 5-84 N_2O emissions for category 2.B.2 Nitric acid production, 2025-2040

Scenario	N2O emissions, kt					
	2005	2020	2025	2030	2035	2040
	Historic values (estimated for WOM)		Projection			
WOM	10.000	5.810	4.986	5.508	5.838	6.130
WEM, WAM	10.000	0.310	0.277	0.306	0.324	0.341

Carbide production

Silicon carbide production

As the silicon carbide production data are confidential, in the report will be presented only the CH4 emission values. In 2018-2020, CH4 emissions resulting from silicon carbide production were around 0.217 kt CH4.

Considering the current economic situation, the following assumptions are considered:

- on the short-term, no new facilities will close or open
- the activity data are equal in all scenarios
- for the WOM scenario, the 2005 EFs were used
- for the WEM scenario the 2020 EF will be used for the entire projection period
- for the WAM scenario a reduction with 5% in 2030 of the WEM EF is considered.

Table 5-85 presents the projected evolution of CH4 emissions for category 2.B.5a Silicon carbide production for the period 2025-2040 in the scenarios considered.

Table 5-85 CH4 emissions for category 2.B.5a Silicon carbide production, 2025-2040

Scenario	CH4 emissions, kt					
	2005	2020	2025	2030	2035	2040
	Historic values (estimated for WOM)		Projection			
WOM	0.830	0.260	0.224	0.246	0.261	0.274
WEM	0.830	0.230	0.206	0.227	0.241	0.253
WAM	0.830	0.230	0.201	0.216	0.229	0.240

Calcium carbide production

As the silicon carbide production data are confidential, the report will be presented only the CO2 emission values. In 2018-2020, CO_2 emissions resulting from silicon carbide production were around 5.323 kt CO_2.

Considering the current economic situation, the following assumptions are considered:

- on the short-term, no new facilities will close or open
- the activity data are equal in all scenarios
- for the WOM scenario, the maximum value of the EF from the period 2000- 2005 were used
- for the WEM scenario, the average value of the EFs of the period 2018-2020 will be used for the entire projection period
- for the WAM scenario a reduction with 5% in 2030 of the WEM EF is considered.

Table 5-86 presents the projected evolution of CO2 emissions for category 2.B.5a Silicon carbide production for the period 2025-2040 in the scenarios considered.

Table 5-86 CO2 emissions for category 2.B.5b calcium carbide production, 2025-2040

Scenario	CO2 emissions, kt					
	2005	2020	2025	2030	2035	2040
	Historic values (estimated for WOM)		Projection			
WOM	60.880	4.577	3.936	4.330	4.590	4.820
WEM	60.880	4.490	3.859	4.245	4.500	4.726
WAM	60.880	4.490	3.764	4.033	4.275	4.489

Metal industry

Emissions from this category cover the production of iron and steel, ferro-alloys production, primary aluminum production, magnesium production, lead production and zinc production.

As magnesium is not produced in Romania, no emissions were estimated for this sub-category, and no projections were made.

Iron and steel production

The main technological flows generally available worldwide in manufacturing of steel products are:

- integrated route (BF-BOF) based on iron ore and coking coal used in blast furnaces, followed by oxygen steelworks, and rolling mills

- electric route (EAF) based on the use of scrap in electric arc furnaces, followed by rolling mills
- direct reduction route, following the chain: iron ore used in reduction furnaces - electric steelworks – rolling mills.

The first flow is specific to large integrated factories, the last two being found in smaller factories. The iron and steel industry in Romania were initially develop based on local reserves of iron ore and coal and was designed in integrated flow.

In the integrated factories, process flow structure underwent several changes over time. Maintaining the main stages of the flow (pig iron production, steel making and rolling), changes were made mainly in intermediate stages.

Factories, and, in recent years, mini-mills based on electric arc furnaces were widely developed as Siemens Martin furnaces (BF-OH flow) were decommissioned and the amount of available scrap increased. At the same time, the relatively low cost of scrap used in electric arc furnace compared with the high cost of pig iron used in LD converters (BF-BOF flow) made the share of electric steel in steel production increase.

Table 5-87 shows the main iron and steel producers in Romania and changes in the types of steelmaking processes used.

Table 5-87 Overview of factories and steelmaking processes in Romania

Factory location	Year of foundation	Steelmaking route		
		Past	Actual	Future
Galaţi	1961	BF - BOF	BF- BOF	DRI-EAF
Hunedoara	1882	BF- OH	EAF	EAF
Târgoviște	1973	EAF	EAF	EAF
Câmpia Turzii	1920	EAF	EAF	EAF
Reşiţa	1771	BF-OH	EAF	EAF
Oţelu Roşu	1796	EAF	EAF	EAF
Călăraşi	1976	EAF	EAF	EAF

EAF = electric Arc Furnace; BF = Blast Furnace; BOF = Basic Oxygen Furnace; OH = Siemens Martin/Open Hearth Furnace, DRI = Direct Reduction Iron

The main sectors that use steel are construction, with a share of around 38%, followed by automotive industry (16%) and mechanical engineering (14%).

Because on the BF-BOF route, the CO_2 EF are much higher (around 5 times) than those resulted on EAF route, nationwide manufacturing structure significantly influences the emissions level.

The most important quantity of steel in Romania is made on BF-BOF route. It must be noted that the entire production of BOF steel is made in only one facility.

The economic crisis has strongly affected Romania's steel production, which decreased in 2009 by about 45% compared to 2008 and approx. 55% compared to 2007. The year 2010 marked an increase in the amount of steel produced (by 37% compared to the previous year) to a value of 3,734 kt (but still 27% lower than in 2008). In 2014-2018, the steel production at the national level increased from 3,275 kt in 2014 to 3,700 kt in 2018. In the years 2019 and 2020 steel production registered a decrease reaching a value of 2875 kt in 2020. It should be noted that over 99% of the steel produced in Romania is carried out in industrial facilities covered by the EU-ETS.

Given the current economic situation, it is considered an assumption for the projection of GHG emissions the low production of some production units. Considering the evolution of domestic and international market demand

and trends provided by CNSP, in 2030 the steel production will amount 2730 kt steel, and 2930 kt in 2040. For all scenarios are used the same activity data.

For the WOM scenario, the following assumptions are considered:

- two manufacturing flows are used: integrated and electric flow
- the values of the emission factors for CO2 are constant for each type of flow and are equal to the values from 2005 (Table 5-87). The emission factor value for CH4 is the default, presented in the 2006 IPCC guidelines.

For WEM scenario, the effect of Directive 2010/75/EU will be considered, and the following assumptions will be considered:

- in the medium term, the change of the manufacturing flow at the Galati plant from integrated to flow using the direct reduction of ores followed by steel production in electric arc furnaces is considered. Starting with 2030, no more integrated steel will be produced in Romania.
- CO_2 emission factor values decrease for the EAF steel from the average value registered in the period 2018-2020 to the value presented in Table 5-88. The value for the DRI technology will be constant for the entire forecast period. The emission factor value for CH_4 is the default EF, presented in the 2006 IPCC guidelines.

For WAM scenario, the effect of Directive 2010/75/EU and of the National Strategy for Competitiveness are considered. The assumptions used are:

- in the medium term, the change of the manufacturing flow at the Galati plant from integrated to flow using the direct reduction of ores followed by steel production in electric arc furnaces is considered. Starting with 2030, no more integrated steel will be produced in Romania.
- CO_2 emission factor values decrease for the EAF steel from the average value registered in the period 2018-2020 to the value presented in Table 5-88. The value for the DRI technology will be constant for the entire forecast period. The emission factor value for CH_4 is the default EF, presented in the 2006 IPCC guidelines.

Table 5-88 The EFs values used in CO_2 emissions projections for category 2.C.1. – Iron and Steel Production

Product	EF, t CO_2/t steel		
	WOM	WEM (in 2040)	WAM (in 2040)
BOF steel	1.911	0	0
EAF steel	0.032	0.019	0.018
Direct ore reduction	-	0.700	0.700

Table 5-89 shows the projected evolution of CO_2 emissions from 2.C.1.- *Iron and steel production* category for the period 2025÷2040 in the scenarios considered.

Table 5-89 The CO_2 emissions projection from 2.C.1. Iron and steel production, 2025÷2040

Scenario	CO_2 emissions, kt					
	2005	2020	2025	2030	2035	2040
	Historic values (estimated for WOM)		Projection			
WOM	8674.352	4007.763	3308.076	2398.530	2608.740	2780.730
WEM	8674.352	3512.671	2904.096	892.500	968.000	1029.500
WAM	8674.352	3512.671	2904.096	891.000	966.500	1028.000

Table 5-90 shows the projected evolution of CH_4 emissions from 2.C.1.- *Iron and steel production* category for the period 2025÷2040 in the scenarios considered.

Table 5-90 The CH4 emissions projection from 2.C.1. Iron and steel production, 2025÷2040

Scenario	CH4 emissions, kt					
	2005	2020	2025	2030	2035	2040
	Historic values (estimated for WOM)		Projection			
WOM	0.460	0.165	0.181	0.13	0.141	0.151
WEM, WAM	0.460	0.160	0.133	0.000	0.000	0.000

Ferro-alloys production

Since 1989 till 1993, ferro-alloys production in the Romanian steel industry declined with almost 60 %. The next period is characterized by a slow recovery till 1996 and then decreased again in 1999. After this historic low, production increased in 2004 to a value close to that of 1989, after which it decreased sharply in 2008 considering the economic crisis. In 2009, ferro-alloy production rose slightly compared to 2008. 2010 marked an increase in the amount of ferro-alloy produced (by 200% over the previous year) but still 17% compared to production in 2004.

In 2011, ferroalloys' production decreased again to 23 kt, and 13.65 kt in 2012. In the period 2013-2020, the production of ferroalloys ceased.

The main uncertainties affecting this subcategory are related to the developments in the steel sector, and the foreign market (share of transportation costs in the cost of production of ferro-alloys is low).

Given the current economic situation we assume that national ferro-alloys production will not resume and will not be realized projections for this category.

Aluminum production

Primary aluminum industry in Romania is represented by a single production unit which is vertically integrated upstream as it has its own alumina processing factory and makes up processing to the final product.

This unit is included in the EU-ETS, so that emissions from the industrial processes are found entirely under this legislation.

Since 1989, primary aluminum production in Romania decreased from about 265 kt to 107 kt in 1992. This period is followed by 16 years of continuous production growth, the maximum recorded being 265 kt in 2008. On the economic crisis, quantities of primary aluminum produced in Romania decreased by about 25% in 2009 compared to 2008. 2010 marked a slight increase in the amount of aluminum produced to a value of 206 kt (but still 22% less than in 2008). In 2011, aluminum production registered a slight increase compared to 2010 to a value of 224 kt, followed by a decrease in 2012 to 202.6 kt. In 2013 and 2014, the average production was approx. 195 kt of primary aluminum and increased to 207 kt in 2016. In 2018, the production of primary aluminum was 210 kt and 192 kt in 2020.

It is worth noting that between 1989÷2012 there were significant changes in manufacturing technology of primary aluminum, changes which reflect in the evolution of emission factors for CO_2 and PFC. Thus since 2003 only the technology with pre-baked anode cells operated by the center (CWPB) is used.

Aluminum production technology is at a mature stage of development, so emission reduction potential is limited, and there are no prospects for the development of new technologies in the near future.

Prices for most non-ferrous metals (including aluminum) are determined by the London Metal Exchange (LME) and therefore, they are not necessarily correlated with the volume of production conducted by an individual factory. Contracts between producers of non-ferrous metals and their customers always refer to the LME price, regardless of the size of the contract. Thus, the aluminum industry operates in a global marketplace.

Given the current economic situation, the following assumptions are considered:

- on the short-term, no new facilities will close or open
- based on the domestic and international market demand and trends presented by CNSP, it is projected that the production of primary aluminum will be 174 kt in 2025 and 186 kt in 2040.
- the activity data are equal in all scenarios.

For CO_2 emissions projections the following assumptions for emission factors are considered:

- for the WOM scenario, the maximum value of the emission factor from 2000-2005 will be used, and it will be kept constant for the forecast period (1.690 t CO_2/t primary aluminum)
- for WEM and WAM scenarios, the effect produced by the application of Directive 2010/75/EU will be considered. Thus, the emission factor will decrease by 5% till 2030 and will reach a value of 1.45 t CO_2/t primary aluminum in 2040.

Table 5-91 shows the projected evolution of CO_2 emissions for category 2.C.3.- *Aluminum production* for the period 2025÷2040 in the scenarios considered.

Table 5-91 The CO_2 emissions projection for 2.C.3. Aluminum production, 2025÷2040

Scenario	CO2 emissions, kt					
	2005	2020	2025	2030	2035	2040
	Historic values (estimated for WOM)		Projection			
WOM	372.620	325.241	281.260	293.555	305.297	314.455
WEM, WAM	372.620	314.900	264.617	269.237	270.974	269.799

For PFC emissions projections the following assumptions for emission factors are considered:

- for the WOM scenario, the value of the emission factor from 2005 will be used, and it will be kept constant for the forecast period (0.399 t CO_{2eq}/t primary aluminum)
- for WEM scenario, the effect produced by the application of Directive 2010/75/EU will be considered. The emission factor used represents the average value from the last three years (2018-2020), respectively 0.020 t CO_{2eq}/t primary aluminum, and will remain constant until 2040.
- for WAM scenario, the effect produced by the application of Directive 2010/75/EU and the National Strategy for Competitiveness will be considered. The emission factor used represents the minimum value from the last three years (2018-2020), respectively 0.018 t CO_{2eq}/t primary aluminum, and will remain constant until 2040.

Table 5-92 shows the projected evolution of PFC emissions for category 2.C.3.- *Aluminum production* for the period 2025÷2040 in the scenarios considered.

Table 5-92 The PFC emissions (as CO2 eq) projection from 2.C.3. Aluminum production, 2025÷2040

Scenario	PFC emissions, kt CO2 eq					
	2005	2020	2025	2030	2035	2040
	Historic values (estimated for WOM)		Projection			
WOM	95.280	76.788	66.404	69.307	72.079	74.241
WEM	95.280	3.520	3.329	3.474	3.613	3.721
WAM	95.280	3.520	2.996	3.127	3.252	3.349

Lead production

Lead is obtained from two types of raw materials: concentrated lead ores (primary lead) and recycled lead (secondary lead). The primary lead is obtained from ore containing sulphur and other lead compounds and from other metals (mainly zinc, silver and copper). The main techniques applied to the melting process are based on using shaft furnace or electric furnace. The main refining techniques are pyrometallurgical or hydrometallurgical.

The secondary production of refined lead amounts to the processing of recycled lead to prepare it for reuse. Most of this recycled lead comes from scrapped lead acid batteries.

As the lead production is confidential, in the report will be presented only the CO_2 emission values.

Lead production in Romania decreased from 1989 to 1992. This period was followed by a series of 16 years of a continuous increase in production, the maximum value being recorded in 2005 (exceedingly even the production of 1989). Due to the economic crisis, the quantities of lead produced in Romania decreased by approx. 85% in 2009 compared to 2008.

In 2014-2018, CO_2 emissions resulting from lead production increased about ten times, from 0.677 kt CO_2 in 2014 to 7.735 kt CO_2 in 2018, with a maximum value of 9.159 kt CO_2 in 2017. CO2 emission in 2020 were 7.970 kt CO_2.

Considering the current economic situation, the following assumptions are considered:

- on the short-term, no new facilities will close or open
- the activity data are equal in all scenarios
- for the WOM scenario, the 2005 EFs were used
- for the WEM the average EFs from the period 2018-2020 were used for the entire projection period
- for the WAM scenario are considered that the EFs will be lower than the one considered in WEM scenario

Table 5-93 shows the projected evolution of CO_2 emissions for category 2.C.5.- *Lead production* for the period 2025-2040 in the scenarios considered.

Table 5-93 The CO_2 emissions projection from 2.C.5. Lead production, 2025-2040

Scenario	CO_2 emissions, kt					
	2005	2020	2025	2030	2035	2040
	Historic values (estimated for WOM)		Projection			
WOM	18.270	8.209	6.764	7.061	7.343	7.562
WEM	18.270	7.970	6.567	6.855	7.129	7.342
WAM	18.270	7.970	6.403	6.512	6.772	6.975

Zinc production

Zinc is manufactured from two types of raw materials: from zinc concentrate (primary zinc) and from recycled zinc (secondary zinc).

The primary zinc is manufactured from ore which content around 85% zinc sulphide and 8-10% iron sulphide, with a total zinc concentration of approx. 50%. Significant activities for primary zinc production are the transfer and storage of raw materials and products; oxidation of zinc concentrates in the presence of air; manufacture of electrochemical or zinc pyrometallurgical and refining of zinc.

Secondary zinc is obtained from metallic waste and materials containing zinc - other than the extracted ores / concentrates obtained by mining operations.

As the zinc production is confidential, the report will be presented only the CO_2 emission values.

Zinc production in Romania decreased from 1989 to 1991 when it reached a value of 30% of the output of 1989. This period was followed by 18 years of a continuous increase in production, the maximum value being recorded in 2008 (double value compared to 1989). Due to the economic crisis, the quantities of zinc produced in Romania decreased being almost zero. In 2014-2020, CO_2 emissions resulting from zinc production had values lower than 1.5 kt CO2.

Considering the current economic situation, the following assumptions are considered:

- on the short-term, no new facilities will close or open
- for the WOM scenario is used the maximum value of the EFs from the period 2000-2005
- for the WEM is used the average value of the EFs from the period 2018-2020
- for the WAM scenario the EF used represent 98% from the value of the EF used in WEM scenario

Table 5-94 shows the projected evolution of CO_2 emissions from 2.C.6.- *Zinc production* category for the period 2025-2040 in the scenarios considered.

Table 5-94 The CO_2 emissions projection for category 2.C.6. Zinc production, 2025-2040

Scenario	CO_2 emissions, kt					
	2005	2020	2025	2030	2035	2040
	Historic values (estimated for WOM)		Projection			
WOM	97.690	0.567	0.465	0.486	0.506	0.521
WEM	97.690	0.550	0.451	0.472	0.491	0.506
WAM	97.690	0.550	0.448	0.466	0.485	0.500

Non-energy products from fuels and solvent use

In this sector are included the resulted emissions from non-energy use of products, and the emissions from solvents used.

Given that 2018 ÷ 2020 emissions from category 2.D *Non-energy products from fuels and the use of solvents* contributed by approx. 0.5 % of the total net GHG emissions in Romania (excluding LULUCF) and the difficulty of projection, in the long run, the way of carrying out the activities that determine these emissions' occurrence, the extrapolation method will be used.

Thus, the emissions forecast for the WOM scenario is made by extrapolating the 2005 emission value with an annual rate of 0.8% for the period 2006 ÷ 2040.

For WEM and WAM scenarios, technological improvements, environmental protection investments are considered, contributing to the reduction of emissions.

Thus, CO_2 emissions will gradually decrease with 19% in 2030 compared with the value registered in 2020, and with 14% in 2040 (vs. 2030 emissions value)

In Table 5-95 are presented the evolution of CO_2 emissions projection for the category 2.D. Non-energy products from fuels and solvent use for the period 2025-2040.

Table 5-95 The CO_2 emission of for category 2.D.- Non-energy products from fuels and solvent use, 2025-2040

Scenario	CO_2 emissions, kt					
	2005	2020	2025	2030	2035	2040
	Historic values (estimated for WOM)		Projection			
WOM	1262.17	560.60	456.89	392.47	354.79	337.41
WEM, WAM	1262.17	544.27	443.58	381.04	344.46	327.58

Product uses as substitutes for ODS

Category **2.F**. - *Products uses as substitutes for ozone depleting substances* includes the following subcategories: *Refrigeration and Air conditioning* (2.F.1), *Foams blowing agents* (2.F.2), *Fire protection* (2.F.3), *Aerosols* (2.F.4) and *Solvents* (2.F.5).

At the national level, estimates for fluorinated gas emissions include emissions from the manufacture, operation and decommissioning of equipment. For most of the subcategories in estimating emissions presented in the national GHG inventory a Tier 2 method from 2006 IPCC GLs are used.

In the period 1989-2020, the accounted values present a sharp increase from 0.15 kt CO_{2eq} (1989) to 1988 kt CO_{2eq} (2020).

In the period 2014-2020 there is a tendency to decrease the annual growth rate. Thus, in the period 2018-2020 the average annual growth rate was 2.7%. This trend is maintained for most of the subcategories.

Category Air conditioning and refrigeration equipment - 2.F.1. weights about 97.3% of the total category 2.F, Aerosols - 2.F.4 represents 2.3%, Foams - 2.F.2. (0.07%) and Fire-fighting installations - 2.F.3. (0.33%). These weights were calculated as average values for the period 2018-2020.

For the Solvents category - 2.F.5. no fluorinated gas emissions are recorded, and no projections will be presented.

In the period 2018-2020, there was an increase in emissions from sub-category 2.F.1 of approx. 4.7%, from 1846 kt CO_{2eq} (2018) to 1934 kt CO_{2eq} (2018).

In the period 2018-2020, there is a decrease of emissions from sub-category 2.F.2 - Foams, from 1.68 kt CO_{2eq} (2018) to 0.52 kt CO_{2eq} (2020).

For category 2.F.3 Fire protection, in the period 2018-2020 the emission values are almost constant, around 4.9 kt CO_{2eq}.

Emissions from category 2.F.4. Aerosols recorded an increasing trend from 40.93 kt CO_{2eq} (2018) to 49.11 kt CO_{2eq} (2020).

In WEM and WAM scenarios were considered the effects of the following regulations:

- Regulation no. 517/2014 on fluorinated greenhouse gases (F-gases) which repeal Regulation No. 842/2006 have been applying since 1 January 2015 and aims to reduce these emissions by two thirds in 2030 compared to 2015 levels.
- Directive 40/2006 / EC (MAC) on emissions from air conditioning systems in motor vehicles who provides the gradual replacement of air-conditioning systems for vehicles using HFC-134a.
- Law 30/2020 (Kigali Amendment, 2016) published in the Official Gazette. no. 275/2 Apr. 2020 by which emission limits are set for substances in category F gases (HFCs and HCFCs) until 2045.

Given the high uncertainties on the use of fluorinated gases for the projections, an extrapolation method for emissions was used. For each sub-category and scenario, emissions were extrapolated using the methodology and factors set out in guidelines for achieving sectoral emission projections[56].

Table 5-96 presents the projected evolution of HFC emissions (as CO_{2eq}) for category 2.F for 2025-2040 in the three scenarios considered.

Table 5-96 HFC emissions (as CO_{2eq}) for the category 2.F, 2025-2040

Scenario	HFC emissions, kt CO_{2eq}					
	2005	2020	2025	2030	2035	2040
	Historic values (estimated for WOM)		Projection			
WOM	374.57	2648.27	3303.95	3506.91	3562.29	3573.36
WEM, WAM	374.57	1988.57	1891.42	1760.79	1707.88	1654.96

Starting with the year 2017 from the category 2.F1 are estimated PFC emissions and therefore the projections are elaborated. The assumptions used are similar to those for HFC emissions. Table 5-97 presents the projected evolution of PFC emissions (as CO_{2eq}) for category 2.F for 2025-2040 in the scenarios considered.

Table 5-97 PFC emissions (as CO_{2eq}) for the category 2.F, 2025-2040

Scenario	PFC emissions, kt CO_{2eq}					
	2005	2020	2025	2030	2035	2040
	Historic values (estimated for WOM)		Projection			
WOM	0.000	0.026	0.043	0.045	0.046	0.046
WEM, WAM	0.000	0.024	0.023	0.022	0.021	0.024

Other product manufacture and use

This category includes emissions from electronic equipment production, emissions of SF6 and PFCs from products other than those of the previous categories and N_2O emissions from the use of products.

Considering that emissions from category 2.G *Other product manufacture and use* represent around 0.07% of the total net GHG emissions (without LULUCF) in the period 2018÷ 2020 and the difficulty to conduct long-term projections of activities that causes these emissions, the extrapolation method for emissions was used.

Thus, the projection of N_2O emissions for the WOM scenario is made by extrapolating the emission value from 2005 with the average annual rates of 0.8% for the period 2006 ÷ 2040. For the WEM and WAM scenarios, it is considered that they will evolve at different annual average rates (between 1% and 2%).

[56] 1GHG Projection Guidelines, Part B: Sectoral Guidance, Final report, CLIMA.A.3./ SER/ 2010/0004, 2012

For SF_6 emissions in the WOM scenario, the emissions were extrapolated, considering the methodology and coefficients presented in the *Sectoral Guidelines for making emission projections* for this type of scenario.

For WEM and WAM scenarios for SF6 emissions, the effects of the Regulation no. 517/2014 on fluorinated greenhouse gases application are considered, emissions being extrapolated using the methodology and coefficients presented in the *Sectoral Guidelines for the realization of emission projection.*

In Table 5-98 and Table 5-99 are presented the projected evolution of N_2O and SF_6 emissions for category 2.G - Production and use of other products for the period 2025-2040 in the scenarios considered.

Table 5-98 N_2O emissions for category 2.G - Production and use of other products, 2020-2040

Scenario	N_2O emissions, kt N_2O					
	2005	2020	2025	2030	2035	2040
	Historic values (estimated for WOM)		Projection			
WOM	0.00760	0.00717	0.00753	0.00800	0.00866	0.00956
WEM, WAM	0.00760	0.00696	0.00732	0.00777	0.00840	0.00927

Table 5-99 SF_6 emissions for category 2.G - Production and use of other products, 2020-2040

Scenario	SF_6 emissions, kt SF_6					
	2005	2020	2025	2030	2035	2040
	Historic values (estimated for WOM)		Projection			
WOM	0.000687	0.00369	0.00209	0.00123	0.00118	0.00113
WEM, WAM	0.000687	0.00358	0.00202	0.00119	0.00114	0.00110

A.4.3 Agriculture

The following direct GHG emissions occur in the Agricultural sector:

- CH4 from enteric fermentation
- CH4 and N2O from manure management
- CH4 from rice cultivation
- N2O from use of fertilizers
- CH4 and N2O from agricultural residue burning in the field.

Enteric fermentation

GHG emissions projections related to animal husbandry are presented below.

WOM Scenario

The evolution of the number of animals in the period 2025÷2040 was achieved by extrapolating the values from 2005 with the following average annual rates (maintained from the previous National Communication):

- 1,1% for cattle
- 1,9% for swine
- 1,4% for sheep
- 1,1% for goats
- 2,0% for horses
- 1,1% for poultry

The forecasts for the years 2025-2040 were calculated based on the 2006 IPCC Gls and are based only on the evolution of the number of animals of each species. The emissions predicted in the WOM scenario for the livestock sub-sector are shown below.

Table 5-100 CH4 emissions from enteric fermentation in the WOM scenario

CFR	Category	WOM Enteric methane emissions (Gg)					
		Inventory		Projections			
		2005	2020	2025	2030	2035	2040
3A	Dairy cattle	199.59	235.18	248.41	262.37	277.12	292.70
	Non-dairy cattle	76.74	90.43	95.51	100.88	106.55	112.54
	Sheep	59.47	70.08	74.02	79.34	85.06	91.18
	Swine	10.29	12.13	12.81	20.50	22.52	36.06
	Goats	3.43	4.04	4.27	4.51	4.76	5.03
	Horses	15.04	17.72	18.68	18.87	19.06	19.25
	Buffalo	2.46	2.90	3.06	3.23	3.42	3.61
	Total 3A	**367.29**	**432.47**	**460.43**	**494.99**	**524.44**	**568.97**

WEM Scenario

In the scenario with measures, livestock were disaggregated into the two major livestock systems (domestic and industrial). This disaggregation also required the modification of the values of the duration of housing, the gross energy ingested, the quality of the feed administered, the nitrogen excreted and the waste management system. Given that the measures have a higher probability of being implemented at the level of large farms that raise animals in an industrial system, the share of emission reductions is addressed in a higher percentage to this category.

The assumptions in the scenario with measures were as follows:

- Reduction of methane emissions from enteric fermentation by 5% in 2025, in cattle and pigs in the industrial system, due to the improvement of genetic material and feed quality; reducing emissions by 10% for all categories in the industrial system, and 7% for bulls, respectively 10% for pigs, buffaloes and sheep in the household system (farmers with a larger number of heads, who receive Agri-environmental and Climate subsidies) in 2030; 17% reduction for all categories in the industrial system and 10% for those in the household system, in 2035; 20% reduction in all categories in the industrial system and 15% in those in the household system, in 2040.

GHG emissions from the WEM scenario are presented in Table 5-101.

Table 5-101 CH4 emissions from enteric fermentation in the WEM scenario

CFR	Category	WEM Enteric methane emissions (Gg)					
		Inventory		Projections			
		2005	2020	2025	2030	2035	2040
3A	Dairy cows	199.59	138.47	87.64	84.57	79.96	76.80
	Non-dairy cows	76.74	48.61	39.27	38.88	35.76	41.51
	Sheep	59.47	80.13	186.17	178.75	175.12	161.67

	Pigs	10.29	5.07	73.80	71.86	70.88	70.77
	Goats	3.43	8.06	31.15	41.87	51.72	63.67
	Horses	15.04	7.65	12.36	11.63	9.98	8.37
	Buffalo	2.46	1.07	1.30	1.20	1.20	1.17
	Total 3A	**367.02**	**289.06**	**431.69**	**428.75**	**424.63**	**423.96**

WAM scenario

The number of animals is identical to that in the WEM scenario. The assumptions for the WAM scenario were as follows:

- Reduction of methane emissions from enteric fermentation by 5% in 2025, 10% in 2030, 15% in 2035 and 20% in 2040, for all livestock raised in the industrial system, due to the change in the quality and quantity of rations

The GHG emissions in the WAM scenario are presented in Table 5-102.

Table 5-102 CH4 emissions from enteric fermentation in the WAM scenario

CFR	Category	WAM - CH_4 emissions from enteric fermentation (Gg)					
		Inventory		Projections			
		2005	2020	2025	2030	2035	2040
3A	Dairy cows	199.59	138.47	86.45	81.34	76.02	70.77
	Non-dairy cows	76.74	48.61	38.38	36.94	33.29	36.52
	Sheep	59.47	80.13	184.61	175.86	171.16	156.41
	Pigs	10.29	5.07	72.25	68.79	66.55	65.20
	Goats	3.43	8.06	30.96	41.41	50.44	61.65
	Horses	15.04	7.65	12.29	11.50	9.75	8.05
	Buffalo	2.46	1.07	1.30	1.18	1.17	1.12
	Total 3A	**367.02**	**289.06**	**426.24**	**417.03**	**408.38**	**399.72**

Manure management

For the category manure management were developed three scenarios.

WOM scenario

The assumptions for this scenario are the same with those used in estimation of GHGs emissions from the enteric fermentation.

Table 5-103 CH4 emissions from manure management in the WOM scenario

CFR	Category	WOM Methane emissions from manure management (Gg)					
		Inventory		Projections			
		2005	2020	2025	2030	2035	2040
3B a	Dairy cattle	10.85	12.78	13.50	14.26	15.06	15.91
	Non-dairy cattle	2.61	3.08	3.25	3.43	3.62	3.83
	Sheep	1.76	2.07	2.32	2.34	2.36	2.37

	Swine	18.78	22.13	27.36	30.06	33.03	36.29
	Goats	0.09	0.11	0.11	0.12	0.12	0.13
	Horses	1.3	1.53	1.35	1.37	1.38	1.39
	Buffalo	0.22	0.26	0.27	0.34	0.36	0.45
	Poultry	2.23	2.63	2.78	3.45	3.65	4.54
	Total 3B a	**37.84**	**44.59**	**50.95**	**55.38**	**59.59**	**64.92**

Table 5-104 Direct and indirect N2O emissions in WOM scenario

CFR	Category	WOM Direct N_2O emissions (Gg)					
		Inventory		Projections			
		2005	2020	2025	2030	2035	2040
3B b	Dairy cattle	0.53	0.62	0.66	0.70	0.74	0.78
	Non-dairy cattle	0.17	0.20	0.21	0.22	0.24	0.25
	Sheep	0.46	0.54	0.57	0.61	0.66	0.71
	Swine	0.7	0.82	0.87	0.96	1.05	1.16
	Goats	0.04	0.05	0.05	0.05	0.06	0.06
	Horses	0.09	0.11	0.11	0.11	0.11	0.12
	Buffalo	0.01	0.01	0.01	0.01	0.01	0.01
	Poultry	0.1	0.12	0.12	0.13	0.14	0.15
	Total	**2.1**	**2.47**	**2.61**	**2.80**	**3.00**	**3.22**

CFR	Category	WOM Indirect N_2O emissions (Gg)					
		Inventory		Projections			
		2005	2020	2025	2030	2035	2040
3B b	N volatilization	141.9	167.205	176.606	186.535	197.023	208.100
	N_2O_g	2.23	2.63	2.78	2.93	3.10	3.27
	N leach	0.03	0.04	0.04	0.04	0.05	0.05
	N_2O_l	0.0004	0.0005	0.0005	0.0005	0.0006	0.0006
	Total	**2.23**	**2.63**	**2.78**	**2.93**	**3.10**	**3.27**
	Total direct + indirect	**4.33**	**5.10**	**5.39**	**5.73**	**6.10**	**6.49**

For indirect N2O, emissions in historical years are not presented disaggregated by animal category, therefore emission forecasts were presented in the same manner.

WEM scenario

For 3B category – Animal manure management, forecasts were based on growth rates provided by the Animal Husbandry Policy Directorate (Ministry of Agriculture and Rural Development). For the categories of interest for forecasts, the following population dynamics have been established:

- growth rates for dairy cattle, non-dairy cattle, and buffalo:
  - +0,77%/year, for 2020-2025 period and
  - +0,28%/year, for 2025-2030

- growth rates for sheep and goat:
  - 0,326%/year, for 2020-2025 period and
  - 0,635%/year, for 2025-2030
- growth rates for fattening pigs:
  - 1,78%/year, for 2020-2025 period and
  - 0,88%/year, for 2025-2030
- growth rates for sows:
  - 1,81%/year, for 2020-2025 period and
  - 0,88%/year, for 2025-2030
- growth rates for laying hens and broilers:
  - 0,48%/year, for 2020-2025 period and
  - 0,617%/year for 2025-2030
- decreasing rates, compared to 2020:
  - horses: 1%/year
  - rabbits 5%/Year.

The number of animals for fattening were corrected for number of days of life, according to the equation of equation 10.1 of the IPCC GLs, 2019 and according to the rearing system.

For the fattening pigs category, the herds were corrected with 90 days of life in the industrial system and 200 days of life in the household system, and for broilers, the herds were corrected with 42 days of life in the industrial system and 90 days of life in the household system.

Based on the data provided by the Animal Husbandry Policy Directorate (Ministry of Agriculture and Rural Development), the following manure management systems were used:

- cattle, sheep and goat manure, poultry - 100% solid storage
- pig manure – 50% solid storage (traditional system) and 50% liquid storage (industrial system).

Based on the report of the National Institute of Statistics regarding the Structural Survey in Agriculture (2016) and the Agricultural Census (2020 – provisional data), an estimate was established of the percentage of animals that are in households (entities without legal personality) and how many in the industrial system. For pig herds, in the Ministry of Environment, Waters and Forests data request address to the Ministry of Agriculture and Rural Development, it was established that 50% of the herd is in an industrial exploitation system, with a manure collection system on grates and a water cushion (lower emissions of methane and nitrous oxide).

Considering the structure of agriculture (previously presented), in the opinion of the expert, for forecasts, the following structure of the herds was established:

- dairy cattle: 20% in industrial system (650 kg/head) in 2025 and 22% in 2030; those from the traditional system have an average weight of 470 kg/head
- non-dairy cattle: 40% industrial system in 2025 and 45% in 2030 (average weight 481 kg); those in the traditional system have an average mass of 200 kg (being raised only for slaughter and own consumption);
- sheep: 85% traditional system (including transhumance), for both target years
- goats: 90% traditional system, for both target years
- dairy buffaloes: 10% farm system (which includes grazing 180 days/year) in 2025 and 12% in 2035 (average weight of 550 kg); those in the household system have an average mass of 490 kg. For the category of

other buffaloes, the same percentages are kept for the target years and the weight of 200 kg, in both exploitation systems; the data related to the herds of milk buffaloes were taken from the Ministry of Agriculture and Rural Development response address, technical report, at the request of the Ministry of Environment, Waters and Forests

- horses: 90% household system in 2025 and 2030, with an average mass of animals of 450 kg
- for rabbits, the masses used in RO-IIR-2022 were taken over, regardless of the breeding system
- laying hens represent 40.90% of the total flock, and in the broiler sector the percentage is 59.10%. (https://www.revista-ferma.ro/articole/zootehnie/gaina-multimilionara-avicultura-intre-statistici-si-proiecte-tip). The situation at the level of 2025 could increase the share of birds raised in an intensive system, but considering the increase in the price of electricity, at least in the sector of laying hens, it cannot be higher than 5%. Estimated, at the level of 2025 and 2030, 50% of the flock of laying hens will be raised in an intensive system
- broilers - estimated at the level of 2025, 45% of the flock will be produced, in an intensive system and 48%, at the level of 2030
- for pig herds, at the level of 2021, 50% were exploited in the industrial system and 50% in the household system, according to the data of the Animal Husbandry Policy Directorate (Ministry of Agriculture and Rural Development). We estimate that these percentages are valid for fattening pigs and less so for sows, which, according to the expert, are 75% raised in an industrial system. For the target years, we maintain the specified percentages at the 2021 level.

The assumptions in the scenario with measures were as follows:

- Reducing methane emissions from litter management by 5% in 2025, 10% in 2030, 15% in 2035 and 25% in 2040 due to better manure management and an increase in the proportion of farmers receiving subsidies and complying Agri environment and climate measures.
- Reduction of direct and indirect N2O emission from garbage management by 5% in 2025, 12% in 2030, 15% in 2035 (17% in pigs for indirect N2O, because they are in high proportion in the industrial system, where no phenomena of washing or infiltration) and 25% in 2040, due to the application of better manure management and the increase in the share of farmers receiving subsidies and complying with Agri-environment and climate measures and best available techniques (BAT), for large farms pigs and birds.

Table 5-105 CH4 emissions from manure management in the WEM scenario

CFR	Category	WEM Manure management methane emissions (Gg)					
		Inventory		Projections			
		2005	2020	2025	2030	2035	2040
3B a	Dairy cows	10.85	7.53	3.92	3.85	3.81	3.65
	Non-dairy cows	2.61	1.87	1.35	1.34	1.26	1.51
	Sheep	1.76	2.38	7.07	6.92	6.74	6.14
	Pigs	18.78	10.45	9.27	9.17	9.05	8.67
	Goats	0.09	0.21	1.16	1.49	2.01	2.42
	Horses	1.3	0.64	2.05	1.85	1.67	1.40
	Buffalo	0.22	0.1	0.74	0.69	0.64	0.57
	Birds	2.23	1.79	2.14	2.09	2.03	1.88
	Total 3B a	**37.84**	**24.97**	**27.69**	**27.40**	**27.21**	**26.24**

Table 5-106 Direct and indirect N2O emissions in the WEM scenario

CFR	Category	WEM Manure management N_2O direct emissions (Gg)					
		Inventory		Projections			
		2005	2020	2025	2030	2035	2040
3B b	Dairy cows	0.53	0.62	0.67	0.63	0.62	0.58
	Non-dairy cows	0.17	0.20	0.26	0.31	0.29	0.36
	Sheep	0.46	0.54	0.33	0.32	0.32	0.29
	Pigs	0.7	0.82	0.70	0.68	0.67	0.66
	Goats	0.04	0.05	0.06	0.07	0.10	0.12
	Horses	0.09	0.11	0.14	0.13	0.12	0.10
	Buffalo	0.01	0.01	0.01	0.01	0.01	0.01
	Birds	0.1	0.12	0.03	0.03	0.03	0.03
	Total	**2.1**	**2.47**	**2.20**	**2.18**	**2.16**	**2.14**
CFR		**WEM Manure management N_2O indirect emission (Gg)**					
		Inventory		Projections			
		2005	2020	2025	2030	2035	2040
3Bb	N volatilization	141.9	116.98	109.43	105.14	104.00	103.14
	N2Og	2.23	1.84	1.72	1.65	1.63	1.62
	N leach	0.034	0.027	0.0910	0.0736	0.0895	0.0850
	N2Ol	0.00040	0.00032	0.00107	0.00087	0.00105	0.00100
	TOTAL	**2.230**	**1.839**	**1.721**	**1.653**	**1.631**	**1.621**
	Total direct + indirect	**4.330**	**4.313**	**3.925**	**3.829**	**3.793**	**3.762**

WAM scenario

The number of animals is identical to that in the WEM scenario. The assumptions for the WAM scenario were as follows:

- Reducing methane emissions from waste management by 5% in 2025, 12% in 2030, 12% in 2035 and 15% in 2040, due to improved techniques for incorporating composted manure into the soil, covering composting piles and recovering methane through anaerobic digestion, in digesters
- Reduction of direct and indirect N2O emissions by 5% in 2025, 10% in 2030, 17% in 2035 and 25% in 2040 due to improved techniques for incorporating composted manure into the soil, covering fermentation piles and decreasing the time between application and incorporation.

Table 5-107 CH4 emissions from manure management in the WAM scenario

CFR	Category	WAM - CH_4 emission from manure management (Gg)					
		Inventory		Projections			
		2005	2020	2025	2030	2035	2040
3B a	Dairy cows	10.85	7.53	3.72	3.46	3.35	3.10
	Non-dairy cows	2.61	1.87	1.28	1.20	1.11	1.28
	Sheep	1.76	2.38	6.72	6.22	5.93	5.22
	Pigs	18.78	10.45	8.81	8.26	7.97	7.37

	Goats	0.09	0.21	1.10	1.34	1.76	2.06
	Horses	1.3	0.64	1.95	1.66	1.47	1.19
	Buffalo	0.22	0.1	0.70	0.62	0.56	0.48
	Birds	2.23	1.79	2.03	1.88	1.79	1.60
	Total 3B a	**37.84**	**24.97**	**26.31**	**24.66**	**23.94**	**22.31**

Table 5-108 Direct and indirect N2O emissions in the WAM scenario

CFR	Category	WAM N_2O direct emissions form manure management (Gg)					
		Inventory		Projections			
		2005	2020	2025	2030	2035	2040
3B b	Dairy cows	0.53	0.62	0.63	0.57	0.53	0.43
	Non-dairy cows	0.17	0.20	0.24	0.28	0.25	0.27
	Sheep	0.46	0.54	0.31	0.29	0.26	0.22
	Pigs	0.7	0.82	0.67	0.61	0.56	0.49
	Goats	0.04	0.05	0.06	0.07	0.08	0.09
	Horses	0.09	0.11	0.14	0.11	0.10	0.07
	Buffalo	0.01	0.01	0.01	0.01	0.01	0.00
	Birds	0.1	0.12	0.03	0.03	0.03	0.02
	Total	**2.1**	**2.47**	**2.09**	**1.96**	**1.79**	**1.61**

CFR		WAM N_2O indirect emissions from manure management (Gg)					
		Inventory		Projections			
		2005	2020	2025	2030	2035	2040
3Bb	N volatilization	141.9	116.98	103.96	94.63	86.32	77.36
	N2Og	2.23	1.84	1.63	1.49	1.36	1.22
	N leach	0.034	0.027	0.0865	0.0662	0.0743	0.0638
	N2Ol	0.00040	0.00032	0.00102	0.00078	0.00088	0.00075
	TOTAL	**2.230**	**1.839**	**1.635**	**1.488**	**1.357**	**1.216**
	Total N_2O direct + indirect	**4.330**	**4.313**	**3.729**	**3.446**	**3.152**	**2.822**

Rice cultivation

In this sector are included the resulted emissions from the rice cultivation. Given that 2018 ÷ 2020 emissions from category 3.C Rice cultivation contributed by approx. 0.02 % of the total net GHG emissions in Romania (excluding LULUCF) and the difficulty of projection, in the long run, the way of carrying out the activities that determine these emissions' occurrence, the extrapolation method will be used.

Thus, the emissions forecast for the WOM scenario is made by extrapolating the 2005 emission value for the period 2006 ÷ 2040.

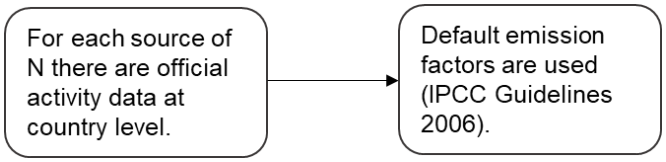
For WEM and WAM scenarios, are considered the average emissions from the period 2018-2020.

Agricultural soils

This chapter presents the methods, activity data and forecasts of nitrous oxide (N2O) emissions resulting from anthropogenic activities and inputs or from nitrogen (N) mineralization.

N2O emissions can result directly (from the soils on which nitrogen is applied from various organic and mineral sources) and indirectly (**a.** after the volatilization of NH3 and NOx from cultivated soils and from the burning of fossil fuels and biomass and subsequent redeposition of these gases and their products – NH4+ and NO3− to soils and waters; and **b.** after leaching and leaching of N, especially as NO3− from cultivated soils). Direct emissions and indirect emissions of N2O from cultivated soils are estimated separately from a methodological point of view but using common activity data.

To estimate direct emissions of cultivated soils, Tier 1 of the methodology proposed by the IPCC Guide 2006 was adopted, which assumes the following:



N2O emissions were estimated for the years 2025, 2030, 2035 and 2040.

Direct N2O emissions

Method. Equation 11.1 from the methodology proposed by the IPCC Guide 2006 was used to estimate direct emissions (Direct N2O–N). The default values used for emission factors are shown below:

Emission factors	Default value	Uncertainty range
EF_1	0.01	0.003 – 0.03
EF_{1FR}	0.003	0.000 – 0.006
EF_{3PR}	0.02	0.007 – 0.06

Scenarios. Depending on the environmental policies adopted, a "scenario with measures" (WEM), a "scenario with additional measures (WAM)" and a "scenario without measures" (WOM) were realized.

For the WOM scenario, a five-year linear increase in emissions was simulated as a result of the inputs increase and/or production increase compared to the reference year, 2005, as below:

Category	2005	2010	2015	2020	2025	2030	2035	2040
F_{SN}	-	+4%x5	+8%x5	+12%x5	+16%x5	+20%x5	+24%x5	+28%x5
F_{AM}	-	+1,5%x5	+3%x5	+4,5%x5	+6%x5	+7,5%x5	+9%x5	+10,5%x5
F_{PRP}	-	+2%x5	+4%x5	+6%x5	+8%x5	+10%x5	+12%x5	+14%x5
F_{CR}	-	+0,15%x5	+0,5%x5	+1%x5	+1,5%x5	+2%x5	+2,5%x5	+3%x5

The WEM scenario reflects the current state generated by the application of measures in accordance with the legislative provisions: Directive 91/676/EEC (nitrates directive), Government Decision no. 964/2000 regarding the approval of the Action Plan for the protection of waters against nitrate pollution from agricultural sources; MADR's Code of Good Agricultural Practices; Directive 86/278/EEC regarding the recycling of sewage sludge in agriculture;

Order 344/2004 of MADR and the Romanian Ministry of the Environment regarding the recycling of sewage sludge in agriculture.

The WAM scenario is possible in the conditions where there are some policies, strategies and programs of measures intended to intensify actions to increase the sustainability, resilience of the environment and reduce the effects of agricultural production on the climate. Thus, the implementation of Directive 2018/851/PE, CE aimed at increasing the recycling of biowaste was considered, which is essential for meeting the EU objective of recycling 65% of municipal waste by 2035 (EEA, 2020) which can contribute to reducing the amounts of synthetic fertilizers. At the same time, the natural replacement of some of the plant varieties and hybrids with those that resulted, among others, because of the research programs funded under the Framework Program for Research, Development, and Innovation of the European Union, ORIZONT 2020, must also be considered. They will have greater efficiency in the use of nutrients and water. Also, the effects of the new crop cultivation technologies built within the research projects financed by the same program, which aim at the valorization of bio-waste, the reduction of GHG emissions, the protection of soils, the resilience of ecosystems, etc., can be considered.

Activity data. The following sources were used:

a. Total quantities of synthetic fertilizers with N, P and K used in the period 2016-2021 and consumption forecasts for the years 2030 and 2050 and data on the cultivated land surfaces in Romania with the main crops in the period 2010-2021 and forecasts for the years 2030 and 2050 (Annex_1: Data tables from the Ministry of Agriculture and Rural Development (MADR) submitted to the Ministry of Environment, Water and Forests by address no. 4646/27.07.2022)
b. For inputs of organic N of animal origin, the animal herds from the MADR source were used and also used in the estimation of emissions from animal breeding and manure management
c. The EUROSTAT source was used for sewage sludge.

N-N2O emissions from synthetic fertilizers (category F_{SN})

Method and activity data. The amount of N_N2O results from multiplying the total annual amount of synthetic fertilizers with N by the emission factor (Table 109).

Table 5-109 N_N2O emissions resulting from the use of synthetic fertilizers with N (kt N_N2O/year)

	2005	2010	2015	2020	2025	2030	2035	2040
N_N2O_$\mathbf{F_{SN}}$ WOM	4,70	5,64	6,58	7,52	8,46	9,40	10,34	11,28
N_N2O_$\mathbf{F_{SN}}$ WEM	4,70	4,80	5,62	7,37	6,96	8,96	9,04	9,11
N_N2O_$\mathbf{F_{SN}}$ WAM	4,70	4,80	5,62	7,37	6,96	7,84	7,68	7,52

N-N2O emissions from organic fertilizers (category F_{ON})

The term " applied organic nitrogen fertilizer" (F_{ON}) refers to the amount of organic nitrogen applied to soils from various organic fertilizers other than those produced by animals raised under grazing conditions.

Method and activity data. Equation 11.3 (IPCC Guide 2006) was used to calculate F_{ON}, which sums up the following categories: F_{AM} = annual amount of N from manure applied to soils, kg N /year; F_{SEW} = total annual amount of N from sewage sludge applied on soils, kg N/year; F_{COMP} = total annual amount of N from compost applied to soils, kg N/year; F_{OOA} = annual amount of organic amendments used as fertilizers (e.g. recyclable waste, guano, brewing waste, etc.), kg N/year (Table 110).

F_{AM} was calculated with Equation 11.4 (IPCC Guide 2006).

For the F_{SEW} calculation, the amount of sewage sludge applied in agriculture was multiplied by 0.05, which represents the nitrogen applied to land from the sewage sludge (EMEP/EEA, 2019).

No official activity data was available for F_{COMP} and F_{OOA}.

Table 5-110 N_N2O emission for FON category (kt N_N2O/year)

	2005	2010	2015	2020	2025	2030	2035	2040
$F_{ON}=F_{AM} + F_{SEW} + F_{COMP} + F_{OOA}$ WOM	4,53	4,88	5,23	5,58	5,94	6,30	6,66	7,02
$F_{ON}=F_{AM} + F_{SEW} + F_{COMP} + F_{OOA}$ WEM	4,53	3,63	3,65	3,37	3,58	3,75	3,91	4,29
$F_{ON}=F_{AM} + F_{SEW} + F_{COMP} + F_{OOA}$ WAM	4,53	3,63	3,65	3,37	3,37	3,36	3,36	3,36

N in urine and dung deposited by grazing animals on pasture, range and paddock (F_{PRP})

To estimate the N-N2O emissions coming from the manure from the animals grazing on the pasture, range and in the paddocks, Equation 11.5 was used (IPCC Guide 2006).

Activity data used also in the chapter on animal husbandry (Chapter 10, Section 10.5) were used. Nex(T) – the annual average of N excreted per head of animal corresponding to each species, respectively category T in the country, kg N /animal/year was calculated using Equation 10.30 from Chapter 10.

From crop residues and forage /pasture renewal (FCR)

The calculation of the amount of nitrogen (N) generated by the crop residues (above and below ground), including N-fixing crops and those resulting from forage/pastures/ renewal was carried out with Equation 11.6 (IPCC Guide 2006).

The activity data used for the application of this equation and the calculation of nitrogen resulting from plant residues of agricultural crops were the following:

- The total productions of agricultural crops came from official sources (MADR)
- Crop(T) – was calculated with Equation 11.7 (IPCC Guide 2006). The default values of emission factors and other terms of the equation were used according to the Guide.

Table 5-111 Emissions of N_N2O for FCR category

	2005	2010	2015	2020	2025	2030	2035	2040
N_2O-N/F_{CR} (Gg/year) WOM	6,70	6,75	6,87	7,04	7,20	7,37	7,54	7,71
N_2O-N/F_{CR} (Gg/year) WEM	6,70	6,40	6,76	4,43	4,29	4,29	4,45	5,07
N_2O-N/F_{CR} (Gg/year) WAM	6,70	6,40	6,76	4,43	4,27	4,25	4,38	4,97

Table 5-112 Direct emissions of N_N2O from managed soils

	2005	2010	2015	2020	2025	2030	2035	2040
Total direct emissions (N-N_2O_Gg/year) WOM	20,98	22,82	24,72	26,68	28,64	30,61	32,57	34,54
Total direct emissions (N-N_2O_Gg/year) WEM	20,98	19,13	20,60	19,68	19,96	22,32	22,90	24,57
Total direct emissions (N-N_2O_Gg/year) WAM	20,98	19,13	20,60	19,68	19,57	20,46	20,44	21,23

Indirect N2O emissions from manages soils

N2O from N leaching/ runoff from managed soils in regions where leaching/runoff occurs

Method and activity data. Indirect emissions are produced because of volatilization (NH3, NOx) and leaching ($NO3^-$) of N applied to soils. To estimate the N2O emissions generated by the atmospheric deposition of volatilized N, Equation 11.9 (IPCC Guide 2006) was used.

Activity data:

- F_{SN}, F_{ON} and F_{PRP} values were those previously calculated for direct N2O emissions
- the $Frac_{GASF}$ value (Table 11.3, IPCC Guide 2006) was 0.10 with an uncertainty range between 0.03 and 0.3
- the $Frac_{GASM}$ value (Table 11.3, IPCC Guide 2006) was 0.20 with an uncertainty range between 0.05 and 0.5
- the EF_4 value (Table 11.3, IPCC Guide 2006) was 0.010 with an uncertainty range between 0.002 and 0.05

Table 5-113 Total indirect emission of N_N2O from managed soils

	2005	2010	2015	2020	2025	2030	2035	2040
Total indirect emissions WOM	6,52	6,92	7,31	7,71	8,11	8,50	8,90	9,29
Total indirect emissions WEM	6,52	6,02	6,48	6,87	6,48	6,99	7,05	7,35
Total indirect emissions WAM	6,52	6,02	6,48	6,87	6,37	6,79	6,74	6,93

Table 5-114 Total N_N2O emissions from managed soils

	2005	2010	2015	2020	2025	2030	2035	2040
Total N-N_2O emissions (Gg/an) WOM	27,50	29,74	32,04	34,39	36,75	39,11	41,47	43,83
Total N-N_2O emissions (Gg/an) WEM	27,50	25,15	27,07	26,55	26,43	29,31	29,95	31,93
Total N-N_2O emissions (Gg/an) WAM	27,50	25,15	27,07	26,55	25,94	27,24	27,19	28,15

Field burning of agricultural residues

In this sector are included the resulted emissions from the field burning of the agricultural residues. Given that 2018 ÷ 2020 emissions from category 3.F contributed by approx. 0.06 % of the total net GHG emissions in Romania (excluding LULUCF) and the difficulty of projection, in the long run, the way of carrying out the activities that determine these emissions' occurrence, the extrapolation method will be used.

Thus, the emissions forecast for the WOM scenario is made by extrapolating the 2005 emission value for the period 2006 ÷ 2040.

For WEM and WAM scenarios, are considered the average emissions from the period 2018-2020.

Liming

Soil amendment with calcareous materials is used to reduce soil acidity and improve plant growth in cropping systems, especially agricultural land, and managed forests. Adding carbonates to soil as lime (e.g. calcium carbonate (CaCO3) or dolomite (CaMg(CO3)2) leads to CO2 emissions as calcareous materials dissolve and release bicarbonate (2HCO3), which evolves into CO2 and water (H2O).

Method. Tier 1 of the methodological approach (IPCC Guidelines 2006) was used to determine these emissions. CO2 emissions from calcium carbonate amendments applied to soil were estimated with Equation 11.12 (IPCC Guidelines 2006).

Scenarios. Two scenarios have been developed, without measures and with measures.

The WOM scenario assumes a five-year increase, compared to 2005, of 1, 2, 3, 4, 5, 6 and 7% for the years between 2010-2040.

The WEM scenario results from the actual calculation data and considers the measures that are currently applied, and which were discussed above.

Activity data. For the historical years, the data already reported were used, and for the forecast years, in the absence of official data, data were proposed by the expert, as follows: for calcium carbonate, in the year 2025, the average of the years 2005-2020; for 2030 a 5% increase compared to 2025 was proposed, for 2035 a 7.5% increase compared to 2025, and for 2040 a 10% increase compared to the same year; for dolomite, in 2025 the average of the years 2005-2020 was proposed; for 2030, a 2.5% increase compared to 2025 was proposed, for 2035 a 5% increase compared to 2025, and for 2040 a 7.5% increase compared to the same year.

Emission factors. Default emission factors (EF) (0.12 for limestone and 0.13 for dolomite) were used (IPCC Guidelines 2006).

Table 5-115 CO2 emission from soil liming

	2005	2010	2015	2020	2025	2030	2035	2040
Total C_CO_2 emissions (tone/year) WOM	85,78	90,18	94,58	98,99	103,39	107,79	112,19	116,60
Total C_CO_2 emissions (tone/an) WEM	85,78	53,21	31,32	52,88	55,80	58,57	59,97	61,36

Urea application

The use of urea as a nitrogen fertilizer for agricultural soils leads to a loss of CO2 that has been fixed in the industrial production process. Urea (CO(NH2)2) is converted to ammonium (NH4+), hydroxyl ion (OH−) and bicarbonate (HCO3−) in the presence of water and urease enzymes. Similar to the soil reaction after adding calcareous amendments, the bicarbonate that forms evolve into CO2 and water.

Tier 1 of the methodological approach was used to determine these emissions (2006 IPCC Guidelines). CO2 emissions from urea fertilization were estimated using Equation 11.13 (2006 IPCC Guidelines).

Scenarios. Two scenarios have been developed, without measures and with measures.

The WOM scenario assumes a five-year increase, compared to 2005, of 8, 10, 12 and 14% in the years 2025-2040.

The WEM scenario results from the actual calculation data and considers the measures that are currently applied, and which were discussed above.

Activity data. For the historical years, the data already reported were used, and for the forecast years, in the absence of disaggregated official data, data were proposed by the expert, as follows: in the year 2025, the average of the years 2005-2020 was proposed; for 2030 a 10% increase compared to 2025 was proposed, for 2035 a 12.5% increase compared to 2025, and for 2040 a 15% increase compared to the same year.

Emission factors. The default emission factor (EF) of 0.20 was used for carbon emissions from urea application (IPCC Guidelines, 2006).

Table 5-116 CO2 emission from urea fertilization

	2005	2010	2015	2020	2025	2030	2035	2040
Total C_CO_2 emissions (tone/an) WOM	52,75	58,03	63,30	68,58	73,86	79,13	84,41	89,68
Total C_CO2 emissions (tone/an) WEM	52,75	53,91	62,95	82,67	63,07	69,38	70,96	72,53

A.4.4. LULUCF

The projections of quantitative levels were based on linear models in which area and time variable were assimilated as factorial variables. The Data Analysis was used to determine the parameters of the linear models, to test the significance of the regression coefficients, and validate the regression model. The GHG emissions-removals evolution related to LULUCF Sector were relatively constant during the 1989–2006-time segment, being in direct relation to the variables run: (i) AD (kha) developed through approach 1 type; (ii) EFs related to the carbon pools - LB, DOM, Soil - Tier 1 (IPCC 2006); (iii) Warm temperate climate zone classification (IPCC 2006). The removals increased rapidly in the 2006–2008-time segment, generating a spike, after which there was a decreasing trend until 2020. GHG emissions-removals for the 2007-2020 time segment have their correspondence related to the following drivers: (i) AD(kha) estimated following the approach 3 type, [LPIS-IACS + $CLC_{reference\ years[1990;2000;2006;2012;2018]}$ + LiDAR + aero-photogrammetry] technologies; (ii) EFs related to the carbon pools - LB, DOM, Soil - as CS and D (IPCC 2006 and IPCC Refinement 2019), respectively Tier 1 and Tier 2; (iii) classification in the Warm temperate climate zone (IPCC 2006). In Table 5-117 are presented the GHG emissions-removals evolution in the 1989-2040 period for all developed scenarios - WOM, WEM, WAM.

Table 5-117 LULUCF Sector's GHG emissions-removals projections related to WOM, WEM, WAM scenarios

Scenario (kt CO_2 eq)	Historical trend					Projections			
	1989	2000	2005	2012	2020	2025	2030	2035	2040
WOM						-21607.49	-18749.29	-15780.35	-12785.41
WEM	-21456.19	-31393.60	-31810.41	-30860.35	-32893.96	-31316.32	-31680.39	-31163.94	-31519.17
WAM						-37039.21	-38795.77	-40402.44	-42100.37

A.4.5 Waste

Stored waste

For the WOM scenario, the forecasted evolution of the quantities of waste stored in the municipal waste landfills, estimated according to the evolution of the forecasted amount of waste in the analyzed period, considered the following rates of variation compared to the historical year 2005:

- for the quantities of waste stored in non-compliant landfills, an annual growth rate of 5% until 2020 was considered, followed by an annual growth rate of 2%
- for the quantities of waste stored in non-compliant landfills, the historical value recorded in 2005 was considered constant for the year 2020, followed by a decrease in the quantities by 1% per year
- for the amounts of composted waste, the historical value recorded in 2005 was considered constant
- for the quantities of incinerated waste, the historical value recorded in 2005 was considered constant.

For the WEM scenario, the forecasted evolution of the quantities of waste deposited in the landfills considered the following general premises:

- the evolution of the population both in urban and rural areas
- the evolution of the population's income and the evolution of the Gross Domestic Product
- composition of municipal waste
- European and national legislation on the characteristics and composition of waste to be disposed of in landfills
- operation of household waste landfills
- the economic evolution of the society, especially regarding the packaging waste and assimilated to them
- investments to be made in the Waste sector, until the compliance with European Directives
- implementation at national level of long-term investment plans and integrated waste management systems at county level.

Thus, for the quantities of waste stored in municipal waste depots, estimated according to the forecasted demographic evolution in the analyzed period and the need to comply with the commitments assumed at the European level, the following rates of variation were considered compared to the historical year 2020:

- for the quantities of waste stored in compliant landfills, it was considered that they should decrease by 5% per year after the historical year 2020
- for the quantities of waste stored in non-compliant landfills, it was considered that they should be zero after 2020
- for the quantities of composted waste, an annual growth rate of 20% until 2025 was considered, and, respectively, an annual growth rate of 2% until 2040
- for the quantities of incinerated waste, the historical value recorded in 2020 was considered constant
- starting from the year 2025, a constant quantity of 650,000 t/year is considered, which will be treated through energy recovery in recovery facilities and/or in cement factories
- regarding the amount of waste that will be treated with anaerobic digestion with biogas recovery, an increase of 5% per year for the period 2021-2030 compared to 2020 is considered, followed by an annual increase of 2% per year for the period 2031-2040.

For the WAM scenario, the forecasted evolution of the quantities of waste stored in landfills considered the following rates of variation, compared to the historical year 2020:

- for the quantities of waste stored in compliant landfills, it was considered that they should decrease by 5% per year after the historical year 2020
- for the quantities of waste stored in non-compliant landfills, it was considered that they should be zero after 2020
- for the quantities of composted waste, an annual growth rate of 25% until 2025 was considered, and, respectively, an annual growth rate of 1% until 2035
- for the quantities of incinerated waste, the historical value recorded in 2020 was considered constant
- starting with the year 2025, a constant quantity of 800000 t/year is treated by energy recovery in recovery installations and/or in cement factories
- regarding the amount of waste that will be treated with anaerobic digestion with biogas recovery, an increase of 6% per year for the period 2021-2030 compared to 2020 is considered, followed by an annual increase of 2% per year for the period 2031-2040.

For all forecast scenarios, together with the implementation at national level of long-term investment plans and integrated waste management systems at county level, a decrease in landfill gas was considered starting with 2020 of 40% in each year, this amount being burned at the torch.

Composted waste

For the WOM scenario, the quantities of composted waste were considered constant, equal to the historical value recorded in 2005.

For the WEM scenario, for the quantities of waste treated by composting was considered an annual growth rate of 20% until 2025, and, respectively, an annual growth rate of 2% per year until 2040.

For the WAM scenario, for the quantities of waste treated by composting was considered an annual growth rate of 25% until 2025 and, respectively, an annual growth rate of 1% per year until 2040.

Incinerated waste

In the WOM scenario, it was considered that no waste incineration plants would be built.

In the WEM scenario, an incineration capacity of about 400,000 t/year starting with the year 2025 and of about 250,000 t/year residual waste coming from sorting stations or from mechano-biological treatment plants, with high PCI, was considered, which will be treated in cement plants or will be thermally recovered by another process.

In the WAM scenario was considered an incineration capacity of about 500,000 t/year starting with 2025 and about 300,000 t/year residual waste from sorting stations or mechanical-biological treatment plants, with high PCI, which will be treated in cement plants or will be thermally recovered by another process,

Table 5-118 shows the evolution of CH4 emissions for this CRF category in the three analyzed scenarios.

Table 5-118 Evolution of CH4 emissions, in kt, during 2005÷2040

Emission sources CH_4	Scenario	2005	2020	2025	2030	2035	2040
		Inventory		Projections			
5.A Solid waste storage	WOM	**102.60**	**107.65**	**104.43**	**101.58**	**99.12**	**97.04**
5.A.1 Waste stored in compliant landfills		9.35	14.40	15.84	17.42	19.17	21.08
5.A.2 Waste stored in non-compliant landfills		93.25	93.25	88.59	84.16	79.95	75.95
5.B Biological treatment of solid waste		**3.24**	**3.24**	**3.24**	**3.24**	**3.24**	**3.24**
5.B.1 Composting		3.24	3.24	3.24	3.24	3.24	3.24
5. B.2 Anaerobic digestion at biogas facilities		0	0	0	0	0	0
5.C Incineration and burning waste in open space		0.01	0	0.01	0.01	0.01	0.01
5.C.1 Waste incineration		0.01	0	0.01	0.01	0.01	0.01
TOTAL		**105.85**	**110.89**	**107.68**	**104.83**	**102.37**	**100.29**
5.A Solid waste storage	WEM	**102.6**	**145.56**	**38.57**	**28.64**	**21.14**	**15.48**
5.A.1 Waste stored in compliant landfills		9.35	86.67	38.57	28.64	21.14	15.48
5.A.2 Waste stored in non-compliant landfills		93.25	0	0.00	0.00	0.00	0.00
5.B Biological treatment of solid waste		3.24	2.27	4.69	5.32	5.87	6.47
5.B.1 Composting		3.24	1.50	3.73	4.12	4.54	5.02
5. B.2 Anaerobic digestion at biogas facilities		0	0.7695	0.96	1.20	1.32	1.45

5.C Incineration and burning waste in open space		0.01	0	0	0	0	0
TOTAL		**105.85**	**147.83**	**43.26**	**33.95**	**27.01**	**21.95**
5.A Solid waste storage		**102.6**	**145.56**	**28.34**	**16.06**	**9.01**	**4.97**
5.A.1 Waste stored in compliant landfills		9.35	86.67	28.34	16.06	9.01	4.97
5.A.2 Waste stored in non-compliant landfills		93.25	0	0	0	0	0
5.B Biological treatment of solid waste		**3.24**	**2.27**	**4.57**	**4.81**	**5.05**	**5.31**
5.B.1 Composting	WAM	3.24	1.50	4.57	4.81	5.05	5.31
5. B.2 Anaerobic digestion at biogas facilities		0	0.77	1.00	1.30	1.43	1.57
5.C Incineration and burning waste in open space		**0.01**	**0**	**0**	**0**	**0**	**0**
5.C.1 Waste incineration		0.01	0	0	0	0	0
TOTAL		**105.85**	**147.83**	**32.91**	**20.87**	**14.07**	**10.27**

In Table 5-119 the evolution of N2O emissions for this CRF category is presented in the three analyzed scenarios.

Table 5-119 Evolution of N2O emissions in kt during 2005÷2040

Emission sources N_2O	Scenario	2005	2020	2025	2030	2035	2040
		Inventory		Projections			
5.B Biological treatment of solid waste		**0.1942**	**0.1942**	**0.1942**	**0.1942**	**0.1942**	**0.1942**
5.B.1 Composting		0.1942	0.1942	0.1942	0.1942	0.1942	0.1942
5.C Incineration and burning waste in open space	WOM	**0.028**	**0.028**	**0.028**	**0.028**	**0.028**	**0.028**
5.C.1 Waste incineration		0.028	0.028	0.028	0.028	0.028	0.028
TOTAL		**0.2222**	**0.2222**	**0.2222**	**0.2222**	**0.2222**	**0.2222**
5.B Biological treatment of solid waste		**0.1942**	**0.090**	0.224	0.247	0.273	0.301
5.B.1 Composting		0.1942	**0.090**	0.224	0.247	0.273	0.301
5.C Incineration and burning waste in open space	WEM	**0.028**	**0.0053**	0.0053	0.0053	0.0053	0.0053
5.C.1 Waste incineration		0.028	0.0053	0.0053	0.0053	0.0053	0.0053
TOTAL		**0.2222**	**0.095**	**0.229**	**0.252**	**0.278**	**0.306**
5.B Biological treatment of solid waste		**0.1942**	**0.090**	0.274	0.288	0.303	0.319
5.B.1 Composting		0.1942	0.090	0.274	0.288	0.303	0.319
5.C Incineration and burning waste in open space	WAM	**0.028**	**0.053**	0.053	0.053	0.053	0.053
5.C.1 Waste incineration		0.028	0.053	0.053	0.053	0.053	0.053
TOTAL		**0.22**	**0.095**	**0.280**	**0.294**	**0.308**	**0.324**

For the WOM scenario, the value of CO2 emissions resulting from waste incineration was considered constant and equal to the historical value recorded in 2005, respectively 89.87kt. For the WEM and WAM scenarios, the value of CO2 emissions was considered constant and equal to the historical value recorded in 2020, respectively 10.27 kt.

Wastewater

In 2020, the GHG emissions from the waste sector were 5916.18 kt CO2 eq, which represents 5.35% of total GHG emissions. The domestic and industrial wastewater treatment sector contributed 33.08% to the GHG emissions of the waste sector.

Between 1989 and 2020, these emissions were reduced by 49.52% considering the legislative requirements imposed because of Romania's accession to the European Union.

Directive 91/271/EEC of urban wastewater treatment, amended and supplemented by Directive 98/15/EEC, is the legal basis of Community legislation in the field of wastewater. This directive was fully transposed into Romanian legislation by GD no. 188/2002 for the approval of the rules regarding the discharge conditions of wastewater in the water environment, amended and supplemented by GD no. 352/2005, as well as by amending and supplementing some normative acts that transpose the community acquis in the field of environmental protection.

In order to implement and comply with the provisions of Directive 91/271/EEC on wastewater treatment, Romania obtained transitional periods so as on December 31, 2015 all agglomerations with more than 10,000 inhabitants to comply with the provisions from the point of view of wastewater collection and treatment, and on December 31, 2018 all agglomerations with 2,000 - 10,000 inhabitants must comply in terms of the collection and secondary treatment of wastewater. The final deadline for the implementation of the Directive was December 31, 2018.

Table 5-120 shows the wastewater discharged between 2018 and 2020 and the treatment modality.

According to the data made available by the Romanian Waters National Administration in 2020, the total volume of discharged water was 4207.51 million m3, of which 2484.19 million m3 (59.04%) is cold water classified in the category of water used that should not be treated and 1723.23 million m3 is water that should be treated (Table 5-120).

In 2020, there were 1184 municipal and industrial wastewater treatment facilities classified by treatment stage:

- First stage: 34 installations
- Second stage: 948 installations
- Third stage: 202 installations.

This situation is changing considering the expansion of sewage systems financed by government programs.

Table 5-120 Wastewater discharged in 2018 and treatment method, Source: NIR2018, NIR2020

Category	2018		2020	
	Volume (million m^3)	Percentage of total	Volume (million m^3)	Percentage of total
Domestic wastewater discharged	1233.89	51.91	1117.06	63.82
Discharged industrial wastewater	1128.37	47.47	603.01	34.99
Treated domestic wastewater	1160.73	48.83	841.50	48.83
Treated industrial wastewater	972.94	40.93	705.35	40.03
Total wastewater to be treated	2370.69	99.73	1723.32	100
Sufficiently treated wastewater	1541.83	64.86	1378.92	80.02
Insufficiently treated wastewater	604.37	25.42	174.84	10.15
Untreated clean water	224.49	9.44	169.56	9.84
Total wastewater discharged	**2377.09**	-	**1723.23**	-

The works on the wastewater collection and treatment were carried out within the Large Infrastructure Operational Program 2014 – 2020.

For the WOM scenario, the forecasted evolution of CH4 emissions was estimated by extrapolating the historical emissions recorded in 2005, with an average annual growth rate of 0.1% in the period 2005 - 2030, which considers the forecasted decrease in the population. The value in 2030 remains constant in the period 2030-2040.

For the WEM scenario and, respectively, the WAM measures scenario, the forecasted evolution of CH4 emissions was estimated by extrapolating the historical emissions recorded in 2020 with an average annual rate of decrease of 1%, considering the following:

- Population decline
- Increase in the population connected to the sewage system with treatment
- The construction of modern waste treatment stations and, respectively, the modernization of the existing ones.

For the WOM scenario, the forecast evolution of N2O emissions remains constant at the 2005 value.

For the WEM scenario and, respectively, the WAM scenario, the evolution of emissions of N2O for the period 2021-2040 was estimated by extrapolating the emissions related to 2020, with an average annual rate of decrease of 1%, considering the following:

- Population decline
- Increase in the population connected to the sewage system with treatment
- The construction of modern wastewater treatment stations with nitrification and denitrification.

Tables 5-121 and 5-122 present the CH4 emissions resulting from wastewater treatment in the three scenarios.

Table 5-121 Evolution of CH4 emissions in the period 2005 - 2040 - WOM scenario

Source of CH_4 emissions	Scenario	2005	2025	2030	2035	2040
		Inventory	Projections			
Domestic and commercial water treatment	WOM	102.56	104.63	105.15	105.15	105.15
Industrial water treatment		9.45	9.64	9.69	9.69	9.69
TOTAL emissions of CH_4 (kt)		**112.01**	**114.27**	**114.84**	**114.84**	**114.84**

Table 5-122 Evolution of CH4 emissions in the period 2018 - 2040 – WEM and WAM scenarios

Source of CH_4 emissions	Scenario	2018	2020	2025	2030	2035	2040
		Inventory		Projections			
Domestic and commercial water treatment	WEM	57.93	53.25	50.71	48.29	45.99	43.80
Industrial water treatment		9.58	7.70	7.33	6.98	6.65	6.33
TOTAL emissions of CH_4 (kt)		**67.51**	**60.25**	**58.04**	**55.27**	**52.64**	**50.13**
Domestic and commercial water treatment	WAM	57.93	53.25	50.71	48.29	45.99	43.80
Industrial water treatment		9.58	7.70	7.33	6.98	6.65	6.33
TOTAL emissions of CH_4 (kt)		**67.51**	**60.25**	**58.04**	**55.27**	**52.64**	**50.13**

Table 5-123 presents the N2O emissions resulting from wastewater treatment in the three scenarios.

Table 5-123 Evolution of N2O emissions in the period 2005 – 2040 - WEM and WAM scenarios

Wastewater treatment	Scenario	2005	2018	2020	2025	2030	2035	2040
			Inventory			Projections		
TOTAL emissions of N_2O (kt)	WOM	1.47	1.44	1.43	1.47	1.47	1.47	1.47
	WEM	-	1.44	1.44	1.37	1.30	1.24	1.18
	WAM	-	1.44	1.44	1.37	1.30	1.24	1.18

B. Assessment of aggregate effect of policies and measures

To establish the aggregated effect of applied policies and measures, the difference of GHG emissions obtained in scenario WEM scenario and ones obtained in scenario WOM scenario are performed. The difference between GHG emissions estimated for WEM scenario and WAM scenario represents the potential effect of the planned policies and measures. Quantitative estimates of the effects of policies and measures on emissions by sector and total are presented in Table 5-124.

Table 5-124. Quantitative estimates of the effects of policies and measures (kt CO2 eq.)

Analysis	Sector	2025	2030	2035	2040
Diff. WOM-WEM	Energy*	38614.49	46978.89	48503.21	51247.54
	Transport	356.16	1696.33	3814.90	6389.55
	IPPU	3958.41	5611.79	6078.98	6450.93
	Agriculture	5065.03	6098.89	7687.60	9222.95
	Forestry/LULUCF	9714.31	12937.34	15390.63	18741.56
	Waste management/waste	3122.36	3381.36	3569.27	3715.91
	TOTAL	**60474.60**	**75008.27**	**81229.68**	**89378.89**
Diff. WEM-WAM	Energy*	1289.04	1441.26	2452.09	4760.87
	Transport	735.98	863.59	1481.23	1527.20
	IPPU	0.39	127.39	135.15	140.95
	Agriculture	170.81	361.57	487.99	704.44
	Forestry/LULUCF	5725.57	7113.10	9230.84	10567.89
	Waste management/waste	258.72	327.16	323.62	291.93
	TOTAL	**7444.53**	**9370.48**	**12629.70**	**16466.08**

*Also includes emissions from transport sector

C. Methodology

The methodology for achieving emission forecasts for greenhouse gas (GHG) emissions is both based on historical data from the National Emissions Inventory (NIGHGE) between 1989 – 2020 and on forecasts of macroeconomic indicators considered in the strategies of the Romanian Government and policies adopted for the economic and social development of the country in conjunction with the EU Directives.

According to the National Emissions Inventory the energy sector is the main source of greenhouse gas (GHG) emissions (about 70% of total emissions). To this aim, the GHG emissions forecasts are determined based on energy and non-energy sectors of the national economy.

Non-energy sectors of the national economy that contribute to GHG emissions are:

- forestry - in terms of atmospheric carbon sequestration options
- agriculture - to evaluate CH4 emissions from livestock digestion and manure fermentation and N2O emissions from the application of nitrogen fertilizers
- industry - to assess emissions from industrial processes
- solvents and other products
- liquid and solid waste management to assess emissions of CH4, N2O and CO2.

Projections of GHG emissions are performed for three scenarios. specifically:

- a reference scenario "business as usual" (scenario without measures - WOM) feasible in the future without including special activities to reduce GHG emissions
- a reduction scenario that is similar to the reference scenario in terms of development of socio-economic indicators, but contains policies and measures to reduce GHG emissions (scenario with measures - WEM)
- a reduction scenario with additional measures that is similar to the reduction scenario but contains additional measures to reduce GHG emissions (scenario with additional measures - WAM).

According to the National Emissions Inventory, technological processes that determine GHG emissions and mitigation options were identified for each sector.

Hierarchy of options within a sector is based on detailed analyses, using various criteria, specifically:

- degree of reduction of CO2 and other GHG emissions
- cost-benefit ratio of the GHG emission reduction option
- indirect economic impact (jobs. lower imports)
- slight possibilities of implementation
- long-term support of the reduction option, etc.

For each analyzed sector, it is explained how the reference scenario and the two alternative scenarios were defined given the specificity of each sector.

Both achieving the GHG emission forecasts and assessing the reduction alternatives is particularly difficult, and therefore we resort to special programs that allow the identification of sectors of low importance to GHG emissions, correlated with the socio-economic development level of the country.

Energy

Projections of GHG emissions in the energy sector are determined regarding the energy demand sub-sector (industry, transport, agriculture, households, and commercial consumers) and supply sub-sector (primary energy resource extraction, their conversion in refineries, power plants, thermal power plants, transmission and distribution of energetic products to consumers).

The National Commission for Strategy and Prognosis has determined the evolution of the total energy demand and by types of energy resources, for the sectors defined according to the IPCC: electricity and heat generation, transport, industry, agriculture, construction, services, and population using the methodology for drawing up the Energy Balance Forecast.

The determination of the energy consumption and resources is carried out separately for each energy carrier highlighted in the Annex of NIS Report - The energy balance and the structure of the energetic equipment -. But

at the end, in order to obtain the Energy Balance Forecast, some of the results are aggregated (consumptions and exports), thus resulting total energy quantities, not separated by energy carriers.

In this case, the indicators are extracted from the energy balances drawn up for each energy carrier at the prior stage of results aggregation, for which the following steps are considered:

Determination of energy consumption

A particular energy carrier may be used in the final consumption as such or may require conversion to another energy carrier. Their use for final consumption is realized separately. at least for the below economic sectors (but also for export where appropriate):

- industry
- non-energy use
- agriculture
- construction
- transport
- services (less transport)
- residential sector
- the consumption in the energy sector benefits from similar treatment of final consumption, although it does not represent final consumption.

Final consumptions are determined as a product between a macroeconomic indicator of the activity level within the given economic sector (gross added value, production of goods and services, etc.) and the intensity of the energy consumption of this sector, calculated for the energy carrier in question. The intensity of consumption (or its increase) is generally determined with econometric equations.

The energy quantities used in the transformation are obtained in such a way as to cover a specific demand for the energy carrier resulted from the transformation (electricity, heat, petroleum products, etc.) and for a certain transformation efficiency.

Resources Determination

The production and import of a particular energy carrier shall be determined in such a way as to balance the consumption (final consumption and for processing). For calculating the production, the following elements are taken into consideration:

- its own historical values
- the opening of new deposits
- the evolution of the energetic equipment structure
- information on the hierarchy of production costs
- restrictions in fossil fuels use, due to international agreements, etc.

The import is calculated either as a quantity for demand completion or as a substitution of a part of the production as result, for example, of the resources price variation at international level, the change in production costs, etc.

The methodology explicitly captures how substitutions take place between different resources, which contribute either to final consumption balancing or to a consumption balancing for transformation.

Scenarios for consumption evolution and how it is balanced with different resources

The implementation of a certain scenario, while calculating the consumptions and resources, can be performed through the following elements:

- the evolution of macroeconomic indicators, which directly influence the final energy consumption and indirectly the consumptions in transformation
- the final consumptions obtained in the frame of a "business as usual" scenario can be amended with "energy savings" according to the National Energy Efficiency Action Plan, described for a scenario that involves measures to increase the consumption efficiency
- modification of the energetic equipment's fleet as a result, for example, of a measures plan to reduce emissions in the energy sector. This leads to changes in the production structure, to an increase of the transformation efficiency, to the change of the energy mix, to the appearance of a substitution between import and export, etc.
- the establishment of a resource substitution, based on the provisions of a strategy, international agreement, etc.

Accepted hypotheses

1. The production of crude oil and natural gas does not go through any significant increase (for example, determined by the opening of new deposits)

2. The efficiency of energy consumption at the level of the economy sectors goes through a rate of improvement

3. There are/are not extensive substitutions of the resources used by households as a result, for example, of the expansion of gas supply network, increase of electricity-based household consumption, etc.

4. The increase of electricity production from renewable sources accompanies the increase of renewable generation capacities described in the Adopted Plans

5. The production of nuclear energy shall correspond to the plans adopted

6. Coal to be gradually substituted with natural gas, both in the case of electricity generation and heat production

7. The efficiency of the different resources conversion into electricity remains constant and is equal with the value corresponding to the agreed period.

To establish the GHG emission projections, the following equation is used in accordance with NIGHGE 2020:

GHG Emissions = AD x EF, where: AD is the projected activity date

EF is the forecast emission factor on NIGHGE 2020 categories.

IPPU

According to the 2006 IPCC guidelines, this sector includes GHG emissions from activities related to the production process in the industry and emissions associated with the use of the products.

The GHG emissions projections have been elaborated for the categories and types of GHG from the IPPU sector for which emissions are registered in the 2022 (Table 5-125)

Table 5-125 Categories and types of GHG emissions from the IPPU sector

CRF Category	CO_2	CH_4	N_2O	HFC	PFC	SF_6	NF_3
2 A Mineral industry							
2.A.1. Cement production	✓						
2.A.2. Lime production	✓						
2.A 3 Glass production	✓						
2.A.4. Other uses of carbonates in processes	✓						
2 B Chemical industry							
2.B.1. Ammonia production	✓						
2.B.2. Nitric acid production			✓				
2.B.3. Production of adipic acid							
2.B.4. Caprolactam, glyoxal and glyoxylic acid production							
2.B.5. Carbide production	✓	✓					
2.B.6. Titanium dioxide production							
2.B.7. Caustic soda production							
2.B.8. Petrochemistry and black smoke production							
2.B.9. Production of fluorochemical compounds							
2.B.10. Other							
2 C Metal industry							
2.C.1. Iron and Steel production	✓	✓					
2.C.2. Ferroalloys production							
2.C.3. Aluminum production	✓				✓		
2.C.4. Magnesium production							
2.C.5. Lead production	✓						
2.C.6. Zinc production	✓						
2.C.7. Other							
2 D Non-energy products from fuels and solvent use							
2.D.1. Lubricant use	✓						
2.D.2. Paraffin wax use	✓						
2.D.3. Other	✓						
2 E. Electronics industry							
2 F Products used as substitutes for ozone-depleting substances							
2.F.1 Refrigeration and air conditioning				✓			
2.F.2. Foam blowing agents				✓			
2.F.3. Fire protection				✓			
2.F.4. Aerosols				✓			
2.F.5 Solvents							
2.F.6 Other applications							
2.G. Other product manufacture and use							
2.G.1. Electrical equipment						✓	
2.G.2. SF_6 and PFCs from other product use							
2.G.3. N_2O from product uses			✓				
2.G.4. Other							
2.H. Other							

GHG emissions for non-energy sectors were calculated using spreadsheet models. Activity data are correlated with various parameters such as: gross value added in industry, production structure by types of industrial processes. The emission factors used are either category-specific (determined based on the analysis of historical

data) or in accordance with the IPCC 2006 guidelines. The sub-sector-specific assumptions, presented in chapter 5A, were also considered. The following calculation formula was used to estimate emissions:

$$E_g(t) = \sum_{i=1}^{n}\sum_{j=1}^{m}\sum_{k=1}^{p} A_j(t-1)\cdot p_k \cdot (1 + r_j(t))\cdot EF_{g,k}(t)$$

where:

Eg(t) – projected greenhouse gas emissions g in year t
i – sector of activity, which is a source of GHG emissions
j – sub-sector of activity, which is a source of GHG emissions
k – product or material used for the production or use of which GHG emissions result
pk – the share of the product / quantity of material used in the activity data of the sub-sector
rj(t) – factor of increase or decrease of activity data at the level of the activity sub-sector
EFg,k(t) – emission factor for the greenhouse gas g for the product or material used, in year t.

For categories 2.D, 2.F and 2.G, considering the difficulty to estimate in the long run the way of carrying out the activities that have an influence on the amount of GHG emissions, were used the extrapolation method (based on historical data).

Agriculture

The following direct GHG emissions occur in the Agricultural sector:

- CH4 from enteric fermentation
- CH4 and N2O from manure management
- CH4 from rice cultivation
- N2O from use of fertilizers
- CH4 and N2O from agricultural residue burning in the field.

To establish the GHG emission projections, the following equation is used in accordance with NIGHGE 2022:

$$GHG_{Emissions} = AD \times EF$$

where:

AD = the projected activity date
EF = forecast emission factor.

The activity data were taken from the National Institute of Statistics, from the Ministry of Environment, Waters and Forests and the Ministry of Agriculture and Rural Development.
To establish the emission factors for the forecast, the equations specific to the animal husbandry sector and manure management from chapter 10, respectively those for plant production, related to chapter 11 of the IPCC guide, 2006, were used. For the livestock and manure management category, method 2 was used for all categories of animals (except rabbits) and for all greenhouse gases, and for the plant sector the implicit emission factors related to calculation method 1 were used.

LULUCF sector

Methodology for developing GHG emissions-removals projections related to the LULUCF Sector[57][58][59][60]. The methodology for carrying out GHG projections is based both on historical data from NGHGI 2022, 1989-2020, and on the forecasts of macroeconomic indicators considered in the strategies developed by the Romanian Government and PaMs adopted for economic and social development of the country, together with EU Directives and PaMs. For the LULUCF Sector analysis, the reference year for Romania is 1989, and for the EU-28 is 1990; 2005 is the year the EU began to consistently implement several GHG removals policies and measures to meet its targets. Since 2007, data-information are used to generate AD (kha) by processing maps through complex query and intersection processes, respectively using a type 3 approach-explicit geospatial [LPIS-IACS + $CLC_{reference\ years\ [1990;2000;2006;2012;2018]}$ + LiDAR + aero-photogrammetry] technologies. In this respect, the analysis assumes three-time segments: (i) 1989-2005; (ii) 2005-2012; (iii) 2012-2020. The GHG emissions-removals levels are expressed as a simple arithmetic mean, and the specific dynamics either for the defined time segments or for the analyzed period are highlighted with the help of the average indicators of the time series: (i) the absolute average change and (ii) the rate of the relative average change. Over time, research on the GHG emissions-removals evolution-projection has considered the following: (i) synthetic characterization of the evolution through relevant indicators; (ii) detachment of systematic elements that reveal patterns or repeatability of evolution over time; (iii) study and interpretation of the past evolution depending on the dynamics of land use categories. Theoretically, the determination of the projection through the method of absolute mean change implies that the adjusted values are determined with the following recurrence relation:

$$\hat{y}_k = y_0 + k \cdot \overline{\Delta}, k = \overline{0,T} \quad (1)$$

where y0 is the term considered as the basis of adjustment (year 1989), k is the temporal series, T is the unit of time and $\overline{\Delta}$ represents the absolute mean change which is calculated as the simple arithmetic mean of the absolute changes based on the chain:

$$\overline{\Delta} = \frac{(y_1-y_0)+(y_2-y_1)+\ldots+(y_{T-1}-y_{T-2})+(y_T-y_{T-1})}{T-1} = \frac{y_T-y_0}{T-1} \quad (2)$$

The first and last adjusted value are equal to the first and last empirical value, as follows:

$$\text{for } k = 0 \rightarrow \hat{y}_0 = y_0 + 0 \cdot \overline{\Delta} = y_0 \quad (3)$$

$$\text{for } k = T \rightarrow \hat{y}_T = y_1 + (T-1) \cdot \overline{\Delta} = y_1 + (T-1) \cdot \frac{y_T-y_0}{T-1} = y_T \quad (4)$$

For extrapolation, the k series is continued until the last unit of time related to the researched horizon - the year of 2040. The evolution of the surfaces related to the specified areas has a linear projection over time that will be estimated by the method of absolute mean change. The average index method is applied if the surfaces have a decreasing trend and the projection by the average increase method generates negative terms or equal to zero. The adjusted values are determined with the following recurrence ratio:

$$\hat{y}_k = y_1 \cdot \overline{I}^{k-1}, k = \overline{1,T} \quad (5)$$

[57] Statistica - Isaic-Maniu Alexandru, Mitrut Constantin, Voineagu Vergil. Editura Universitară. 2004
[58] Statistică. Aplicaţii practice. Lilea E., Gogu E., Bentoiu G.C., Biji E-M. Editura Universitară. 2017
[59] Statistică aplicată în științele socio-umane. Opariuc-Dan Cristian. Editura ASCR, Cluj Napoca, 2009
[60] Metode cantitative de cercetare. Designuri și aplicații în științele sociale. Diaconu-Gherasim, Loredana R., Măirean C., Curelaru M. Editura Polirom. 2022

where y_1 is the term considered as the basis for adjustment (year 1989 in the reference scenario-WOM (business as usual), year 2005 in the case scenario with existing measures-WEM and year 2012 in the case of the scenario with additional measures-WAM) and represents the average index calculated as simple geometric mean of relative changes based on in the chain:

$$\overline{I} = \sqrt[T-1]{\frac{y_2}{y_1} \cdot \frac{y_3}{y_2} \cdot \frac{y_4}{y_5} \cdot \ldots \cdot \frac{y_{T-1}}{y_{T-2}} \cdot \frac{y_T}{y_{T-1}}} = \sqrt[T-1]{\frac{y_T}{y_1}} \quad (6)$$

The first and last adjusted value are equal to the first and last empirical value, as follows:

$$\text{for } k = 1 \rightarrow \hat{y}_1 = y_1 \overline{I}^{1-1} = y_1 \quad (7)$$

$$\text{for } k = T \rightarrow \hat{y}_T = y_1 \cdot \overline{I}^{T-1} = y_1 \cdot \left(\sqrt[T-1]{\frac{y_T}{y_1}}\right)^{T-1} = y_T \quad (8)$$

Based on the index, the average rate (R) with the relation is calculated:

$$\overline{R}(\%) = \overline{I}(\%) - 100 \quad (9)$$

and together with the average level and the absolute average change, it contributes to the statistical characterization of the time series. Once the surfaces have been estimated, we start from the hypothesis that the quantitative level of GHG depends on the surface of the specified area and/or on the time variable, a function that is determined using the regression method. The regression method is a statistical approach for determining the connection between variables using mathematical functions, called regression functions. A mathematical expression obtained from the processing of experimental data that approximates the interdependence between two or more variables of a system or process is referred to as a regression function. When the connections between the various variables cannot be demonstrated theoretically accurately enough, a regression function must be determined. The following processes were involved in estimating a mathematical model that was linked to a certain type of projection: (i) intuition of mathematical relations of the models based on the graphical representation of the correlation; (ii) application of the Pearson coefficient to determine the intensity and direction of the link between GHG emissions-removals as a function of time and/or specific areas of different land categories. The Pearson coefficient ranges from -1 to +1; the closer it is to zero, the lower the bond's intensity, and the closer it is to one, the stronger the relationship. The relationship is directly proportional if the values are greater than zero, and inversely proportional if the values are negative; (iii) estimating the parameters for each model, most often using the least squares method; (iv) choosing the model that most accurately represents the relationship highlighted by the data (minimum criterion); (v) testing the significance of the chosen model and the coefficients of the functions found; (vi) assessing the model's significance and the coefficients of the functions identified; (vii) economic interpretation of the tested parameters; (viii) use of the model for simulations and projections. There are one-factor regression (single) and multi-factor regression (multiple), depending on the number of influencing factors for the resulting characteristics. Unifactorial regression considers quantifying dependencies in the form of unifactorial models, testing hypotheses, and demonstrating predictive calculations. The unifactorial model describes the relationship between the two variables, x and y, the other factors being considered with constant action. The theoretical equation of this regression is of the form:

$$y_i = f(x_i) + u_i, i = \overline{1,n} \quad (10)$$

where u_i represents the action of other factors (disturbance), and n the number of observations. The estimation of the parameters of this model is done using the least squares method, which involves minimizing the sum of the squares of the deviations of the empirical values (y_i) from the estimated values ($\hat{y}_i$):

$$\sum_{i=1}^{n}(y_i - \hat{y}_i)^2 \to 0 \quad (11)$$

In unifactorial linear models, the resultant variable depends on a single factor by the relation:

$$y_i = a + b \cdot x_i + u_i i = \overline{1,n} \quad (12)$$

The estimation of the parameters of this model can also be done using the least squares method, which involves minimizing the sum of the square deviations of the empirical values (y_i) from the estimated values ($\hat{y}_i$):

$$\sum_{i=1}^{n}(y_i - \hat{y}_i)^2 = \sum_{i=1}^{n}\left(y_i - \hat{a} - \hat{b} \cdot x_i\right)^2 \to 0 \quad (13)$$

where $\hat{a}$ and $\hat{b}$ are the estimators of the linear model parameters. Minimizing the amount involves determining the stationary points that result from solving the system obtained by canceling the partial derivatives of the function:

$$F(\hat{a}, \hat{b}) = \sum_{i=1}^{n}\left(y_i - \hat{a} - \hat{b} \cdot x_i\right)^2 \quad (14)$$

we arrive at the following system of equations:

$$\begin{cases} n\hat{a} + \hat{b}\sum x_i = \sum y_i \\ \hat{a}\sum x_i + \hat{b}\sum x_i^2 = \sum x_i y_i \end{cases} \quad (15)$$

and after performing the calculations the following estimation relations are obtained:

$$\hat{a} = \frac{\sum_{i=1}^{n} y_i \sum_{i=1}^{n} x_i^2 - \sum_{i=1}^{n} x_i \sum_{i=1}^{n} x_i y_i}{n\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2} \quad (16)$$

$$\hat{b} = \frac{n\sum_{i=1}^{n} x_i y_i - \sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i}{n\sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2} \quad (17)$$

In the case of multifactorial regression, a resultant variable is defined according to several factorial variables which implies the use of multifactorial regression:

$$y = f(x_1, x_{2,}\ldots, x_n) + u_i, i = \overline{1,n} \quad (18)$$

where u_i represents the action of other factors (disturbance), and n the number of observations. If the connection between each factor and the resultant variable is linear, then the regression function becomes:

$$y_{x_1, x_{2,}\ldots, x_n} = a_0 + a_1 \cdot x_1 + a_2 \cdot x_2 + \ldots + a_n \cdot x_n \quad (19)$$

in which a_0 is the parameter that concentrates the influence of the unregistered factors, considered with constant action; $x_1, x_{2,}\ldots, x_n$ are the factorial variables included in the research report; and $a_1, a_{2,}\ldots, a_n$ are regression coefficients, which show how much the resultant variable changes when the factorial variable changes by one unit. The estimation of the parameters of this model can be done using the least squares method, which involves minimizing the sum of the squares of the deviations of the empirical values (y_i) from the estimated values ($\hat{y}_i$):

$$\sum_i (y_i - \hat{y}_i)^2 = \sum_i (y_i - \hat{a}_0 - \hat{a}_1 \cdot x_1 - \hat{a}_2 \cdot x_2 - \ldots - \hat{a}_n \cdot x_n)^2 \quad (20)$$

where, $(\hat{a}_i)_{i=\overline{0,n}}$ are the estimators of the linear model parameters.

Minimizing the amount involves determining the stationary points that result from solving the system obtained by canceling the partial derivatives of the function:

$$F(\hat{a}_0, \hat{a}_1, \hat{a}_2, \ldots, \hat{a}_n) \sum_i (y_i - \hat{a}_0 - \hat{a}_1 \cdot x_1 - \hat{a}_2 \cdot x_2 - \ldots - \hat{a}_n \cdot x_n)^2 \to 0 \quad (21)$$

The following system of equations is constructed based on empirical data:

$$\begin{cases} n \cdot a_0 + a_1 \cdot \sum_i x_{i1} + a_2 \cdot \sum_i x_{i2} + \ldots + a_n \cdot \sum_i x_{in} = \sum_i y_i \\ a_0 \cdot \sum_i x_{i1} + a_1 \cdot \sum_i x_{i1}^2 + a_2 \cdot \sum_i x_{i1} \cdot x_{i2} + \ldots + a_n \cdot \sum_i x_{i1} \cdot x_{in} = \sum_i x_{i1} \cdot y_i \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ a_0 \cdot \sum_i x_{in} + a_1 \cdot \sum_i x_{i1}^2 + a_2 \cdot \sum_i x_{in} \cdot x_{i2} + \ldots + a_n \cdot \sum_i x_{in}^2 = \sum_i x_{in} \cdot y_i \end{cases} \quad (22)$$

Based on the theoretical elements presented, it was necessary to decide on the statistical significance of the regression parameters and the validity of the adopted model. If the regression coefficients of the estimated models belong to a confidence interval that also contains the value of 0, the model was abandoned. After verifying the significance of the parameters, the next step was to validate the statistically specified model using the ANOVA test. Validating the model, which was assumed to be significant for the regression parameters, was done by interpreting a specific p-value test. Once validated, the model was used in projection simulation.

Selecting methodologies and assumptions. The relevant assumptions, methodologies, and models for the elaboration of policies, measures and projections were selected during the planning period of NC8. The work is based on established methods and models that have been used for many years and assessed to be the most relevant and suitable. The methodologies and models are continuously developed and improved. Assumptions are made based on available data and on expert knowledge. For projections, sensitivity analyses are performed by applying a range of lower and higher estimates to the key assumptions. These are chosen to reflect the sensitivity of the model when changing some key parameters over a range of values. The result of the sensitivity analyses is described in the textual part of the NC8.

Assumptions. Since the last submission, LULUCF projections have been recalculated based on new historical data. Projected values are based on the same modelling exercise and have only been updated according to the changes made in the GHG inventory. For the LULUCF Sector, WOM, WEM, WAM scenarios are available.

- Regarding the Forestland category, some additional assumptions were made to estimate future GHG emissions. The assumptions for each scenario are described in detail. Based on forest structure information measured by the National Forest Inventory (NFI) for the years 2012 and 2017, all three scenarios' future projections consider the age-structure dynamics of the forest. The implementation team used an ad-hoc model for projections which uses both the forecast calculations presented in 5. C section for AD as area, harvest, and forest growth due to the age-class distribution. In the case of the WOM scenario, we assume that the forecasting of the annual harvest values is based on 1989-2012 historical data. The maximum allowable cut does not have any restriction in this scenario, although present in the forest legislation in Romania. Regarding the WAM scenario, additional planting activity is quantified in line with the NRRP policy program by raising the forestland area to approximately 56.700 ha during 2020 - 2030 (L-FL category). The mitigation impact of the new afforested land was quantified using methodology and growth values from those reported in RO - NIR 2022 (section 6.2.2.2). Additional measures regarding annual forest harvest are quantified as Romania plans to adopt measures in the new forest strategy (e.g., "The development of an adequate and environmentally friendly forest transport infrastructure with many beneficial effects … an effective system to combat illegal logging"). Quantified measures are also implemented in the HWP pool through NRRP, adding an inflow of wood. In WEM and WAM scenarios, the projected values of the harvest rates are based on the 2013-2020 historical data, with the additional measure

of the maximum annual allowable cut (according to the forest legislation). The values can exceed the yearly merchantable volume growth estimated at 22.2 million. m3/year[61].

- Non-forest categories: (i) cropland - assume an average of the activity data (kha) for the 2012-2020 period, CSC related to living biomass and soil carbon pools lower in relation to the last submission. Emissions from dead organic matter are the largest sources in croplands. The emissions are projected to decrease slightly based on a projected slight decrease in emissions per area for the last ten years. SOC on annual cropland is projected to slightly increase in the next period due to implementation of the APIA payment measures for farmers which promotes beneficial practices for environment and climate (for example: crop diversification; greening; cover crops; over 30% of the straw remains on the field etc.). Consequently, the Soil pool under CL will maintain its sink behavior for GHG emissions which is also in accordance with the country specific parameters developed for soil carbon pool. (ii) grassland - assume a mean of the activity data (kha) for the 2012-2020 period, CSC related to living biomass and soil carbon pools lower in relation to the last submission. SOC under GL is projected to slightly increase in the next period due to policy affecting grassland management. After the implementation of the Gov. decision no. 34/2013, the assumption is that SOC increases are expected to take place over the years in mineral soils under grassland category due to improved management practices which include, among others, balanced fertilization according to fertilization plans (based on agrochemical studies), controlled grazing etc. This regulation stipulates that starting from the year 2020, all the farmers who apply for subsidies and own grassland, must implement the pastoral improvement management practices plans for increasing the grassland quality. Therefore, for the next period, the Soil pool under GL will behave as sink for GHG emissions. (iii) wetlands - the emissions projections follow the same methodology as the one used in the NGHGI; (iv) settlements - expert judgments assume a constant population that settles mainly in urban and suburban regions with a corresponding demand for infrastructure, establishments of power lines and forest roads. Emissions are projected to be at the same level for the whole projection; (v) other land - it has been assumed that the annual LUC from forest land to other land remains. Work is ongoing to develop suitable activity data and associated estimates. Further work is needed to develop projections for LULUCF subcategories based on sound methodologies and an acceptable level of understanding of the impact of the most important drivers of change.

Uncertainty in Projections. Last NGHGI submission, performed a complete uncertainty assessment for the LULUCF Sector subcategories. Uncertainties tend to be higher for some sources and can vary significantly between individual sources. The development of GHG scenarios adds another layer of uncertainty. In general, the uncertainty associated with projected activity data is considerably higher, while the uncertainty in the emission factors might be in a range like that of the uncertainty levels in the inventory. Overall, there are different types of uncertainty that can be identified in emissions projections: (i) inaccuracy of the database; (ii) assumptions on activities and key drivers; (iii) impacts of policies and measures; (iv) weather conditions and/or climate changes. The main uncertainty factors are described for each subcategory in the following: a. the forest subcategory, including harvested wood products, has the highest impact on LULUCF projection results. Consequently, the uncertainties for this subcategory are expected to account for most of the uncertainty in the total LULUCF trends. A particularly high level of uncertainty is associated with the simulated changes in forest soil C stock; b. for non-forest subcategories, the uncertainty level is closely linked *with (i) the simulated changes in living biomass C stock; (ii) historical activity data (kha); (iii) expert judgement on some parameters; (iv) country specific emission factors; (iv) policies and measures that may affect farmers decisions*.

Changes with respect to previous submission

[61] State Of The Forests in Romania, http://mmediu.ro/categorie/starea-padurilor/209, last accessed, 27.10.2022

According to Article 18 (3) of Regulation 2018/1999/EU, Member States shall communicate any substantial changes to the information reported pursuant to this Article during the first year of the reporting period. Changes with respect to the previous GHG emissions projections of 2022 are influenced by the following main factors: (i) changes in the historical activity data AD(kha); (ii) update of new emission factors; (iii) changes in assumptions for activity scenarios have changed; (iv) these changes can be triggered by additional policies and measures and revisions of policies or measures; (v) changes in the models used for activity or emission scenario; (vi) update of area for organic soils; (vii) update of carbon stock change for the all carbon pools. The following figure shows a comparison of past trends and scenarios with measures (WEM) for the GHG emissions-removals level by LULUCF Sector.

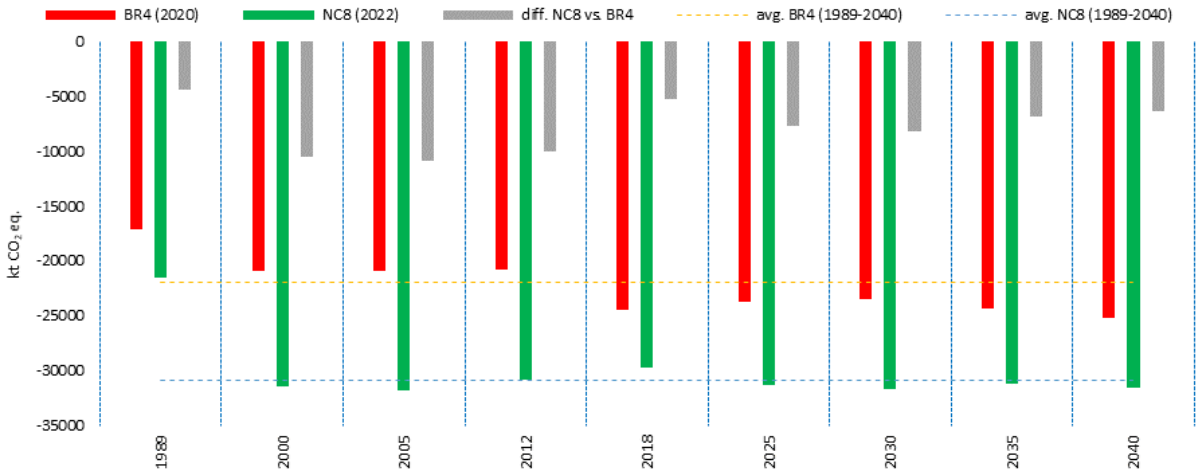


Figure 5-5 Comparison of projections related to previous submission - LULUCF Sector

Waste

To establish the GHG emission projections, the following equation is used in accordance with NIGHGE 2022:

$$GHG_{Emissions} = AD \times EF$$

where:

AD = the projected activity date
EF = forecast emission factor.

The activity data and emissions factors are presented in chapter 5.A.4.5.

D. Sensitivity analysis

D.1 Sensitivity analysis of GHG emission projections to changes in economic and social development of Romania

The achievement of GHG emission projections is based on assumptions about high-uncertainty macroeconomic indicators on the forecast horizon until 2040 due to the national and global economic crisis due to the COVID19 pandemic and the lack of strategies for the 2030-2040 horizon on industry, agriculture, transport, etc. Since December 2020, the National Recovery and Resilience Plan (NRRP) is under public debate, a strategic document of Romania setting out the areas and priorities of investments as well as the reforms developed for each investment area, in line with the Country Specific Recommendations (CSR), as well as the European Commission Regulations, the financing of which is provided from the Redress and Resilience Facility (RRF) which aims as a general objective to improve Romania's economic status, strengthening resilience in periods of pandemic crisis and ensuring long-term economic growth. Economic development is a dominant factor affecting the results of forecasts.

From the overall objective of the NRRP several specific objectives derive concerning:

- Infrastructure investments which aim to develop specific infrastructure in areas considered strategic for Romania such as transport, climate change, energy and renewable energy, environment, energy efficiency, modernization of local public services, health, and education
- Investments in digitalization and green transition which aim to the alignment with the objectives set by the European Union and contained in the European Green Deal, but also to increasing Romania's resilience capacity in times of pandemic crisis.
- Investments in the competitiveness of the business environment and access to research and innovation which are intended to strengthen the economic competitiveness of SMEs on the European market, increase added value, improve the quality of products and services obtained, refurbish, robotics and automate industrial processes, digitize the activity of SMEs, as well as the development of research, innovation and smart specialization activities by the National Institutes for Research and Development and SMEs, which ultimately aim to place competitive products and services on the market in line with quality requirements and prices of consumers.

Having in view the uncertainties regarding Romania's economic and social development in 2022 to analyze the sensitivity of GHG emission forecasts to the assumptions envisaged, minimum and maximum scenarios for the economic recovery are carried out against the reference scenario for which the forecasts were made. Sensitivity analysis refers to economic development because the effect of other factors is substantially lower.

Taking into consideration the share of about 70% of emissions from the combustion of fuels in total GHG emissions in Romania, the sensitivity analysis focuses on GHG emissions due to the energy sector.

Table 5-126. presents the main indicators considered in the sensitivity analysis for alternative scenarios compared to the reference scenario. Population evolution is considered the same in all 3 scenarios. The evolution of macroeconomic indicators determines variation in energy and electricity consumption with significant influences on GHG emissions.

To elaborate forecasts for the 2020 – 2040 period, were used the average annual GDP growth rate in mentioned period (Table 5126) indicated by the National Commission for Strategy and Prognosis (reference scenario) and the European Commission in June 2022 (minimum scenario).

Table 5-126 The average annual growth rate of GDP during 2005 – 2040 (%)

Year	2005	2016	2017	2018	2019	2020	2021-2025	2026-2030	2031-2035	2036-2040
	Inventory						Projections			
National Commission for Prognosis (September 2022)	4.7	4.8	7.1	4.4	4.1	-3.8	5,05	3.52	-	-
Parameters recommended by the European Commission (June 2022)						-3,75	3,63	3.04	2,16	1.27

The evolution of macroeconomic and energy indicators for the three scenarios is presented in Table 5-127.

Table 5-127 The evolution of macroeconomic and energy indicators in 2020÷2040 period in all three scenarios

Scenario	INDICATOR	MU	2020	2025	2030	2035	2040
			Inventory	Projections			
MINIMUM	Gross domestic product	10^9Euro_{2020}	218.9	265.0	310.0	345.0	376.0
	Primary energy consumption	10^6tep	32.171	32.98	34.75	35.98	38.33
	Final energy consumption	10^6tep	23.513	24.90	26.55	27.20	29.90
	Gross electricity consumption	TWh	54.68	57.20	59.40	60.70	61.75
REFERENCE	Gross domestic product	10^9Euro_{2020}	218.9	280.0	333.0	363.8	398.8
	Primary energy consumption	10^6tep	32.171	33.693	35.637	36.979	39.822
	Final energy consumption	10^6tep	23.513	25.458	27.042	28.724	31.290
	Gross electricity consumption	TWh	54.68	58.25	61.76	62.76	63.73
MAXIMUM	Gross domestic product	10^9Euro_{2020}	218.9	289.0	348.0	375.13	405.0
	Primary energy consumption	10^6tep	32,171	33.94	36.76	38.10	40.34
	Final energy consumption	10^6tep	23.513	26.63	28.83	30.87	32.01
	Gross electricity consumption	TWh	54.68	58.25	62.79	63.96	64.63

The assumptions for macroeconomic restructuring during 2020÷2040 period for the alternative scenarios considered for sensitivity analyses are presented in Table 5-128.

Table 5-128 The evolution of the structure of Gross Added Values in 2020÷2040 period

Scenario	Value	2020	2025	2030	2035	2040
		Inventory	Projections			
MINIMUM	Gross value added, of which:	100%	100%	100%	100%	100%
	Industry	22.42	24.5	20.3	20.1	20.9
	Agriculture	4.38	5.5	6.3	5.2	5.0
	Construction	7.25	8.0	8.0	8.0	8.2
	Services	65.95	62.0	65.4.4	66.7	65.9
REFERENCE	Gross value added, of which:	100%	100%	100%	100%	100%
	Industry	22.42	21.90	21.32	20.17	19.87
	Agriculture	4.38	4.50	4.02	3.15	3.23

	Construction	7.25	7.87	8.41	8.04	7.24
	Services	65.95	65.73	66.25	68.30	69.07
MAXIMUM	Gross value added, of which:	100%	100%	100%	100%	100%
	Industry	22.42	24.5	23.7	23.1	22.9
	Agriculture	4.38	6.0	4.5	4.5	4.0
	Construction	7.25	7.50	8.00	8.00	8.00
	Services	65.95	62.0	63.9	64.40	65.10

In Table 5-129 the evolution of CO2 emissions due to the energy sector is presented in the reference scenario and in the alternative scenarios (minimum and maximum).

Table 5-129 Evolution of CO2 emissions for alternative scenarios in 2018÷2040 (thousand t CO2)

Scenario	Indicators	2018	2020	2025	2030	2035	2040
		Achieved		Forecasted			
Minimum	A. Burning fuels	**68859.19**	**62508.31**	**64635.87**	**59448.95**	**61784.80**	**62483.98**
	1. Energy sector	25594.24	18262.98	11756.45	5256.98	5786.53	5135.89
	2. Manufacturing and Construction sector	14019.39	14714.29	20975.66	22699.78	22654.48	22786.45
	3. Transport	18176.82	18122.95	21156.75	20765.96	21975.85	22899.45
	4. Other sectors	10440.96	10760.06	10145.78	10123.67	10765.56	10976.65
	5.Others	627.79	648.03	601.23	602.56	602.38	685.84
Reference	A. Burning fuels	**65423.74**	**62508.31**	**66956.47**	**63694.66**	**67996.31**	**72122.13**
	1. Energy sector	24173.50	18262.98	12189.22	5606.32	6045.32	5485.05
	2. Manufacturing and Construction sector	12098.27	14714.29	21175.95	22237.70	23536.55	24602.30
	3. Transport	18177.85	18122.95	22015.35	24046.50	26281.68	28523.53
	4. Other sectors	10357.11	10760.06	10945.35	11141.36	11436.24	11779.15
	5.Others	617.01	648.03	630.60	662.77	696.57	732.10
Maximum	A. Burning fuels	**65423.74**	**62508.31**	**68742.54**	**65181.94**	**68732.34**	**71900.32**
	1. Energy sector	24173.50	18262.98	12457.64	5457.55	5958.96	5236.88
	2. Manufacturing and Construction sector	12098.27	14714.29	21456.88	22778.80	24086.75	24699.75
	3. Transport	18177.85	18122.95	22825.75	24675.98	26198.79	28051.23
	4. Other sectors	10357.11	10760.06	11356.87	11598.75	11783.98	11657.68
	5.Others	617.01	648.03	645.4	670.86	703.86	754.78

The sensitivity analysis for the combustion of fuels by the energy sector (energy industry, manufacturing and construction, transport and other sectors) in relation to economic development at national level allows the following conclusions to be drawn:

- CO2 emissions increase with the increase of GDP and decrease with the decrease of GDP. However, the increase in emissions in the maximum scenario is smaller than the decrease in the minimum scenario, given that the higher the GDP, the more funds will be available for new technologies
- In the case of manufacturing industry and construction, it is also noted that emissions increase with GDP, but the increase is less than the decrease in the minimum scenario which demonstrates the existence of funds for environmental protection and increased energy efficiency
- In the case of the transport sector in the maximum scenario, there is an increase in emissions accompanied by a GDP growth lower than the decrease in the minimum scenario although the increase in living standards of the population increases mobility but there are funds to renew the fleet of cars with high performance cars (emissions reduced, electric machines)
- The structure of the electricity production facilities does not differ significantly in the analyzed scenarios. The difference in emissions in this sector depends mainly on meeting the demand for electricity and heat
- The impact on emissions in other sectors such as residential, agriculture and services are not significant.

D.2 Sensitivity analysis for LULUCF sector

The projections for the LULUCF Sector are based on several assumptions which are characterized by uncertainties and the results must be interpreted in this key. A sensitivity projection has been calculated related to the LULUCF Sector. The calculations of the sensitivity projections show that the projection with no climate effect (BAU without CC) results in an increase in net removals until 2040 instead of a decrease as in the business-as-usual projection (BAU). The removals are projected to be around -15 million tons in 2040 which is about 3 million tons higher compared to the reference projection with climate effect.

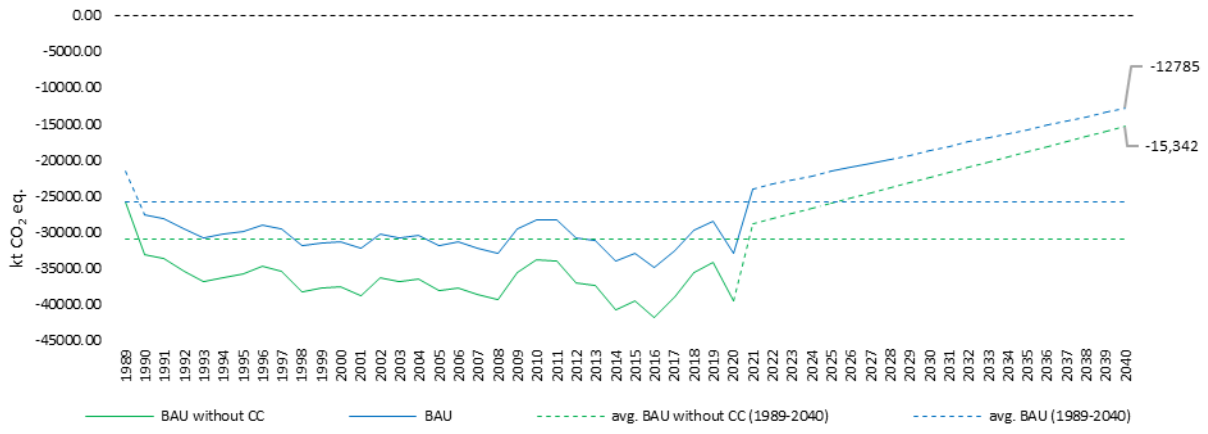


Figure 5-6 Sensitivity analysis related to LULUCF Sector

6. VULNERABILITY ASSESSMENT, CLIMATE CHANGE IMPACTS AND ADAPTATION MEASURES

A. Expected impacts of climate change

During the last years, the impacts of climate change on Romanian society and ecosystems have grown and climate change issues have become increasingly important on the Romanian political agenda. Expected impacts affect all socio-economic sectors in Romania. For instance, a net increase in thermal-related mortality, caused by the sharp increase in mortality associated with high temperatures, is identified in urban environment, under the pessimistic scenario RCP 8.5, by the end of the century. Another example of climate change impact is on water supply/demand and agriculture.

One of the first national strategies on climate change, which includes an important section on adaptation, was approved in July 2013, by GD 529/2013. Romania's National Strategy on Climate Change was based on the Climate Change Adaptation Guide published in 2008 and was updated, together with the associated action plan, in October 2016, for the period up to 2020, with vision elements for 2030 and 2050. This strategy addressed the impacts of observed and future-projected climate change on water resources, agriculture, energy, transport, industry, the insurance sector, biodiversity, health, tourism and recreation, forestry, and infrastructure. The strategy approved in 2016 added new elements regarding adaptation to climate change through institutional cooperation, in an operationalized, integrated and multi-sectoral way, providing, together with the Action Plan, the basis for the implementation and concrete application of the identified and selected adaptation measures.

In 2022, the President of Romania Klaus Iohannis decided to establish a working group on climate change under the coordination of the climate and sustainability department of the presidency's administration. This working group elaborated the report "Limiting climate change and its impact: an integrated approach for Romania" which identified a series of challenges Romania is facing. The report is also presenting a set of measures to effectively respond to them (https://www.presidency.ro/ro/presa/clima-si-sustenabilitate/raportul-limitarea-schimbarilor-climatice-si-a-impactului-lor-o-abordare-integrata-pentru-romania). The report emphasizes the need to ensure a healthy environment and limit the effects of extreme weather and climate phenomena and associated natural disasters, as well as enabling access to clean energy, job generation and green economic growth.

Currently, a new process of updating climate change strategies is underway in Romania, by developing an updated adaptation strategy and an associated action plan, spanning the period up to 2030, with elements of a long-term vision (up to 2050). In addition to the adaptation strategy, the long-term mitigation strategy (until 2050) is also being developed.

This chapter presents updated information compared to the previous report on climate regime trends, scenarios of future climate change and adaptation measures from the perspective of climate impact and vulnerability to climate change of the socio-economic environment in Romania.

A.1 Changes observed in the climatic regime in Romania

Air temperature

The analysis carried out using data collected at meteorological stations for the period 1961 -2021 highlights significant changes in the temperature field during summer, spring, and winter (see Figure 6-1) and in annual values:

- the increasing trends of the seasonal temperature are statistically significant (at a confidence level of 90%) throughout Romania, in winter and summer
- in spring, temperatures rise significantly in almost the whole country, even if, in general, with a lower magnitude than in winter and summer

In autumn there are upward trends, but generally lower and the number of stations where the trend is statistically insignificant is higher than in spring.

Precipitations

Based on the statistics of observations recorded in the period 1961-2021 at 104 meteorological stations, the following precipitation characteristics were identified:

- increasing trends in the amount of seasonal precipitation are present in most of the country, in autumn (at 90% confidence level)

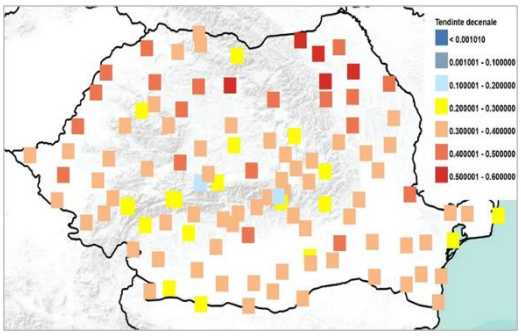
Statistically significant decreasing trends (90% confidence level) are identified for a few weather stations in winter, spring, and summer.

Trends in other climate indicators

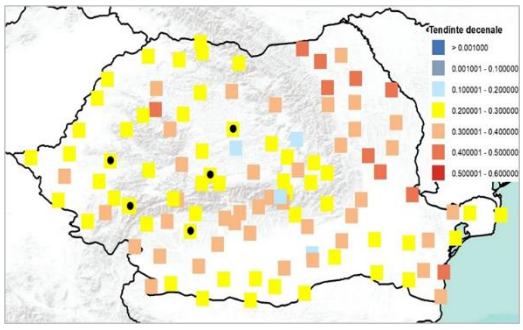
The analysis carried out using data collected at weather stations, in the period 1961-2021, also reveals significant changes in other climate indicators:

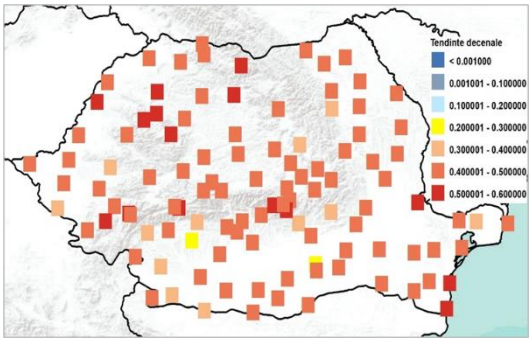
- although there are no increasing trends in the seasonal amounts of precipitation, there are increasing trends in the seasonal maxima of daily precipitation, both in winter and in summer (Bojariu et al. 2015).
- the snow depth and extent decrease significantly especially in central, western and northern regions of the country; decreasing trends of the snow cover are also present, locally, in southern and eastern Romania
- the maximum duration of heat waves is increasing in southern and western regions of Romania (the heat wave is defined in Romanian legislation as the interval with at least two consecutive days in which the temperature is higher than 37 °C)
- in the case of Bucharest (the largest urban agglomeration in the country) the weather station located in the center of the city shows a higher temperature increase trend than the one located at the northern part of the town, illustrating the impact of urban development and the heat island effect of the city on amplification of heat stress.

DJF (Winter)

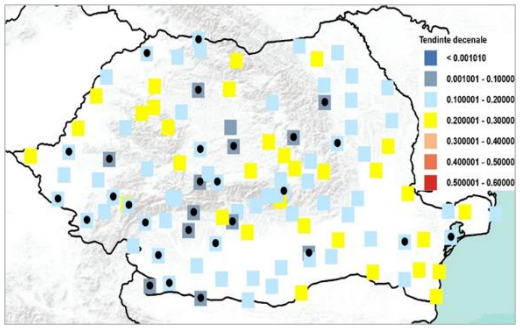


MAM (Spring)





JJA (Summer)



SON (Autumn)

Figure 6-1 Seasonal trends of air temperature increase at 113 meteorological stations, in the interval 1961-2021.[62]

Many of these observed trends are expected to continue in the near future, and some of them to intensify in the medium to long term as global warming accelerates towards the end of the century.

A.2 Scenarios regarding climate change in Romania

The results based on the ensembles of numerical experiments with global climate models show a progressive increase in air temperature during the 21st century, for all seasons, but more pronounced in summer and winter. In the near future (2021-2050), the results of the climate models show for Romania an average monthly increase in temperature (up to 3 °C in summer) and an average monthly reduction in the amount of precipitation (8-9% during the summer), in the most pessimistic scenario with the highest global greenhouse gas concentrations (GHCs) at the end of this century (Figure 6-2) (Bojariu et al, 2021).

The differences related to the scenarios are relatively small for the first decades of the 21st century. Large differences in climate are expected towards the end of the 21st century. For the most pessimistic scenario (RCP 8.5), the increase in the average monthly temperature in Romania will exceed 6 °C during the summer, in the period 2061-2090 compared to the period 1961-1990 (Bojariu et al., 2021). Projections also show that changes in average temperature and precipitation occur along with changes in the statistics of extreme events. The intensity of precipitation is increasing throughout the country, but more pronounced in the mountain areas. The number

[62] Significant upward trends at (90% confidence level) are represented by shades of color (highest increase in red). Black circles illustrate locations without statistically significant trends.

of days with heat waves is also increasing, especially in the southern, southeastern, and western region of the country (Bojariu et al, 2015).

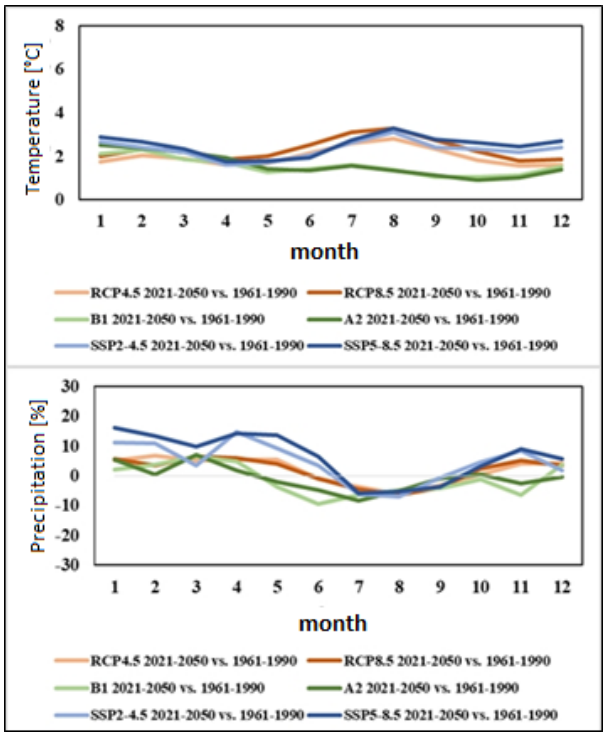


Figure 6-2 Multiannual average monthly change (2021-2050 vs. 1961-1990 of the air temperature (in °C, top) and precipitation (in %, bottom)[63] averaged over the entire territory of Romanian, under the conditions of the analyzed climate scenarios

In the context of global warming, changes in Romania's climate regime are modulated by regional conditions. Regional modeling and dynamic downscaling provide additional policy-relevant information on the spatial nature of climate change.

B. Vulnerability assessment

The updates made using the new CMIP6 climate models under new scenarios (SSP 5 RCP 4.5 and SSP5 RCP 8.5) did not significantly change the climate change image obtained with the projections of the CMIP3 and CMIP5 climate models. Significant climate changes are still expected during the next decades in Romania. Soon (2021-2050), the most pressing consequences are those related to the increase in the average monthly temperature (by more than 3 °C during the summer) and the reduction of the average monthly precipitation amounts (8-9% during the summer), under the most pessimistic scenario, with implications in electricity generation, agriculture, and water resource management. Projections also show that changes in average temperature and precipitation occur along with changes in the statistics of extreme events. The number of days with heat waves will also increase, especially in the southern, southeastern, and western regions of the country, so an increased vulnerability to heat

[63] The assessed changes under scenario A2 and B1 are calculated using climate model runs from CMIP3. The assessed changes under the scenario RCP 4.5 and RCP 8.5 are calculated using runs with climate models from CMIP5, and those under the scenarios SSP5 RCP 4.5 and SSP5 RCP 8.5 with climate models from CMIP6.

stress is favored especially in the large urban agglomerations of the above-mentioned regions. The intensity of the precipitation will increase throughout the country, but more pronounced in the mountain areas, which can favor flash floods. The impact of increased precipitation intensity is higher in urban areas where the soil is sealed from the atmosphere to a high degree. Averaged snow depth and snow extent have been further reduced and these trends will continue in the future.

The increased evapotranspiration and the downward trend of precipitation amount in summer, corroborated with the reduction of snow depths in the cold season, the change of liquid/solid precipitation ratio in winter and changes in the seasonal cycle of river flows will favor a tendency towards reduced water supply, especially in warm season, in river basins from Southern and Eastern Romania. This pattern of change will intensify competition between different water users, such as those in electricity generation, agriculture, industry, tourism, and households (Bojariu et al., 2021).

Climate vulnerability together with the climate exposure is a component of the impact of climate hazards on human systems and ecosystems. In this context, the climate-related hazards due to temperature increase (e.g., heat waves, wildfires, droughts), and precipitation modifications (droughts, episodes with extreme precipitation, floods) affect all socio-economic sectors in Romania. However, climate change will not have the same impact for all population categories. Some communities will have to face greater challenges than others. For instance, climate impacts will be stronger for those living in climate-sensitive areas, such as large urban agglomerations, floodplains or plains most affected by drought. Moreover, climate-related vulnerability is amplified by poor infrastructure but also it changes with age, sex, poverty level and chronic diseases of people. Vulnerability to climate change in Romania was analyzed by Xie (2014) for some sectors, such as energy, transport, urban environment, water resources, agriculture and forestry and based on his study, an extensively vulnerability analysis was presented in the previous national communication (Ministry of Environment, 2017). While the vulnerability analysis presented in the previous national communication remains generally valid, there is new available knowledge on specific vulnerabilities related to climate change. New studies have been carried out for assessing the impact of heatwaves in Romanian urban areas. A new finding is the strong response of mortality caused by Circulatory System Diseases to high urban and low rural temperatures for women. Our findings suggest that women are statistically more vulnerable than men to thermal stress under the same climate hazard and exposure (either urban or rural ones) and this should be added to the list of more known vulnerable categories such as children, old people and people cu chronic diseases, in order to effectively adapt to climate change (Chitu et al., 2022).

C. Adaptation measures

Romania's National Strategy on Climate Change, approved in July 2013 by the Government targeted the impacts of climate change on water resources, agriculture, energy, transport, industry, the insurance sector, biodiversity, health, tourism and recreational activities, forestry and infrastructure. Romania's National Strategy on Climate Change was updated to make it more operational effective by the Ministry of Environment, Water and Forests with the financial support of the European Union and the technical assistance of the World Bank. The operationalized version was approved by the Government of Romania in October 2016. Complementary to the new strategy for 2016-2030, the action plan targeted specific measures to adapt to climate change, for the period

2016-2020, to operationalize and implement the strategy [64]. The action plan also proposed measures to increase the use of insurance for damage caused by climate hazards by creating climate risk insurance funds. Also, the provided adaptation measures aimed to ensure the protection of the biodiversity of ecosystems in Romania by increasing the capacity to face the impact of climate change.

A new strategy and associated action plan dedicated to adaptation to climate change are being developed. This new update covers the period 2021-2030, with vision elements up to 2050. The new strategy for adaptation will also have a dedicated platform (RO-ADAPT), following the model of the European platform Climate - ADAPT[65].

The report of the working group issued by the department of climate and sustainability of the presidential administration in Romania[66] recommends two types of adaptation approach: systemic and regional/local measures. Among the systemic ones, there are measures such as:

- the development of roadmaps for adaptation and resilience at the sectoral level in the context of Romania's new national adaptation strategy
- continuous development of the RO-ADAPT platform, including a section dedicated to the National Climate-Health Observatory
- Regional and local measures proposed in the aforementioned report aim at:
- the development of a network of certified experts to be consulted by town halls in the context of local adaptation, with at least 5 experts in each development region of Romania
- adaptation strategies and associated action plans, developed at the level of each territorial-administrative unit (UAT).

Adapting to climate change and mitigating its effects (by reducing GHG emissions) involve smart climate actions, defined as those that simultaneously bring benefits to adaptation, mitigation, the environment (by preserving / restoring biodiversity) and the economy. The sectoral adaptation measures presented below are updates of those presented in the previous national communications (Ministry of Environment, 2017).

C.1. Agricultural and rural development

The action plans associated to adaptation strategies in Romania include state-funded adaptation measures based on the European Union's Common Agricultural Policies (CAP) to counter the potentially negative impact climate change can have on the agriculture and rural development sector. The updated action plan promotes risk management schemes as essential tools for restoring potential production and compensating for economic losses associated with weather events. Green payments for agricultural practices (through the European Agricultural Guarantee Fund) and a set of additional measures also provide an important incentive for farmers to sustainably manage their land and thus adapt to climate change. Nature-based solutions are investigated and to be used where appropriate (e.g., establishing tree canopies to protect soil from erosion and ensure an improved local water cycle).

[64] Romania - 2016-2020 National action plan on climate change . Available at: http://documents.worldbank.org/curated/en/254931468188327164/Romania-2016-2020-National-action-plan-on-climate-change-summary-report

[65] Climate – ADAPT. Availale at: https://climate-adapt.eea.europa.eu/

[66] The report "Limiting climate change and its impact: an integrated approach for Romania". Available at: https://www.presidency.ro/ro/presa/clima-si-sustenabilitate/raportul-limitarea-schimbarilor-climatice-si-a-impactului-lor-o-abordare-integrata-pentru-romania

C.2. Water resources

Investments in reducing losses in water distribution networks and in the reuse of treated wastewater in industrial sectors – especially for large utilities and in areas climate prone to water depletion – are key to reducing the risk associated with short and medium-term water resource depletion. In addition, the updated action plans target policies and measures that include priorities for establishing consumption requirements, for the protection of critical sources of water supply in local communities and regulations for limiting the use of groundwater in catchment regions. Short- and medium-term research activities are also proposed for the scientific substantiation of the measures envisaged to reduce the risk of water resource deficit. In terms of flood risk reduction, upgrading the existing radar network to measure extreme precipitation and map the flood risks. Reassessing regulations for monitoring and managing building activities in high flood risk areas are also key priorities. A key measure aims to improve the ecological safety of dams and dikes through planned major investments to build, restore and improve flood management infrastructure. Changes in agricultural technologies aimed at conserving the water resource are also important. In general, saving and making efficient use of the water resource are essential measures in the new climate context.

C.3. Human environment (infrastructure and urban planning)

The updated action plans have promoted actions that support the holistic approach in urban planning and infrastructure development to better integrate climate change adaptation measures. Policies that drive development in areas less likely to be exposed to climate risk are important, as are policies or initiatives to increase the physical robustness of vulnerable urban infrastructure. Local or national regulations for new constructions must be based on updated scientific and technical knowledge including analysis of local hazards such as heat waves, urban floods, etc. Nature-based solutions are also aimed at including more areas with natural features in the artificially built environment of cities (e.g., increasing green and blue areas).

C.4. Transportation

The starting point for adaptation activity in this sector is the identification of vulnerability to the impact of climate change - both on infrastructure and services - to define short-, medium- and long-term responses. The updated action plans recommend that the review of emergency preparedness planning and vulnerability assessments be launched as a matter of priority, to increase the robustness of disaster responses and to establish where the greatest risks are. Overall, the main challenge is to put into practice those measures that increase the resilience of Romania's transport infrastructure and services by increasing 'green' mobility in the new climatic context.

C.5. Industry

The updated action plans include adaptation measures to support the following two strategic objectives: (i) increasing protection and preparedness for climate change emergencies in key industries; and (ii) increasing the awareness of private owners of industrial enterprises regarding the need for measures to adapt to climate change, including the efficient use of energy and water resources. Several actions to strengthen adaptation capacities for different industry sectors are needed to support these objectives, including improving knowledge and expertise on risk management and knowledge transfer on adaptation good practice. In this context, actions to increase the use of insurance against industrial losses due to climate hazards are also being considered, including the development of climate change insurance solutions and the creation of industrial climate risk insurance funds.

C.6. Energy

Both in terms of the vulnerabilities of critical energy infrastructure to extreme climate events and in terms of the potential impact of climate change on energy demand, the priority for the energy sector is the development of supply and demand adaptation measures in the energy strategy for the next period. Measures in this area will be

stimulated by a study to identify risks to critical energy infrastructure, as well as capacity-building and training actions to close the existing knowledge gap. Electrification on a large scale, increasing energy efficiency and saving energy resources against the background of increasing the share of renewable energies in the context of a diverse and robust energy mix, with the use of elements based on solutions inspired by nature is essential in this regard.

C.7. Tourism and recreation

The main recreation measures support the protection and expansion of natural recreational areas in urban and peri-urban areas and their accessibility for a diverse public. Pressure to designate these areas as eligible for built-up is a major risk and therefore their recreational and conservation status should be established and enforced. In addition, a policy on the spectrum of recreational opportunities should be implemented. Key measures in the field of tourism use a two-fold approach: firstly, exploiting the opportunities, and on the other hand, avoiding the risks associated with climate change. Therefore, the main priority is strategic planning at the national level, paying special attention to competitive tourism sectors and less dependent on climate change (e.g., ecotourism and spa tourism). Other priorities include supporting the development of mountain eco-resorts in all four seasons and adapting sea-shore tourism to climate change in the context of a prolonged summer season.

C.8. Forestry

Adaptation actions in forestry are built around three key objectives. First, improving forest management to support its capacity to adapt to climate change - in practice this includes updating sustainable forest management techniques and improving economic skills and market intelligence among economic operators. Secondly, adapting forest regeneration practices to the needs imposed by climate change - key actions in this regard are the updating of forest regeneration techniques and related capacity building actions. Thirdly, minimizing the risk of climate change for forestry - the key actions underlying the achievement of this objective consist in maintaining and improving the system of monitoring and observing risks such as forest pests, forest fires (in the context of increasing intensity, frequency and duration of heat waves and reduction in water resources) and invasive species, as well as other capacity-building measures and investments in risk management to face climate hazards.

C.9. Biodiversity

Adaptation measures aim to ensure that biodiversity will have the capacity to cope with the impacts of climate change. The most important measures are assessing the vulnerability of natural habitats and protected species to climate change and integrating climate change adaptation into national strategies and action plans for the protection of species, especially to control alien invasive species. The use of green infrastructure is also a key element needed to ensure the connectivity of populations or ecological corridors. In addition, ecosystem resilience would greatly benefit from improving the conservation status of swamps, lakes and dykes and ensuring the restoration and/or ecological recovery of wetland habitats in the Lower Danube basin. Other actions in biodiversity include the development of ecosystem services assessment, the ecosystem approach and adaptive management in decision-making systems, and the promotion of scientific research to increase knowledge and understanding the role of biodiversity and its contribution to climate change adaptation. These actions need to be supported by technical capacity building and human resources to strengthen and implement knowledge on the importance of biodiversity for climate change adaptation.

C.10. Public health and emergency services

The impact of climate change on public health results from the direct effects of extreme weather events and from several indirect effects that occur over a longer period (e.g., changing patterns of infectious diseases, disruption of agricultural systems, urbanization and migration of population). The adaptation measures presented in the updated action plan continue to aim at the objective of developing the capacity to monitor climate hazards with

impact on public health. This is in turn supported by capacity-building actions in training, research, and evaluation of the capacity for early detection of public health problems and related investments in the modernization of its surveillance technology. Secondly, the priority measures for the protection of citizens' health from the impact of disasters related to climate hazards assume the strengthening of the emergency management system in Romania by: (a) finalizing and harmonizing the regulatory framework for the national emergency management system; and (b) developing the risk reduction strategy and measures to reduce vulnerability to natural disasters in critical areas in Romania. These actions are continuously supported by a series of priority measures to strengthen risk monitoring capacities and early warning systems. In this context, the updated action plan recommends priority investments, such as the modernization of emergency communications and information management systems regarding natural disasters. A new proposed element is the establishment of a National Climate-Health Observatory, incorporated in the new Ro-ADAPT platform, dedicated to adaptation in Romania which is also mentioned in the presidential report.

C.11. Public education and a raising awareness

The priority actions that support the objective of improving population awareness regarding the climate impacts and adaptation to climate change are of two types: (a) campaigns to raise awareness and inform target groups; and (b) media campaigns to inform the general public. These actions must be supported by the development of structured partnerships between public authorities and civil society organizations. Improving citizens' climate change education is addressed through a range of educational actions at different levels - pre-university, university, and postgraduate education, as well as lifelong learning and vocational training. A report[67] ("Education on climate change and the environment in sustainable schools"), developed by a group of experts, at the initiative of the President of Romania, which was published in 2022 proposes measures such as:

- updating school programs of biology classes with notions of environment and climate change
- a dedicated web platform
- promoting good practices and actions for the environment
- teacher training program and course materials on the environment and climate change
- rewarding teaching staff involved in environment and climate education.

C.12. Insurance as a tool for adapting to climate change

The insurance sector is affected by climate change, but it can play an essential role in the process of adapting to it. The Romanian programs in the insurance sector require increased support because, at present, their presence and efficiency are limited. In addition, new insurance products may be developed that specifically target the consequences of climate change. The updated action plan lists priority actions that: (a) support increased use of and access to insurance products against climate change-related extreme events and (b) increase the capacity of the insurance sector to increase the capacity to cope with climate change.

[67] Education on climate change and the environment in sustainable schools. Available at: https://www.presidency.ro/ro/presa/clima-si-sustenabilitate/raportul-educatia-privind-schimbarile-climatice-si-mediul-in-scoli-sustenabile

7. FINANCIAL, TECHNOLOGICAL AND CAPACITY-BUILDING SUPPORT

Romania is not a Party included in Annex II to the Convention, therefore it is not mandatory to have in place measures to fulfil the obligations regarding the financial, technological, and capacity-building support provided to Parties not included in Annex I to the Convention (non-Annex I Parties), including information to show how this support is new and additional.

Romania is firmly committed to the international legal framework developed by the UN, the 2030 Agenda for Sustainable Development, The Paris Agreement and the United Nations Framework Convention on Climate Change which put the climate change topic on the top of the UN agenda. We are committed to the implementation of the Paris Agreement and highly aware of the urgency of action to keep the global average temperature to well below 2°C above preindustrial levels and shifting towards low greenhouse gas emissions development pathway while fostering climate resilience. Therefore, Romania has and will continue to offer financial support for the purpose of assisting non-Annex I Parties to mitigate GHG emissions and to adapt to the side-effects of climate change.

Despite of global and regional context in 2022, Romania remains committed to pursue its pledge, as an EU member state and donor of official development assistance, to protect its ODA budget and by 2030 allocate ODA representing 0.33% of the national GNI.

In line with the legal framework on development cooperation (Law no 213/2016), the budgetary planning of the ODA in Romania includes an Annual Plan on development cooperation and humanitarian assistance at the level of the Ministry of Foreign Affairs, as the coordinator of the national policy. Romania's national ODA also includes a wide range of public institutions involved in supporting developing countries through their own budget, reported annually to the OECD.

Climate change and environmental protection represent themes of interest in the Romanian policy of development cooperation and humanitarian aid, financed through both bilateral and multilateral assistance.

The multiannual strategic program on the international development cooperation and humanitarian assistance for the period 2020 – 2023 integrates the thematic and geographical priorities of Romania in this policy. This document includes sustainable economic development as a key priority theme of interest for the development cooperation projects and programs implemented by Romania. In this regard, special attention is drawn to climate change and environmental protection, also representing a cross cutting theme, as climate change has also been associated with the increase of the frequency of natural disasters in the past years.

In terms of financing, Romania has provided support both through bilateral and multilateral channels.

Since its operationalization in 2018, the Romanian Agency for International Development Cooperation (RoAid) has been mostly involved in bilateral implementation of projects and programs in this area. These projects focus on promoting sustainable energy and development, environmental protection through mitigation and adaptation, all these by organizing exchanges of expertise or offering donations.

In 2020 Romania, through its public institutions, financed ODA programs and projects as aid to environment summing up to 1.2 mil EURO, most of which had represented the contributions to international organizations of the Ministry of Environment. There were also other programs and projects implemented by RoAid in collaboration with regional organizations and UN agencies in support of environmental protection.

The ODA data for 2021 is yet to be validated by the OECD and 2022 data has not been processed yet.

The geographic and thematic priorities of Romania are defined in the Multiannual strategic program on the international development cooperation and humanitarian assistance for the period 2020 – 2023.

According to the Multiannual strategic program, geographical areas of interest in the field of development cooperation and humanitarian aid are the extended Black Sea Region, the Western Balkans, North Africa and Middle East, Sub-Saharan Africa, Central and South-East Asia, the Caribbean, as well as Pacific Small Island Developing States.

Climate change and environmental protection are integrated within one of the five main thematic priorities, which is sustainable economic development. Besides this, other themes of interest are governance and inclusive societies, consolidation of rule of law and fight against corruption, peace and security and education and youth promotion.

Within the sustainable economic development thematic priority, a central role is played by the transfer of expertise and concrete support in areas such as environmental protection including the research and development dimension, fight against the effects of climate change, renewable energy, and eater sanitation.

In implementing development cooperation projects and programs Romania promotes an active partnership with the private and the non-governmental sector as well as the civil society and other national experts to increase the efficiency of the activities, taking into consideration the possibility of sharing expertise from national experience. The international organizations also represent an important partner and actor in implementing ODA activities considering both their wide geographical coverage and the numerous and well-prepared experts.

Romania aims to support both mitigation and adaptation actions in development cooperation projects implemented, especially in support of sustainable development of partner countries. Capacity – building activities are integrated in the technical assistance and exchanges of expertise organized by the Romanian public institutions.

Proposals for development cooperation and humanitarian aid projects or programs to be included in the Annual Plan implemented by RoAid are being evaluated taking into consideration the beneficiaries' needs and existing capacities or policies. The overall framework of analysis is presented in the Multiannual strategic program. With the support of the diplomatic missions and consulates, an assessment is made regarding the situation and requirements of the targeted state or region and how the proposal of a certain project would contribute to responding to these issues.

Although Romania is not included in Annex II to the United Nations Framework Convention on Climate Change, Romania remains committed to protect its ODA budget and increase its funds to reach the 0.33% of GNI by 2030. In this sense, the national volume of ODA has continuously and steadily raised in last couple of years, our country also supports the collaboration with new partners on development cooperation and humanitarian assistance including the private sector, NGOs, civil society, academia, and other national and international experts who can provide good practices examples.

As stated above, the national commitment to reach the level of 0.33% of the GNI as ODA by 2030 is integrated in the Romanian Multiannual strategic program on the international development cooperation and humanitarian assistance for the period 2020 – 2023. The state budget representing the funding source for ODA programs and

projects implemented by different public institutions including climate finance assistance is approved on an yearly/ annual basis, therefore financial predictions for next years are limited.

Considering the recent operationalization of the Romanian Agency for International Development Cooperation and to establish clear provisions regarding the implementation of ODA programs and projects and the role of the Ministry of Foreign Affairs, a series of internal procedures were approved in the field of development cooperation for both structures. There are constant efforts and progress made to strengthen the national policy and implementation of ODA activities by public institutions.

A recent collaboration Roadmap was established by the MFA, the Agency and the OECD regarding development cooperation and humanitarian assistance as another step taken towards enhancing our policy, implementation and evaluation of programs and projects.

Romania, through the collaboration with international organizations and by implementing bilateral projects, supports both mitigation and adaptation.

One of Romania's main objectives in development cooperation that is also mentioned in the Multiannual strategic program is to support development strategies of the partner countries in relation to resilience, climate change and environment protection, while being sensitive to each country's specific context.

The geographic prioritization of ODA programs and projects within the Multiannual strategic program on international development cooperation and humanitarian assistance for the period 2020 – 2023, mentions the Sub-Saharan Africa and LDCs, the Middle East and North Africa and the SIDS of the Caribbean and South Pacific as key regions of interest for Romania. The main areas of action in these regions include sustainable economic development, fighting climate change effects, soil erosion and in the SIDS disaster risk reduction and reconstruction programs after natural disasters.

Romania contributes to multilateral assistance by contributing to European and international conventions such as the UNFCCC, the Convention on Long-Range Transboundary Air Pollution (UNECE) and the Environmental Fund for the implementation of the Protocol on Substances that Deplete the Ozone Layer. Besides these, through the Annual Plan for Development Cooperation and Humanitarian Assistance of the MFA, the Agency has allocated voluntary contributions to UN agencies such as UNDP and UNHCR, active in environmental protection and climate change, but also to organizations such as Green Climate Fund. Furthermore, the Agency, with the support of the private sector and other actors has implemented bilateral projects in developing countries in the concerned areas.

As previously mentioned, Romania's objective in implementing ODA programs and projects is to respect and support the partner's national strategies and its needs. In this context, when analyzing proposals of projects within the Annual Plan on development cooperation and humanitarian assistance of the MFA, there are taken into consideration the beneficiaries' needs and existing capacities or policies.

Through bilateral projects, Romania has promoted the sustainable development of partner countries and use of renewable and green energy and resources.

As previously mentioned, the climate change is introduced as a thematic priority in development cooperation programs and projects implemented by Romanian public institutions, both with the support of multilateral organizations or through bilateral activities in partner countries.

Within our ODA thematic priority sustainable economic development, a central role is played by the transfer of expertise and concrete support in areas such as environmental protection, including the research and

development dimension, the fight against the effects of climate change, renewable energy and water and sanitation. Capacity – building activities are integrated in the technical assistance and exchanges of expertise organized by the Romanian public institutions.

At the same time, one of Romania's main objectives in development cooperation that is also mentioned in the Multiannual strategic program is to support the development strategies of the partner countries in relation to resilience, climate change and environment protection, while being sensitive to each country's specific context.

Romania reports information on financial contribution for 2019 and 2020 provided through multilateral channels related to implementation of the Convention. In 2019, Romania provided 2,196,729.47 RON (518,353.30USD) through multilateral channels ("Other multilateral climate change fund"). In 2020 Romania provided 4,754,288.18RON (1,120,237.55USD) through multilateral channels.

More details can be found in the CTF tables 7(a), part of the 5th Biennial Report.

In 2019 and 2020 Romania has not developed activities related to bilateral cooperation (Table 7(b)), technology support and transfer (Table 8) and capacity-building (Table 9). Thus, the CTF tables 7(b), 8 and 9 of 5th Biennial Report were not reported.

8. RESEARCH AND SYSTEMATIC OBSERVATION

According to UNFCCC requirements, systematic research and observations are carried out for a better understanding of the effects of climate change in Romania, so that they can be used to propose mitigation and adaptation measures for greenhouse gas emissions to be adopted. In this context, Romania is synchronized with international efforts (for example, contributing to the activities of the Global Climate Observing System (GCOS). This chapter presents reports on the general policy and funding related to research and systematic observation (section 8A), research carried out at national, European and international level (section 8B) and systematic observations (section 8C).

A. General policy on and funding of research and systematic observation

Research activities in Romania consist of topics related to the climate system, climate-related impact, risk reduction and adaptation for policy support. National research activities have been carried out together with participation in international and European programs such as Horizon 2020, Horizon Europe, Joint Programming Initiative (JPI) Climate, JPI Water, European Cooperation in Science and Technology (COST). The main coordinator of Romanian research is the Ministry of Research, Innovation and Digitization, which supports the basic funding of national research and development institutes and, together with the Ministry of Education, offer financial support for research projects selected from national calls organized by the Executive Unit for the Financing of Higher Education, Research, Development and Innovations (UEFISCDI). Also, the Ministry of Research, Innovation and Digitization financially supports for Romanian teams a part of the contributions to European and international research.

The Ministry of Environment, Water and Forests coordinates and financially supports applied research on water management, climate-related environmental risks, and sustainable planning. The Ministry of Development, Public Works and Administration manages the Transnational Danube Program, which supports projects on climate change adaptation and climate risk assessment in relation to disaster management in the Danube basin regions. The Ministry of Agriculture finances projects related to the impact of climate change on agriculture.

Regarding systematic observations, Romania has participated in different fields of climate monitoring, both at national level and within European and global programs (such as GCOS). Romania continued the international data exchange and contributed to the European and global databases. The National Meteorological Administration as institution and with an expert contributed to the report on the climate state of Europe in 2022, developed under the auspices of the World Meteorological Organization (WMO) and the Copernicus Program of the European Union. Also, the National Meteorological Administration has added information to the annual reports on the global state of the climate developed by the WMO.

B. Research

Cooperation in the field of international research

Romanian research on climate change is synchronized with major international scientific programs in the field of global change research such as the Global Climate Research Program (WCRP). The National Meteorological Administration is scientifically involved in WCRP-related activities. Romania also contributed to the work of the

Intergovernmental Panel on Climate Change (IPCC). An expert from the National Meteorological Administration contributed, within Working Group I, to the elaboration of the Six-th IPCC Report, the first volume of which was published in 2021. The National Meteorological Administration coordinates Romania's contributions to the IPCC.

Cooperation in European research

Romanian institutions have carried out research projects within the Horizon 2020 and Horizon Europe framework programs and have participated in COST actions and other European climate-related programs (for example, the Danube Transnational Programme). Synergy and cooperation between European Union and national research programs are enhanced through participation in the Joint Program Initiatives (JPIs). Romania is a member of JPI Water, JPI Ocean, JPI on Agriculture, Food Security and Climate Change and an associate member of JPI Climate.

National research programs

National climate change activities in Romania consist of research projects financially supported, mainly by:

- Ministry of Innovation and Digitization (for example, the environmental section of the National Research Program for Research, Development, and Innovation IV)
- Ministry of Environment, Waters and Forests
- Ministry of Agriculture
- Ministry of Development, Public Works and Administration.

In recent years, the physical basis of climate change has been the main field of climate research in Romania. Romanian scientists analyzed regional climate variability and change in observed data and results from global and regional climate models to identify policy-relevant risks related to climate change for disaster risk reduction and sustainable adaptation planning. However, Romania needs more research on climate change mitigation and adaptation. Research institutes and socio-economic actors must join efforts to reduce the knowledge gaps between the physical basis of climate change and that of climate-related impact, risk and adaptation and mitigation. The most relevant research projects and networks funded at national level are listed in Annex 4.

C. Systematic observation

Meteorological observations are integrated, both at European and worldwide levels. Romania participates in various fields of climate monitoring, at national level and in European and global programs. Romania operates observation systems for the monitoring of essential climate variables (ECVs) covering:

- Atmospheric climate variables (including measurements for some atmospheric components such as ozone
- Climate of the Black Sea
- Terrestrial climate variables.

Romania complies with GCOS requirements. GCOS monitoring principles and best practices are considered in systematic observation activities. In Romania, these activities have been synchronized with the European Union and WMO programs (especially those in Region VI) and with GCOS. Romania has also exchanged data internationally and contributed to European and global databases.

The National Meteorological Administration (ANM) is the main organization that records systematic observations of the atmosphere and, to a lesser extent, of maritime and terrestrial climate. These observations are recorded

by the National Meteorological Network, designed for observations, primary validations, and data transfer to the national database.

The National Meteorological Administration has seven Regional Meteorological Centers, which manage the network of meteorological and rain gauge stations. The network includes 166 operational meteorological stations that are all equipped with automatic equipment, measuring the air temperature, relative air humidity, wind speed and direction, atmospheric pressure, and amount of precipitation. Apart from these, certain weather stations are equipped with horizontal visibility, snow cover, soil temperature and radiometric (net, global and diffuse) measuring devices. Several meteorological stations (24) operate autonomously. There are also 64 pluviometric stations which provide the daily amounts of precipitation and the thickness of the snow layer in the cold season and 68 meteorological stations which carry out a program of agrometeorological measurements. The program of upper-air measurements takes place at the Bucharest Aerologic Observatory, including two daily radio soundings (at 00:00 and 12:00 UTC). Daily PILOT wind measurements using balloons are also performed at the Bucharest station at 06:00 UTC. In 2003, the National Integrated Meteorological System (SIMIN) was established. Within the SIMIN network, the national weather radar network was updated.

Currently, the national weather radar network consists of 7 operational systems, including 5 S-band systems and 2 C-band systems. These weather radars are of the Doppler type, with single (horizontal) polarization. Thus, the national weather radar network integrates two types of equipment produced by different manufacturers of radar systems (Enterprise Electronic Corporation and Metstar). The radar products, generated from the raw data from each individual system are available both at the National Weather Forecast Center and at the Regional Weather Centers. Furthermore, some of the radar products from all 7 systems are combined into a single product, called the National Radar Mosaic (NRM), available in three versions and generated every 10 minutes. The radar information from the network of the National Meteorological Administration is also useful for neighboring countries, with which bilateral collaboration protocols are concluded. Also, Romania contributes operationally with raw radar data to the Operational Program on the Exchange of Weather Radar Information (OPERA), these data being integrated into the European radar mosaic.

Meteorological satellite observations refer to the first phase reception and processing of real-time digital images and data from the METEOSAT-7 and MASG-1 geostationary satellites in 3 and 12 spectral channels, respectively. Operational processing of the EUMETSAT / SAFNWC model began in February 2005, resulting in 8 nowcasting products every 15 minutes, which are transmitted to the National Forecast Centre.

Systematic observations of hydrological variables and the Black Sea climate are also recorded by the National Institute of Hydrology and Water Management. The GeoEcoMar also performs climate-relevant measurements of oceanographic and marine ecosystem variables and geological indicators in the Black Sea. The Institute of Marine Research (Constanța) carries out other measurements of the climate indicators relevant for Black Sea ecosystems. The GeoEcoMar and the Institute for Marine Research contribute to the regional components of the Global Ocean Observing System (GOOS): EuroGOOS and Black Sea GOOS. In addition, the national and regional environmental protection agencies collect data mainly on atmospheric components and pollutants.

Romania contributes to the free exchange of data under the national legislation (e.g. Meteorology Law) and international regulations (e.g. ECOMET norms). The National Meteorological Administration participates in the international exchange of meteorological data with 23 stations in the Regional Basic Synoptic Network (RBSN) and 14 stations in the Regional Basic Climatological Network (RBCN). The National Meteorological Administration also submitted data to the European Climate Assessment & Dataset project (ECA & D).

9. EDUCATION, TRAINING AND PUBLIC AWARENESS

The EU Strategy for Education and Training 2020 focused on lifelong learning and mobility, quality and effectiveness of education, equality, and innovation.

The National Sustainable Development Strategy of Romania for 2030 is mentioning that the Romanian educational and training system is a priority objective of strategic importance and basic preconditions for an effective implementation of the principles of sustainable development in the medium and long run, through the National Action Plan 2016-2020.

Improving the education sector has a significant impact on economic growth through employment, relevant skills training, and personal development.

In this respect, Table 9-1 presents the main education objectives for EU in 2020, Romania objectives in compliance with the Education and vocational training in Romania for 2016-2020, approved by GD no.317/2016, and achieved key indicators.

The EU, as can be seen, reached almost all its targets, while Romania missed all the targets it assumed for 2020 in the field of continuing professional education and training.

Table 9-1 Education objectives in UE and Romania and achieved indicators, 2020

Objectives Europe 2020	Objectives for Romania	Accomplished 2020	
		UE (27)	Romania
Percentage of early school leavers, between 18 and 24 years old, to be below 10%	11.3%	9.9%	15.6%
At least 40% of people between the ages of 30 and 34 to have completed tertiary studies	26.7%	41.1%	26.4%
At least 15% of people aged between 25 and 64 must participate in lifelong learning programs	10%	9.1%	1.0%
75% of the 20–64-year-old population to be occupied	70%	71.7%	65.2%

Source: EUROSTAT (EDAT_LFSE_14, EDAT_LFSE_03, TRNG_LFSE_01, LFSI_EMP_A)

The educational system in Romania strives to connect with the concept of education for sustainable development, with thematic content integrated into formal, non-formal and informal educational systems on the three dimensions: socio-cultural, environmental, and economic, such as: biodiversity conservation, environmental protection and improvement, environmental quality, environmental regeneration, recycling and reuse of materials.

Thus, through President Klaus Iohannis Project "Educated Romania" (2018-2030), strategic objectives and targets were established within the 10 priority directions, following an in-depth analysis of the existing situation of Romanian education in the period 2016-2020.

Of interest for this Report, we mention the following priority directions and the corresponding objectives, within the "Educated Romania" Project:

- V.4. The infrastructure of the education system; Objective 5. Support and develop a network of Green Schools, according to the concept implemented by The Center for Green Schools, USA
- V.5. Competency-focused curriculum and assessment; Objective 1. Promoting a competency-based curriculum design model for pre-university education through:
  - promoting a sustainable lifestyle
  - the correlation of learning objectives with public policies or with the major objectives of student assessment (e.g. ensuring functional literacy, education for the environment, sustainability and climate, education for health, for society, etc.).

The Government of Romania assumed the objectives and strategic targets of this Project through the Memorandum on the implementation of the "Educated Romania" Project and the approval of its priorities in the reform of the national education system, and through the issuance of the Prime Minister's Decision no.391/2021 establishing the Inter-ministerial Committee for monitoring the implementation of the "Educated Romania" Project.

At the same time, at the level of the Presidential Administration, the Working Group on the topic of education on climate changes and the environment was established, which developed the Report "Education on climate change and the environment in sustainable schools".

This Working Group, including representatives of the Presidential Administration, the Ministry of Education, the Ministry of Environment, Waters and Forests, educational institutions, students, teachers, and parents, as well as NGOs with extensive experience in developing and implementing educational projects on the environment and climate change, met periodically throughout 2021. The main objective of this Working Group is to contribute to the improvement of the quality of education on climate change and the environment by developing a climate education program at national level.

The Working Group Report targets pre-university education and widening access to climate change and environmental education and includes a series of proposals and concrete measures for the period 2022-2030. Once implemented, all of these will increase students' access to information about the factors leading to environmental degradation and accelerating climate change. At the same time, the practical component was also considered, thus providing the students with the context to get involved, during schooling, in applied environmental protection activities.

Also, the President of Romania promulgated the Law no.14/2022 which lays the foundations for a Strategy on environmental education and encourages the formation of environmental skills among students, by including them in the skill areas of the national curriculum for primary and secondary education. This Law no.14/2022 supplements the National Education Law no.1/2011, with subsequent additions and amendments, and stipulates that the Ministry of Education, in collaboration with the Ministry of Environment, Waters and Forests, will develop the Strategy on environmental education. Following all these actions and elaborate documents, the Ministry of Education recently published for public consultation the draft National Strategy on Education for the Environment and Climate Change 2023-2030 and the draft GD for its approval.

Another national strategic document of interest is the Integrated National Plan in the field of energy and climate change 2021-2030 - NECP, approved by GD no.1076/2021, which establishes the main national objectives for 2030 (GHG emissions, RES share in gross final energy consumption, energy efficiency) and proposes a series of policies and measures within the 6 pillars (priority dimensions of analysis). Education is approached at the level of the Research, innovation, and competitiveness dimension by proposing the development of educational resources at

all levels, and as cross-sectoral policies and measures regarding education and public awareness, the following are provided:

- Increasing the quality of education in the field of energy and human resources continuous vocational training, considering the need to supplement the qualified personnel in the field of energy. To this aim, the development of specific educational packages at all levels is mentioned: high schools, public vocational schools and public vocational schools in dual system, continuous vocational training at the workplace, faculties, master's programs, and doctoral schools
- Increasing the level of population information and awareness regarding the impact of climate change and energy efficiency, as well as adaptation by introducing in school programs courses aimed at understanding climate change, achieving energy savings and related activities
- Improving citizens' degree of education regarding the reduction of GHG and adaptation to climate change
- Improving/developing knowledge and understanding of the role and contribution of biodiversity in adapting to climate change
- Preparing information campaigns to define the emissions caused by various types of equipment or properties
- Increasing investments in equipment and know-how to reduce unitary energy consumption
- Implementation of a system for evaluating and monitoring the impact of socio-economic development and coordinating measures to increase bio-capacity, including for reducing Romania's ecological footprint
- Implementation of mobility schemes at macro-regions level, for the transfer of good practices, investment programs for the joint use of services.

One of the three horizontal principles, relevant for all operations financed from ESIF, is the sustainable development (polluter pays, resilience to disasters, efficient use of resources, mitigation and adaptation to climate change, conservation, and protection of biodiversity etc.).

During 2014-2020 programming period, the following Operational Programs had substantial allocations for the implementation of the Education and Vocational Training Strategy in Romania for the 2016-2020 period:

- Human Capital Operational Program 2014-2020 (POCU) with a total allocation of €4.36 billion from the European Social Fund (ESF) and the national contribution, of which approx. 1.15% represents the amount allocated for the objectives related to climate change, with the following priority axes of interest - PA.1. Jobs for young people initiative, PA.2. Improving the situation of young people from NEET category, PA.3. Jobs for all and PA.6. Education and skills; until December 2020, 1,599 projects were contracted, with an eligible value of approx. €4.51 billion
- Regional Operational Program 2014 – 2020 (POR) with a total allocation of €8.25 billion from the European Regional Development Fund (ERDF) and the national contribution, of which approx. 23.50% represents the amount allocated for the objectives related to climate change, with the following priority axes of interest - PA.3. Supporting the transition to a low-carbon economy, PA.4. Supporting sustainable urban development and PA. 10. Improving the educational infrastructure; until June 2020, an eligible value of approx. €9.86 billion was contracted

Also, in addition to the European funds, the apprenticeship can be financed from the employers' own funds, from the unemployment insurance budget - at the request of the employers and from sponsorships, in compliance with Law no.32/1994 on sponsorship, with subsequent amendments and additions.

For the future period 2021-2026, Romania's National Recovery and Resilience Plan (PNRR) is structured on 15 components that cover all 6 pillars provided by the Regulation and allocates for Pillar VI. Policies for the new generation – Component C15. Education has a total proposed budget of €3.60 billion, for the implementation of 7 reforms and 18 investments.

Future investments through the PNRR will contribute to

- the re- and up-skilling of specialists and workers in the fields of buildings' energy efficiency and the circular economy, to support the green and digital transition of buildings, strengthening the potential for innovation and growth, promoting economic and social resilience and ensuring quality jobs and social inclusion
- the vocational training of teachers, including the development of managerial skills and skills related to the green transition
- the CVET and reconversion of workers during the coal phase-out process
- the inclusive education, vocational training in dual system, development of digital skills, etc.

A. Education

In Romania the main responsible authorities for the initial and continuing vocational education and training systems (IVET and CVET) are: Ministry of Education, Ministry of Research, Innovation and Digitalisation and Ministry of Labour and Social Protection, together with National Authority for Qualifications (ANC), National Agency for Community Programs in the Field of Education and Vocational Training (NACPEVT), National Centre for Development of Vocational and Technical Education (including dual) (CNDIPT) and the National Agency for Employment (NAE).

IVET is the professional education and training set out within the national education system.

Thus, the national pre-university education system comprises the following levels:

a) early education, 0-6 years old, consisting of the pre-school level, 0-3 years and 3-6 years, comprising the small group, the middle group and the large group
b) primary education (6-11 years old), comprising the preparatory class and grades I to IV
c) secondary education, which includes lower secondary education or gymnasium (11-15 years old) upper secondary education (15-19 years old) which can be: high school education and vocational education (dual if possible) lasting at least 3 years;
d) tertiary non-university education, which includes post-secondary education.

High school education is organized in two cycles: the lower cycle of high school, consisting of the 9th and 10th grades, and the high school cycle of 11th / 12th grade.

High school education comprises the following branches and profiles:

a) theoretical branch, with the humanist and math profiles
b) technological branch, with technical profiles, services, natural resources and environmental protection
c) vocational branch with military, theological, sports, artistic and pedagogical profiles.

Higher education is structured as - vocational and technological, professional, and post-secondary education are organized for specializations and qualifications established by the Ministry.

Higher education also includes university education, structured on three levels of study (bachelor, master and doctoral or postgraduate education).

By Labor Code, in Romania there are covered the procedures regarding the CVET, respectively getting new competences and skills, including the assessment of knowledge level and certification according to occupational standards.

The integration of sustainable development principles into initial education and training systems (pre-university, university, and post-secondary education) is achieved at the level of the developed learning instruments and methodologies, by raising the awareness of environmental protection, pollution prevention and control, biodiversity conservation.

One of the fundaments of the Romanian education is to familiarize the children with the natural environment to set up the positive attitude towards the protection of the environment.

Environmental protection and climate change issues are present in the curricular activities in gymnasium, technical colleges (dual education system) and the high schools. The focus is also on teachers CVET to gain attitudes and active civic behavior of pupils and students in support of sustainable development, such as raising awareness of environmental issues, developing attitudes and specific skills.

The state and private Universities prepare the future specialists in the fields of environmental protection and climate change. We mention, below, some of the university centers with such interests:

"Babeş Bolyai" University from Cluj-Napoca - UBB

UBB includes 22 Faculties, 32 Doctoral fields (including environmental science) and 85 research departments, of which we mention:

- Bachelor degree program on science - management - environmental audit and Master degree in the field of sustainable development and environmental management, within the Faculty of Environmental Science and Engineering
- The Research Center for Sustainable Development, within the Faculty of Geography, member of the Network for Sustainable Development Solutions within the United Nations Organization.

University of Bucharest - UB

UB is composed of 19 Faculties, with 97 Bachelor programs, 215 Master programs, 21 Doctoral schools in specific fields and a school for interdisciplinary doctoral studies, over 50 centers and 9 research stations, of which we mention:

- Bachelor and Master studies in environmental science with reference to environmental policies for sustainable development within the Faculties of Biology and Geography
- The Systemic Ecology, Eco-diversity and Sustainability Research Centre of the Faculty of Biology and the Centre for environmental research and impact studies within the Faculty of Geography.

Polytechnic University of Bucharest - UPB

Currently, UPB has 15 Faculties with departments in which 55 Research Centers have been established, involved in several fields, of interest for this Report, being:

- Research Centre for Environmental Protection and Ecological Technologies, within the Faculty of Applied Chemistry and Materials Science
- The Faculty of Biotechnical Systems Engineering, which organizes Bachelor and Master studies in the field of engineering and management in environmental protection, and which also manages the "Biotechnical Systems" Research and Development Centre
- The Faculty of Energy, which organizes Master studies in the field of environmental management and sustainable development, and which also owns the Centre for Energy Research and Environmental Protection
- Faculty of Chemical Engineering and Biotechnologies with Bachelor and Master studies in the field of engineering and environmental protection.

University of Agronomic Sciences and Veterinary Medicine from Bucharest - USAMV

USAMV is composed of 7 Faculties and a non-university Tertiary College, of which the following have developed interesting study programs:

- Master studies in the field of sustainable agriculture and Research Centre for Sustainable Agriculture, within the Faculty of Agriculture
- Bachelor studies in the field of engineering and environmental protection in agriculture, master studies in engineering and environmental protection in the rural area and the Research Centre in Rural Engineering and Environmental Protection
- Doctoral schools in the fields of sustainable rural development, the impact of climate change in agriculture, fruit growing, viticulture, etc.

"Ovidius" University of Constanta - UOC

UOC in numbers means 16 Faculties, 79 Bachelor programs, 60 Master and 5 Doctoral schools, of which with interest in environmental and climate change topics:

- Faculty of Natural Sciences and Agricultural Sciences that organizes Bachelor studies in environmental science - ecology and environmental protection and Master's programs in the fields of biodiversity conservation and environmental impact analysis and assessment.

University of Petroşani – UPET

UPET includes 3 Faculties and manages 23 Bachelor, 20 Master and 4 Doctoral schools, of which of interest, are:

- The Faculty of Mines with the following programs
  - Bachelor studies in the field of engineering and environmental protection in industry
  - Master studies: Environmental quality control and monitoring; Environmental management and protection
  - Postgraduate for professional conversion / re-skilling in the field of ecological education and environmental protection.

UPET is part of the EURECA-PRO Alliance, formed by 9 European universities that have joined forces to enable students and professors to study, teach and research in the field of responsible consumption and production, within an integrated and virtual European campus, until in 2040. Thus, UPET will contribute to the highly topical

issue of sustainable consumption and production under the umbrella of Sustainable Development Objective no.12.

B. Training

In Romania, the national education system also includes permanent education (CVET / VET). Romania has the advantage of already having a well-defined legal framework that supports lifelong learning. This regulatory framework, made up of laws on education, apprenticeship, internships (Law No 335/2013 on the conduct of internships for graduates of higher education, as amended and supplemented), volunteering (Law No 78/2014 on regulating the volunteering activity) and adult vocational training, is a very valuable point that can serve as a basis for the further development of the CVET system. Existing regulations were implemented and must be monitored and assessed consistently to expand and improve the CVET system. Thus, in 2015, the Government adopted the National Lifelong Learning Strategy 2015-2020, approved by GD no.418/2015.

Promoting CVET is essential to achieve the key European and national sustainable development goals. Even if there is an approved Strategy, when it comes to monitoring the implementation, Romania is still extremely deficient, the indicator related to participation in lifelong learning, of at least 15% of people aged between 25 and 64, being in 2020 far below the proposed target (Table 9-1).

CVET has a decisive role in increasing the productivity and sustainable development of the country, but it seems that the constant effort of the National Agency for Community Programs in the Field of Education and Professional Training (NACPEVT) is not enough.

Regarding the training and education projects carried out by Romania in European partnerships, NACPEVT, the agency responsible for the management of dedicated EU programs, mentions that, during 2016-2020, a series of projects were carried out (Table 9-2) in the field of sustainable development, GHG emissions reduction and mitigation of climate change impact, having consortium leaders or partners from Romania, namely:

Table 9-2 NACPEVT projects in fields of environmental protection, climate changes and sustainable development

Program	Projects type	Number of projects
Erasmus+ 2016-2020	Mobility in the field of school education	13
	Mobility in the field of vocational education and training	14
	Mobility in the field of adult education	4
	Youth mobility	78
	Strategic cooperation in the field of school education	277
	Strategic cooperation in higher education	4
	Strategic cooperation in the field of vocational education and training	6
	Strategic cooperation in the field of adult education	3
European Solidarity Corps 2018-2020	Volunteer projects	11
	Solidarity projects	16

Source: NACPEVT

Actions dedicated to reducing climate changes impact, whether we are talking about investment projects, reports - analyses - research, dissemination events, knowledge sharing or trainings/vocational trainings, were also carried out within other various European, Norway or EEA grants (European Economic Area).

To this aim, during 2016-2019, Romania had within the LIFE Program 2014-2020, 6 projects approved for financing under Romanian coordination and 3 projects with Romanian companies as partners in international consortia.

The Executive Unit for the Financing of Higher Education, Research, Development, and Innovation (UEFISCDI) under the Ministry of National Education provides consultancy and technical assistance for the development and management of projects within the national and international programs related to scientific research, technological development and stimulation of innovation, including the fields of environmental protection - climate change and sustainable development. UEFISCDI manages the National Research-Development and Innovation Plan for the period 2015 - 2020 (PNCDI III), priority P3. European and international cooperation through which Romania is actively participating in the EU Research and Innovation Framework Program - Horizon 2020, in the Joint Programming Initiatives (JPI), in the European Innovation Partnerships (EIP), and in other initiatives, programs, and European and international bi- and multilateral conventions. Thus, Romania was present in projects financed by:

- ERA-NET Co-fund for example – ACT call for projects proposals "Accelerating CCS Technologies" (4 projects in 2016 and 2 in 2018); the call SUSFOOD2 "SUStainable FOOD production and consumption" (1 project in 2017 and 3 in 2019); the call Sustainable Urbanization Global Initiative (1 project in 2016)
- Horizon 2020 with 1,055 contracts signed up to now, benefiting from a net EU contribution of approx. €301.9 million, involving 1,618 organizations, of which higher or secondary education units 20.7%
- Norwegian and EEA Financial Mechanism – Research program (PA02) with the thematic areas of interest Energy and Environment (4 projects in 2018 and 10 in 2019).

The Norwegian and EEA Financial Mechanism had a substantial allocation, for the period 2014-2021, of €504.7 million to support 953 projects in various fields within 12 programs of interest for the present Report being:

- Innovation, research, education, and competitiveness – Competitive Europe; with an estimated impact of approx. 3 th. MWh saved and 80 th. tons of CO2/year reduced, thanks to a total allocation of approx. €106.5 million, of which €12 million for the program managed by NACPEVT:
  - Education, scholarships, apprenticeships and entrepreneurship for youth (204 projects)
- Environment, energy, climate change and low-carbon economy – Green Europe; approx. €89.5 million allocation for programs managed by MMAP:
  - Renewable energy, energy efficiency, energy security (121 projects)
  - Environment, adaptation to climate change and ecosystems (14 projects).

Through the allocations highlighted above, the Norwegian and EEA Grants contribute to the implementation of 5 of the 17th United Nations goals regarding sustainable development:

- 4. Quality education
- 7. Clean energy at affordable prices
- 11. Sustainable cities and communities
- 12. Responsible consumption and production
- 13. Climate actions

C. Public awareness

The role of civil society is increasingly better defined and consolidated in the process of information-education, involvement and awareness; actions developed through various NGO projects / campaigns addressed to the general public. The Civil Society Development Foundation manages one of the most comprehensive and up-to-date news websites (www.stiri.ong) structured in 10 fields of interest, including environment and education. During 2016-2020, there are several examples of projects, events, and actions such as:

- Greening campaigns in the countryside, mounted trails, riverbeds; Nationwide recycling patrols among preschool and pre-university education students
- Education and information sessions on environmental protection and selective waste collection; for the co-creation and development of alternative energy production solutions: Annual Forestry Forum; Guerrilla Verde educational caravans; Young Ambassadors in the Fight against Climate Change
- Training sessions addressed to:
  - educators to introduce the concept of permaculture in the education of preschoolers; for developing skills for climate change education in vulnerable communities
  - the general public to prevent food waste, for sustainable project management
- Supporting actions / initiation of public policies / measures to increase energy efficiency; of integrated and efficient waste management; to improve air quality; environmental protection.

We can say that the most vocal and active NGOs were: Association Let's Do It, Romania!; Bankwatch Romania; Greenpeace Romania; WWF Romania; New Horizons Foundation; Association Reper21; Foundation for the Development of Civil Society; Pro Vobis – National Resource Centre for Volunteering; NGO21 network; Children's Forest Association; EcoStuff Romania; Terra Millennium III Foundation; ViitorPlus – association for sustainable development; The Natura2000 Romania Coalition, the Environ Association, Centre for Sustainable Policies Ecopolis and many others.

The COVID-19 pandemic has facilitated free online access for both students and teachers to a rich, often high-quality professional training resource in the field of sustainable development and climate change mitigation. Another ground-breaking example that demonstrates that civil society was not paralyzed and was more creative in 2019-2020 is the EDUboost podcast series on sustainable education for children by the Bigger Picture Digital Education Association.

The Ministry of Environment, Waters and Forests through the National Administration of the Environmental Fund had and has an important role in the promotion and support of education and public awareness activities closely related to the reduction of climate changes impact and GHG emissions, through the following programs:

- Promotion of non-polluting and energy efficient vehicles (Rabla Plus) – for legal entities / 2017, 2019, 2020
- Stimulating the renewal/replacement of old and polluting vehicles at national level (Rabla) – for legal entities / 2017, 2019, 2020
- Reducing GHG emissions in transport, by promoting the infrastructure for non-polluting road transport vehicles from an energy point of view: charging stations for electric vehicles, in municipalities (Electrical Charging Stations Program) / 2019
- Public awareness campaigns regarding waste management / 2019
- Modernization of public lighting systems (Public lighting) UAT / 2020

- Installation of heating systems that use renewable energy, including the replacement or addition of classic heating systems (Casa Verde) – for individuals / 2017
- Carrying out works for increasing energy efficiency in single-family homes (Energy efficient house) – for individuals / 2020
- Installation of PV systems for electricity production, in order to cover the consumption requirement and deliver the surplus to the national grid (Casa Verde Fotovoltaice) – for individuals / 2019, 2020
- Installation of PV systems for isolated households not connected to the electricity distribution network / 2020
- Replacement of used electrical and electronic equipment with more energy-efficient ones (Rabla for household appliances) – for individuals / 2018, 2019, 2020.

Additionally, each local public administration promotes the concepts/measures of reducing GHG emissions and adapting to climate change by encouraging and supporting local NGOs to compete for calls for public education and awareness projects funded from the local budget.

The Corporate Social Responsibility (CSR) campaigns and programs of the private business environment in Romania should also be mentioned. During 2016-2020, the most valuable CSR campaigns in the fields of energy and environment were awarded at the CSR Romania Awards, among which as an example:

- Environment category: Coca-Cola HBC Romania (Recycling Map www.hartareciclarii.ro, 2020); NESTLÉ ROMANIA (Nestlé for a waste free world, 2020); Lidl Discount (Food Bank, 2019); Carrefour Bio & Co (We cultivate solidarity! 2018); Daikin Air Conditioning Central Europe Romania (Daikin. We plant air! 2018); REWE Romania (PENNY Market – We go green because we care, 2018); Kaufland Romania (The first public network in Romania of fast charging stations for electric cars, 2017); MOL Romania (Green spaces, 2019 and 2016); Raiffeisen Bank (I'velo 2.0 – automated bike-sharing system, 2017; I'velo, 2016);
- Education category: Flanco Retail (We care: Implementation of afterschool centers, 2020); Coca-Cola HBC Romania (Youth has the power, 2019); OMV Petrom (Petrolist School, 2019; Vocational Romania, 2018 and 2016); Engie Romania (Meeting with energy, 2016); Orange Foundation (#SuperCoders, 2018; Digitaliada, 2017); Carrefour (Lust for books, 2017); Groupe Renault (Double click on education, 2017).

Annex. Supplementary documents

Annex 3 CRF Table 7, Summary overview for key categories, NGHG inventory 2020, submission 2022 v7

KEY CATEGORIES OF EMISSIONS AND REMOVALS (1)	Gas	Criteria used for key source identification		Key category excluding LULUCF	Key category including LULUCF
		L	T		
1.A.1 Fuel combustion - Energy Industries - Liquid Fuels	CO_2	X	X	X	X
1.A.1 Fuel combustion - Energy Industries - Solid Fuels	CO_2	X	X	X	X
1.A.1 Fuel combustion - Energy Industries - Gaseous Fuels	CO_2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Liquid Fuels	CO_2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Solid Fuels	CO_2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Gaseous Fuels	CO_2	X	X	X	X
1.A.2 Fuel combustion - Manufacturing Industries and Construction - Other Fossil Fuels	CO_2	X	X	X	X
1.A.3.b Road Transportation	CO_2	X	X	X	X
1.A.3.d Domestic Navigation - Liquid Fuels	CO_2		X	X	
1.A.4 Other Sectors - Liquid Fuels	CO_2	X	X	X	X
1.A.4 Other Sectors - Solid Fuels	CO_2		X	X	X
1.A.4 Other Sectors - Gaseous Fuels	CO_2	X	X	X	X
1.A.4 Other Sectors - Biomass	CH_4	X	X	X	X
1.A.5 Other (Not specified elsewhere) - Liquid Fuels	CO_2	X		X	X
1.A.5 Other (Not specified elsewhere) - Solid Fuels	CO_2		X	X	
1.B.1 Fugitive emissions from Solid Fuels	CH_4	X	X	X	X
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CO_2	X	X	X	X
1.B.2.a Fugitive Emissions from Fuels - Oil and Natural Gas - Oil	CH_4		X	X	X
1.B.2.b Fugitive Emissions from Fuels - Oil and Natural Gas - Natural Gas	CH_4	X	X	X	X
1.B.2.c Fugitive Emissions from Fuels - Venting and flaring	CH_4	X		X	X
2.A.1 Cement Production	CO_2	X	X	X	X
2.B.1 Ammonia Production	CO_2	X	X	X	X
2.B.2 Nitric Acid Production	N_2O		X	X	X
2.B.8 Petrochemical and Carbon Black Production	CO_2		X	X	
2.C.1 Iron and Steel Production	CO_2	X	X	X	X
2.C.3 Aluminium Production	PFCs		X	X	X
2.F.1 Refrigeration and Air conditioning	Aggregate F-gases	X	X	X	X
3.A Enteric Fermentation	CH_4	X	X	X	X
3.B Manure Management	CH_4	X		X	
3.B Manure Management	N_2O	X	X	X	X
3.D.1 Direct N2O Emissions From Managed Soils	N_2O	X	X	X	X
3.D.2 Indirect N2O Emissions From Managed Soils	N_2O	X	X	X	X

KEY CATEGORIES OF EMISSIONS AND REMOVALS (1)	Gas	Criteria used for key source identification		Key category excluding LULUCF	Key category including LULUCF
		L	T		
3.F Field burning of agricultural residues	CH_4		X	X	X
4.A.1 Forest Land Remaining Forest Land	CO_2	X	X		X
4.A.2 Land Converted to Forest Land	CO_2	X	X		X
4.B.1 Cropland Remaining Cropland	CO_2	X	X		X
4.B.2 Land Converted to Cropland	CO_2	X	X		X
4.C.1 Grassland Remaining Grassland	CO_2	X	X		X
4.C.2 Land Converted to Grassland	CO_2		X		X
4.E.2 Land Converted to Settlements	CO_2	X	X		X
4.G Harvested Wood Products	CO_2	X	X		X
5.A Solid Waste Disposal	CH_4	X	X	X	X
5.D Wastewater Treatment and Discharge	CH_4	X	X	X	X
5.D Wastewater Treatment and Discharge	N_2O		X		X

Note: *L = Level assessment; T = Trend assessment.*

(1) This table is filled automatically based on the IPCC Tier 1 methodology.

Annex 4 Climate-related research projects

Nr.	Program	Acronym	Project Title	Web address
1	JPI Water/ H2020	IMDRPFLOOD	Improving Drought and Flood Early Warning, Forecasting and Mitigation using real-time hydroclimatic indicators	http://imdroflood.meteoromania.ro/
2	JPI Climate/H2020	URCLIM	Advance on Urban Climate Services	http://www.urclim.eu/
3	JPI Climate/H2020	INDECIS	Integrated approach for the development across Europe of user-oriented climate indicators for GFCS high-priority sectors: agriculture, disaster risk reduction, energy, health, water and tourism.	http://www.indecis.eu/
4	H2020	EXHAUSTION	Exposure to heat and air pollution in EUrope – cardiopulmonary impacts and benefits of mitigation and adaptation	https://www.exhaustion.eu/
5	Copernicus Climate Change Service (C3S)	WECTOU	Weather and Climate for Tourism	http://wectou.meteoromania.ro/
6	Program of the European Space Agency	LST-CCI	User Case Study focused on intercomparison and integrated use of LST in urban climate studies (LST-CCI)	https://climate.esa.int/en/projects/land-surface-temperature/about/
7	FACCE – JPI/H2020	SUSCAP	Developing resilience and tolerance of crop resource use efficiency to climate change and air pollution	https://suscap.pubpub.org/
8	National Research Program - UEFISCDI-PCE	SYNUHI	Synergies between the Urban Heat Island and heat waves in Romania: challenges induced by climate change and adaptation options	http://synuhi.meteoromania.ro/
9	Horizon Europe	MAGDA	Meteorological assimilation from Galileo and Drones for Agriculture	https://www.futurewater.eu/projects/magda-meteorological-assimilation-from-galileo-and-drones-for-agriculture/
10	Horizon Europe	OptFor-EU	OPTimising FORest management decisions for a low-carbon, climate resilient future in Europe	(The project starts in 2023)