REPUBLIC OF CROATIA
MINISTRY OF ENVIRONMENT AND ENERGY

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 2019

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EKONERG – Energy Research and Environmental Protection Institute
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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 Kyoto Protocol. 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 primarily in Article 75 Paragraph 3 of the Air Protection Act (OG 130/11, 47/14, 118/18).

Regulation (EU) No 525/2013 of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision 280/2004/EC (hereinafter: Regulation) and Commission Implementing Regulation (EU) No 749/2014 of 30 June 2014 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) No 525/2013 of the European Parliament and of the Council (hereinafter: Implementing Regulation) are applicable regulations of the European Union which prescribe the obligations and the way of reporting for Member States.

Article 14 of the aforementioned Regulation prescribes the content of the report. The report includes projections of greenhouse gas emissions by sources and their removal by sinks, composed of the following components:

- projection of greenhouse gas emission, organised by sector and by gas,
- projections of emissions of ETS and ESD sectors,
- 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 method and conditions for implementation of the regulation governing the monitoring of greenhouse gas emissions are regulated by the Implementing Regulation, which in Article 23 further defines the scope of Report. The required parameters for projections, which must be included in the Report, and recommended parameters for projections are defined in Annex XII of the aforementioned Implementing Regulation.

Accordingly, the Report includes:

- assumptions for general economic parameters,
- assumptions for energy sector,
- assumptions for industrial processes and product use sector,
- assumptions for transport sector,
- assumptions in agriculture sector,
- assumptions in waste sector,
- assumptions in LULUCF sector (LULUCF – eng. Land use, land use change and forestry).

The Report includes projections of greenhouse gas emissions by sources and their removal by sinks for the years 2020, 2025, 2030 and 2035.

CRF Category	Data type	Data source
General parameters	GDP – yearly growth rate Population Coal price Crude oil price Natural gas price	Draft of Integrated National Energy and Climate Plan of the Republic of Croatia for the period from 2021 to 2030
Energy	Fuel consumption Electricity generation Electricity imports Final energy demand	National energy balance Draft of Integrated National Energy and Climate Plan of the Republic of Croatia for the period from 2021 to 2030
Transport	Number of passenger kilometres Number of tonne-kilometres Energy demand in transport sector	ODYSSEE database Draft of Integrated National Energy and Climate Plan of the Republic of Croatia for the period from 2021 to 2030
Industrial processes and product use	Production index	Sectorial studies (cement, glass and nitric acid production) National Bureau of Statistics Draft of Integrated National Energy and Climate Plan of the Republic of Croatia for the period from 2021 to 2030
	Use of solvents	Inventory Report of air pollutants on the Croatian territory under the Convention on Long-range Transboundary Air Pollution (CLRTAP)
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 FAOSTAT database
LULUCF	Land area of each sub-category	NIR 2018
	The assumed emission factors by sinks	CFR 2018
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)	Sustainable Waste Management Act Waste Management Plan of the Republic of Croatia Sustainable Waste Management Act (OG 94/13, 73/17, 14/19) Waste Management Plan of the Republic of Croatia for the period 2017 – 2022 (OG 3/17)

CRF Category	Data type	Data source
	The organic fraction of solid waste Share of methane recovered/flared The amount of composted organic waste	Directive (EU) 2018/850 of the European Parliament and of the Council of 30 May 2018 amending Directive 1999/31/EC on the Landfill of Waste Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on Waste

2. Projection of greenhouse gas emissions

This chapter presents the historical greenhouse gas emissions in the period from 1990 to 2016 and projections of greenhouse gas emissions for the period from 2020 to 2035. The emissions are presented as total emissions of greenhouse gases by sectors and by gases.

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 (abb. GWP). In this case, the emission of greenhouse gases is presented as equivalent emission of carbon dioxide (CO_2eq). In case of removing emissions of greenhouse gases, it refers to outflows (sinks) of greenhouse gas emissions and the amount is shown as 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.

Particularly the emissions of certain greenhouse gases are presented:

- 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' assumes a consistent application of policies and measures, which application is already in progress and application of adopted policies and measures, which application is likely, but still not begun. Scenario 'with additional measures' is based on application of planned policies and measures.

Emission projections start from the inventory of greenhouse gas emissions (NIR 2018) which includes an inventory of emissions and sinks of greenhouse gases for the period 1990 – 2016 (submission of 5th November 2018). Reference year for projection is 2015.

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 2035.

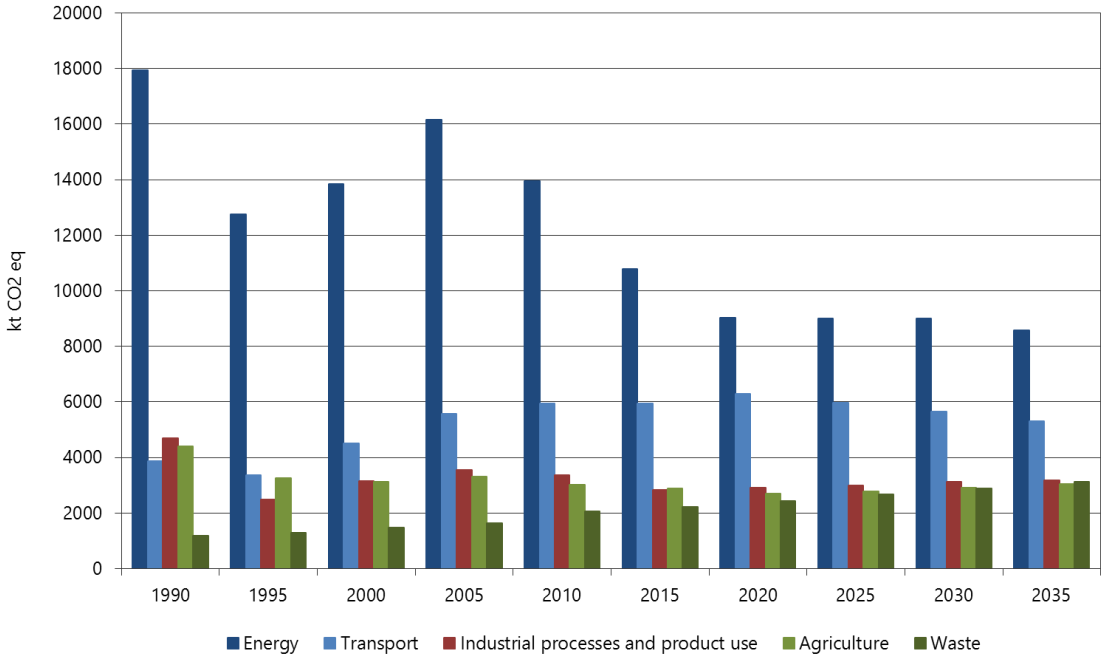

Figure 2-1: Historical and projected greenhouse emissions by sectors, 'with existing measures' scenario

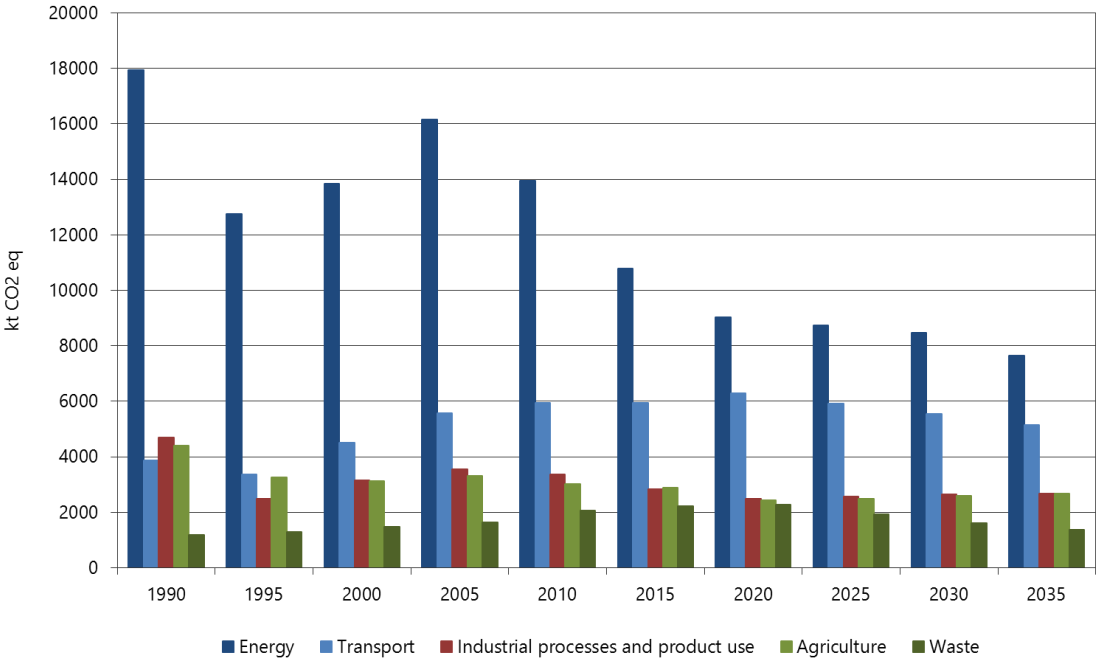

Figure 2-2: Historical and projected greenhouse emissions by sectors, 'with additional measures' scenario

The energy sector covers all activities that involve fuel combustion from stationary sources and fugitive emission from fuels. The emission from energy sector in 2016 amounted to 10901 kt CO_2 and it is the main source of anthropogenic emission of greenhouse gases, it accounts approximately 44% of the total greenhouse gases emission in 2016. In the 'with existing measures' scenario, projections show decrease in emissions until 2020 as the growth of demand is mainly satisfied by the development of the renewable energy sources in spite of fossil fuel consumption. In the period from 2020 to 2035, this scenario shows a stagnation and slight decrease due to expected development of the renewable energy sources even without the additional measures, mainly due to market competitiveness and impact of the EU ETS. Most measures to reduce emissions in the energy sector are defined by 2020, so it has not yet been determined which will be implemented after 2020. In scenario 'with additional measures', all measures planned in the energy sector were taken into account and projections show a steeper trend of emission reduction.

The transport sector includes emissions from fuel combustion in road transportation, civil aviation, railways and navigation. The emission from transport sector in 2016 amounted to 6137 kt CO_2eq, which makes about 24.9% of total Croatia's greenhouse gases emission. In the 'with existing measures' scenario in the period from 2020 to 2035, projections indicate stagnation and slight decrease of emissions. Factors that encourage the growth of emissions are expected increase in economic activities and living standard, while the emission reductions are primarily affected by the measures to increase energy efficiency and use of electricity and renewable sources in transport. Most of the existing measures have defined duration by 2020 so in this scenario not many measures are simulated after 2020. In scenario 'with additional measures', projections show a continuous trend of reducing emissions by 2035, primarily due to expected measures to increase rail transport and development of electric vehicles, which will be the key condition for the strong reduction of emissions in 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 Industrial processes and product use sector in 2016 amounted to 2524 Gg CO_2eq, which is 10.2% of the total Croatia's greenhouse gases emission in 2016. The projections of emissions indicate

an increase in 'with existing measures' scenario due to expected increase in production to the maximum utilization of existing productive capacity in the period until 2035. 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 10% of total greenhouse gas emissions in 2016 (emission is 2931 Gg CO_2eq). The projections indicate an increase in emissions after 2015, implying a growth of emissions from the agricultural sector based on the assumed increase in livestock population and crop production (assumption based on expert judgement of University of Zagreb, Faculty of Agriculture experts) and normalization of agricultural production (trend analysis).

The Waste sector participates in the total Croatia's greenhouse gases emission with 9.2% in 2016 (emission is 2276 Gg CO_2eq). The projections of emissions indicate an increase in 'with existing measures' scenarios due to expected increase of waste quantities in the period until 2035 as a result of higher living standards, despite the effects of measures undertaken to avoid/reduce and recycle waste. The implementation of 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 potential of CO_2 emission reduction, which can be achieved by implementing the measures included in the scenarios 'with existing measures' and 'with additional measures' is balanced in the Energy sector.

In the year 2016, removals by sink in the LULUCF sector were -5422 Gg CO_2eq. Projections of removals up to 2040 amount -1767 Gg CO_2eq sinks 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 and their aggregated trend is shown in Figure 2-3.

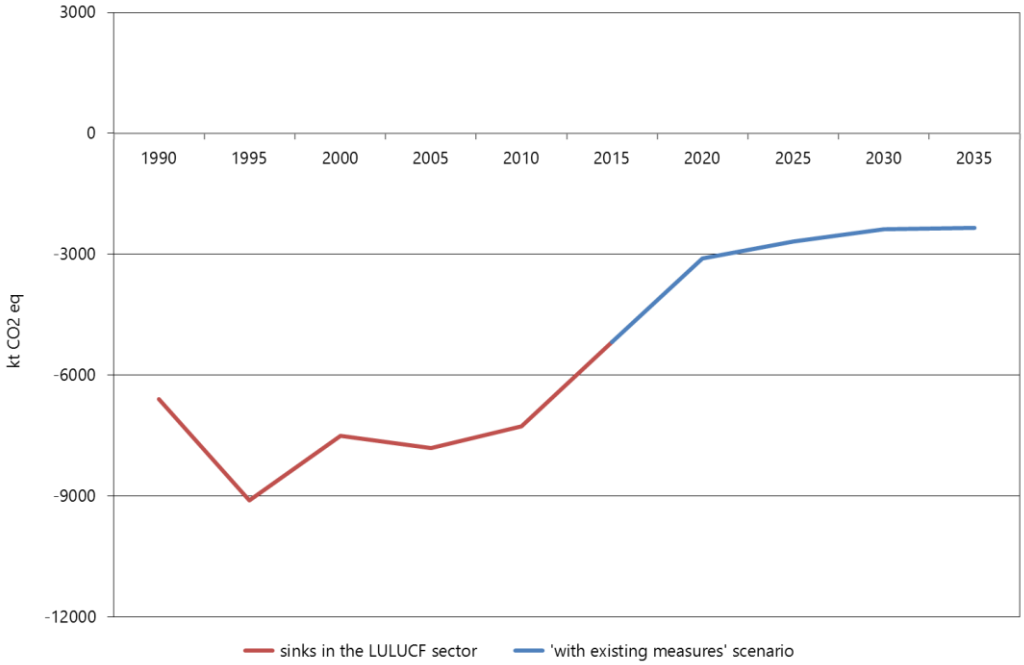

Figure 2-3: Historical and projected greenhouse removals in the LULUCF, 'with existing measures' scenario

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 2035 are shown in Figure 2-4.

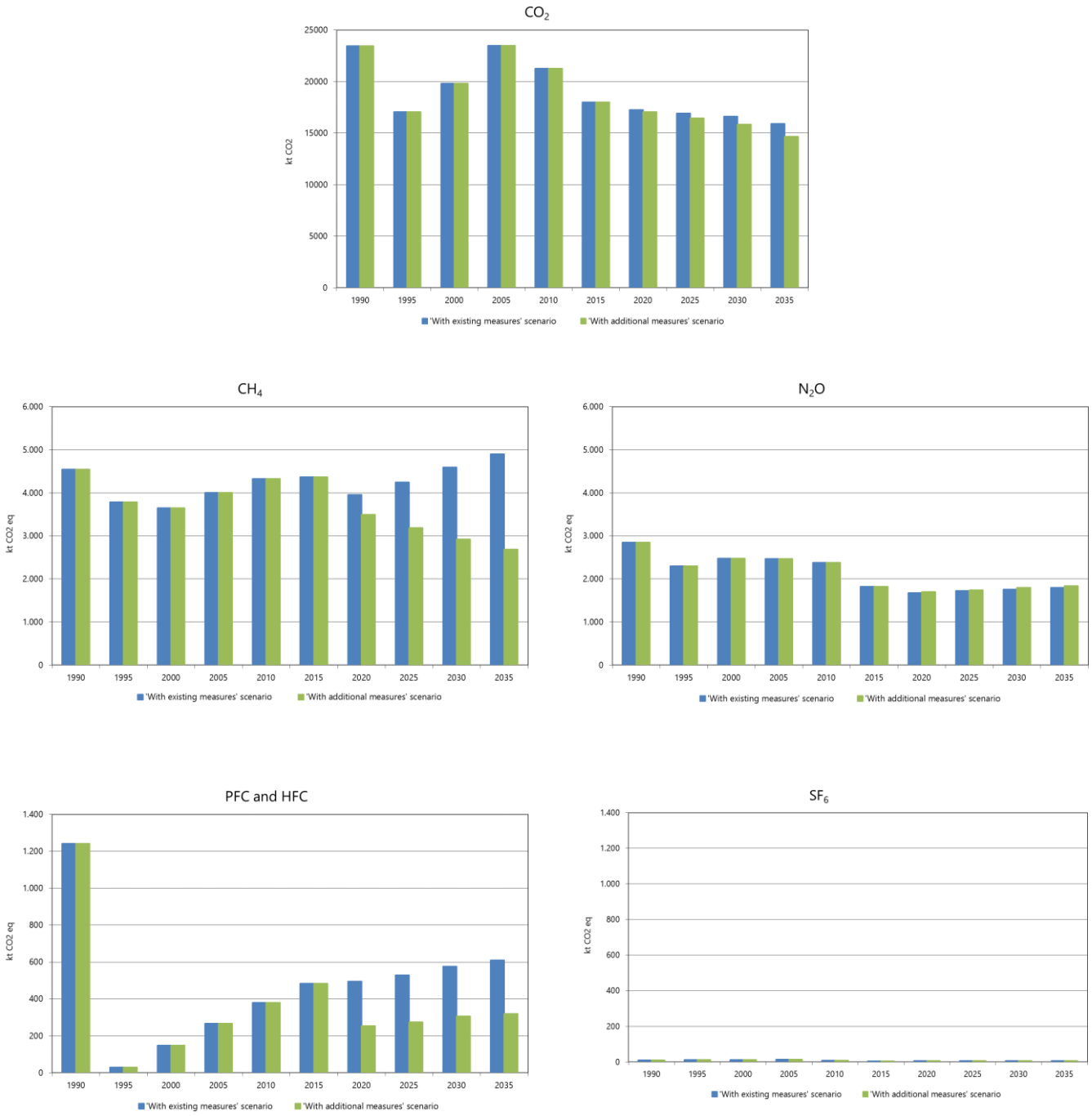

Figure 2-4: Projections of greenhouse gas emissions by gases

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 2035 are shown in Table 2-1.

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

CO2	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
'With existing measures' scenario	23442	17040	19816	23490	21245	17997	17232	16915	16618	15914
'With additional measures' scenario	23442	17040	19816	23490	21245	17997	17047	16428	15828	14653
CH4	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
'With existing measures' scenario	4545	3784	3644	4006	4326	4365	3951	4242	4593	4897
'With additional measures' scenario	4545	3784	3644	4006	4326	4365	3493	3189	2922	2685
N2O	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
'With existing measures' scenario	2847	2301	2479	2463	2380	1818	1677	1722	1756	1796
'With additional measures' scenario	2847	2301	2479	2463	2380	1818	1701	1737	1795	1836
PFC and HFC	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
'With existing measures' scenario	1240	29	148	266	379	482	495	529	575	610
'With additional measures' scenario	1240	29	148	266	379	482	252	275	307	320
SF6	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
'With existing measures' scenario	10	11	12	13	9	5	6	6	7	7
'With additional measures' scenario	10	11	12	13	9	5	6	6	7	7
TOTAL	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**
'With existing measures' scenario	32085	23165	26098	30238	28339	24667	23360	23415	23549	23223
'With additional measures' scenario	32085	23165	26098	30238	28339	24667	22500	21635	20858	19500

The energy sector has the most significant anthropogenic sources of CO_2 emissions, with maximum value from 15914 kt CO_2 (for the 'with existing measures' scenario) to 14652 kt CO_2 (for the 'with additional measures' scenario) in 2035.

The most important source of CH_4 emissions is waste sector, which projections in 2035 have the maximum of 4897 kt CO_2eq for the 'with existing measures' scenario, or 2685 kt CO_2eq for the 'with additional measures' scenario.

The most important source of N_2O emissions is agriculture sector, which projections in 2035 have the maximum of 1796 kt CO_2eq for the 'with existing measures' scenario, or 1836 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 2035 have the maximum value of 617 kt CO_2eq for the 'with existing measures' scenario and 327 kt CO_2eq for the 'with additional measures' scenario.

2.3. Total projections

Total projections of greenhouse gas emissions (without LULUCF) for 'with existing measures' and 'with additional measures' scenarios, for the period until 2035 are shown in Figure 2-5 and Table 2-2.

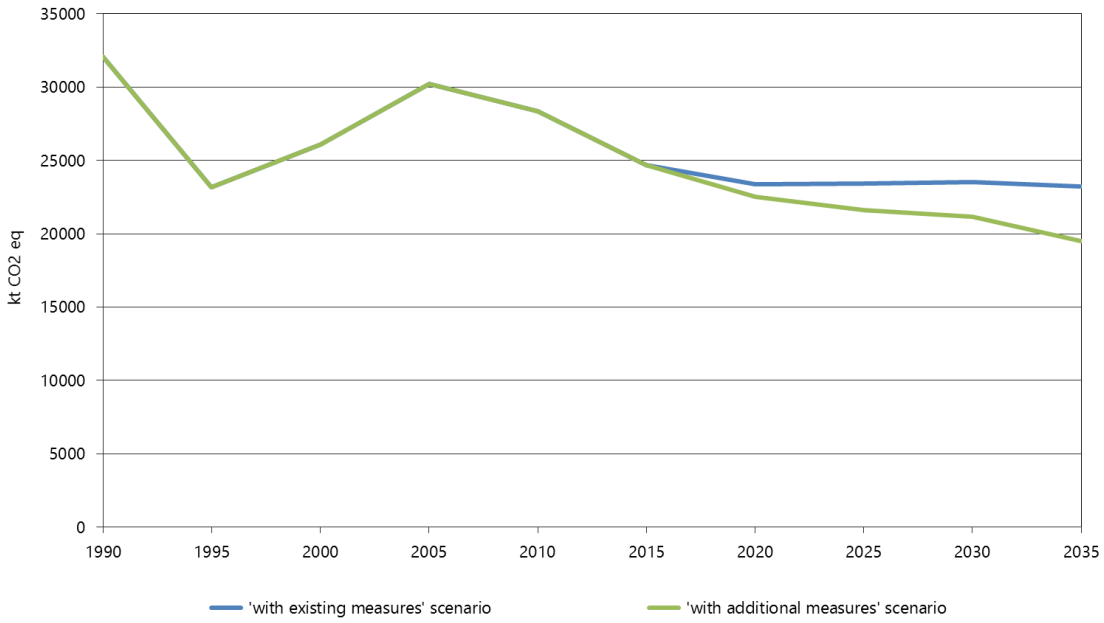

Figure 2-5: Total projections of greenhouse gas emissions (without LULUCF) for period until 2035

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

'With existing measures' scenario	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
Energy	17951	12754	13851	16169	13952	10776	9027	9012	8998	8574
Transport	3881	3368	4499	5562	5952	5952	6278	5959	5641	5304
Industrial processes and product use	4681	2488	3154	3545	3357	2832	2919	2998	3113	3189
Waste	1174	1291	1462	1641	2049	2231	2444	2658	2889	3117
Agriculture	4398	3264	3131	3321	3030	2875	2692	2786	2907	3038
TOTAL	**32085**	**23165**	**26098**	**30238**	**28339**	**24667**	**23360**	**23415**	**23549**	**23223**

'With additional measures' scenario	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
Energy	17951	12754	13851	16169	13952	10776	9027	8748	8469	7657
Transport	3881	3368	4499	5562	5952	5952	6278	5917	5556	5138
Industrial processes and product use	4681	2488	3154	3545	3357	2832	2489	2553	2649	2682
Waste	1174	1291	1462	1641	2049	2231	2276	1932	1602	1360
Agriculture	4398	3264	3131	3321	3030	2875	2430	2486	2581	2662
TOTAL	**32085**	**23165**	**26098**	**30238**	**28339**	**24667**	**22500**	**21635**	**20858**	**19500**

Projections show that in the 'with existing measures' scenario, in 2035 the emission is reduced by 27.6% compared to 1990, while in the 'with additional measures' scenario emission is reduced by 39.2% compared to 1990.

In the 'with existing measures' scenario, projections show decrease of emissions until 2020. In the period from 2020 to 2035, this scenario shows just a slight decrease of emission.

In the 'with additional measures' scenario, projections show a steady downward trend of emissions.

In scenario 'with additional measures' in relation to the scenario 'with existing measures' in 2035, greenhouse gas emissions will be reduced by 16.0%.

2.4. Emissions of ETS and ESD sectors

Historical emissions and projections of greenhouse gas emissions in ETS and ESD sectors for 'with existing measures' and 'with additional measures' scenarios are shown in Table 2-3.

Table 2-3: Historical emissions and projections of greenhouse gas emissions in ETS and ESD sectors, kt CO_2eq

	2010	2015	2020	2025	2030	2035
'With existing measures' scenario	28339	24667	23360	23415	23549	23223
ETS	8710	8386	7359	7235	7133	6795
ESD	19598	16249	15972	16151	16388	16402
'With additional measures' scenario	28339	24667	22500	21635	20858	19500
ETS	8710	8386	7198	6921	6663	6156
ESD	19598	16249	15272	14686	14168	13319

Emissions within the ETS in 2015 encompassed 34.0% of total emissions, amounting to 8386 kt CO_2eq. Projections indicate that in 2020 the ETS covers approximately 31.5% of total emissions, while in 2035 29.3% of total emissions in 'with existing measures' scenario. According to the 'with additional measures' scenario 32.0% of emissions will be included in 2020 and 31.6% of emissions will be included in 2035.

In the 'with existing measures' scenario, projections of EU ETS emissions show decrease of emissions in 2020 by 12.2% compared to 2015. In the period from 2020 to 2035, this scenario shows additional slight decrease of emission (by 19.0% in 2035 compared to 2015).

In the 'with additional measures' scenario, projections show a steady downward trend, primarily due to planned actions to promote usage of renewable energy sources and energy efficiency. Compared to 2015, emission projections show a decrease in emissions of 26.6% in 2035.

In 2015, emissions within ESD sector amounted to 16249 kt CO_2eq, which represents 66% of total emissions.

In the 'with existing measures' scenario, projections show a slight increase of emission in period from 2015 to 2035 (by 1% in 2035 compared to 2015). Compared to 2005, emission projections show a decrease in emissions of 18.3% in 2020, 16.2% in 2030 and 16.1% in 2035.

In the 'with additional measures' scenario, further reduction of emissions is expected, by 18% in 2035 compared to 2015, ie. if compared with 2005, emission reductions amount to 21.9% in 2020, 27.5% in 2030 and 31.9% in 2035.

Historical emissions and projections of greenhouse gas emissions in ETS and ESD for two scenarios are shown in Figures 2-6 and 2-7.

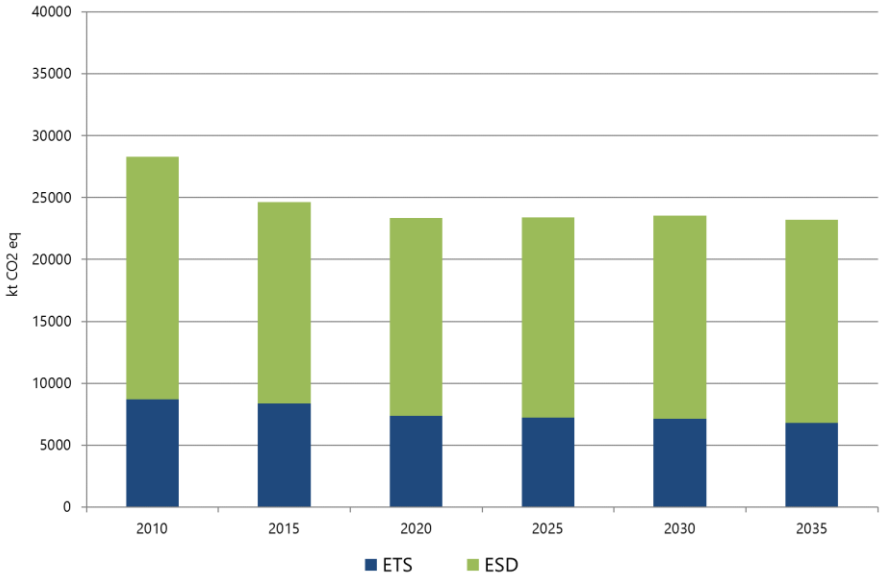

Figure 2-6: Historical emissions and projections of emissions within ETS and ESD, 'with existing measures' scenario

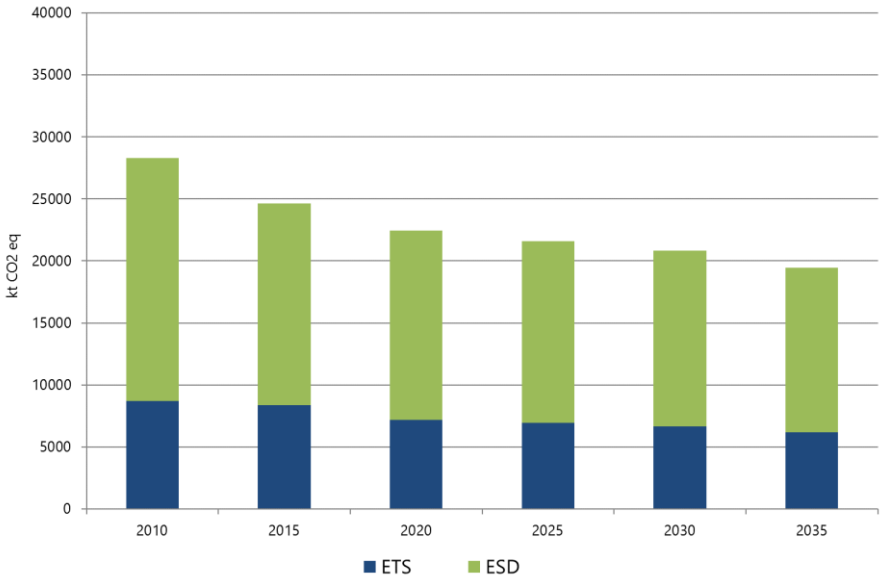

Figure 2-7: Historical emissions and projections of emissions within ETS and ESD, 'with additional measures' scenario

3. Policies and measures included in the projections

Policies and measures to reduce emissions from sources and increase sinks 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 the implementation of policies and measures to reduce emissions of greenhouse gases' that was prepared as a separate document.

Projections cover the period until 2035, with five-year steps.

The observation time horizon until 2035 can be divided into three periods: 1) First commitment period of the Kyoto Protocol from 2008 to 2012, which has ended; 2) Second commitment period from 2013 to 2020; and 3) Third period after 2020. The second commitment period until 2020 is characterised by the regulation of the transfer of the EU acquis, mostly the climate and energy package adopted in 2009. After 2020, the trend should be towards the established long-term goals defined by the EU document Roadmap for moving to a competitive low-carbon economy in 2050 (the aim of the European Union to reduce greenhouse gas emissions by 85 % - 95 % until 2050) and Climate and Energy Framework until 2030.

Republic of Croatia is in the process of adopting of the Integrated National Energy and Climate Plan of the Republic of Croatia for the period from 2021 to 2030 as well as Low-Carbon Development Strategy of the Republic of Croatia for the period until 2030 with a view to 2050 where a range of possible measures and scenarios for achieving objectives were closely considered.

3.1. Energy

The projections of greenhouse gas emissions in the energy sector are based on assumptions, objectives, measures and guidelines provided by the draft of the Integrated National Energy and Climate Plan of the Republic of Croatia for the period from 2021 to 2030.

The Plan provided projections of the final energy consumption and gross final energy consumption until 2030, with a view of 2050, for two scenarios with measures. The Plan was based on the national assumptions of macroeconomic indicators.

The 'with existing measures' scenario represents a group effect of measures that are under implementation or adopted with enforcement of existing instruments and measures arising from the transfer of the EU acquis. The detail list and description of measures included is listed in the separated Report on Policy and Measures.

The 'with additional measures' scenario is based on the application of the planned policy and measures, as listed in the Report on Policy and Measures. It is equivalent of the Low-Carbon Scenario S2 from the Integrated National Energy and Climate Plan of the Republic of Croatia for the period from 2021 to 2030. For some of the goals from the Plan the instruments are not yet defined but it is expected that they will be defined by following implementing documents.

3.2. Transport

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

The 'with existing measures' scenario represents a group effect of measures that are under implementation and adopted with 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 Policy and Measures.

The 'with additional measures' scenario is based on the application of the planned policy and measures, as listed in the Report on Policy and Measures. It is equivalent of the Low-Carbon Scenario S2 from the Integrated National Energy and Climate Plan of the Republic of Croatia for the period from 2021 to 2030. For some of the goals from the Plan the instruments are not yet defined but it is expected that they will be defined by following implementing documents.

3.3. Industrial processes and product use

Industrial processes and product use sector, which includes the process emission from industrial processes and product use, contributes to total greenhouse gases emission with 10.2% in 2016, of which 91% comes from the key emission sources: Cement Production, Ammonia Production, Nitric Acid Production, Petrochemical and Carbon Black Production, Non-energy Products from Fuels and Solvent Use and Consumption of HFCs in Refrigeration and Air Conditioning Equipment.

The 'with existing measures' scenario assumes that production in industrial processes will reach planned, maximum values until 2035, which will affect the increase in emissions. The implementation of process measures is prescribed by the sectoral legislation.

The 'with additional measures' scenario includes implementation of cost- effective measures to reduce greenhouse gases emissions in the production of cement, glass and nitric acid and the reduction of emissions of volatile organic compounds, controlled substances and fluorinated greenhouse gases. The scenario comprises process emissions. Emissions from fuel combustion are included in the Energy sector.

The 'with additional measures' scenario is based on the application of the planned measures as listed in the Report on Policy and Measures.

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

- reduction of clinker factor in cement production;
- increase of recycled glass in the glass production;
- reduction of N_2O emission in nitric acid production (catalytic decomposition);
- reducing emissions of volatile organic compounds in solvent use sector;
- handling of substances that deplete the ozone layer and fluorinated greenhouse gases;
- technical and organizational measures for collection, reuse, recovery and destruction of controlled substances and fluorinated greenhouse gases;
- capacity building and strengthening knowledge of authorized repairers;
- leakage detection of controlled substances and fluorinated greenhouse gases;
- a fee to cover the costs of collection, reuse, recovery and destruction of controlled substances and fluorinated greenhouse gases.

3.4. Agriculture

The agriculture sector in total greenhouse gas emissions has a share of about 10% in 2016. 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 husbandry (enteric fermentation), which accounts for about 82% of the sectoral CH_4 emissions.

In the period until 2035, a recovery of agricultural production and increase of the number of animals is expected.

Both scenarios: 'with existing measures' and 'with additional measures' assume that there will be an increase in agricultural production (restoration of the livestock fund in the period from 2015 to 2020 and continued population increase until 2035, with the of crop production based on indicative trends in the period from 2000 to 2009) and sustainable consumption of fertilizer (on the level of the 2007-2014 period average).

Policies and measures included in the development of the 'with existing measures' scenario:

- executing the Rural Development Programme for the period 2014-2020, including changing the system of cattle farming (manure removal system and genetic improvement) and diet (increasing digestibility, improving the quality of voluminous forage, improving grazing systems, use of additives in animal feed)

Scenario 'with additional measures' assumes implementation of additional measures:

- Change in diet of cattle and pigs and animal feed quality,
- Changes in animals waste management systems, including aerobic decomposition of manure and biogas production
- Improvements in synthetic fertilizer application methods,
- Hydromeliorative field interventions,
- Introduction of new cultivars, varieties and cultures.

3.5. Waste

The Waste sector contributes to total greenhouse gas emission with 9.2% in 2016, of which 99.8% comes from the key emission sources: solid waste disposal and wastewater treatment and discharge. Of these, 75% 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. The implementation of process measures is prescribed by the sectoral legislation - Sustainable Waste Management Act (OG 94/13, 73/17, 14/19) and Waste Management Plan of the Republic of Croatia for the period 2017 – 2022 (OG 3/17).

The 'with additional measures' scenario includes projections of greenhouse gas emissions from solid waste disposal and biological treatment of solid waste – composting. The remaining activities are not provided for measures to reduce greenhouse gas emissions. The 'with additional measures' scenario includes a more intensive application of measures defined by sectoral legislation, in relation to the 'with existing measures' scenario, with the implementation of binding targets in accordance with EU legislation - Directive (EU) 2018/850 of the European Parliament and of the Council of 30 May 2018

amending Directive 1999/31/EC on the Landfill of Waste and Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018 amending Directive 2008/98/EC on Waste.

The 'with additional measures' scenario is based on the application of the planned measures as listed in the Report on Policy and Measures.

Measures for reducing greenhouse gas emissions from Waste sector include:

- preventing the generation and reducing the amount of solid waste;
- increasing the amount of separately collected and recycled solid waste;
- methane flaring;
- reducing the amount of disposed biodegradable waste;
- use of biogas for biomethane production and electricity and heat generation.

By applying measures to prevent the generation and reduce the amount of solid waste, increase the amount of separately collected and recycled solid waste, methane flaring and reduce the amount of disposed biodegradable waste, reduction of CH_4 emission is achieved that is calculated in the Waste sector. The implementation of the measure for use of biogas for biomethane production and electricity and heat generation creates potentials for reduction of CO_2 emission that is calculated 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' (WEM) scenario only. The 'without measures' (WOM) and 'with additional measures' (WAM) scenarios have been omitted due to a lack of capacity of Croatia for development of these projections, which is in accordance with Article 14, Paragraph 1, Item a), Regulation (EU) 525/2013 of the European Parliament and of the Council of May 21, 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC. The projections were made based on statistical analysis of the trend of activity data and implied emission factors for the period 2007-2016, 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 this documents, for afforestation of bare productive forest land on an annual basis of about 2 kha, thereby increasing the surface in the category 'Forest land' ('Grassland converted to Forest land') is planned. According to the expert judgment, this conversion will be carried out over an area of 1.8 kha annually (including both afforestation seeding and the natural expansion of forests). Since the 'Wetlands' have already been partially protected by the Law on Nature Protection and on the basis of 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 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.

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 Annex XII of Implementing Regulation.

The 'with existing measures' and 'with additional measures' scenarios included policies and measures for reduction of emissions from sources and increase greenhouse gases sinks. 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, more advanced model were used, whose outputs were the inputs for the integrated energy model. Output data are structured in accordance with the structure of 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 in regard to the assumptions and limitations. The model is detailed to the level of individual production units, present and future.

Projections were made until 2035, 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 and calculates CO_2, CH_4 and N_2O emissions.

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	
As described in the Chapter 3, projections of GHG emissions for this report are taken from the draft of the Integrated National Energy and Climate Plan of the Republic of Croatia for the period from 2021 to 2030. 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, a 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) 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 projections done for the needs of the Green Book of the draft of the Energy Strategy of the Republic of Croatia: A. Akrap and K. Ivanda: Projections of the population of the Republic of Croatia, 2018.
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 of energy efficiency and fuel switches in industrial sector; – renovation of 0.75% surface are of the buildings annually to the nearly Zero Energy Building standard (includes 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 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: – renovation of 1.3% of the buildings annually to the nearly-zero energy standard (include the use of renewable sources);

Energy and Transport	
	– support for the development of the share of electric vehicles to 3.5% in 2030 and 25% of the passenger road transport in 2050; – support for the purchasing of the new electric and hybrid vehicles until the share of 1% in total number of vehicles; – intermodal shift with the goal to increase the share of the transport of goods to rails to 30% until 2050; – improvements of energy efficiency in 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: – until 2020, installed capacities of renewable energy sources power plants are as defined by the National Action Plan for Renewable Energy Sources by 2020 and Tariff system for renewable energy and efficient cogeneration (OG 133/2013, 151/2013, 20/2014, 107/2014 i 100/2015); – 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 cost mnimization 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 certain extent without the need of the public support for the solar PV system and wind; – the analysis showed no new coal power plants will be competent on the market; – gradual decrease of 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 cost mnimization 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;

Energy and Transport	
	– the analysis showed that renewable energy sources will be competent to certain extent without the need of the public support for the solar PV system and wind; – the analysis showed no new coal power plants will be competent on the market; – gradual decrease of 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 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 2035, in steps of five years. The model is of 'bottom-up' type, because it starts from the sectoral data and individual emission sources and calculates CO_2, CH_4, N_2O, HFC, PFC and SF_6 emissions.

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 2035. 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). Assumptions for 'with existing measures' scenario: – no installation of additional capacity; – production will reach the maximum value by 2035. 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. According to the "realistic scenario", by the year 2020 achieving the level of physical volume of industrial production on the level of 2008 is expected, when it reached the highest level of economic activity in Croatia. Process emissions from economic activities, as defined by IPCC methodology, included in the sector Industrial processes and product use were estimated on the basis of 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 population. The scenario includes the implementation of measures defined in the strategic and sectoral planning documents included in the business policy of cement and nitric acid manufacturers, conditioned by market demands, laws and regulations and the requirements of the application of best available techniques in the production process. Assumptions for 'with additional measures' scenario: – the application of cost- effective measures to reduce greenhouse gas emissions in the production of cement, glass and nitric acid and the reduction of emissions of volatile organic compounds, controlled substances and fluorinated greenhouse gases.

Industrial processes and product use
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 tabular Calculation interface was used. The model is structured in accordance with the table structure of the inventory of United Nations Framework Convention on Climate Change. It is the engineering simulation model.

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

Projections are made by 2020, indicative until 2035, 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 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. In order to determine the key parameters for projections (number and types of livestock, crop production), the extrapolation of historical input data was used and expert assessment that includes historical data and sectoral strategic and development documents. Assumptions: – uncertainties due to the lack of adequate and reliable statistics 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 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 2035, 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 management
The projections were carried out based on expected development and future state of parameters relating to the amount of generated and landfilled solid waste (municipal solid waste, industrial waste and sludge from wastewater treatment), fraction of landfilled organic waste, fraction of methane recovered/flared in total methane generation from landfills, as well 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 gross value added and the decline of population, which includes the goals by 2035. Assumptions for the scenario 'with existing measures': – Solid waste disposal - continuous increase of generated and landfilled solid waste quantities in the period until 2035 as a result of higher living standards, despite the effects of measures undertaken to avoid/reduce and recycle waste. The objectives are defined by sectoral legislation; – Composting - increase in the amount of solid waste that is being processed by composting; – Incineration of waste - increase in the quantity of incinerated clinical waste; – Wastewater treatment and discharge - continuous increase in the quantity of wastewater treated in industry sectors, decrease in the quantity of wastewater treated in residential/commercial sectors and decrease the number of population with individual system of drainage (septic tank). Greenhouse gas emissions which, according to the IPCC methodology, are included in the Waste sector were estimated on the basis of sectoral analysis and projected macroeconomic indicators on the annual increase in gross domestic product, gross value added and decline of population. The scenario includes the implementation of measures defined in the strategic and planning sectoral documents. Assumptions for the scenario 'with additional measures': – 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 or 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. 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, 2 and 3 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 of sub-categories of this sector in the Report of the National Inventory of Croatia for 2018 have been recognized as the key ones, whether the trend or 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 historic for the period from 2007 to 2016 for each carbon pool. Alternative 1 was used, whereat the activity data (in this case the size of the sub-categories of land) and emission factors for the period from 2020 to 2040, in this case the size of the sub-categories of land, were estimated using the linear extrapolation (or average values – e.g. for Wildfires) within the past ten years, from 2007 to 2016. For estimation of the projections for the biomass pool under subcategory Forest land remaining Forest land data on wood increment and wood removals from Forest management area plan for the period 2016-2025 were taken into account. Also, for Harvested wood products pool, reference historical period for projection estimate was 2000-2009, because of large fluctuation in input data. Correction of activity data (HWP production) for the period 2012-2016 was performed to avoid non-consistency of time series data. In cases where the linear extrapolation had unrealistic extreme values (for example, negative values on areas in "Land converted to wetlands"), the arithmetic means of information on specific activity or implied emission factor for the past years were used. Expert assessment to predict the annual volume of afforestation ("Land converted to forest land'). All pools estimated in NIR 2018 have been taken into account when compiling projections of GHG emissions/removals. Some pools (e.g. dead wood for „Forest land remaining forest land") have been omitted because of insufficient data (same as in NIR 2018 also). Croatia is planning significant improvements in estimation of projections of GHG emissions/removals in the future period. Main steps of planned projects and activities should be oriented in modelling of projections estimation for key source subcategories and pools mentioned above. Results should decrease uncertainty in estimation and further use of Grade 2.

Assumptions and input parameters used in the preparation of projections for this year's Report are presented in Table 4-5.

Table 4-5: Assumptions for projections – LULUCF

LULUCF
The projections were carried out based on the expected future state of the parameters that determine a potential for emissions mitigation. Key parameters for screening were determined based on the parameters in the relevant Guideline for projections (land area of each subcategory, emission factors assumed by sinks) and expert judgment for surface renovated and forest land. Assumptions: – Total area of 'forest land' and 'settlements' will be increased – Land conversion to forest land will remain at the annual level (1.8 kha / year) – Areas of 'wetlands' will not increase – Areas of burned areas will not increase.

4.2. Parameters on projections

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

Parameter		2015	2020	2025	2030	2035
GDP – annual growth rate	%	2.4	3.1	2.3	2.0	1.9
Population	million people	4.204	3.984	3.834	3.755	3.648
Coal prices	USD/t	4.9	6.4	7.9	8.6	9.1
Oil prices (1% S)	USD/barrel	41.0	62.0	83.0	94.0	103.0
Gas prices	USD/Mbtu	63.0	70.0	77.0	80.0	81.0

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

Parameter		2015	2020	2025	2030	2035
Total energy consumption						
Coal	ktoe	683.2	400.7	327.0	253.3	149.9
Oil	ktoe	4489.8	3120.1	3161.6	3203.1	3000.3
Gas	ktoe	2369.8	2338.4	2392.6	2446.8	2571.6
Renewable	ktoe	1959.9	2075.7	2506.0	2936.3	3102.9
Other	ktoe	9.3	10.4	10.5	10.6	10.4
Total	ktoe	8523.6	8507.2	8846.0	9184.9	9067.8
Total electricity generation						
Coal	TWh	2.31	1.55	1.52	1.49	0.75
Oil	TWh	0.22	0.08	0.10	0.12	0.13
Gas	TWh	1.19	2.18	2.93	3.67	4.75
Renewable	TWh	7.51	8.97	10.03	11.10	12.62
Nuclear	TWh	0.00	0.00	0.00	0.00	0.00
Other	TWh	0.00	0.00	0.00	0.00	0.00
Total	TWh	11.24	12.77	14.58	16.40	18.25
Net electricity imports	TWh	6.79	6.54	5.21	3.89	2.71

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

Parameter		2015	2020	2025	2030	2035
Final energy consumption						
Industry	ktoe	1089.5	1135.9	1161.3	1186.7	1169.6
Transport	ktoe	2107.2	2107.2	2195.0	2257.4	2319.7
Households	ktoe	2415.0	2415.0	2352.0	2399.8	2447.6
Agriculture, forestry and fisheries	ktoe	230.6	230.6	218.9	212.2	205.6
Services	ktoe	742.9	742.9	825.6	887.8	950.0
Other	ktoe	0.0	0.0	0.0	0.0	0.0
Total	ktoe	6585.2	6585.2	6727.4	6918.5	7109.7

Table 4-9: Parameters on projections – weather parameters

Parameter	2015	2020	2025	2030	2035
Heating degree days	2288	2288	2261	2235	2208
Cooling degree days	NE	NE	NE	NE	NE

Table 4-10: Parameters on projections – industrial processes and product use (%)

Parameter	1990	2010	2015	2020	2025	2030	2035
Production index for industry*							
Cement production	2642764 t	5	-6	33	36	40	41
Glass production	275490 t	-16	-14	1	13	27	39
Nitric acid production	332460 t	1	1	-13	-13	-10	-10
CO_2 emissions**							
Solvent use	139.32 Gg CO_2eq	-51	-64	-59	-56	-52	-49
HFC emissions***							
Consumption of HFCs in refrigeration and air conditioning equipment	(1995) 29.30 Gg CO_2eq	1292	1646	1687	1806	1960	2080

*, **, *** the percentage change in relation to 1990 (1995)

Table 4-11: Parameters on projections – transport

Parameter		2015	2020	2025	2030	2035
Number of passenger kilometres, all modes	10^9 pkm	49.01	50.41	52.06	54.46	56.56
Transport of goods	10^9 tkm	14.42	16.05	18.08	20.16	22.15
Energy consumption in road transport	ktoe	1898.9	1977.8	1999.0	1967.4	1937.7

Table 4-12: Parameters on projections – agriculture

Parameter		2015	2020	2025	2030	2035
Dairy cattle	1000 heads	165	168	175	180	185
Non-dairy cattle	1000 heads	240	270	285	320	340
Sheep	1000 heads	590	620	650	675	700
Goats	1000 heads	65	68	70	72	75
Horses	1000 heads	20	22	23	24	25
Mules/asses	1000 heads	2	2	3	3	4
Swine	1000 heads	1195	1050	1100	1250	1400
Poultry	1000 heads	6048	6231	10500	10800	11000
Wheat	t	864865	1002001	1042030	1178645	1253541
Maize	t	2551245	2205554	2239040	2256114	2321660
Potatoes	t	313056	160630	132738	104879	81805
Sugar beets	t	1847208	1408317	1471355	1497069	1565167
Tobacco	t	14166	12041	12794	13712	14570
Sunflowers	t	112321	109745	114592	129556	143115
Rape seed	t	79103	70933	90782	99821	113869
Tomatoes	t	44265	41278	50494	53804	57893
Barley	t	280698	243098	250955	278746	294361
Oats	t	57647	76089	74009	82453	87101
Cabbages and other brassicas	t	80057	57412	63091	63099	67856
Garlic	t	6359	4534	5288	5757	6224
Onions	t	38380	33475	40069	44763	49231
Rye	t	381	500	500	500	500
Sorghum	t	1298	1891	2357	2761	3161
Watermelons	t	42913	31346	33683	35274	37370
Soybeans	t	141488	174867	185521	190140	203482
Beans, dry	t	1110	500	500	500	500
Cabbages and other brassicas	t	1374	3050	3903	4708	5514
Lentils	t	38	0	0	0	0
Peas, dry	t	908	98	0	0	0
Vetches	t	2239	1585	1512	1462	1254
Clover	t	170218	143473	148600	157171	160825
Alfalfa	t	228802	128002	238183	101624	284798
Applying nitrogen	kg	99000	99000	99000	99000	99000

Table 4-13: Parameters on projections – waste

Parameter		1990	2010	2015	2020	2025	2030	2035
Amount of generated solid waste ('with existing measures' scenario)	t	1780400	2037477	2344964	2342063	2533945	2767231	2960167
Amount of generated solid waste ('with additional measures' scenario)	t	1780400	2037477	2344964	2180724	2147482	2138273	2122973
Organic fraction of solid waste ('with existing measures' scenario)	%	67	68	65	65	65	65	65
Organic fraction of solid waste ('with additional measures' scenario)	%	67	65	65	24	18	12	9
Amount of landfilled solid waste ('with existing measures' scenario)	t	1050436	1998994	1918659	1823998	1973436	2155119	2305377
Amount of landfilled solid waste ('with additional measures' scenario)	t	1050436	1998994	1918659	1090362	536871	427655	318446

Table 4-14: Parameters on projections – LULUCF

Parameter – Activity data	AD units	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
4.A.1. Forest land remaining forest land	(kha)	2312.18	2313.05	2313.60	2313.15	2311.95	2312.22	2312.39	2312.48	2312.57	2312.67
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
4.B.1. Cropland remaining cropland	(kha)	1618.22	1601.56	1585.07	1576.80	1556.79	1520.42	1492.27	1460.71	1429.15	1397.59
4.B.2. Land converted to cropland	(kha)	6.95	5.73	4.51	8.75	10.43	12.03	13.43	14.90	16.37	17.83
4.C.1. Grassland remaining grassland	(kha)	1178.31	1181.19	1184.15	1160.99	1141.46	1120.46	1105.05	1084.34	1065.39	1046.44
4.C.2. Land converted to grassland	(kha)	32.03	39.72	47.34	39.97	50.54	67.96	57.72	57.72	57.72	57.72
4.D.1. Wetlands remaining wetlands	(kha)	68.41	69.39	70.37	71.35	72.32	73.31	74.30	75.28	76.27	77.25
4.D.2. Land converted to wetlands	(kha)	3.91	3.92	3.93	3.06	2.15	1.22	1.68	1.68	1.68	1.68
4.E.1. Settlements remaining settlements	(kha)	188.41	192.38	196.37	200.35	204.32	209.54	214.56	219.59	224.63	229.66
4.E.2. Land converted to settlements	(kha)	15.91	17.16	18.40	45.77	53.04	54.05	55.26	56.45	57.64	58.83
4.F.1. Other land remaining other land	(kha)	231.51	231.51	231.51	231.46	231.46	231.46	265.75	300.25	332.99	365.72
4.III.B Cropland	(kha)	6.95	5.73	4.51	8.75	10.43	12.03	13.43	14.90	16.37	17.83
4.III.D Wetland	(kha)	3.91	3.92	3.93	3.06	2.15	1.22	1.68	1.68	1.68	1.68
4.III.E Settlements	(kha)	15.91	17.16	18.40	45.77	53.04	54.05	55.26	56.45	57.64	58.83
4.V.A Forest land remaining forest land	(ha)	482.15	3010.79	37363.79	912.50	687.67	4067.94	6098.68	6098.68	6098.68	6098.68
4.V.A Land converted to forest land	(ha)	NO	9.92	78.14	17.50	18.00	153.50	201.44	201.44	201.44	201.44
4.V.B Cropland remaining cropland	(ha)	NO	NO	NO	NO	NO	1134.38	370.76	370.76	370.76	370.76
4.V.C Grassland remaining grassland	(ha)	461.10	2193.25	41569.27	2425.00	502.23	6642.24	7869.01	7869.01	7869.01	7869.01

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

Parameter – Emissions factors - Biomass	EF units	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
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	0.35	0.30
4.A.2. Land converted to forest land	(tC/ha)	2.28	2.01	2.03	-0.01	0.41	0.63	0.61	0.61	0.61	0.61
4.B.1. Cropland remaining cropland	(tC/ha)	-0.02	-0.02	-0.04	-0.03	-0.01	-0.01	-0.03	-0.04	-0.06	-0.07
4.B.2. Land converted to cropland	(tC/ha)	0.19	0.15	0.15	0.26	0.27	0.15	0.63	0.85	1.07	1.28
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
4.C.2. Land converted to grassland	(tC/ha)	-0.19	-0.39	-0.32	-0.14	-0.64	-0.59	-0.48	-0.42	-0.36	-0.29
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
4.D.2. Land converted to wetlands	(tC/ha)	-0.54	-0.54	-0.54	-0.07	-0.06	-0.11	-0.09	-0.09	-0.09	-0.09
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
4.E.2. Land converted to settlements	(tC/ha)	-0.28	-0.34	-0.32	-0.80	-0.20	-0.17	-0.05	0.04	0.13	0.21
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
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
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
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
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
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
4.V.B Cropland remaining cropland	CO2 (t/AD unit)	NO	NO	NO	NO	NO	30.43	28.88	28.88	28.88	28.88
4.V.B Cropland remaining cropland	CH4 (t/AD unit)	NO	NO	NO	NO	NO	0.09	0.09	0.09	0.09	0.09
4.V.B Cropland remaining cropland	N2O (t/ADunit)	NO	NO	NO	NO	NO	0.01	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
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
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

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

Parameter – Emissions factors - Soil	EF units	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
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	-0.21	-0.20
4.B.1. Cropland remaining cropland	(tC/ha)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.B.2. Land converted to cropland	(tC/ha)	-1.11	-1.12	-1.13	-1.10	-0.97	-0.89	-0.81	-0.63	-0.51	-0.39
4.C.2. Land converted to grassland	(tC/ha)	1.07	1.08	1.09	1.09	1.09	1.08	1.07	1.06	1.05	1.04
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
4.E.2. Land converted to settlements	(tC/ha)	-2.56	-2.56	-2.56	-2.56	-2.56	-2.56	-2.56	-2.56	-2.56	-2.56
4.III.B Cropland	(kg N2O–N/ha)	1.24	1.24	1.25	1.22	1.07	0.98	0.88	0.78	0.68	0.58
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
4.III.E Settlements	(kg N2O–N/ha)	2.91	2.92	2.91	2.90	2.89	2.89	2.89	2.89	2.88	2.88

5. Sensitivity analysis of projections

In this section the sensitivity of projections on a few selected parameters which largely determined the uncertainty of the projections was analysed. Sensitivity was analysed on qualitative and where possible quantitative level. Influence of the following parameters was analysed:

- Rate of economic development
- Influence of change in temperature on heating and cooling energy demand
- Hydrology in the production of hydroelectric power
- Development of agriculture.

The influence of some factors can be significant from the point of view of emission trends and / or from the point of view of variability around the mean value. The trend applies to sequences of long duration while the variability is related to one or several years.

Emissions are calculated as the product of activities and emission factors. Some factors affect more the activity i.e. fuel consumption distance travelled number of livestock etc. Another affect more the emission factors for example t CO_2/MWh t N_2O/km etc. Dependence of emission on starting values is mainly of linear type whereat some parameters have influence through many sectors which is discussed below.

The rate of economic growth affects all the sectors more the activities and relatively less the emission factors. The impact on emission factors is reflected through a long-term period thus a reduced economic potential in a long-term period will result in weaker technological advances which affects the emission factors. Croatia has relatively low emissions and individual disorders can have a strong impact on overall emissions.

The increase of GDP is assumed by 2040 in all analysed scenarios in average of 1.4% by 2040 which makes a nominal increase of 63% compared to 2010.

For this economic growth expects the emission to be about 7.1% higher in 2030 and about 12.3% higher in 2040 compared to the presented scenarios assuming the same carbon intensity of the economy. However the implementation of emission reduction measures will reduce and cut the link between GDP and emissions in the long term. Thus the GDP growth can also contribute to emissions reduction when it comes to investments in low carbon technology industry and services.

Influence of change in temperature on heating and cooling energy demand

Change in temperature will affect the decrease in heating energy demand but on the other side it will increase the cooling energy demand. The goal of climate policy is to keep the global temperature rise within 2°C. The temperature increase has been determined in Croatia since the measurements have been carried out. An increase of about 1°C is assumed by 2050.

Heating requirements. The indoor temperature in buildings is mainly 20°C but the temperature of the heated rooms is usually maintained at the level up to 24°C. In addition to these assumptions the reduction in heat required for heating could be between 7.7 and 11.3% in the continental part of Croatia and between 12.7 and 24.2% in the coastal part of Croatia.

Cooling requirements. Unlike heating requirements there is no such dependence between the need for comfortable cooling and the outdoor air temperature since in the influence of heat gains due to solar radiation is dominant in this case. At the moment it is not possible to estimate the influence of external

temperature change on cooling requirements due to data availability. The only possible estimation suggests that the impact will be less expressed comparing to heating requirements.

Other impacts on energy. Changes in temperature precipitation and wind energy will affect the production of renewable energy sources. These impacts need to be quantified and embedded in operational planning especially at the regional and local level where large variations are possible.

Hydrology in the production of hydroelectric power

Generation from large hydropower plants varies from 4 TWh to 8 TWh depending on hydrology. This represents 20% or 40% of the total electricity generation in Croatia. Emissions from the electroenergy sector can vary considerably based on the cycles of dry and humid years that can last for several years.

The lack of generation from hydropower plants is supplemented by increased production from thermal power plants or by increased imports. In the case of extreme drought the increase in emission could occur in 2030 in the scenario with additional measures in amount of 4.2% of the total emissions in Croatia respectively.

Development of agriculture

The characteristics of agriculture in Croatia are extremely small estates; the average family farm has only 2 hectares. According to the 2003 Agriculture Census only 20% of the processed land is in private ownership with an average of 159 hectares. The similar situation is in the field of cattle breeding. Thus for example 96% of all diary producers own only 15 cows while 90% of pork production is handled by 200000 small farms where 170000 farms have less than 10 pigs. Such fragmentation and predominantly old populations prevent faster development. Agriculture will change slowly thus Croatia will have a big challenge in emissions.

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