



REPUBLIC OF CROATIA
MINISTRY OF ECONOMY AND SUSTAINABLE
DEVELOPMENT

Report on projections of greenhouse gas emissions by sources and removals by sinks

Republic of Croatia

REPORT OF PROJECTIONS OF GREENHOUSE GAS EMISSIONS BY SOURCES AND REMOVALS BY SINKS

REPUBLIC OF CROATIA

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Zagreb, March 2023

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1. Introduction

'Report on projections of greenhouse gas emissions by sources and removals by sinks' (hereinafter: the Report) is an integral part of the national system for monitoring the implementation of policies and measures for greenhouse gas emissions reduction and projections of greenhouse gas emissions related to the fulfilment of commitments under the United Nations Framework Convention on Climate Change (hereinafter: the Convention) and the Paris Agreement. The Republic of Croatia is required to report to the European Commission on monitoring the implementation of these policies and measures and emission projections, based on the regulations that apply to the Member States of the European Union. The legal basis for preparation of the Report in the national legislation is in Act on Climate Change and Ozone Layer Protection (OG 127/2019).

Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council (hereinafter: Regulation (EU) 2018/1999) and Commission implementing regulation (EU) 2020/1208 of 7 August 2020 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999 of the European Parliament and of the Council and repealing Commission Implementing Regulation (EU) No 749/2014 (hereinafter: Implementing Regulation (EU) 2020/1208) are applicable regulations of the European Union which prescribe the obligations and the way of reporting for Member States.

Article 18 and Annex VII of the Implementing Regulation (EU) 2020/1208 prescribes the content of the report. The report includes projections of greenhouse gas emissions by sources and their removal by sinks for 2023, composed of the following components:

- projection of greenhouse gas emission, organised by sector and by gas,
- projections of emissions of ETS and sectors outside the EU ETS, in accordance with Regulation (EU) 2018/842 (ESR sector),
- projections of emissions from sources and removals by sinks in accordance with Regulation (EU) 2018/841 (LULUCF),
- policies and measures included in the projections,
- descriptions of methodologies, models, underlying assumptions and key input and output parameters for projections,
- sensitivity analysis of projections on input data.

The report for 2023 includes projections of emissions by sources and their removal by sinks for 2025, 2030, 2035, 2040, 2045 and 2050.

The Report presents the total projections of greenhouse gas emissions by sources and their removal by sinks and separately by the following sectors:

- Energy,
- Transport,
- Industrial processes and product use,
- Waste,
- Agriculture,

- Land use, land use change and forestry (LULUCF).

To prepare the Report on projections of greenhouse gas emissions for 2023 the following data sources were used for the parameters used:

CRF Category	Data type	Data source
General parameters	GDP – yearly growth rate	Integrated Energy-Climate Plan of the Republic of Croatia for the period from 2021 to 2030
	Population	Energy Development Strategy of the Republic of Croatia until 2030 with a view to 2050 (OG 25/2020)
	Fuel oil price	Low-Carbon Development Strategy of the Republic of Croatia until 2030 with a view to 2050 (OG 63/2021)
	Natural gas price	
Energy	Fuel consumption	National energy balance
	Electricity generation	Integrated Energy-Climate Plan of the Republic of Croatia for the period from 2021 to 2030
	Electricity imports	Energy Development Strategy of the Republic of Croatia until 2030 with a view to 2050 (OG 25/2020)
	Final energy demand	
Transport	Number of passenger kilometres	ODYSSEE database
	Number of tonne-kilometres	Integrated Energy-Climate Plan of the Republic of Croatia for the period from 2021 to 2030
	Energy demand in transport sector	Energy Development Strategy of the Republic of Croatia until 2030 with a view to 2050 (OG 25/2020)
Industrial processes and product use	Production index	Sectorial studies (cement, use of N ₂ O in the food industry and for medical purposes) National Bureau of Statistics Integrated Energy-Climate Plan of the Republic of Croatia for the period from 2021 to 2030 Low-Carbon Development Strategy of the Republic of Croatia until 2030 with a view to 2050 (OG 63/2021)
	Use of solvents	Inventory Report of air pollutants on the Croatian territory under the Convention on Long-range Transboundary Air Pollution (CLRTAP) Low-Carbon Development Strategy of the Republic of Croatia until 2030 with a view to 2050 (OG 63/2021)
Agriculture	Number and type of livestock	National Bureau of Statistics Croatian Agricultural Agency Faculty of Agriculture FAOSTAT database
	Plant production	National Bureau of Statistics Statistical reports on plant production

CRF Category	Data type	Data source
		FAOSTAT database
LULUCF	Land area of each sub-category	NIR 2022
	The assumed emission factors by sinks	CFR 2022 – submission of 14th October 2022
Waste	<p>The amount of generated solid waste (municipal, industrial, sludge from wastewater treatment)</p> <p>The amount of landfilled solid waste (municipal, industrial, sludge from wastewater treatment)</p> <p>The organic fraction of solid waste</p> <p>Share of methane recovered/flared</p> <p>The amount of composted organic waste</p>	<p>Sustainable Waste Management Act Waste Management Plan of the Republic of Croatia</p> <p>Sustainable Waste Management Act (OG 94/2013, 73/2017, 14/2019, 98/2019)</p> <p>Waste Management Plan of the Republic of Croatia for the period 2017 – 2022 (OG 3/2017, 1/2022)</p> <p>Low-Carbon Development Strategy of the Republic of Croatia until 2030 with a view to 2050 (OG 63/2021)</p> <p>Ministry of Economy and Sustainable Development:</p> <ul style="list-style-type: none"> - Waste Management Information System - Environmental Pollution Register

2. Projection of greenhouse gas emissions

This chapter presents greenhouse gas emissions for the initial year of projections (2020) and greenhouse gas emissions projections for the period from 2025 to 2050. The emissions are presented as total emissions of all greenhouse gases converted to carbon dioxide emission equivalent and as emissions of each greenhouse gas.

Since greenhouse gases have different irradiation properties and consequently different contribution to the greenhouse effect, emissions of each gas are multiplied by their Global Warming Potential (GWP). In this case, the emission of greenhouse gases is presented as an equivalent emission of carbon dioxide (CO₂eq). In the case of removing emissions of greenhouse gases, it refers to outflows (sinks) of greenhouse gas emissions and the amount is shown as a negative value. The global warming potentials of individual gases used in the Report are the values determined in the 5th Assessment Report of the Intergovernmental Panel on Climate Change and are listed in the Annex to Commission Delegated Regulation (EU) 2020/1044 of May 8, 2020 supplementing Regulation (EU) 2018/1999 of the European Parliament and of the Council with regard to values for global warming potentials and the inventory guidelines and with regard to the Union inventory system and repealing Commission Delegated Regulation (EU) No 666/2014. The global warming potentials used in the Report are listed below.

Gas	GWP
Carbon dioxide (CO ₂)	1
Methane (CH ₄)	28
Nitrous oxide (N ₂ O)	268
HFC-23	12400
HFC-32	677
HFC-125	3170
HFC-134a	1300
HFC-143a	4800
HFC-227ea	3350
HFC-236fa	8060
HFC-365mfc	804
SF ₆	23500

Projections of greenhouse gas emissions are shown separately for the following sectors:

- Energy,
- Transport,
- Industrial processes and product use,
- Agriculture,
- Waste,
- LULUCF.

The calculation includes projections of emissions resulting from human activities that include the following direct greenhouse gases:

- CO₂,
- CH₄,
- N₂O,
- HFCs,
- SF₆.

According to the Guidelines for the preparation of National Communications by Parties included in Annex I to the Convention, projections are presented for two scenarios: 'with existing measures' scenario and 'with additional measures' scenario. Scenario 'with existing measures' includes the application of current policies and measures whose implementation is already in process, i.e. the application of policies and measures that have been adopted. Scenario 'with additional measures' is based on the application of planned policies and measures.

Emission projections start from the Inventory of greenhouse gas emissions (NIR 2022) which includes an inventory of emissions and removals of greenhouse gases for the period 1990 – 2020 (submission of 14th October 2022).

2.1. Projections of greenhouse gas emissions by sectors

Projected trends in greenhouse gas emissions by sectors are presented in Figures 2-1 to 2-2. Emissions are presented for 'with existing measures' scenario and 'with additional measures' scenario for the period from 2025 to 2050.

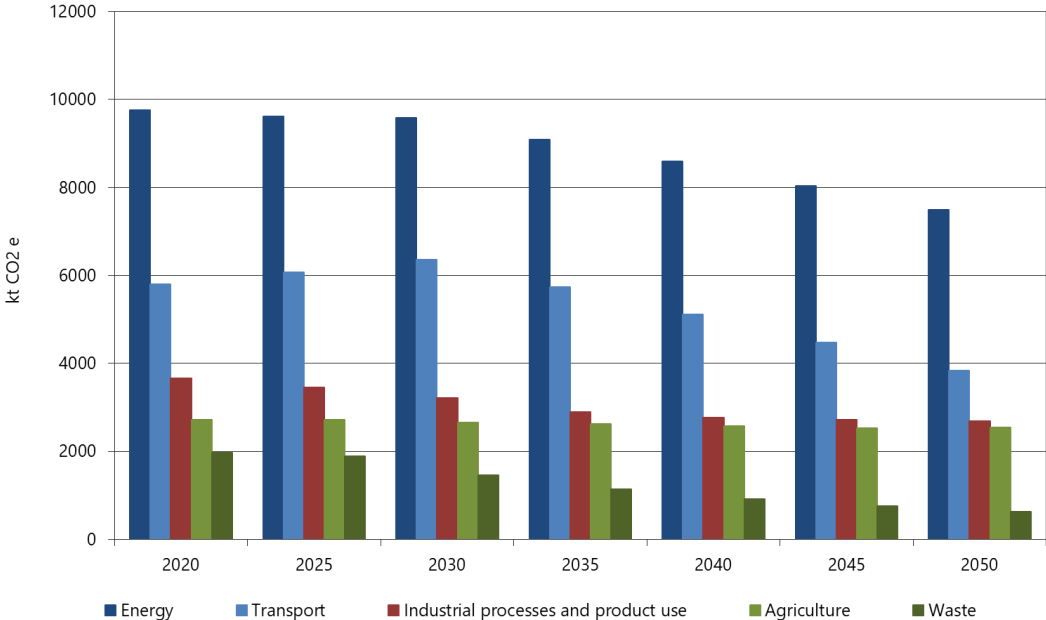


Figure 2-1: Projections of greenhouse gas emissions by sectors, 'with existing measures' scenario

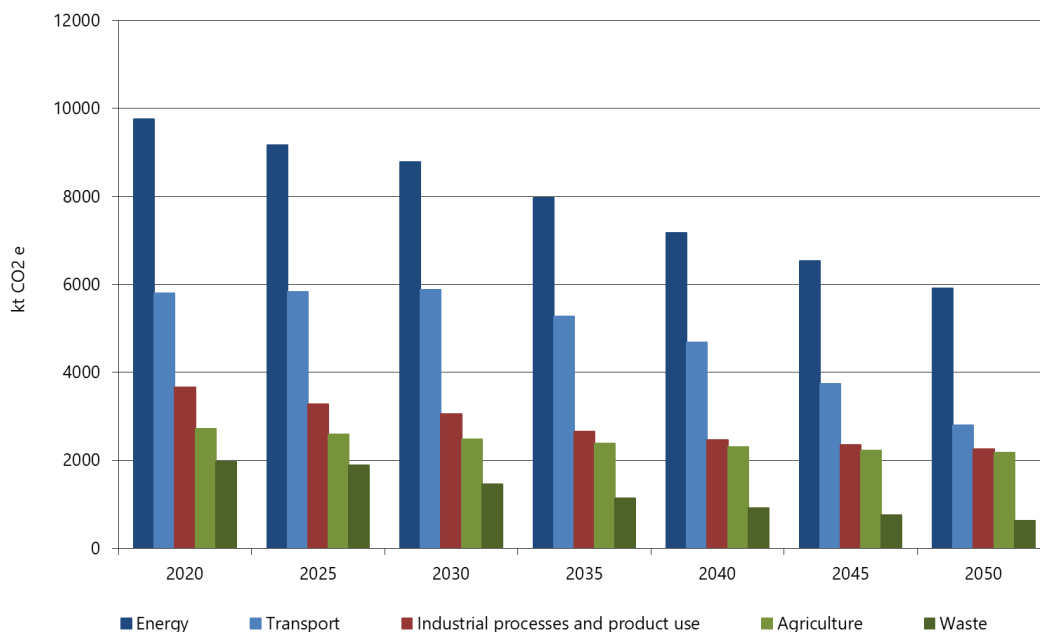


Figure 2-2: Projections of greenhouse gas emissions by sectors, 'with additional measures' scenario

The **Energy sector** covers all activities that involve fuel combustion from stationary sources and fugitive emission from fuels. The emission from the Energy sector in 2020 amounted to 9,756.71 kt CO₂eq and it is the main source of anthropogenic emission of greenhouse gases, it accounts for approximately 40.8% of the total greenhouse gases emission in 2020 (without LULUCF). In the 'with existing measures' scenario, projections show a decrease in emissions in the period from 2035 onwards because in that period it is expected that the growth of demand will be compensated primarily by the implementation of measures for the use of renewable energy sources, energy efficiency measures and due to the impact of the EU ETS. In scenario 'with additional measures', all measures planned in the Energy sector were taken into account and projections show a steady trend of emission reduction.

Changes compared to the previous submission

In the Energy sector, there was a change in CH₄ emission projections compared to the previous submission. Namely, an error was observed in the model that occurred during the creation of projections for the previous submission, related to the emission factors for biofuels. The error is now fixed. Also, in the scenario 'with additional measures', larger amounts of solid biomass (1.A.2. and 1.A.4.a.) are included compared to the scenario 'with existing measures', which results in higher CH₄ emissions.

In the Energy sector, there was a change in CO₂ emission projections due to corrections of emission factors for coal in 1.A.1.a. and for petrol coke in 1.A.2.b.

The **Transport sector** includes emissions from fuel combustion in road transportation, civil aviation, railways and navigation. The emission from the Transport sector in 2020 amounted to 5,796.77 kt CO₂eq, which makes about 24.3% of total Croatia's greenhouse gases emission (without LULUCF). In the 'with existing measures' scenario in the period up to 2030, projections show an increase in emissions. Factors that encourage the growth of emissions are expected increase in economic activities and living standard and consequently increase in the number of fossil fuel vehicles. In the period from 2035 onwards, emission reductions are expected, which are primarily affected by measures to increase energy efficiency and the use of electricity and renewable sources in transport. In scenario 'with additional measures', projections show a continuous trend of reducing emissions by 2050, primarily due to expected measures

to increase rail transport and the development of electric vehicles, which will be the key condition for the strong reduction of emissions in the transport sector in long term.

Changes compared to the previous submission

In the Transport sector, there was a change in CH₄ emission projections compared to the previous submission. Namely, an error was observed in the model that occurred during the creation of projections for the previous submission, related to the emission factors for biofuels. The error is now fixed. Also, in the 'with additional measures' scenario, larger amounts of biomethane (1.A.3.b.) are included compared to the 'with existing measures' scenario, which results in higher CH₄ emissions.

In the Transport sector in sub-sector 1.A.3.d., in the period from 2035 to 2050, a higher level of domestic shipping activity is included in the scenario 'with additional measures' compared to the scenario 'with existing measures', which results in higher consumption fuel and consequently higher CO₂ emissions.

The **Industrial processes and product use sector** includes the process emissions from industrial processes and product use, while fuel combustion emissions from this sector are included in the Energy sector. The emission from the Industrial processes and product use sector in 2020 amounted to 3,655.04 kt CO₂eq, which is 15.3% of total Croatia's greenhouse gases emission in 2020 (without LULUCF). The projections of emissions indicate stagnation and a slight reduction in emissions in the 'with existing measures' scenario due to measures for controlled substances and fluorinated greenhouse gases reduction. The implementation of process measures in 'with existing measures' scenario is prescribed by the sectoral legislation. The projections of emissions indicate a decrease in 'with additional measures' scenario due to the implementation of cost-effective measures to reduce emissions.

Changes compared to the previous submission

In the projections of fluorinated greenhouse gases, there was a significant change compared to the previous submission due to the recalculations of the historical series due to the update of activity data and the emission calculation methodology.

The **Agriculture sector** covers about 11.4% of total greenhouse gas emissions (without LULUCF) in 2020 (emission is 2,714.26 kt CO₂eq). Projections indicate emission reductions in both the 'with existing measures' scenario due to implemented measures, while the reduction in the 'with additional measures' scenario is stronger due to the strengthening of additional measures, especially in emission sources of livestock and mineral fertilizers.

Changes compared to the previous submission

In the Agriculture sector, there was a change in the CO₂, CH₄ and N₂O emission projections compared to the previous submission due to recalculations of the historical series. Namely, in the inventory of NIR 2022 emissions (for the last historical year - 2020), information on the rabbit population is included as a new source in 3.A. and 3.B. and information on the use of dolomite (CaMg(CO₃)₂) as a new source in 3.G. The input data on activity in 2020 was retained for all years of emission projections.

The **Waste sector** participates in total of Croatia's greenhouse gases emission (without LULUCF) with 8.3% in 2020 (emission is 1,970.32 kt CO₂eq). Projections of emissions of greenhouse gases from the Waste sector are based on the implementation of measures prescribed by sectoral legislation, harmonized with EU legislation. The 'with existing measures' scenario includes the existing legal framework of the Republic of Croatia and the adopted EU legal framework from the waste sector for the period until 2050. The projections of emissions indicate a decrease in 'with existing measures' scenario

due to the implementation of cost-effective measures to reduce emissions. The 'with additional measures' scenario is the same as the 'with existing measures' scenario since no additional measures to reduce emissions of greenhouse gases have been identified. The potentials of CO₂ emission reduction, which can be achieved by implementing the measures included in the 'with existing measures' scenario and the 'with additional measures' scenario are estimated in the Energy sector.

Changes compared to the previous submission

In the Waste sector, subsector 5.B., there was a change in the greenhouse gas projections compared to the previous submission. Namely, an error was observed in the model that occurred during the creation of projections for the previous submission. The error has now been corrected and for this reason there has been a change in the projections.

In the year 2020, removals by the sink in the **LULUCF sector** were -5,572.98 kt CO₂eq. Projections of removals in 2050 amount to -2,337.13 kt CO₂eq per year. These projections are made by sectorial sub-categories 'Forest land', 'Cropland', 'Grasslands', 'Wetlands', 'Settlements', 'Other land' and 'Harvested wood products' for the scenario 'with existing measures' (Figure 2-3).

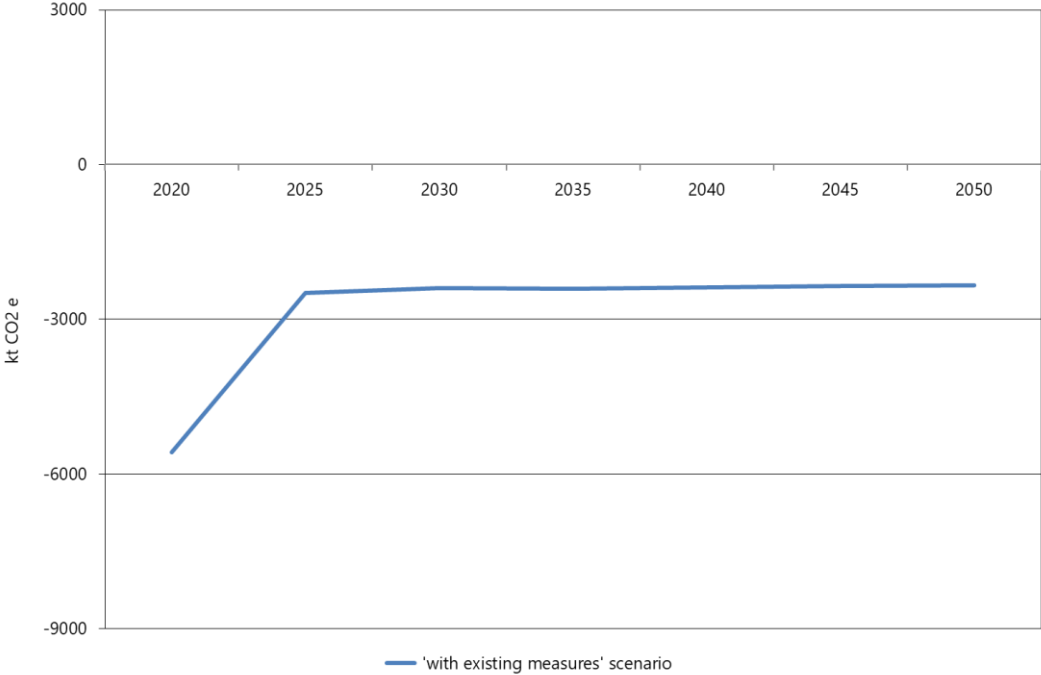


Figure 2-3: Greenhouse gas removals in the LULUCF sector, 'with existing measures' scenario

2.2. Projections of greenhouse gas emissions by gases

Trends in emissions, by greenhouse gases (CO₂, CH₄, N₂O, HFCs and SF₆), for 'with existing measures' and 'with additional measures' scenarios, in the period from 2020 until 2050 are shown in Figure 2-4.

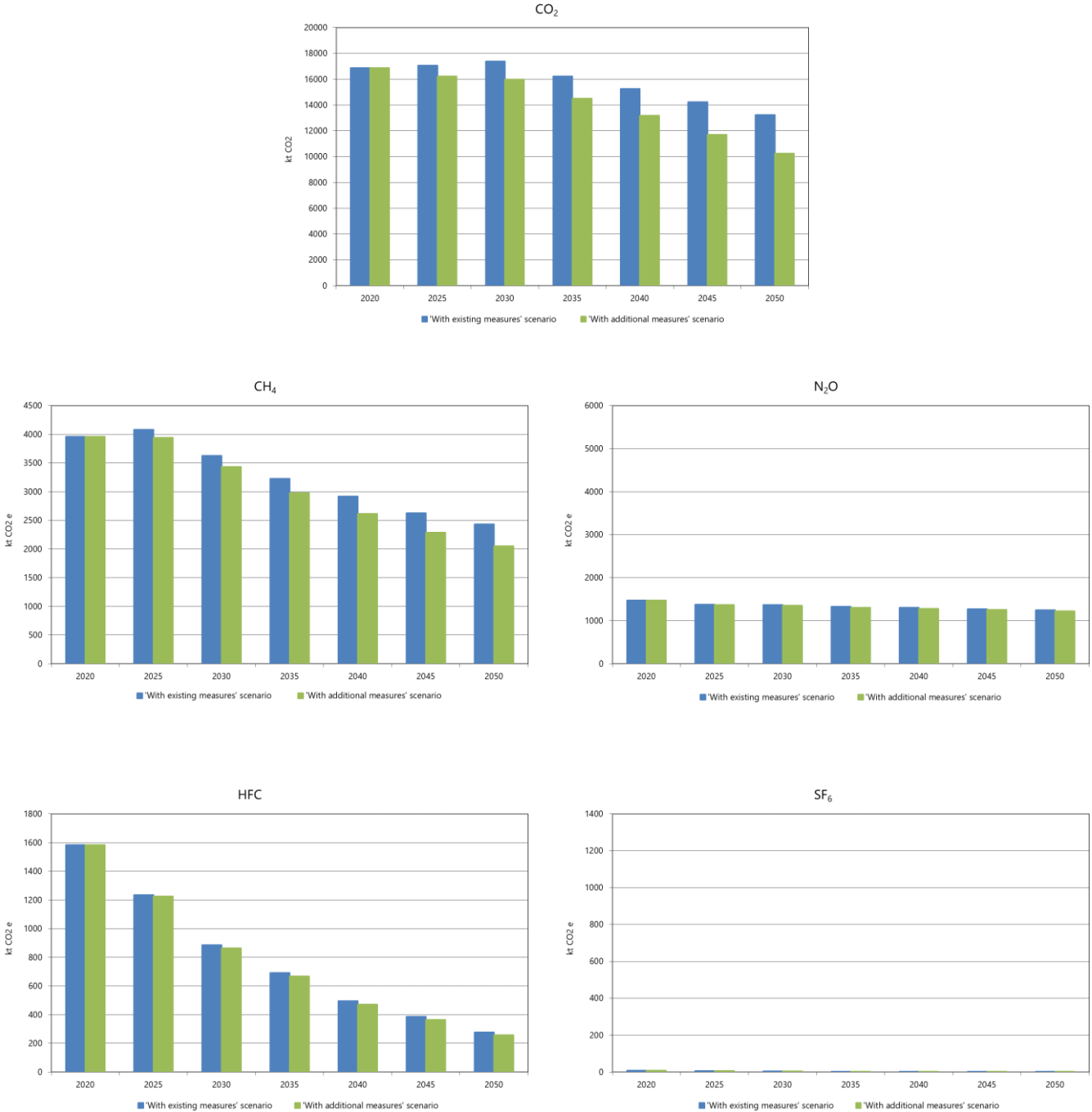


Figure 2-4: Projections of greenhouse gas emissions by gases

Projections of greenhouse gas emissions CO₂, CH₄, N₂O, HFCs and SF₆, for 'with existing measures' and 'with additional measures' scenarios, in the period from 20250 until 2050 are shown in Table 2-1.

Table 2-1: Projections of greenhouse gas emissions by gases, kt CO₂eq

CO₂	2020	2025	2030	2035	2040	2045	2050
'With existing measures' scenario	16870,53	17055,19	17389,94	16226,77	15244,42	14216,24	13220,24
'With additional measures' scenario	16870,53	16220,17	15983,57	14496,91	13191,09	11694,92	10230,98
CH₄	2020	2025	2030	2035	2040	2045	2050
'With existing measures' scenario	3956,77	4080,05	3626,21	3225,89	2919,03	2628,75	2434,44
'With additional measures' scenario	3956,77	3942,76	3433,86	2975,28	2611,57	2285,37	2049,44
N₂O	2020	2025	2030	2035	2040	2045	2050
'With existing measures' scenario	1473,11	1378,11	1368,23	1324,58	1299,70	1272,82	1246,45
'With additional measures' scenario	1473,11	1365,65	1352,51	1306,75	1279,45	1250,97	1221,62
HFC	2020	2025	2030	2035	2040	2045	2050
'With existing measures' scenario	1583,66	1234,82	885,98	690,83	495,67	386,49	277,30
'With additional measures' scenario	1583,66	1223,76	863,87	667,55	471,23	364,14	257,05
SF₆	2020	2025	2030	2035	2040	2045	2050
'With existing measures' scenario	9,03	6,75	4,47	3,34	2,21	1,65	1,09
'With additional measures' scenario	9,03	6,70	4,36	3,23	2,10	1,56	1,02
TOTAL	2020	2025	2030	2035	2040	2045	2050
'With existing measures' scenario	23893,10	23754,92	23274,83	21471,41	19961,02	18505,94	17179,53
'With additional measures' scenario	23893,10	22759,04	21638,16	19449,72	17555,45	15596,97	13760,11

The Energy sector has the largest contribution to CO₂ emissions. Projections show emissions of 13,220.24 kt CO₂ (for the 'with existing measures' scenario) and 10,230.98 kt CO₂ (for the 'with additional measures' scenario) in 2050.

The most important source of CH₄ emissions is the Waste sector. Projections for 2050 show 2,434.44 kt CO₂eq for the 'with existing measures' scenario, or 2,049.44 kt CO₂eq for the 'with additional measures' scenario.

The most important source of N₂O emissions is the Agriculture sector. Projections show emissions of 1,246.45 kt CO₂eq for the 'with existing measures' scenario and 1,221.62 kt CO₂eq for the 'with additional measures' scenario in 2050.

The sources of HFCs and SF₆ emissions are in the Industrial processes and product use sector. Although their emissions in absolute terms are not large, due to the large global warming potential (GWP), their contribution is significant. Projections in 2050 have a maximum value of 278.39 kt CO₂eq for the 'with existing measures' scenario and 258.07 kt CO₂eq for the 'with additional measures' scenario.

2.3. Total projections

Total projections of greenhouse gas emissions (without removals) are shown in Table 2-2 and Figure 2-5. Emissions are shown for the 'with existing measures' and 'with additional measures' scenarios, for the period 2020 to 2050.

Table 2-2: Projections of greenhouse gas emissions by sectors, kt CO₂e

'With existing measures' scenario	2020	2025	2030	2035	2040	2045	2050
Energy	9756,71	9611,57	9583,79	9080,12	8586,52	8027,09	7494,64
Transport	5796,77	6071,07	6355,69	5733,26	5111,16	4470,73	3830,95
Industrial processes and product use	3655,04	3449,77	3217,25	2897,76	2767,48	2726,29	2690,77
Waste	1970,32	1896,11	1456,11	1143,01	917,85	751,46	626,47
Agriculture	2714,26	2726,41	2661,98	2617,26	2578,02	2530,37	2536,71
TOTAL	23893,10	23754,92	23274,83	21471,41	19961,02	18505,94	17179,53

'With additional measures' scenario	2020	2025	2030	2035	2040	2045	2050
Energy	9756,71	9162,92	8782,09	7975,67	7179,39	6528,77	5905,21
Transport	5796,77	5829,55	5872,82	5279,93	4686,94	3739,93	2794,09
Industrial processes and product use	3655,04	3283,05	3051,88	2662,53	2462,40	2354,62	2252,51
Waste	1970,32	1896,11	1456,11	1143,01	917,85	751,46	626,47
Agriculture	2714,26	2587,41	2475,27	2388,58	2308,88	2222,18	2181,84
TOTAL	23893,10	22759,04	21638,16	19449,72	17555,45	15596,97	13760,11

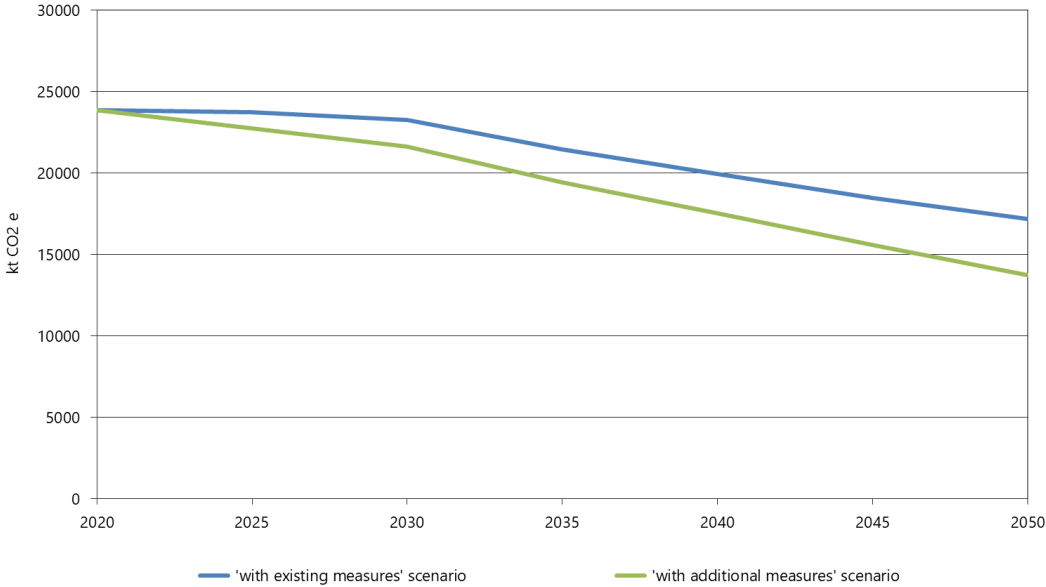


Figure 2-5: Total projections of greenhouse gas emissions (without removals) for the period until 2050

Projections show that in the 'with existing measures' scenario, in 2050 the emission is reduced by 28.1% compared to 2020, while in the 'with additional measures' scenario emission is reduced by 42.4% compared to 2020.

The 'with additional measures' scenario compared to the 'with existing measures' scenario in 2050 reduces greenhouse gas emissions by 19.9%.

2.4. Emission of sectors covered by the EU ETS and non-ETS sectors in accordance with Regulation (EU) 2018/842

Projections of greenhouse gas emissions of sectors covered by the EU ETS and non-ETS sectors under Regulation (EU) 2018/842 (ESR sectors) are shown in Table 2-3 for both scenarios.

Table 2-3: Projections of greenhouse gas emissions in ETS and ESR sectors, kt CO₂eq

	2020	2025	2030	2035	2040	2045	2050
'With existing measures' scenario	23,893.1	23,754.9	23,274.8	21,471.4	19,961.0	18,505.9	17,179.5
ETS	7,287.1	7,211.6	7,170.2	6,727.3	6,472.3	6,304.5	6,141.6
ESR	16,589.4	16,521.5	16,077.6	14,718.5	13,464.6	12,180.1	11,019.4
'With additional measures' scenario	23,893.1	22,759.0	21,638.2	19,449.7	17,555.5	15,597.0	13,760.1
ETS	7,287.1	6,791.8	6,590.7	5,927.4	5,451.9	5,308.5	5,169.8
ESR	16,589.4	15,945.4	15,020.4	13,496.7	12,079.4	10,267.2	8,571.8

Emissions within the ETS in 2020 encompassed 30.5% of total emissions, amounting to 7,287.1 kt CO₂eq. Projections indicate that in 2030 the ETS will cover approximately 30% of total emissions. According to the 'with additional measures' scenario, 32.4% of emissions will be included in ETS in 2040 and under the 'with additional measures' scenario 31.13% of total emissions. In 2050, the ETS will cover 35.7% of total emissions under the 'with existing measures' scenario, and 37.6% of total emissions under the 'with additional measures' scenario.

In the 'with existing measures' scenario, emission projections within the ETS show a decrease in the period up to 2050, by 15.7% in 2050 compared to 2020.

In the 'with additional measures' scenario, emission projections within the ETS show a stronger declining trend. Compared to 2020, projections show a 29.1% reduction in emissions in 2050.

Emissions within the ESR sector in 2015 amounted to 15,708 kt CO₂eq, which represents 65.1% of total emissions.

In the 'with existing measures' scenario, emissions within the ESR sector are expected to decrease in the period from 2020 to 2050 (by 33.6% in 2050 compared to 2020).

In the 'with additional measures' scenario, an additional reduction in emissions within the ESR sector is expected, which would reduce the emissions by 48.3% in 2050 compared to 2020.

Emissions projections within the ETS and ESR sectors, for both scenarios, are shown in Figures 2-6 and 2-7.

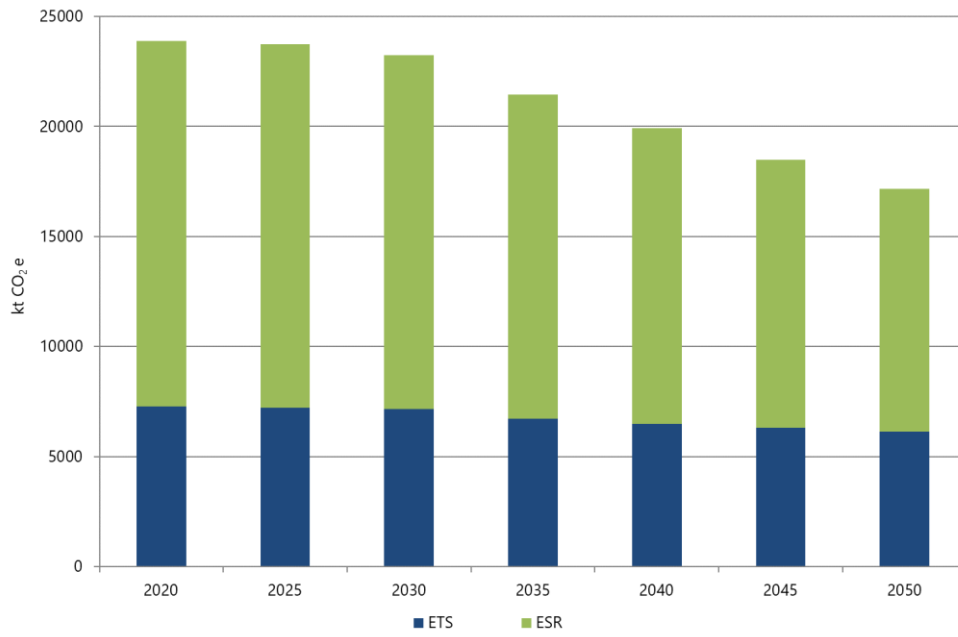


Figure 2-6: Projections of emissions within ETS and ESR, 'with existing measures' scenario

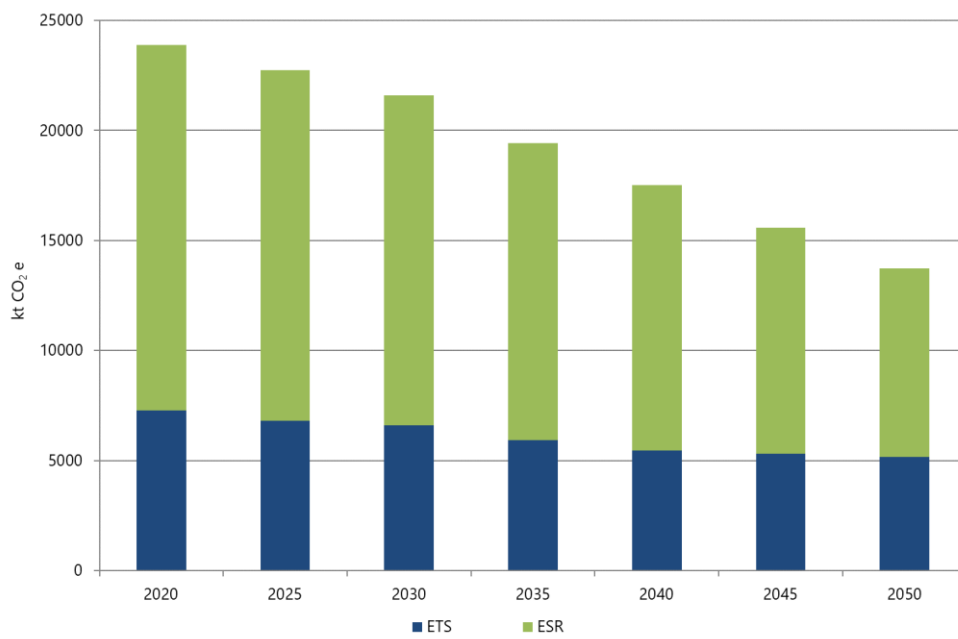


Figure 2-7: Projections of emissions within ETS and ESR, 'with additional measures' scenario

3. Policies and measures included in the projections

Policies and measures to reduce emissions from sources and increase removals of greenhouse gases that are included in the projections are shown separately by sectors. Within each sector, there are measures listed for the 'with existing measures' and 'with additional measures' scenarios without presenting the potential to reduce greenhouse gas emissions. The potential for these policies and measures, as quantified effects of their implementation, are presented in the 'Report on implementation of policies and measures that reduce greenhouse gas emissions by sources or enhance removals by sinks' that was prepared as a separate document.

Projections cover the period until 2050, with five-year steps.

The observation time horizon until 2050 can be divided into four periods: 1) First commitment period of the Kyoto Protocol from 2008 to 2012, which has ended; 2) Second commitment period from 2013 to 2020; 3) Third period from 2021 to 2030; and 4) Fourth period after 2031. After 2020, the trend should go in the direction of the established long-term (until 2050) goals of the European Union's low-carbon scenario.

The GHG projections presented in this report are based on the assumptions, objectives, measures and guidelines provided by the Integrated Energy-Climate Plan of the Republic of Croatia for the period from 2021 to 2030 and the Low-Carbon Development Strategy of the Republic of Croatia until 2030 with a view to 2050 (OG 63/2021).

3.1. Energy

The Energy sector covers all activities that include the consumption of fossil fuels from stationary sources and fugitive emissions from fuels. The emission of the energy sector in 2020 amounted to 9,756.71 kt CO₂eq and is the main source of anthropogenic greenhouse gas emissions with a contribution of 40.8% in the total greenhouse gas emissions in 2020.

The 'with existing measures' scenario represents a group effect of measures that are under implementation or adopted with the enforcement of existing instruments and measures arising from the transfer of the EU acquis. The detail list and description of the measures included are listed in the separated Report on implementation of policies and measures that reduce greenhouse gas emissions by sources or enhance removals by sinks.

The 'with additional measures' scenario is based on the application of existing but also additional measures, as stated in the Report on implementation of policies and measures that reduce greenhouse gas emissions by sources or enhance removals by sinks.

3.2. Transport

The Transport sector includes emissions from fuel consumption in road, air, rail and maritime and river transport, and in 2020 the emissions amounted to 5,796.77 kt CO₂eq, which is 24.3% of the total greenhouse gas emissions of Croatia.

In total final energy consumption, the Transport sector accounts for approximately 33%, the largest share of energy consumption is in road transport with almost 90%.

The 'with existing measures' scenario represents a group effect of measures that are under implementation and adopted with the enforcement of existing instruments and measures arising from the transfer of the EU acquis. The detail list and description of measures included are listed in the separated Report on implementation of policies and measures that reduce greenhouse gas emissions by sources or enhance removals by sinks.

The 'with additional measures' scenario is based on the application of existing but also additional measures, as stated in the Report on implementation of policies and measures that reduce greenhouse gas emissions by sources or enhance removals by sinks.

3.3. Industrial processes and product use

The share of greenhouse gas emissions from the Industrial processes and product use sector is 15.3% of the total emissions of the Republic of Croatia. Emissions from fuel combustion in industrial plants are balanced in the energy sector, while emissions from physical and chemical processes of conversion of raw materials into industrial products, emissions from the use of greenhouse gases in products and emissions from the use of carbon from fossil fuels for non-energy purposes are balanced in the Industrial processes and product use sector.

The 'with existing measures' scenario includes the application of measures defined by strategic and planning sectoral documents included in the manufacturer's business policy, which is conditioned by market requirements, laws and regulations and requirements for the application of best available techniques in production processes. Measures to reduce controlled substances and fluorinated greenhouse gases are provided by law.

The 'with additional measures' scenario includes the application of cost-effective measures to reduce greenhouse gas emissions in cement production and to reduce emissions of controlled substances and fluorinated greenhouse gases.

The 'additional measures' scenario is based on the implementation of the planned measures set out in the Report on implementation of policies and measures that reduce greenhouse gas emissions by sources or enhance removals by sinks.

Process measures for reducing greenhouse gases emissions from Industrial processes and product use sector include:

- reduction of clinker factor in cement production;
- limiting fluorinated greenhouse gas emissions;
- a gradual reduction in the amount of fluorocarbons that can be placed on the market;
- restrictions and prohibitions on placing certain products and equipment on the market;
- reduction of fluorinated greenhouse gas emissions from mobile air conditioning systems.

3.4. Agriculture

The Agriculture sector in 2020 participates in the total greenhouse gas emissions with 11.4%. The most important sectoral emissions are emissions of CH₄ with approximately 37% of total emissions and N₂O with approximately 70% of total emissions. Emissions are caused by different agricultural activities. The CH₄ emission source is animal farming (enteric fermentation), which accounts for about 73% of the sectoral CH₄ emissions.

In the period until 2050, it is expected that there will be a maintenance of the current level or a slight reduction of the livestock fund (with the exception of a slight increase in non-dairy cattle and pigs), and a maintenance or a slight increase in plant production.

In the formation of the scenarios 'with existing measures' and 'with additional measures', the emission projection model used was set using the following assumptions:

- Projections of the trend of input data on activity for livestock and crop production were taken from the global FAO report¹ "The future of food and agriculture - alternative routes until 2050", using the BAU (business as usual) scenario of the report.
- Use of mineral fertilizers obtained by extrapolation of the existing trend for the period from 2000 to 2020.
- Implementation of the Rural Development Programme for the period 2014-2020.
- Minor changes in the livestock system and feeding regime (changes in the fertilization system and genetic progress, increased digestibility and feed quality).

The 'with additional measures' scenario implies the application of the following measures:

- Change in the diet of cattle and pigs and animal feed quality,
- Anaerobic decomposition of manure and biogas production,
- Improvement of buildings or dwellings as well as manure management systems,
- Improvements in synthetic fertilizer application methods,
- Hydromeliorative field interventions and disaster protection systems,
- Introduction of new cultivars, varieties and cultures.

3.5. Waste

The Waste sector contributes to total greenhouse gas emission with 8.2% in 2020, of which 98.8% comes from the key emission sources: solid waste disposal and wastewater treatment and discharge. Of these, 70.2% of emissions related to the disposal of solid waste. The projections include municipal solid waste, industrial waste and sludge from wastewater treatment plants.

The 'with existing measures' scenario includes projections of greenhouse gas emissions from solid waste disposal, biological treatment of solid waste – composting, incineration of waste and wastewater treatment and discharge. Projections of emissions of greenhouse gases from the Waste sector are based on the implementation of measures prescribed by sectoral legislation, harmonized with EU legislation. The implementation of measures is prescribed by the sectoral legislation - Sustainable Waste

¹ FAO. 2018. The future of food and agriculture – Alternative pathways to 2050. Rome. 224 pp. Licence: CC BY-NC-SA 3.0 IGO.

Management Act (OG 94/2013, 73/2017, 14/2019, 98/2019) and Waste Management Plan of the Republic of Croatia for the period 2017 – 2022 (OG 3/2017, 1/2022).

The 'with additional measures' scenario is the same as the 'with existing measures' scenario since no additional measures to reduce emissions of greenhouse gases have been identified. A comparative analysis of a group of countries with similar national characteristics found that national legislation, which is in line with EU legislation, prescribes measures that all Member States should implement by a defined deadline and consider them within the 'with existing measures' scenario.

Assumptions based on the existing legal framework of the Republic of Croatia and the adopted EU legal framework from the Waste sector for the period until 2050 are included in the preparation of projections from the disposal and biological treatment of solid waste (composting). A five-year delay is included in the projections. On 4 July 2018, the new EU rules with legally binding targets for waste recycling and reduction of waste disposal came into force. Croatia was given the possibility of a delay of five years to meet the targets because it is among the Member States that are in 2013 prepared for re-use and recycled less than 20% of its municipal waste and landfilled more than 60% of its municipal waste.

The projections of emissions from waste incineration include the assumption that no more incineration of clinical waste is carried out without energy recovery.

The projections of emissions from wastewater treatment and discharge are estimated based on historical emissions from 2020, using projections of dynamics of the annual growth rate of gross domestic product and the decline of the population.

The 'with existing measures' scenario includes the following measures:

- preventing the generation and reducing the amount of solid waste;
- increasing the amount of separately collected and recycled solid waste;
- ensuring the system of treatment and use of landfill gas;
- reducing the amount of disposed biodegradable waste;
- use of biogas for biomethane production and electricity and heat generation.

Reducing the amount of disposed biodegradable waste results in an increase in the amount of biodegradable waste that is sent to biological treatment processes, such as composting and anaerobic digestion in biogas plants. It causes an increase in CH₄ emissions during the reporting period from composting activities calculated in the Waste sector. The overall effect of reducing the amount of disposed biodegradable waste is positive, i.e., there is a reduction in CH₄ emissions due to the reduction of the amount of disposed biodegradable waste at landfills, which is prescribed by sectoral legislation.

The potentials of CO₂ emission reduction, which can be achieved by implementing the measures included in the 'with existing measures' scenario and the 'with additional measures' scenario are estimated in the Energy sector.

3.6. LULUCF

In the LULUCF sector, projections were made according to sectoral categories: 'Forest land', 'Cropland', 'Grassland', 'Wetland', 'Settlements', 'Other land' and 'Harvested wood products'. The projections were done for the 'with existing measures' scenario only. The 'without measures' and 'with additional measures' scenarios have been omitted due to a lack of capacity of Croatia for the development of these projections, which is in accordance with Regulation (EU) 2018/1999 and Commission implementing regulation (EU) 2020/1208. The projections were made based on a statistical analysis of the trend of activity data and implied emission factors for the period 2009-2020, which included measures that were

in force in 2009. These measures are prescribed by the Forest management plans of Croatia for the periods 2006-2015 and 2016-2025 for forests and forest land. Based on the mentioned document, for afforestation of bare productive forest land and natural expansion of the forest on an annual basis of 1.88 kha, thereby increasing the surface in the category 'Forest land' ('Grassland converted to Forest land') is planned. According to the expert judgment, this conversion includes both afforestation seeding and the natural expansion of forests. The projections for the categories 'Forest land remaining forest' and 'Wood products' are in line with the National Forestry Calculation Plan, including the proposed Forest reference level (FRL) for the period from 2021 to 2025. Since the 'Wetlands' have already been partially protected by the Law on Nature Protection (OG 80/2013, 15/2018, 14/2019, 127/2019) and based on the past trend, it is not assumed that there will be a significant increase in the area under the said category. The measures included in the national LULUCF Action plan and Rural Development Programme of Croatia did not affect the projections for the 'Cropland' and 'Grassland' category, because these documents were drafted in 2014 or 2015, and the assessment of their effect requires a significant capacity building at the national level.

4. Descriptions of methodologies, models, underlying assumptions and key input and output parameters for projections

Projections were made in accordance with the Guidelines for preparation of national reports by Parties included in Annex I to the Convention.

The potential for mitigation of national greenhouse gas emissions is analysed and assessed at the sectoral level. This assessment takes into account the previous trends and the current state as well as the future projections of parameters that determine the potential for mitigating emissions. The model and methodology used in preparing the projections are described by sector, in this chapter. The results of all sectoral models are integrated into the LEAP (Long-Range Energy Alternatives Planning System) software package.

A list of assumptions and input data is provided in tabular form (Tables 4-6 to 4-15). The list contains general parameters and parameters related to the sectors and sub-sectors (Energy, Transport, Buildings, Industrial processes and product use, Agriculture, Waste and LULUCF), in accordance with Implementing Regulation (EU) 2020/1208.

The 'with existing measures' and 'with additional measures' scenarios included policies and measures for the reduction of emissions from sources and increase of greenhouse gases removals. In order to determine the contribution of each individual policy and measure for emissions reduction, the reduction potential was determined. In cases where the emission reduction potential of individual policies and measures cannot be expressed separately, reports are aggregated with other potential policies and measures.

4.1. Descriptions of models and methodologies for projections

Energy and transport

In preparing the projections, a software packages MAED (Model for Analysis of Energy Demand) and MESSAGE (Model for Energy Supply Strategy Alternatives and their General Environmental Impact) were used, in which was created a model of the energy sector in Croatia. For the needs of detailed modelling of the development and optimization of the power sector, a more advanced model was used, whose results were the inputs for the integrated energy model. Output data are structured in accordance with the structure of the inventory of the United Nations Framework Convention on Climate Change. It is the engineering simulation model in which are the scenarios simulated and certain processes and decisions optimized regarding the assumptions and limitations. The model is detailed to the level of individual production units, present and future.

Projections were made until 2050, with a single step every year. The model is of 'bottom-up' type because it starts from the sectoral data and individual emission sources in the power sector. Emissions of CO₂, CH₄ and N₂O are calculated.

Assumptions and input parameters used in the preparation of projections are shown in Tables 4-1, 4-7, 4-8 and 4-11.

Table 4-1: Assumptions for projections – energy and transport

Energy and Transport	
<p>Projections of greenhouse gas emissions for this report are taken from the Integrated Energy-Climate Plan of the Republic of Croatia for the period from 2021 to 2030 and the Low-Carbon Development Strategy of the Republic of Croatia until 2030 with a view to 2050 (OG 63/2021). Below is a more detailed description of the methodology used.</p>	
<p>1. Final energy demand</p>	<p>Final energy demand is projected in different sectors - industry, transport, services, households and agriculture, fisheries and forestry. The bases for projections of activities are national macroeconomic parameters. For the projections of energy intensities, development of technology and changing of lifestyles was taken into account. The scenarios 'with existing measures' and 'with additional measures' modelled the impacts of each measure.</p> <p>The analyses were performed by sub-sectors:</p> <ul style="list-style-type: none"> – industry - by industry and type of fuel used, – transport – by type of transport (road, air, marine and rail) and types of means of transport (cars, buses, motorcycles, light and heavy vans) or purpose (passenger and freight) and by type of technology and fuel used, – services – by branches (tourism, trade, education, health), climatic zone (coastal or continental Croatia), purpose (heating, water heating, cooking, cooling, electrical appliances and lighting), type of fuel used, heating demand is modelled on the level of useful and final energy, – households – by climatic zone (coastal or continental Croatia), purpose (heating, water heating, cooking, cooling, electrical appliances and lighting) and by type of fuel, heating demand is modelled on the level of useful and final energy, – agriculture, fisheries and forestry - by type of fuel. <p>Demographic trends – assumes a scenario of average fertility and average migration, in accordance with the population projections made for the purposes of developing the Energy Development Strategy of the Republic of Croatia until 2030 with a view to 2050 (OG 25/2020).</p>
<p>1.1. 'With existing measures' scenario</p>	
	<p>In the period until 2050, the development was simulated in accordance with the existing policy and measures and market development:</p> <ul style="list-style-type: none"> – market-driven improvements in energy efficiency and fuel switches in the industrial sector; – renovation of 0.75% surface of the buildings annually to the nearly Zero Energy Building standard (includes the use of renewable energy); – penetration of electric and hybrid vehicles with the share in total passenger activity in 2030 2.5% and in 2050 30%; – it is assumed that there will be a stagnation in the use of rail and inland waterways transport for the transport of goods and most of the vehicles will be N2 and N3 category with diesel engines.
<p>1.2. 'With additional measures' scenario</p>	
	<p>Continued support to energy efficiency after 2020, with the following key assumptions:</p>

Energy and Transport	
	<ul style="list-style-type: none"> – renovation of 1.3% of the buildings annually to the nearly-zero energy standard (include the use of renewable sources); – support for the development of the share of electric vehicles to 3.5% in 2030 and 65% of the passenger road transport in 2050; – support for the purchasing of the new electric and hybrid vehicles until the share of 1% in the total number of vehicles; – intermodal shift with the goal to increase the share of the transport of goods to rails (electric locomotives) to 30% until 2050; – in urban passenger transport, electrification of almost 85% of the entire passenger activity is expected by 2050; – improvements in energy efficiency in the industry together with fuel switch towards the use of renewable energy and electricity.
2. Energy transformations and resources	<p>The power system was analysed by the simulation of market development with the software for the hourly optimization of operation and development of the power system. The price of the emission allowances in the EU ETS was assumed as in the EU Reference scenario 2016.</p> <p>The simulation of the operation of the refineries was done to satisfy the domestic demand as possible with the existing capacities, which mean without building new refineries and reducing production in 'with existing measures' and 'with additional measures' scenarios.</p>
2.1. 'With existing measures' scenario	
	<p>Assumptions:</p> <ul style="list-style-type: none"> – for the post-2020 period, the simulation of the market development with the software for the long-term development and operation of the power system was done based on the principle of cost minimization or ideal market conditions. The model included part of the district heating system in the area of big cities with CHP plants; – the price of the emission allowances in the EU ETS was assumed as in the EU Reference scenario 2016; – the analysis showed that renewable energy sources will be competent to a certain extent without the need of the public support for the solar PV system and wind; – the analysis shows that new coal-fired power plants are not competitive due to the increase in the price of emission permits and the reduction of investment costs in renewable energy sources; – a gradual decrease in net imports of electricity.
2.2. 'With additional measures' scenario	
	<p>Assumptions include continuous development of renewable energy policy even after 2020:</p> <ul style="list-style-type: none"> – for the post-2020 period, the simulation of the market development with the software for the long-term development and operation of the power system was done based on the principle of cost minimization or ideal market conditions. The model included part of the district heating system in the area of big cities with CHP plants;

Energy and Transport	
	<ul style="list-style-type: none"> – the price of the emission allowances in the EU ETS was assumed as in the EU Reference scenario 2016; – the analysis showed that renewable energy sources will be competent to a certain extent without the need of the public support for the solar PV system and wind; – the analysis shows that new coal-fired power plants are not competitive due to the increase in the price of emission permits and the reduction of investment costs in renewable energy sources; – a gradual decrease in net imports of electricity.

Industrial processes and product use

In preparing the projections, the engineering simulation model derived in tabular calculation interface was used. The model is structured in accordance with the table structure of the inventory of the United Nations Framework Convention on Climate Change.

The model is detailed to the level of individual production units, the present and future ones.

Projections are made until 2050, in steps of five years. The model is of 'bottom-up' type, because it starts from the sectoral data and individual emission sources. Emissions of CO₂, CH₄, N₂O, HFC and SF₆ are calculated.

Assumptions and input parameters used in the preparation of projections are presented in Tables 4-2 and 4-10.

Table 4-2: Assumptions for projections – industrial processes and product use

Industrial processes and product use
<p>The projections were carried out based on the expected development of certain industries, which includes the production goals by 2050.</p> <p>Emission projections start from the situation and projections of macroeconomic parameters in 2020 - the projected dynamics of the annual growth rate of gross domestic product and gross value added and the decline of population, as well the results of sectoral analysis and studies (cement and the use of N₂O for the food industry and for medical purposes). The projections of macroeconomic parameters are in line with the projections made for the purposes of the development of the Energy Development Strategy of the Republic of Croatia until 2030 with a view to 2050 (OG 25/2020).</p> <p><u>Assumptions for 'with existing measures' scenario:</u></p> <ul style="list-style-type: none"> – no installation of additional capacity; – production will reach the maximum value by 2040; – reduction of emissions of controlled substances and fluorinated greenhouse gases. <p>Regulation (EU) no. 517/2014 on fluorinated greenhouse gases, a gradual reduction in the emission of F gases was established. From 2015 onwards, the total sum of HFC quotas allocated to producers and importers cannot exceed the maximum amount calculated for a calendar year. Projections of F gases for the Republic of Croatia follow the trends of CO₂e emissions at the EU level, for the scenario 'with existing measures'. The same trend of reduction until 2030 was applied until 2050.</p> <p>Process emissions from economic activities, as defined by IPCC methodology, included in the sector Industrial processes and product use were estimated based on detailed sectoral projections of production of cement the use of N₂O for the food industry and for medical purposes and the projected macroeconomic indicators of gross value added by other industrial branches, annual increase rate in gross domestic product and decline of the population.</p>

Industrial processes and product use

The scenario includes the implementation of measures defined in the strategic and sectoral planning documents included in the business policy of manufacturers, conditioned by market demands, laws and regulations and the requirements of the application of best available techniques in the production process.

Measures to reduce controlled substances and fluorinated greenhouse gases are provided by law.

Assumptions for 'with additional measures' scenario:

- the application of cost-effective measures to reduce process greenhouse gas emissions in the production of cement.

By increasing the share of mineral additives in cement, the share of clinker decreases, and thus the need for its production. It is assumed that the share of clinker in cement in 2020 is the same as in the scenario 'with existing measures', in 2030 it is 65% and in 2050 50%. In accordance with the above, based on the planned production of cement, included in the business plans of the manufacturer, projections of the assumed production of clinker were made.

- Reduction of emissions of controlled substances and fluorinated greenhouse gases.

Projections of F gases for the Republic of Croatia follow the trends of CO₂e emissions at the EU level for the scenario 'with additional measures'. The same trend of reduction until 2030 was applied until 2050;

According to good practice, the projections were made for activity data and emission factors:

- activity data – applying Grade of 1, 2 and 3 methods (projections of macroeconomic parameters, effects of policies and measures, sectoral analysis and studies);
- emission factors – applying Grade of 1 and 2 methods (projections based on average values for the previous five-year period, effects of policies and measures, sectoral analysis and studies).

Agriculture

In preparing the projections, a model derived in a tabular calculation interface was used. Engineering simulation model is structured in accordance with the table structure of the inventory of the United Nations Framework Convention on Climate Change.

The model is detailed to the level of individual sources.

Projections are being made until 2050, in steps of five years. The model is of 'bottom-up' type because it starts from the sectoral data and individual emission sources and calculated emissions of CO₂, CH₄ and N₂O.

Assumptions and input parameters used in the preparation of projections are presented in Tables 4-3 and 4-12.

Table 4-3: Assumptions for projections - agriculture

Agriculture

The projections were carried out based on the expected future state of key parameters.

Assumptions for the scenario 'with existing measures' and 'with additional measures':

- To determine the key parameters for making projections (number of significant livestock species and production of significant crops) trends in livestock and crop production taken from the global FAO report "The future of food and agriculture - alternative ways to 2050"² were used, where BAU (business as usual) scenario of the mentioned report was applied. Because there were some differences in activity data in the base year, the BAU scenario data of the FAO report were adjusted, but an identical trend was maintained. For non-significant crops, the historical data from 2020 was retained.

² Source: The future of food and agriculture – Alternative pathways to 2050

- For mineral fertilizers, an extrapolation based on historical input data was used.

Assumptions for the scenario 'with additional measures':

- application of emission reduction potential due to: change of the ratio of certain types of feed in the diet, use of additives and fats in food, improvement of quality of voluminous feeds and improvement of grazing system, shortening of storage/disposal time of manure on the farm, covering of manure disposal site
- increase in the share of cattle, pigs and poultry on anaerobic digestion of manure and production of biogas (digesters) by 30% by 2050
- reduction of consumption of mineral fertilizers due to less need for nitrogen application because of new cultivars, varieties and crops, improvement of application methods and increase of the share of slow-release fertilizers, hydro melioration interventions and disaster protection systems

Estimation uncertainty is relatively high due to the lack of adequate and reliable statistical and economic indicators.

Waste

In preparing the projections, the engineering simulation model derived in tabular calculation interface was used. The model is structured in accordance with the table structure of the inventory of the United Nations Framework Convention on Climate Change.

The model is detailed to the level of individual sources, the present and future ones.

Projections are made until 2050, in steps of five years. The model is of 'bottom-up' type because it starts from the sectoral data and individual emission sources and calculated emissions of CO₂, CH₄ and N₂O.

Assumptions and input parameters used in the preparation of projections are presented in Tables 4-4 and 4-13.

Table 4-4: Assumptions for projections – waste

Waste
<p>The projections were carried out based on expected development and future state of parameters for the projections - the amount of generated and landfilled solid waste (municipal solid waste, industrial waste and sludge from wastewater treatment), the organic fraction of solid waste, the fraction of recovered/flared methane and the amount of composted organic waste. Emission projections start from the situation and projections of macroeconomic parameters in 2020 - the projected dynamics of the annual growth rate of gross domestic product and the decline of the population.</p> <p><u>Assumptions for the 'with existing measures' scenario:</u></p> <ul style="list-style-type: none"> – Solid waste disposal – reduction of the amount of generated and landfilled solid waste due to the application of measures defined by sectoral legislation harmonized with EU legislation. 4 July 2018 came into force the new EU rules with legally binding targets for waste recycling and reduction of waste disposal. Croatia was given the possibility of a delay of five years to meet the targets because it is among the Member States that are in 2013 prepared for re-use and recycled less than 20% of its municipal waste and landfilled more than 60% of its municipal waste. The five-year delay is included in the projections. – Composting – continuous increase in the amount of waste that is being processed by composting due to the application of measures defined by sectoral legislation harmonized with EU legislation. The increase in the amount of waste to be composted depends on the reduction of the amount of landfilled biodegradable waste and the proportion of biodegradable waste that will be treated by composting and digestion. – Waste incineration – no more incineration of clinical waste is carried out without energy recovery. – Wastewater treatment and discharge – continuous increase in the quantity of wastewater treated in industry sectors and decrease in the quantity of wastewater treated in residential/commercial sectors and decrease the population with an individual system of drainage (septic tank).

Waste

Emissions of greenhouse gases that are included in the Waste sector, according to the IPCC methodology, were estimated based on sectoral analysis and projected macroeconomic indicators on the annual increase in gross domestic product and decline of the population.

The scenario includes the existing legal framework of the Republic of Croatia and the adopted EU legal framework from the Waste sector for the period until 2050. Projections of emissions of greenhouse gases are based on the implementation of measures prescribed by sectoral legislation, harmonized with EU legislation.

Assumptions for the 'with additional measures' scenario:

The 'with additional measures' scenario is the same as the 'with existing measures' scenario since no additional measures to reduce emissions of greenhouse gases have been identified.

According to good practice, the projections were made for activity data and parameters included in the models for GHG emission calculation:

- applying Grade of 1 and 2 methods (projections of macroeconomic parameters, effects of policies and measures, sectoral analysis and studies, expert judgement).

LULUCF

In the 'with existing measures' scenario, for all sectoral components, the Projections Guide (A: General Guidelines and B: Sectoral Guide) was used. The most sub-categories of this sector in the Report of the National Inventory of Croatia for 2022 have been recognized as key categories, either by trend or by level. These are:

- 4(III). Direct N₂O emissions from N mineralization/immobilization
- 4.A.1 Forest Land Remaining Forest Land
- 4.A.2 Land Converted to Forest Land
- 4.B.1 Cropland Remaining Cropland
- 4.B.2 Land Converted to Cropland
- 4.C.2 Land Converted to Grassland
- 4.D.2 Land Converted to Wetlands
- 4.E.2 Land Converted to Settlements
- 4.G Harvested Wood Products

If possible, for the aforementioned sub-categories it is recommended to use Grade 2 or 3 when making projections. However, because of insufficient capacities in the system for making projections in the LULUCF sector at the national level, Grade 1 was applied. Emissions and removals are calculated by multiplying the projected activity data on and implied emission factors based on a historical period from 2009 to 2020 for each carbon pools (aboveground/belowground biomass and soil). Alternative 1 was used, where activity data for the period 2025 to 2050, in this case, the area of each subcategory of land, were obtained by applying a trend extrapolation (or average values backwards, e.g. for Wetlands) over the past ten years, from 2009 to 2020. When making projections, for the carbon pool biomass under the category "Forest land remaining Forest land", increment and the planned wood removals from the official "Forest Management Plan for the period 2016-2025" were taken into account. Also, for Harvested wood products carbon stock, the reference historical period for projection estimate was from 2000 to 2009, because of large fluctuation in input data for recent years. Correction of activity data (HWP

production) for the period 2012-2020 was performed to avoid non-consistency of time series data, which is in accordance with the Accounting Plan for Forestry of the Republic of Croatia and the Forest reference level (FRL). In cases where the extrapolated values took unrealistically extreme values, the arithmetic mean of data on a particular activity for the past ten years ('Land converted to grasslands') was used, i.e., expert assessment to predict the annual volume of afforestation ('Land converted to forest land'). All carbon stocks estimated in NIR 2022 have been taken into account when making emission and removal projections. Some carbon stocks (e.g. dead wood for 'Forest land remaining Forest land') have been omitted because of insufficient data (identical to NIR 2022). Croatia is planning significant improvements in the estimation of projections of GHG emissions/removals in the future period. The main steps in this direction are the implementation of projects and activities that should be aimed at modelling the calculation of projections for key subcategories of the sector and their carbon stocks. Results should decrease uncertainty in estimation and further use of Grade 2.

The assumptions and input parameters used in making the projections are shown in tables 4-5 and 4-14.

Table 4-5: Assumptions for projections – LULUCF

LULUCF
<p>The projections were carried out based on the expected future state of the parameters that determine the potential for emissions mitigation.</p> <p>Key parameters for projections were determined based on the parameters in the relevant Guideline for projections (land area of each subcategory, emission factors assumed by carbon stock) and expert judgment for surface renovated and forest land.</p> <p>Assumptions:</p> <ul style="list-style-type: none"> – The total area of 'Forest land' and 'Settlements' will be increased – Land conversion to forest land will remain at the annual intensity (1.88 kha/year) – Areas of 'Wetlands' will not increase – The areas of 'Grassland' and 'Agricultural land' will not change significantly – Areas of burned areas will not increase – The carbon stock in the 'Wood Products' will increase.

4.2. Parameters on projections

Table 4-6: Parameters on projections – general economic parameters

Parametar		2020	2025	2030	2035	2040	2045	2050
GDP – annual growth rate	billion EUR (EC 16)	46.3	51.6	57.5	62.9	68.7	74.8	81.3
Population	million people	4.058	3.937	3.828	3.721	3.614	3.502	3.393
Coal prices	USD/t	6.4	7.9	8.6	9.1	9.6	10.1	10.6
Heavy Fuel Oil prices	USD/barrel	62	83	94	103	111	119	127
Gas prices	USD/Mbtu	70	77	80	81	82	83	84

Table 4-7: Parameters on projections – Energy sector: total energy consumption, total electricity generation

Parametar		2020	2025	2030	2035	2040	2045	2050
Total energy consumption								
Coal and coke	ktoe	361.2	307.3	253.3	149.9	46.5	40.2	33.9
Liquid petroleum fuels	ktoe	2,779.9	3,021.7	3,263.4	2,965.0	2,666.5	2,360.9	2,055.3
Gas	ktoe	2,534.0	2,490.1	2,446.2	2,571.3	2,697.0	2,658.8	2,621.2
Renewable	ktoe	3,160.6	2,953.9	2,747.2	3,008.3	3,269.5	3,310.7	3,351.9
Other	ktoe	437.9	391.4	345.2	117.9	109.9	61.0	-18.8
Total	ktoe	9,273.6	9,164.4	9,055.3	8,812.4	8,569.6	8,219.0	7,868.4
Total electricity generation								
Coal	TWh	1.55	1.27	0.98	0.50	0.01	0.01	0.01
Liquid petroleum fuels	TWh	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Gas	TWh	2.40	2.49	2.59	3.22	3.85	3.88	3.91
Renewable	TWh	9.20	10.98	12.76	14.49	16.22	17.86	19.50
Nuclear	TWh	NO	NO	NO	NO	NO	NO	NO
Other	TWh	NO	NO	NO	NO	NO	NO	NO
Total	TWh	13.19	14.78	16.38	18.25	20.12	21.79	23.47

Table 4-8: Parameters on projections – Energy sector: final energy consumption

Parametar		2020	2025	2030	2035	2040	2045	2050
Final energy consumption								
Industry	ktoe	1,193.7	1,190.5	1,187.2	1,170.2	1,153.3	1,116.5	1,079.7
Transport	ktoe	2,012.1	2,165.9	2,319.7	2,254.7	2,189.6	2,029.9	1,870.2
Households	ktoe	2,284.7	2,369.6	2,454.5	2,364.3	2,274.1	2,128.9	1,983.8
Agriculture, forestry and fisheries	ktoe	247.5	223.1	198.8	193.5	188.2	179.8	171.5
Services	ktoe	749.2	850.0	950.9	975.9	1,000.9	998.7	996.5
Other	ktoe	NA	NA	NA	NA	NA	NA	NA
Total	ktoe	6,445.4	6,778.3	7,111.1	6,958.4	6,805.8	6,445.8	6,085.7

Table 4-9: Parameters on projections – weather parameters

Parametar	2020	2025	2030	2035	2040	2045	2050
Number of heating degree days (HDD)	2,288	2,261	2,235	2,208	2,181	2,156	2,131

Table 4-10: Parameters on projections – Industrial processes and product use

Parametar	2020	2025	2030	2035	2040	2045	2050
Clinker production - 'with existing measures' scenario	kt	2,351	2,525	2,585	2,585	2,585	2,585
Clinker production - 'with additional measures' scenario	kt	2,351	2,223	2,308	2,174	2,041	1,908

Table 4-11: Parameters on projections – Transport

Parametar	2020	2025	2030	2035	2040	2045	2050
Number of passenger kilometres, all modes	10 ⁹ pkm	40.0	41.4	43.2	44.0	44.5	46.2
Transport of goods	10 ⁹ tkm	11.6	11.6	11.6	11.6	11.6	11.6
Energy consumption in road transport	ktoe	2,012.1	2,165.9	2,319.7	2,254.7	2,189.6	2,029.9

Table 4-12: Parameters on projections – Agriculture

Parametar	2020	2025	2030	2035	2040	2045	2050
Dairy cattle	1000 heads	109	171	160	155	148	142
Non-dairy cattle	1000 heads	313	284	288	289	296	303
Sheep	1000 heads	662	639	621	607	595	576
Goats	1000 heads	86	68	66	65	63	62
Horses	1000 heads	26	23	24	25	26	27
Mules/asses	1000 heads	5	3	3	4	4	4
Swine	1000 heads	1033	1204	1226	1220	1222	1221
Poultry	1000 heads	13057	10500	10800	11000	11500	11200
Wheat	1000 heads	84	84	84	84	84	84
Wheat	t	849,656	1,028,720	1,064,901	1,046,561	1,038,850	1,031,561
Maize	t	2,430,598	1,466,304	1,579,681	1,601,893	1,618,633	1,592,702
Potatoes	t	174,279	186,121	201,028	212,581	224,869	237,544
Sugar beets	t	774,331	1,079,313	1,168,764	1,205,044	1,235,848	1,259,446
Tobacco	t	7,084	7,084	7,084	7,084	7,084	7,084
Sunflowers	t	120,012	120,012	120,012	120,012	120,012	120,012
Rape seed	t	119,667	119,667	119,667	119,667	119,667	119,667
Tomatoes	t	33,369	33,369	33,369	33,369	33,369	33,369
Barley	t	321,776	249,112	260,182	259,560	258,277	257,111
Oats	t	65,345	65,345	65,345	65,345	65,345	65,345

Parametar		2020	2025	2030	2035	2040	2045	2050
Cabbages and other brassicas	t	38,533	38,533	38,533	38,533	38,533	38,533	38,533
Garlic	t	1,972	1,972	1,972	1,972	1,972	1,972	1,972
Onions	t	16,351	16,351	16,351	16,351	16,351	16,351	16,351
Rye	t	4,367	4,367	4,367	4,367	4,367	4,367	4,367
Sorghum	t	244	244	244	244	244	244	244
Watermelons	t	15,594	15,594	15,594	15,594	15,594	15,594	15,594
Soybeans	t	266,014	105,529	111,994	112,357	111,976	111,219	110,557
Beans, dry	t	1,325	1,325	1,325	1,325	1,325	1,325	1,325
Fodder peas, dried	t	1,629	1,629	1,629	1,629	1,629	1,629	1,629
Lentils	t	52	52	52	52	52	52	52
Peas, dry	t	170	170	170	170	170	170	170
Vetches	t	0	0	0	0	0	0	0
Clover	t	60,049	60,049	60,049	60,049	60,049	60,049	60,049
Alfalfa	t	201,460	201,460	201,460	201,460	201,460	201,460	201,460
Applying nitrogen	t	98,964	98,267	95,947	93,626	91,306	88,986	86,665

Table 4-13: Parameters on projections – Waste

Parametar		2020	2025	2030	2035	2040	2045	2050
Amount of generated solid waste	t	1,373,503	2,212,504	2,204,261	2,189,563	2178611	2,173,437	216,826
Amount of landfilled solid waste	t	1,459,906	553,126	440,852	328,434	217,861	119,432	21,682
Share of methane recovered/flared	%	8.6	4.2	4.5	4.6	4.1	3.7	3.2

Table 4-14: Parameters on projections – LULUCF

Parameter – Activity data	AD units	2020	2025	2030	2035	2040	2045	2050
4.A.1. Forest land remaining forest land	(kha)	2,312.83	2,274.67	2,236.52	2,198.36	2,160.21	2,122,05	2,083,90
4.A.2. Land converted to forest land	(kha)	67.00	76.00	85.00	94.00	103.00	112,00	121,00
4.B.1. Cropland remaining cropland	(kha)	1,468.32	1,439.42	1,410.52	1,381.62	1,352.72	1,323,82	1,294,92
4.B.2. Land converted to cropland	(kha)	48.96	51.45	53.94	56.43	58.91	61,40	63,89
4.C.1. Grassland remaining grassland	(kha)	1,079.86	1,062.02	1,044.17	1,026.33	1,008.48	990,63	972,79
4.C.2. Land converted to grassland	(kha)	57.32	55.48	55.48	55.48	55.48	55,48	55,48
4.D.1. Wetlands remaining wetlands	(kha)	74.37	75.00	75.45	75.90	76.35	76,81	77,26
4.D.2. Land converted to wetlands	(kha)	0.85	0.85	0.85	0.85	0.85	0,85	0,85
4.E.1. Settlements remaining settlements	(kha)	205.84	209.42	212.53	215.64	218.75	221,86	224,98
4.E.2. Land converted to settlements	(kha)	87.54	96.73	105.92	115.11	124.31	133,50	142,69
4.F.1. Other land remaining other land	(kha)	256.52	318.37	379.03	439.69	500.34	561,00	621,66
4.III.B Cropland	(kha)	48.96	51.45	53.94	56.43	58.91	61,40	63,89
4.III.D Wetland	(kha)	0.85	0.85	0.85	0.85	0.85	0,85	0,85
4.III.E Settlements	(kha)	87.54	96.73	105.92	115.11	124.31	133,50	142,69
4.V.A Forest land remaining forest land	(ha)	5,763.60	5,763.60	5,763.60	5,763.60	5,763.60	5,763,60	5,763,60
4.V.A Land converted to forest land	(ha)	201.36	201.36	201.36	201.36	201.36	201,36	201,36
4.V.B Cropland remaining cropland	(ha)	298.91	298.91	298.91	298.91	298.91	298,91	298,91
4.V.C Grassland remaining grassland	(ha)	7,661.57	7,869.01	7,869.01	7,869.01	7,869.01	7869,01	7,869,01

Table 4-14: Parameters on projections – LULUCF – continued

Parameter – Emissions factors - Biomass	EF units	2020	2025	2030	2035	2040	2045	2050
4.A.1. Forest land remaining forest land	(tC/ha)	0.50	0.40	0.40	0.40	0.40	0.40	0.70
4.A.2. Land converted to forest land	(tC/ha)	0.79	0.79	0.79	0.79	0.79	0.79	0.79
4.B.1. Cropland remaining cropland	(tC/ha)	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06
4.B.2. Land converted to cropland	(tC/ha)	0.47	0.48	0.48	0.48	0.49	0.49	0.50
4.C.1. Grassland remaining grassland	(tC/ha)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.C.2. Land converted to grassland	(tC/ha)	0.12	0.12	0.12	0.12	0.12	0.12	0.12
4.D.1. Wetlands remaining wetlands	(tC/ha)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.D.2. Land converted to wetlands	(tC/ha)	-0.80	-0.80	-0.80	-0.80	-0.80	-0.80	-0.80
4.E.1. Settlements remaining settlements	(tC/ha)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.E.2. Land converted to settlements	(tC/ha)	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10	-0.10
4.V.A Forest land remaining forest land	CO2 (t/AD unit)	31.07	31.07	31.07	31.07	31.07	31.07	31.07
4.V.A Forest land remaining forest land	CH4 (t/AD unit)	0.09	0.09	0.09	0.09	0.09	0.09	0.09
4.V.A Forest land remaining forest land	N2O (t/ADunit)	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4.V.A Land converted to forest land	CO2 (t/AD unit)	31.07	31.07	31.07	31.07	31.07	31.07	31.07
4.V.A Land converted to forest land	CH4 (t/AD unit)	0.09	0.09	0.09	0.09	0.09	0.09	0.09
4.V.A Land converted to forest land	N2O (t/ADunit)	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4.V.B Cropland remaining cropland	CO2 (t/AD unit)	25.51	25.51	25.51	25.51	25.51	25.51	25.51
4.V.B Cropland remaining cropland	CH4 (t/AD unit)	0.07	0.07	0.07	0.07	0.07	0.07	0.07
4.V.B Cropland remaining cropland	N2O (t/ADunit)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.V.C Grassland remaining grassland	CO2 (t/AD unit)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.V.C Grassland remaining grassland	CH4 (t/AD unit)	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4.V.C Grassland remaining grassland	N2O (t/ADunit)	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4-14: Parameters on projections – LULUCF – continued

Parameter – Emissions factors - Soil	EF units	2020	2025	2030	2035	2040	2045	2050
4.A.2. Land converted to forest land	(tC/ha)	-0.24	-0.23	-0.22	-0.21	-0.19	-0.18	-0.17
4.B.1. Cropland remaining cropland	(tC/ha)	-0.01	-0.02	-0.02	-0.02	-0.02	-0.03	-0.03
4.B.2. Land converted to cropland	(tC/ha)	-0.92	-0.92	-0.91	-0.90	-0.90	-0.89	-0.89
4.C.2. Land converted to grassland	(tC/ha)	1.04	1.05	1.06	1.06	1.07	1.08	1.08
4.D.2. Land converted to wetlands	(tC/ha)	-2.72	-2.72	-2.72	-2.72	-2.72	-2.72	-2.72
4.E.2. Land converted to settlements	(tC/ha)	-2.22	-2.22	-2.22	-2.22	-2.22	-2.22	-2.22
4.III.B Cropland	(kg N ₂ O–N/ha)	1.03	1.02	1.01	1.01	1.00	1.00	0.99
4.III.D Wetland	(kg N ₂ O–N/ha)	3.40	3.40	3.40	3.40	3.40	3.40	3.40
4.III.E Settlements	(kg N ₂ O–N/ha)	2.60	2.60	2.60	2.60	2.61	2.61	2.61

5. Sensitivity analysis of projections

Regulation (EU) 2018/1999 recommends that the assumptions and baselines used for joint EU projections should be used as far as possible and justified for national scenarios.

In June 2022, the European Commission drafted the document Recommended parameters for reporting on GHG projections³. Recommended parameters include projections of demographic development, GDP rate, gross value added of individual industries, fuel price projections and emission units. In case of deviation, i.e. non-use of the recommended parameters, it is necessary to make a sensitivity analysis and determine changes in greenhouse gas emissions.

The key differences between the baseline data of the national scenarios presented in this report (the 'with existing measures' scenario and the 'with additional measures' scenario) and the baseline data used by the EU in the common scenarios are population projections and GDP projections and the results of the sensitivity analysis are presented below, i.e. differences in greenhouse gas emissions depending on the differences of these parameters of demographic and economic development.

Information of scenarios is given in Table 5-1.

Table 5-1: Information of scenarios

Scenario	WEM/WAM	Parameters used
Scenario 1	WEM	Population
Scenario 2	WEM	GDP
Scenario 3	WEM	Population, GDP
Scenario 4	WAM	Population
Scenario 5	WAM	GDP
Scenario 6	WAM	Population, GDP

GDP rate

In the analysed scenarios, GDP growth is assumed to average 2.2% by 2030, 1.8% for period 2031 – 2040 and 1.7% for period 2041 – 2050, which is a nominal increase compared to 2020 by 75.8%.

Recommended GDP growth rates in the document Recommended parameters for reporting on GHG projections assume GDP growth by 2050, on average 1.6%, which is a nominal increase of 60.6% compared to 2020.

Using the recommended GDP growth rates, greenhouse gas emissions in 2030 are lower by about 0.1% compared to the 'with existing measures' scenario and by 2.8%, compared to the 'with additional measures' scenario. Greenhouse gas emissions in 2050 are lower by 2.3% compared to the 'with existing measures' scenario and by 5.7%, compared to the 'with additional measures' scenario, assuming the same carbon intensity of the economy. However, the implementation of measures to reduce emissions reduces and, in the long run, breaks the link between GDP and emissions. Thus, GDP growth contributes to reducing emissions when it comes to investments in low-carbon technologies, industry and services.

³ Recommended parameters for reporting on GHG projections in 2021, EC

Population trends

The scenarios presented in this report were made with the assumption that the number of inhabitants in the Republic of Croatia in 2030 is 3,755,419, 3,531,586 in 2040 and 3,295,442 in 2050. Recommended parameters of demographic development projections from the document Recommended parameters for reporting on GHG projections give 1.9% more inhabitants in 2030, 2.3% more inhabitants in 2040 and 3.0% more inhabitants in 2050 compared to the assumed population in the 'with existing measures' scenario and the 'with additional measures' scenario.

Low-carbon scenarios separate GDP from greenhouse gas emissions, while emissions per capita decline. In the scenario 'with existing measures' emission in 2030 amounts to 6.15 t CO₂eq per capita, 5.6 t CO₂eq per capita in 2040 and 5.13 t CO₂eq per capita in 2050. In the 'with additional measures' scenario in 2030, the emission is 5.69 t CO₂eq per capita, 4.9 t CO₂eq per capita in 2040 and 4.1 t CO₂eq per capita in 2050. Variations in demographic trends have a lesser impact on emissions and cannot significantly change the trends set.

With the use of the recommended parameters of demographic development from the document Recommended parameters for reporting on GHG projections, greenhouse gas emissions in 2030 are higher by 1.2% compared to the scenario 'with existing measures' or 0.6% compared to the scenario 'with additional measures', and in 2050 it is higher by 1.4% and 1.0% compared to the presented scenarios, respectively.

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