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 2021

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REPUBLIC OF CROATIA

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EKONERG – Energy Research and Environmental Protection Institute
Koranska 5, 10000 Zagreb, Croatia

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Contents

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 127/19).

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 2021, 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 2021 includes projections of emissions by sources and their removal by sinks for 2020, 2025, 2030, 2035 and 2040.

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 2021 the following data sources were used for the parameters used:

CRF Category	Data type	Data source
General parameters	GDP – yearly growth rate Population Coal price Fuel oil price Natural gas price	Integrated Energy-Climate Plan of the Republic of Croatia for the period from 2021 to 2030 Energy Development Strategy of the Republic of Croatia until 2030 with a view to 2050 (OG 25/20) Proposal of the Low-Carbon Development Strategy of the Republic of Croatia until 2030 with a view to 2050
Energy	Fuel consumption Electricity generation Electricity imports Final energy demand	National energy balance Integrated Energy-Climate Plan of the Republic of Croatia for the period from 2021 to 2030 Energy Development Strategy of the Republic of Croatia until 2030 with a view to 2050 (OG 25/20)
Transport	Number of passenger kilometres Number of tonne-kilometres Energy demand in transport sector	ODYSSEE database Integrated Energy-Climate Plan of the Republic of Croatia for the period from 2021 to 2030 Energy Development Strategy of the Republic of Croatia until 2030 with a view to 2050 (OG 25/20)
Industrial processes and product use	Production index	Sectorial studies (cement, glass and nitric acid production) National Bureau of Statistics Integrated Energy-Climate Plan of the Republic of Croatia for the period from 2021 to 2030 Proposal of the Low-Carbon Development Strategy of the Republic of Croatia until 2030 with a view to 2050
	Use of solvents	Inventory Report of air pollutants on the Croatian territory under the Convention on Long-range Transboundary Air Pollution (CLRTAP) Proposal of the Low-Carbon Development Strategy of the Republic of Croatia until 2030 with a view to 2050
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 2020
	The assumed emission factors by sinks	CFR 2020
Waste	The amount of generated solid waste (municipal, industrial, sludge from wastewater treatment) The amount of landfilled solid waste (municipal, industrial, sludge from wastewater treatment) The organic fraction of solid waste Share of methane recovered/flared The amount of composted organic waste	Sustainable Waste Management Act Waste Management Plan of the Republic of Croatia Sustainable Waste Management Act (OG 94/13, 73/17, 14/19, 98/19) Waste Management Plan of the Republic of Croatia for the period 2017 – 2022 (OG 3/17) Proposal of the Low-carbon Development Strategy of the Republic of Croatia for the period until 2030 with an outlook to 2050 Ministry of Economy and Sustainable Development: - Waste Management Information System - Environmental Pollution Register

2. Projection of greenhouse gas emissions

This chapter presents the historical greenhouse gas emissions in the period from 1990 to 2018 and projections of greenhouse gas emissions for the period from 2020 to 2040. The emissions are presented as total emissions of greenhouse gases by sectors and by gases. 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 (CO_2eq). 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 that are used in the report are presented below.

Gas	GWP
Carbon dioxide (CO_2)	1
Methane (CH_4)	25
Nitrous oxide (N_2O)	298
HFC-23	14800
HFC-32	675
HFC-125	3500
HFC-134a	1430
HFC-143a	4470
HFC-152a	124
HFC-227ea	3220
HFC-236fa	9810
CF_4	7390
C_3F_8	8830
C_2F_6	12200
SF_6	22800

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:

- CO_2,
- CH_4,
- N_2O,
- HFCs and PFCs,
- SF_6.

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 2020) which includes an inventory of emissions and removals of greenhouse gases for the period 1990 – 2018 (submission of 15th April 2020).

2.1. Projections of greenhouse gas emissions by sectors

Historical and 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 1990 to 2040.

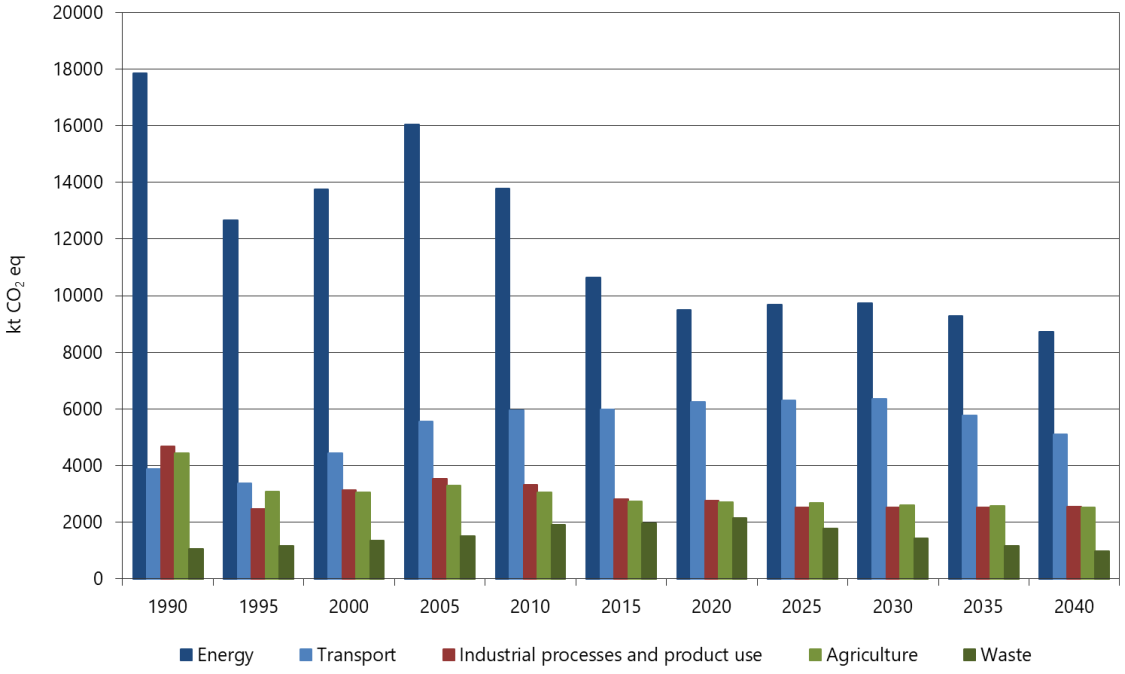

Figure 2-1: Historical and projected greenhouse emissions by sectors, 'with existing measures' scenario

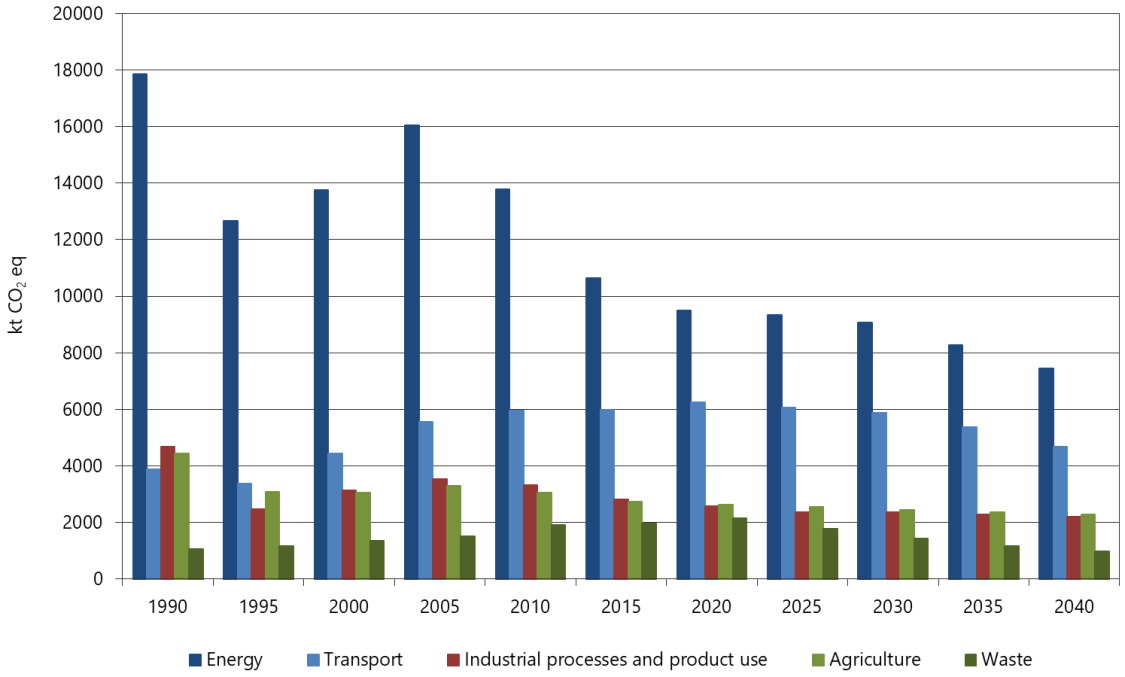

Figure 2-2: Historical and projected greenhouse emissions by sectors, 'with additional measures' scenario

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 2018 amounted to 10,015 kt CO_2 and it is the main source of anthropogenic emission of greenhouse gases, it accounts for approximately 42.1% of the total greenhouse gases emission in 2018. 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.

The Transport sector includes emissions from fuel combustion in road transportation, civil aviation, railways and navigation. The emission from the Transport sector in 2018 amounted to 6,428 kt CO_2eq, which makes about 27.0% of total Croatia's greenhouse gases emission. In the 'with existing measures' scenario in the period up to 2030, projections show a slight increase in emissions. Factors that encourage the growth of emissions are expected increase in economic activities and living standard. 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 2040, 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.

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 2018 amounted to 2,591 kt CO_2eq, which is 10.9% of total Croatia's greenhouse gases emission in 2018. 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.

The Agriculture sector covers about 11.4% of total greenhouse gas emissions in 2018 (emission is 2,720 kt CO_2eq). 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.

The Waste sector participates in total of Croatia's greenhouse gases emission with 8.6% in 2018 (emission is 2,039 kt CO_2eq). 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 2035. 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 CO_2 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.

In the year 2018, removals by the sink in the LULUCF sector were -5094,23 kt CO_{2eq}. Projections of removals in 2040 amount to -2,385.6 kt CO_2eq 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).

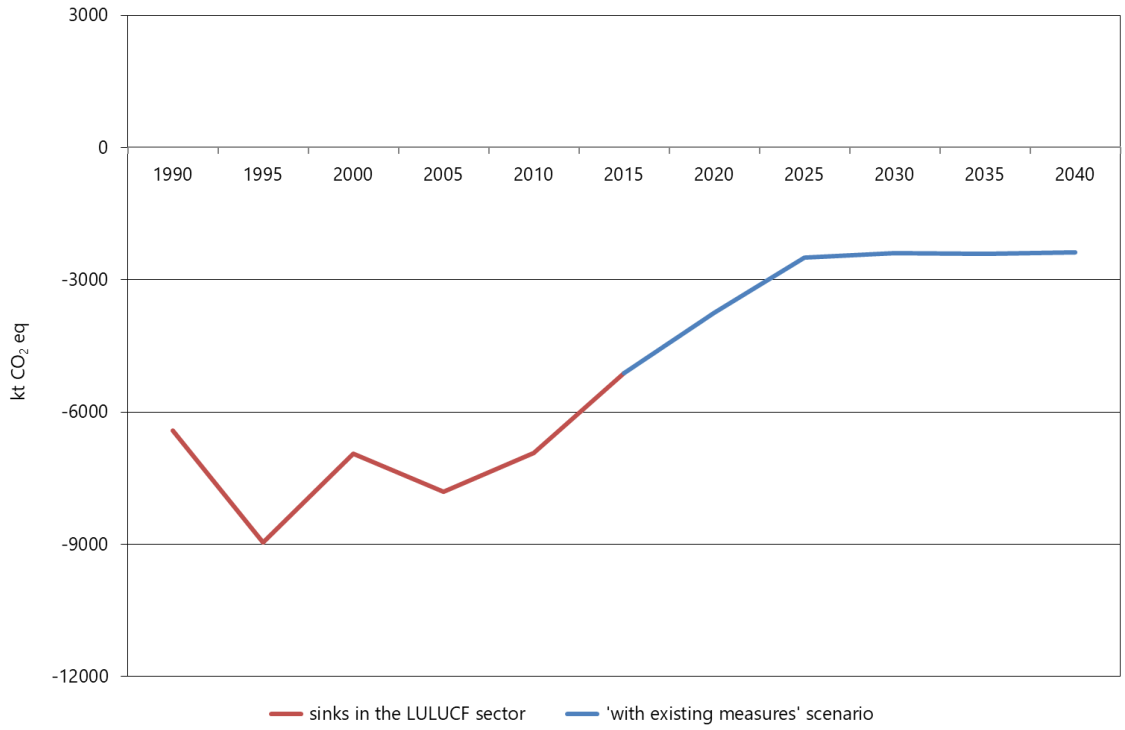

Figure 2-3: Greenhouse gas removals in the LULUCF sector, 'with existing measures' scenario

2.2. Projections of greenhouse gas emissions by gases

Trends in emissions, by greenhouse gases (CO_2, CH_4, N_2O, HFCs and PFCs, SF_6), for 'with existing measures' and 'with additional measures' scenarios, in the period from 1990 until 2040 are shown in Figure 2-4.

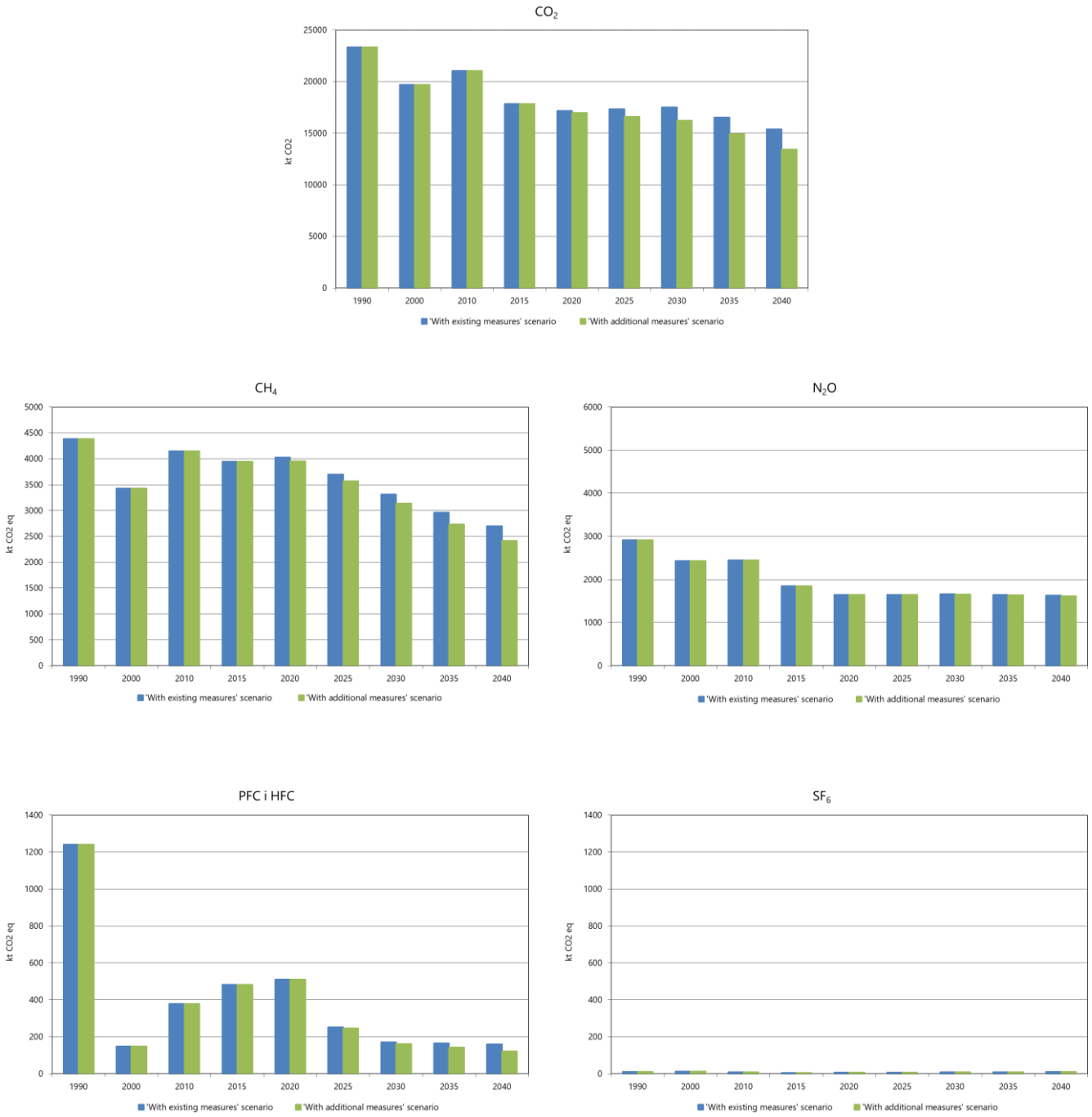

Figure 2-4: Projections of greenhouse gas emissions by gases

Historical emissions and projections of greenhouse gas emissions CO_2, CH_4, N_2O, HFCs and PFCs, SF_6, for 'with existing measures' and 'with additional measures' scenarios, in the period from 1990 until 2040 are shown in Table 2-1.

Table 2-1: Historical emissions and projections of greenhouse gas emissions by gases, kt CO_2eq

CO2	1990	2000	2010	2015	2020	2025	2030	2035	2040
'With existing measures' scenario	23329	19694	21051	17841	17167	17336	17494	16512	15373
'With additional measures' scenario	23329	19694	21051	17841	16979	16604	16213	14924	13437
CH4	1990	2000	2010	2015	2020	2025	2030	2035	2040
'With existing measures' scenario	4382	3426	4145	3947	4026	3695	3311	2962	2699
'With additional measures' scenario	4382	3426	4145	3947	3955	3570	3136	2731	2415
N2O	1990	2000	2010	2015	2020	2025	2030	2035	2040
'With existing measures' scenario	2913	2429	2450	1850	1644	1650	1666	1648	1629
'With additional measures' scenario	2913	2429	2450	1850	1643	1644	1656	1636	1614
PFC i HFC	1990	2000	2010	2015	2020	2025	2030	2035	2040
'With existing measures' scenario	1240	148	379	483	511	251	170	165	160
'With additional measures' scenario	1240	148	379	483	511	246	161	142	122
SF6	1990	2000	2010	2015	2020	2025	2030	2035	2040
'With existing measures' scenario	10	12	9	5	7	7	8	9	10
'With additional measures' scenario	10	12	9	5	7	7	8	9	10
TOTAL	1990	2000	2010	2015	2020	2025	2030	2035	2040
'With existing measures' scenario	31876	25709	28034	24125	23355	22939	22649	21297	19871
'With additional measures' scenario	31876	25709	28034	24125	23094	22072	21175	19441	17598

The Energy sector has the largest contribution to CO_2 emissions, with a maximum value from 15,373 kt CO_2 (for the 'with existing measures' scenario) to 13,437 kt CO_2 (for the 'with additional measures' scenario) in 2040.

The most important source of CH_4 emissions is the Waste sector. Projections for 2040 show 2,699 kt CO_2eq for the 'with existing measures' scenario, or 2,415 kt CO_2eq for the 'with additional measures' scenario.

The most important source of N_2O emissions is the Agriculture sector, which projections in 2040 have the maximum of 1,629 kt CO_2eq for the 'with existing measures' scenario, or 1,614 kt CO_2eq for the 'with additional measures' scenario.

The sources of HFCs and PFCs and SF_6 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 2040 have a maximum value of 1,603 kt CO_2eq for the 'with existing measures' scenario and 122 kt CO_2eq 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 1990 to 2040.

Table 2-2: Historical emissions and projections of greenhouse gas emissions by sectors, kt CO_2eq

'With existing measures' scenario	1990	2000	2010	2015	2020	2025	2030	2035	2040
Energy	17848	13752	13795	10652	9507	9686	9745	9280	8732
Transport	3883	4443	5955	5973	6242	6294	6358	5772	5112
Industrial processes and product use	4670	3132	3317	2823	2752	2517	2521	2527	2534
Waste	1051	1339	1911	1955	2151	1775	1420	1157	972
Agriculture	4423	3042	3056	2722	2703	2667	2605	2560	2520
TOTAL	**31876**	**25709**	**28034**	**24125**	**23355**	**22939**	**22649**	**21297**	**19871**

'With additional measures' scenario	1990	2000	2010	2015	2020	2025	2030	2035	2040
Energy	17848	13752	13795	10652	9507	9340	9069	8279	7445
Transport	3883	4443	5955	5973	6242	6055	5876	5356	4686
Industrial processes and product use	4670	3132	3317	2823	2564	2354	2367	2289	2212
Waste	1051	1339	1911	1955	2151	1775	1420	1157	972
Agriculture	4423	3042	3056	2722	2630	2549	2444	2360	2284
TOTAL	**31876**	**25709**	**28034**	**24125**	**23094**	**22072**	**21175**	**19441**	**17598**

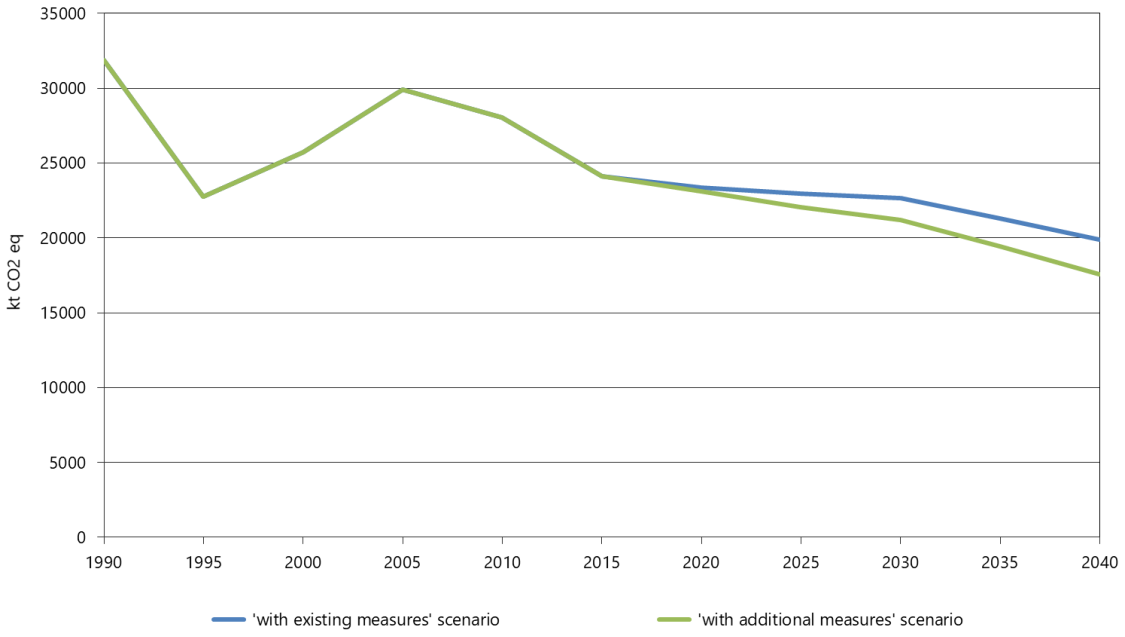

Figure 2-5: Total projections of greenhouse gas emissions (without removals) for the period until 2040

Projections show that in the 'with existing measures' scenario, in 2040 the emission is reduced by 37.7% compared to 1990, while in the 'with additional measures' scenario emission is reduced by 44.8% compared to 1990.

The 'with additional measures' scenario compared to the 'with existing measures' scenario in 2040 reduces greenhouse gas emissions by 11.4%.

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

Historical emissions and 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: Historical emissions and projections of greenhouse gas emissions in ETS and ESR sectors, kt CO_2eq

	2010	2015	2020	2025	2030	2035	2040
'With existing measures' scenario	28,034	24,125	23,355	22,939	22,649	21,297	19,871
ETS	9,390	8,386	7,294	7,238	7,225	6,917	6,573
ESR	18,613	15,708	16,031	15,673	15,397	14,354	13,273
'With additional measures' scenario	28,034	24,125	23,094	22,072	21,175	19,441	17,598
ETS	9,390	8,386	7,107	6,921	6,772	6,235	5,680
ESR	18,613	15,708	15,958	15,122	14,374	13,178	11,891

Emissions within the ETS in 2015 encompassed 34.8% of total emissions, amounting to 8,386 kt CO_2eq. Projections indicate that in 2030 the ETS will cover approximately 32% of total emissions. According to the 'with additional measures' scenario, 33.1% of emissions will be included in 2040 and under the 'with additional measures' scenario 32.3% of total emissions.

In the 'with existing measures' scenario, emission projections within the ETS show a decrease in the period up to 2040, by 21.6% in 2040 compared to 2015.

In the 'with additional measures' scenario, the projections show a stronger declining trend. Compared to 2015, projections show a 32.3% reduction in emissions in 2040.

Emissions within the ESR sector in 2015 amounted to 15,708 kt CO_2eq, which represents 65.1% of total emissions.

In the 'with existing measures' scenario, emissions are expected to decrease in the period from 2020 to 2040 (by 15.5% in 2040 compared to 2015). Compared to 2005, emissions show a decrease of 12.5% in 2020, 16.0% in 2030 and 27.6% in 2040.

In the 'with additional measures' scenario, an additional reduction in emissions is expected, which would reduce the emissions of the non-ETS sector by 24.3% in 2040 compared to 2015, i.e. if compared to 2005, the reduction of emissions would amount to 12.9% in 2020, 21.6% in 2030 and 35.1% in 2040.

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

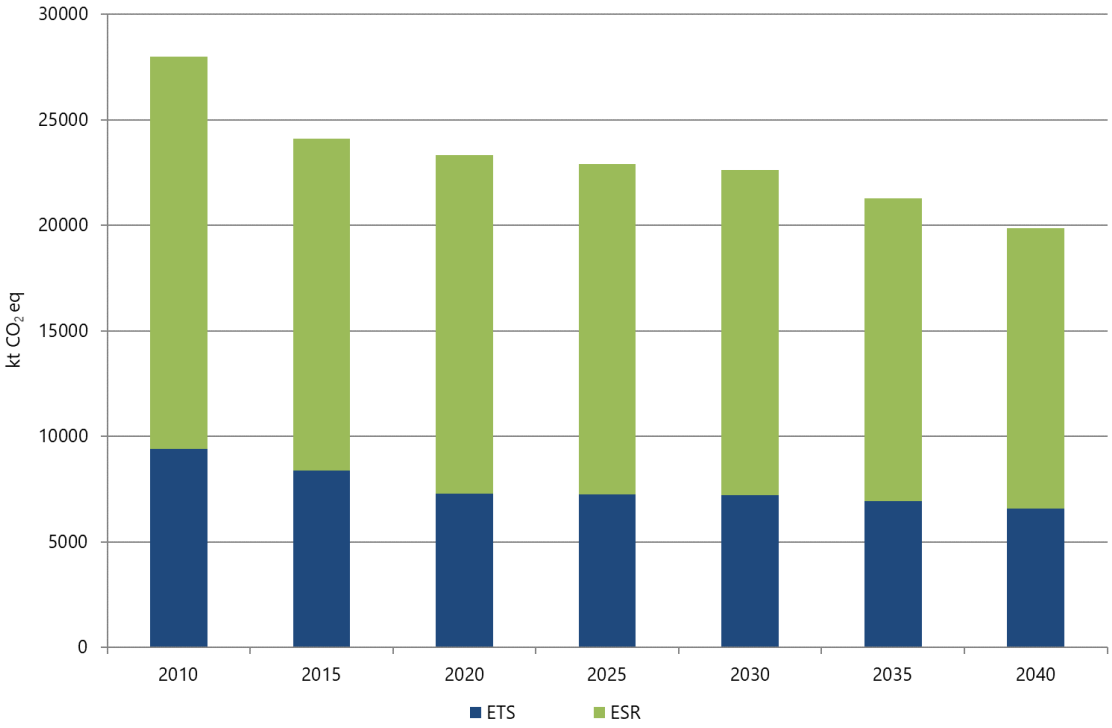

Figure 2-6: Historical emissions and projections of emissions within ETS and ESR, 'with existing measures' scenario

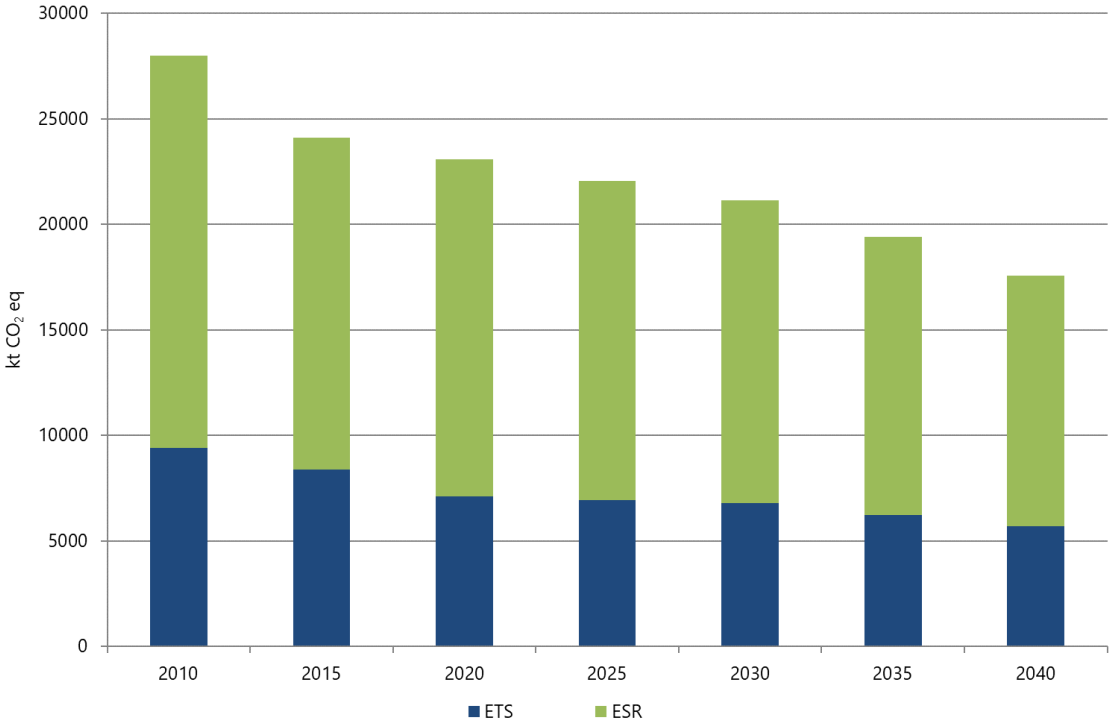

Figure 2-7: Historical emissions and projections of emissions within ETS and ESR, 'with additional measures' scenario

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 2040, with five-year steps.

The observation time horizon until 2040 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 proposal of the Low-Carbon Development Strategy of the Republic of Croatia until 2030 with a view to 2050.

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 2018 amounted to 10,015 kt CO_2eq and is the main source of anthropogenic greenhouse gas emissions with a contribution of 42.1% in the total greenhouse gas emissions in 2018.

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 2018 the emissions amounted to 6,428 kt CO2e, which is 27.0% 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 10.9% 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 2018 participates in the total greenhouse gas emissions with 11.4%. The most important sectoral emissions are emissions of CH_4 with approximately 37% of total emissions and N_2O with approximately 65% of total emissions. Emissions are caused by different agricultural activities. The CH_4 emission source is animal farming (enteric fermentation), which accounts for about 82% of the sectoral CH_4 emissions.

In the period until 2040, a minor increase of the number of the cattle and swine population and a minor decline in poultry and sheep population is expected.

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 report[1] "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 2016.
- 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 8.6% in 2018, of which 99.6% comes from the key emission sources: solid waste disposal and wastewater treatment and discharge. Of these, 86.9% 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 Management Act (OG 94/13, 73/17, 14/19, 98/19) and Waste Management Plan of the Republic of Croatia for the period 2017 – 2022 (OG 3/17).

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

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 2035 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 2018, 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 CH_4 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 CH_4 emissions due to the reduction of the amount of disposed biodegradable waste at landfills, which is prescribed by sectoral legislation.

The potentials of CO_2 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 2009-2018, 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 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 2040, 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 CO_2, CH_4 and N_2O 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	
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 proposal of the Low-Carbon Development Strategy of the Republic of Croatia until 2030 with a view to 2050. Below is a more detailed description of the methodology used.	
1. Final energy demand	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. The analyses were performed by sub-sectors: – 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.
	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 25/20).
1.1. 'With existing measures' scenario	
	In the period until 2050, the development was simulated in accordance with the existing policy and measures and market development: – 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.
1.2. 'With additional measures' scenario	
	Continued support to energy efficiency after 2020, with the following key assumptions:

Energy and Transport	
	– 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	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. 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.
2.1. 'With existing measures' scenario	
	Assumptions: – 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	
	Assumptions include continuous development of renewable energy policy even after 2020: – 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	
	– 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 2040, 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 CO_2, CH_4, N_2O, HFC, PFC and SF_6 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
The projections were carried out based on the expected development of certain industries, which includes the production goals by 2040. Emission projections start from the situation and projections of macroeconomic parameters in 2018 - 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, ammonia and nitric acid production). 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 25/20). Assumptions for 'with existing measures' scenario: – no installation of additional capacity; – production will reach the maximum value by 2040. The Industrial Strategy of the Republic of Croatia 2014 – 2020 defines objectives of industrial development and key indicators of the Croatian industry in the period 2014 – 2020. 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, ammonia and nitric acid 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. 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.

Industrial processes and product use
Assumptions for 'with additional measures' scenario: – the application of cost-effective measures to reduce process greenhouse gas emissions in the production of cement and the reduction of emissions of controlled substances and fluorinated greenhouse gases. – 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. 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 2040, 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 CO_2, CH_4 and N_2O.

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 2017 was retained. – 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 20-23% by 2040

[2] Source: The future of food and agriculture – Alternative pathways to 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 2040, 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 CO_2, CH_4 and N_2O.

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
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 2018 - the projected dynamics of the annual growth rate of gross domestic product and the decline of the population. Assumptions for the 'with existing measures' scenario: – 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). 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 2035. Projections of emissions of greenhouse gases are based on the implementation of measures prescribed by sectoral legislation, harmonized with EU legislation.

Waste
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 2020 have been recognized as key categories, either by trend or by level. These are:

- 4(III). Direct N_2O 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 2018 for each carbon pools (aboveground/belowground biomass and soil). Alternative 1 was used, where activity data for the period 2020 to 2040, 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 2018. 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 2012-2018 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 2020 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 2020). 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
The projections were carried out based on the expected future state of the parameters that determine the potential for emissions mitigation. 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. Assumptions: – 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

Parameter		2018	2020	2025	2030	2035	2040
GDP – annual growth rate	billion EUR (EC 16)	52.0	51.9	58.1	64.2	70.4	76.6
Population	million people	4.204	3.984	3.834	3.755	3.648	3.532
Coal prices	USD/t	4.9	6.4	7.9	8.6	9.1	9.6
Heavy Fuel Oil prices	USD/barrel	41.0	62	83	94	103	111
Gas prices	USD/Mbtu	63.0	70	77	80	81	82

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

Parameter		2018	2020	2025	2030	2035	2040
Total energy consumption							
Coal and coke	ktoe	366.1	400.7	307.6	214.5	128.4	42.2
Liquid petroleum fuels	ktoe	3,314.3	3,188.5	3,128.6	3,068.8	2,774.6	2,480.4
Gas	ktoe	2,303.3	2,338.1	2,306.4	2,274.6	2,251.9	2,229.2
Renewable	ktoe	3,264.7	2,130.1	2,439.6	2,749.1	3,009.6	3,270.2
Other	ktoe	497.9	527.4	436.7	346.0	258.2	170.5

Total	ktoe	9,746.3	8,584.8	8,618.9	8,653.0	8,422.7	8,192.4
Total electricity generation							
Coal	TWh	1.45	1.55	1.15	0.75	0.38	0.01
Liquid petroleum fuels	TWh	0.08	0.04	0.04	0.04	0.04	0.04
Gas	TWh	2.03	2.40	2.51	2.62	2.65	2.69
Renewable	TWh	10.08	9.20	11.21	13.23	15.45	17.66
Nuclear	TWh	NO	NO	NO	NO	NO	NO
Other	TWh	NO	NO	NO	NO	NO	NO
Total	TWh	13.63	13.19	14.91	16.64	18.52	20.40
Net electricity imports	TWh	5.39	6.01	4.96	3.90	2.88	1.86

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

Parameter		2018	2020	2025	2030	2035	2040
Final energy consumption							
Industry	PJ	1,179.8	1,136.5	1,160.5	1,184.5	1,164.9	1,145.2
Transport	PJ	2,329.7	2,244.5	2,228.7	2,212.8	2,133.7	2,054.7
Households	PJ	2,306.5	2,311.6	2,313.3	2,314.9	2,155.3	1,995.6
Agriculture, forestry and fisheries	PJ	226.9	211.5	205.1	198.7	193.4	188.1
Services	PJ	805.7	825.3	880.9	936.5	940.8	945.0
Other	PJ	NA	NA	NA	NA	NA	NA
Total	ktoe	6,848.6	6,729.4	6,791.8	6,854.3	6,594.7	6,335.1

Table 4-9: Parameters on projections – weather parameters

Parameter	2018	2020	2025	2030	2035	2040
Degree-day heating	2,288	2,288	2,261	2,235	2,208	2,181

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

Parameter	2018	2020	2025	2030	2035	2040
Ammonia production	kt	397	397	397	450	450
Nitric acid production	kt	289	293	293	300	300
Clinker production - 'with existing measures' scenario	kt	2,326	2,497	2,525	2,585	2,585
Clinker production - 'with additional measures' scenario	kt	2,326	2,139	2,223	2,308	2,174

Table 4-11: Parameters on projections – Transport

Parameter		2018	2020	2025	2030	2035	2040
Number of passenger kilometres, all modes	10^9 pkm	40.6	41.0	42.2	43.9	44.6	44.9
Transport of goods	10^9 tkm	11.6	11.6	11.6	11.6	11.6	11.6
Energy consumption in road transport	ktoe	1,995.5	2,031.4	2,051.7	2,077.8	2,004.3	1,930.8

Table 4-12: Parameters on projections – Agriculture

Parameter		2018	2020	2025	2030	2035	2040
Dairy cattle	1000 heads	136	177	171	160	156	148
Non-dairy cattle	1000 heads	278	280	284	288	289	296
Sheep	1000 heads	636	653	639	621	607	595
Goats	1000 heads	80	69	68	66	65	63
Horses	1000 heads	24	23	23	23	23	23
Mules/asses	1000 heads	4	3	3	3	3	3
Swine	1000 heads	1049	1200	1204	1226	1220	1216
Poultry	1000 heads	11413	9872	9715	9537	9357	9205
Wheat	t	738,363	682,322	682,322	682,322	682,322	682,322
Maize	t	2,147,275	1,559,638	1,559,638	1,559,638	1,559,638	1,559,638
Potatoes	t	182,261	156,089	156,089	156,089	156,089	156,089
Sugar beets	t	776,491	1,295,459	1,295,459	1,295,459	1,295,459	1,295,459
Tobacco	t	7,561	9,413	9,413	9,413	9,413	9,413
Sunflowers	t	110,790	115,880	115,880	115,880	115,880	115,880
Rape seed	t	155,842	135,810	135,810	135,810	135,810	135,810
Tomatoes	t	22,642	32,456	32,456	32,456	32,456	32,456
Barley	t	227,520	260,426	260,426	260,426	260,426	260,426
Oats	t	44,827	68,333	68,333	68,333	68,333	68,333
Cabbages and other brassicas	t	38,766	34,872	34,872	34,872	34,872	34,872
Garlic	t	1,733	1,172	1,172	1,172	1,172	1,172
Onions	t	21,098	16,220	16,220	16,220	16,220	16,220
Rye	t	4,646	500	500	500	500	500
Sorghum	t	313	0	0	0	0	0
Watermelons	t	27,737	19,707		19,707		19,707
Soybeans	t	245,188	103,610	103,610	103,610	103,610	103,610
Beans, dry	t	1,737	1,340	1,340	1,340	1,340	1,340
Fodder peas, dried	t	2,223	2,347	2,347	2,347	2,347	2,347
Lentils	t	47	50	50	50	50	50
Peas, dry	t	314	142	142	142	142	142
Vetches	t	241	0	0	0	0	0
Clover	t	67,946	24,861	24,861	24,861	24,861	24,861
Alfalfa	t	186,490	187,917	187,917	187,917	187,917	187,917
Applying nitrogen	t	99,420	100,587	98,266	95,964	93,626	91,305

Table 4-13: Parameters on projections – Waste

Parameter		2018	2020	2025	2030	2035	2040
Amount of generated solid waste	t	2,428,937	2,273,117	2,212,504	2,204,261	2,189,563	2,178,611
Amount of landfilled solid waste	t	1,601,602	1,136,559	553,126	440,852	328,434	217,861
The organic fraction of solid waste	%	65	24	18	12	9	6
Share of methane recovered/flared	%	9.4	6.7	4.2	4.5	4.6	4.1

Table 4-14: Parameters on projections – LULUCF

Parameter – Activity data	AD units	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040
4.A.1. Forest land remaining forest land	(kha)	2,312.18	2,313.05	2,313.60	2,313.15	2,311.95	2,312.22	2,312.83	2,274.67	2,236.52	2,198.36	2,160.21
4.A.2. Land converted to forest land	(kha)	3.54	3.78	4.16	7.76	24.94	56.72	67.00	76.00	85.00	94.00	103.00
4.B.1. Cropland remaining cropland	(kha)	1,618.43	1,595.02	1,585.06	1,567.20	1,529.65	1,491.49	1,468.32	1,439.42	1,410.52	1,381.62	1,352.72
4.B.2. Land converted to cropland	(kha)	6.95	11.38	15.81	20.31	42.02	47.52	48.96	51.45	53.94	56.43	58.91
4.C.1. Grassland remaining grassland	(kha)	1,198.56	1,191.09	1,196.86	1,166.82	1,117.93	1,093.82	1,079.86	1,062.02	1,044.17	1,026.33	1,008.48
4.C.2. Land converted to grassland	(kha)	2.49	25.18	34.63	34.14	52.80	62.12	57.32	55.48	55.48	55.48	55.48
4.D.1. Wetlands remaining wetlands	(kha)	66.87	68.62	70.37	72.11	73.86	74.08	74.37	75.00	75.45	75.90	76.35
4.D.2. Land converted to wetlands	(kha)	6.98	5.46	3.93	2.29	0.75	0.84	0.85	0.85	0.85	0.85	0.85
4.E.1. Settlements remaining settlements	(kha)	174.32	180.90	187.49	194.07	200.65	203.14	205.84	209.42	212.53	215.64	218.75
4.E.2. Land converted to settlements	(kha)	26.33	22.24	18.14	42.48	66.70	79.28	87.54	96.73	105.92	115.11	124.31
4.F.1. Other land remaining other land	(kha)	242.73	242.68	229.35	239.06	238.16	238.16	256.52	318.37	379.03	439.69	500.34
4.III.B Cropland	(kha)	6.95	11.38	15.81	20.31	42.02	47.52	48.96	51.45	53.94	56.43	58.91
4.III.D Wetland	(kha)	6.98	5.46	3.93	2.29	0.75	0.84	0.85	0.85	0.85	0.85	0.85
4.III.E Settlements	(kha)	26.33	22.24	18.14	42.48	66.70	79.28	87.54	96.73	105.92	115.11	124.31
4.V.A Forest land remaining forest land	(ha)	482.15	3,010.79	37,363.79	912.50	687.67	4,067.94	5,763.60	5,763.60	5,763.60	5,763.60	5,763.60
4.V.A Land converted to forest land	(ha)	NO	9.92	78.14	17.50	18.00	153.50	201.36	201.36	201.36	201.36	201.36
4.V.B Cropland remaining cropland	(ha)	NO	NO	NO	NO	NO	1,134.38	298.91	298.91	298.91	298.91	298.91
4.V.C Grassland remaining grassland	(ha)	461.10	2,193.25	41,569.27	2,425.00	502.23	6,642.24	7,661.57	7,869.01	7,869.01	7,869.01	7,869.01

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

Parameter – Emissions factors - Biomass	EF units	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040
4.A.1. Forest land remaining forest land	(tC/ha)	0.79	1.12	1.01	0.98	0.90	0.64	0.50	0.40	0.40	0.40	0.40
4.A.2. Land converted to forest land	(tC/ha)	2.28	2.01	2.03	-0.01	0.41	0.63	0.79	0.79	0.79	0.79	0.79
4.B.1. Cropland remaining cropland	(tC/ha)	-0.02	-0.01	-0.04	-0.02	0.02	-0.02	-0.06	-0.06	-0.06	-0.06	-0.06
4.B.2. Land converted to cropland	(tC/ha)	0.19	0.34	0.42	0.47	0.50	0.39	0.47	0.48	0.48	0.48	0.49
4.C.1. Grassland remaining grassland	(tC/ha)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.C.2. Land converted to grassland	(tC/ha)	NO	-1.45	-0.46	-0.21	-1.00	-0.56	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	0.00	0.00	0.00	0.00
4.D.2. Land converted to wetlands	(tC/ha)	-0.54	-0.09	-0.12	-0.10	-0.67	-0.93	-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	0.00	0.00	0.00	0.00
4.E.2. Land converted to settlements	(tC/ha)	-0.39	-0.16	-0.18	-1.16	-0.80	-0.11	-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	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	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	0.01	0.01	0.01	0.01
4.V.A Land converted to forest land	CO2 (t/AD unit)	NO	31.07	31.07	31.07	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)	NO	0.09	0.09	0.09	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)	NO	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4.V.B Cropland remaining cropland	CO2 (t/AD unit)	NO	NO	NO	NO	NO	30.43	25.51	25.51	25.51	25.51	25.51
4.V.B Cropland remaining cropland	CH4 (t/AD unit)	NO	NO	NO	NO	NO	0.09	0.07	0.07	0.07	0.07	0.07
4.V.B Cropland remaining cropland	N2O (t/ADunit)	NO	NO	NO	NO	NO	0.01	0.00	0.00	0.00	0.00	0.00
4.V.C Grassland remaining grassland	CO2 (t/AD unit)	NO	NO	NO	NO	NO	NO	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	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	0.00	0.00	0.00	0.00

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

Parameter – Emissions factors - Soil	EF units	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040
4.A.2. Land converted to forest land	(tC/ha)	-0.29	-0.29	-0.29	-0.28	-0.27	-0.25	-0.24	-0.23	-0.22	-0.21	-0.19
4.B.1. Cropland remaining cropland	(tC/ha)	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02
4.B.2. Land converted to cropland	(tC/ha)	-1.09	-1.01	-0.97	-0.94	-0.93	-0.93	-0.92	-0.92	-0.91	-0.90	-0.90
4.C.2. Land converted to grassland	(tC/ha)	1.11	1.05	1.04	1.04	1.03	1.04	1.04	1.05	1.06	1.06	1.07
4.D.2. Land converted to wetlands	(tC/ha)	-2.72	-2.72	-2.72	-2.72	-2.72	-2.72	-2.72	-2.72	-2.72	-2.72	-2.72
4.E.2. Land converted to settlements	(tC/ha)	-2.21	-2.21	-2.21	-2.22	-2.22	-2.22	-2.22	-2.22	-2.22	-2.22	-2.22
4.III.B Cropland	(kg N2O–N/ha)	1.21	1.12	1.08	1.05	1.04	1.03	1.03	1.02	1.01	1.01	1.00
4.III.D Wetland	(kg N2O–N/ha)	3.40	3.40	3.40	3.40	3.40	3.40	3.40	3.40	3.40	3.40	3.40
4.III.E Settlements	(kg N2O–N/ha)	2.61	2.61	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	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 2020, the European Commission drafted the document Recommended parameters for reporting on GHG projections[3]. 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 analyzed scenarios, GDP growth is assumed to average 2.1% by 2040, which is a nominal increase compared to 2018 by 56.5%.

Recommended GDP growth rates in the document Recommended parameters for reporting on GHG projections assume GDP growth by 2040, on average 1.1%, which is a nominal increase of 28.3% compared to 2018.

Using the recommended GDP growth rates, greenhouse gas emissions in 2030 are lower by about 1.6% compared to the scenarios presented. Greenhouse gas emissions in 2040 are lower by 1.6% compared to the 'with existing measures' scenario and by 1.7%, 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 and 3,531,586 in 2040. Recommended parameters of demographic development projections from the document Recommended parameters for reporting on GHG projections give 2.1% more inhabitants in 2030, and 3.0% more inhabitants in 2040, 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 t CO_2eq/dwelling, and 5.6 t CO_2eq/dwelling in 2040. In the 'with additional measures' scenario in 2030, the emission is 5.6 t CO_2eq/dwelling, and 5 t CO_2eq/dwelling in 2040. 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 0.7% compared to the scenario 'with existing measures' or 1.1% compared to the scenario 'with additional measures', and in 2040 it is higher by 1% and 1.3% compared to the presented scenarios, respectively.

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