2015

REPORT ON PROJECTIONS OF GREENHOUSE GAS EMISSIONS - addition

REPUBLIC OF CROATIA

June 2015

CROATIAN ENVIRONMENT AGENCY

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I INTRODUCTION

'Report on projections of greenhouse gas emissions' (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 the preparation of the Report in the national legislation is primarily in Article 75 Paragraph 3 of the Air Protection Act (Official Gazette 130/11).

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 referred to as 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:

- 'without measures', 'with measures' and 'with additional measures' projections, organized by sector and by gas,
- projections of ETS and non-ETS emissions,
- policies and measures included in projections,

- descriptions of methodologies, models, underlying assumptions and key input and output parameters,
- 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 Ordinance on Greenhouse Gas Emissions Monitoring in the Republic of Croatia (Official Gazette 134/12), which in Article 11 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 IV of the aforementioned Ordinance. Accordingly, the Report includes:

- assumptions for general economic parameters,
- assumptions for energy sector,
- assumptions for industry sector,
- assumptions for transport sector,
- assumptions in agriculture sector,
- assumptions in waste management 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 2015, 2020, 2025, 2030 and 2035.

The Report for 2015 was done without verified technical backgrounds of the Committee for Intersectorial Coordination for Policy and Measures for Climate Change Mitigation and Adaptation.

Below are listed data sources used for the Report:

CRF CATEGORY	DATA TYPE	DATA SOURCE
General parameters	GDP – yearly growth rate Population Coal price Crude oil price Natural gas price	European Commission recommendations
Energy	Fuel consumption Electricity generation	National Renewable Energy Action Plan Third National Energy Efficiency Action

CRF CATEGORY	DATA TYPE	DATA SOURCE
	Electricity imports Final energy demand	Plan for the Period 2014-2016
Transport	Number of passenger kilometres Number of tonne-kilometres Energy demand in transport sector	National Bureau of Statistics
Industry	Production index	Sectorial studies (cement, lime and nitric acid production)
	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 Faculty of Agronomy, Ministry of Agronomy
	Plant production	National Bureau of Statistics Statistical reports on plant production FAOSTAT database
LULUCF	Land area of each sub-category	NIR 2014
	The assumed emission factors by sinks	CFR 2014
Waste	The amount of municipal waste The amount of municipal waste disposed of at landfill The organic fraction of municipal solid waste	Waste Management Strategy Waste Management Plan in the Republic of Croatia Law on Sustainable Waste Management

The Report starts from the last published inventory of greenhouse gas emissions (NIR 2014) which includes an inventory of emissions and sinks of greenhouse gases for the period 1990 – 2012, with updated informations in respect of legislative framework and policies and measures with the state by the end of January 2015. Historical emissions from NIR 2014 were recalculated according to 2006 IPCC Guidelines.

II PROJECTION OF GREENHOUSE GAS EMISSIONS

This chapter presents the historical greenhouse gas emissions in the period from 1990 to 2012 and projections of greenhouse gas emissions for the period from 2015 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 (CO2 eq). 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

Source: 2006 IPCC Guidelines

Sectors are identified according to the Guidelines for the preparation of National Communications by Parties included in Annex I to the Convention (FCCC/CP/1999/7, Part II):

- energy,
- transport,
- industry,
- agriculture,
- waste management,
- 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 three scenarios: 'without measures' scenario, 'with measures' scenario and 'with additional measures' scenario. Scenario 'without measures' assumes that implementation of adopted policies and measures as well as implementation of planned policies and measures will not happen. Scenario 'with 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 last published inventory of greenhouse gas emissions (NIR 2014) which includes an inventory of emissions and sinks of greenhouse gases for the period 1990 – 2012 (made in accordance with the 1996 IPCC Guidelines). In this updated report emissions from NIR 2014 were recalculated according to 2006 IPCC Guidelines which are also used in projections. Reference year for projection is 2012.

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 2-3. Emissions are presented for 'without measures' scenario, 'with measures' scenario and 'with additional measures' scenario for the period from 1990 to 2035.

The energy sector covers all activities that involve fuel combustion from stationary sources and fugitive emission from fuels. The emission from energy sector in 2012 amounted to 13,471 $GgCO_2$ and it is the main source of anthropogenic emission of greenhouse gases, it accounts approximately 50% of the total greenhouse gases emission in 2012. In scenario 'without measures', without implementation of energy efficiency measures and renewable energy policy and an increase in a number of fossil fuel power plants to reduce the import of electricity by 2020, projections show strong growth until 2020 and moderate growth thereafter. In the 'with measures' scenario, projections show continuous downward trend in emissions by 2015 because of economic downturn and implementation of measures to encourage the use of renewable energy sources and energy efficiency. In the period from 2015 to 2020, the increase in emissions is a result of expected increase in installed capacity in thermal power plants using fossil fuels to reduce the import of electricity. After 2020, this scenario shows a slight increase due to expected increase in economic activity and new power plants. Most measures to reduce emissions in the energy sector are planned 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 steady trend of a slight reduction of emissions.

The transport sector includes emissions from fuel combustion in road transportation, civil aviation, railways and navigation. The emission from transport sector in 2012 amounted to 5,709 $GgCO_2$ eq, which makes about 21.5% of total Croatia's greenhouse gases emission. In scenario 'without measures', projections show a continuous trend of reducing emissions by 2015, while there is an increase expected in the period up to 2020, primarily due to strong ties with expected increase in GDP. In the 'with measures' scenario in the period from 2015 to 2020, projections indicate stagnation

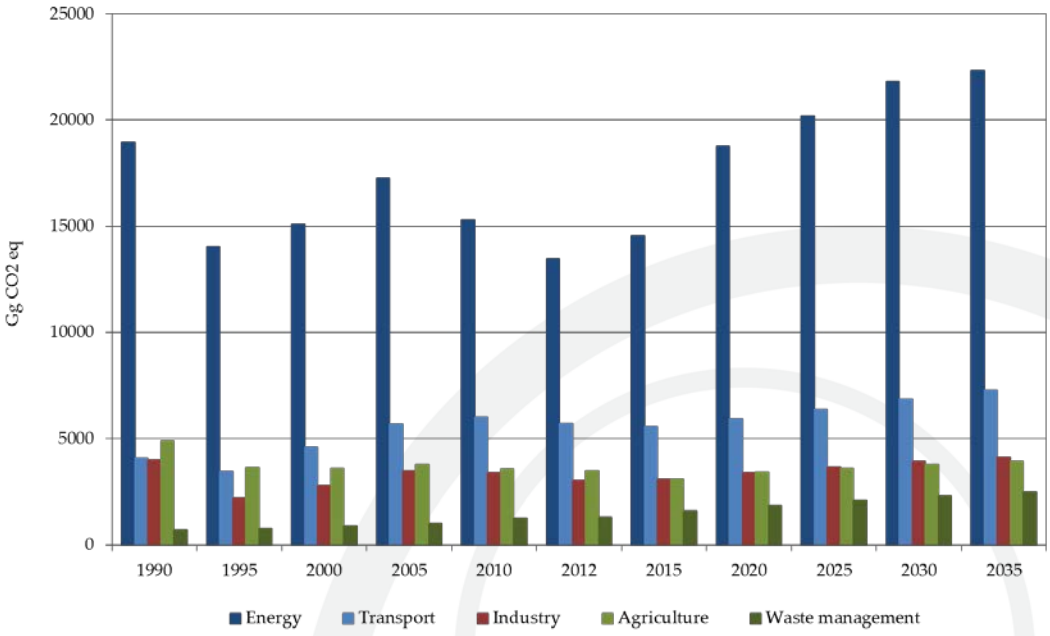
of emissions. Factors that encourage the growth of emissions are expected increase in economic activities and living standards, while the emission reductions are primarily affected by the measures to increase energy efficiency and use of renewable sources in transport. Most of the existing measures have projected duration by 2020 so after that the emissions show a slight increase. In scenario 'with additional measures', projections show a continuous trend of reducing emissions by 2020, primarily due to planned additional measures to increase energy efficiency [10]. Even though there is an expected development of the technology foreseen, after 2020, projections show a slight increase, mainly due to expected economic growth, increase in the number of vehicles, number of passenger and goods transports with yet undefined measures to reduce greenhouse gas emissions.

The industry sector includes the process emission, while emission from fuel combustion in industry is included into energy sector. The emission from industry sector in 2012 amounted to 3,041 $GgCO_2$ eq, which makes about 11% of total Croatia's greenhouse gases emission in 2012. Solvent use sector, which is observed within the framework of industry sector, contributes to the total greenhouse gas emission with about 0,6% (153.6 $GgCO_2$ eq). The projections of emissions indicate an increase in all scenarios, due to expected increase in production to the maximum utilization of existing productive capacity in the period until 2035, despite the implementation of cost-effective measures to reduce emissions.

The agriculture sector covers about 12,9% of total greenhouse gas emissions in 2012 (emission is 3,501 $GgCO_2$ eq). The projections indicate an increase in emissions after 2015 because of a recovery of livestock (assumption based on expert judgement and draft version of "*Improving NH3, CH4 and N2O emission calculations from manure management and drafting EFs report"*, University of Zagreb, Faculty of Agriculture) and normalization of agricultural production (trend analysis).

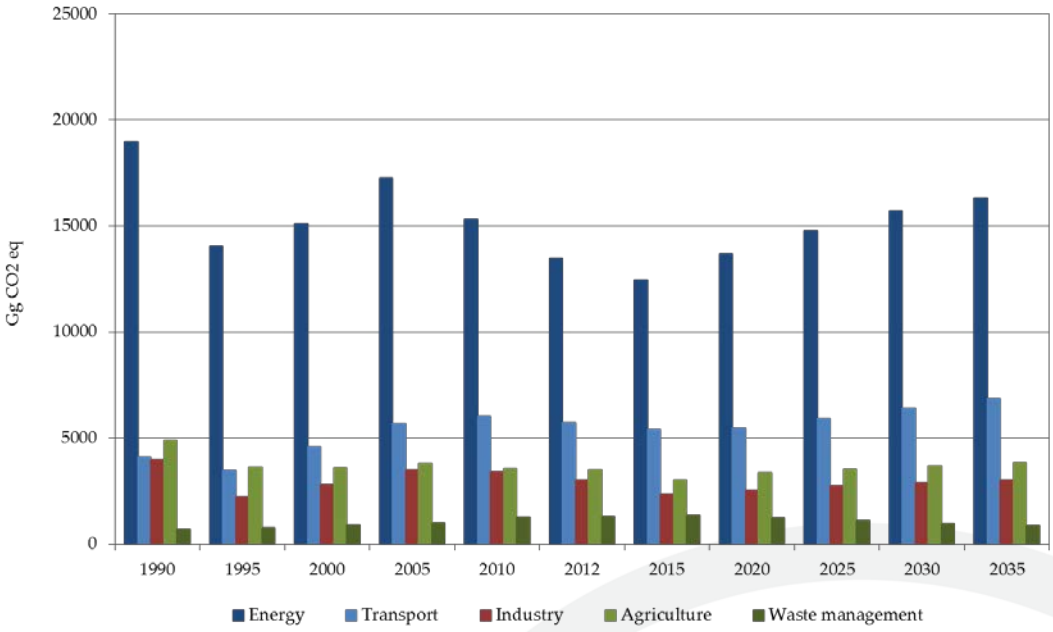
The waste management sector participates in the total emission of greenhouse gases with about 4,9% in 2012 (emission is 1,316 $GgCO_2$ eq). Projections indicate emission reduction in scenarios 'with measures' and 'with additional measures' after 2015. The potential of CO_2 emission reduction, which can be achieved by implementing the measures included in the scenarios 'with measures' and 'with additional measures' is balanced in the Energy sector.

In the year 2012, removals by sink in the LULUCF sector were -6,536 $GgCO_2eq$. Projections up to 2035 exceed 8,000 $GgCO_2$ sinks per year (excluding emissions from fires). These projections are made by sectorial sub-categories 'Forest land', 'Cropland', 'Grasslands', 'Wetlands', 'Settlements' and 'Other land' for the scenario with existing measures and are separately shown in Figure 2- 4.



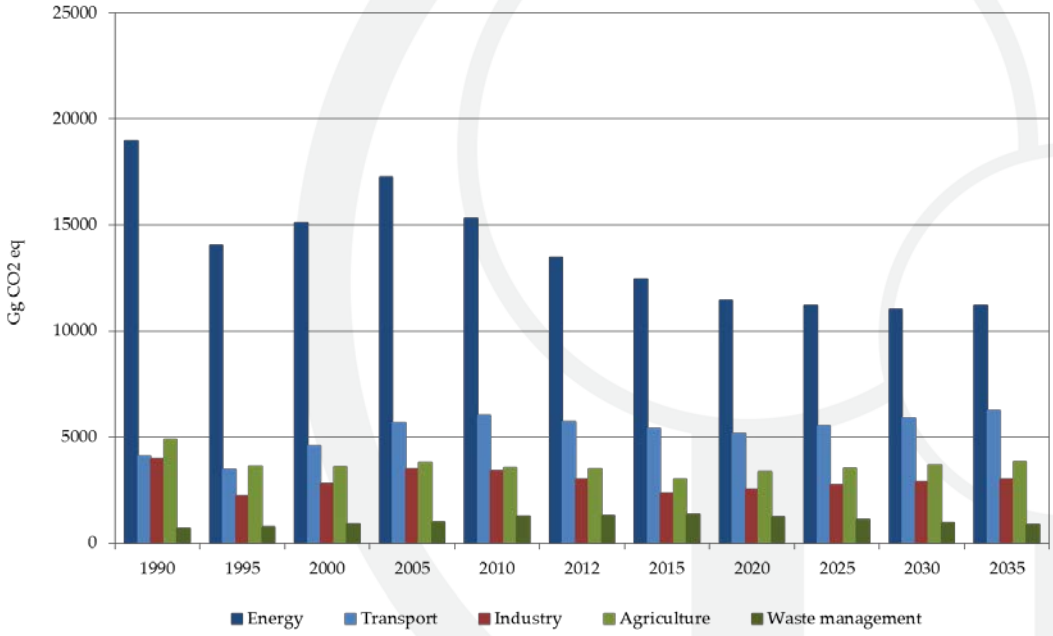
Source: [7], EKONERG

Figure 2-1: Historical and projected greenhouse emissions by sectors, 'without measures' scenario



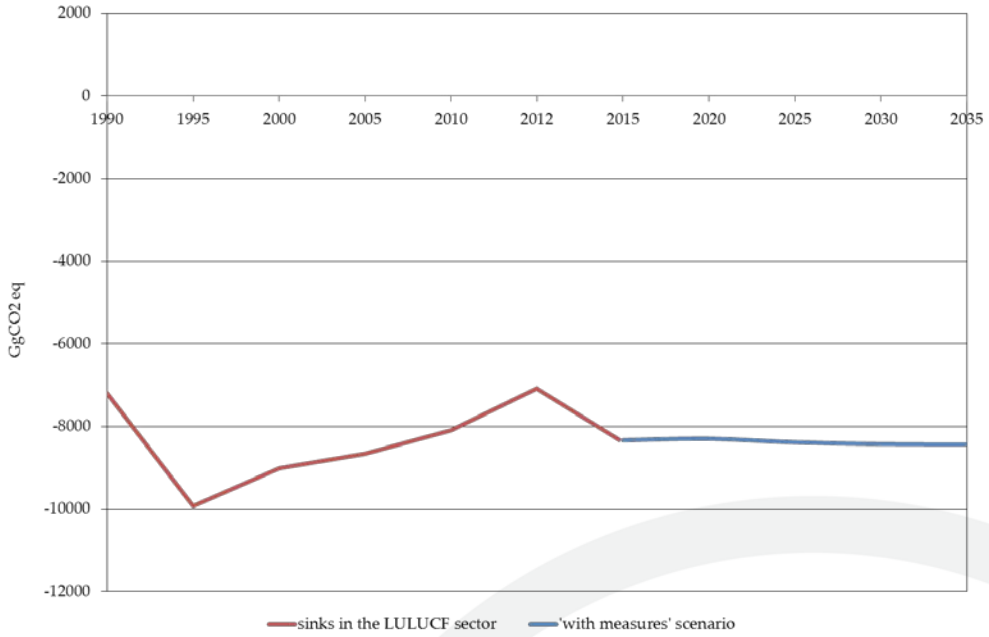
Source: [7], EKONERG

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



Source: [7], EKONERG

Figure 2-3: Historical and projected greenhouse emissions by sectors, 'with additional measures' scenario

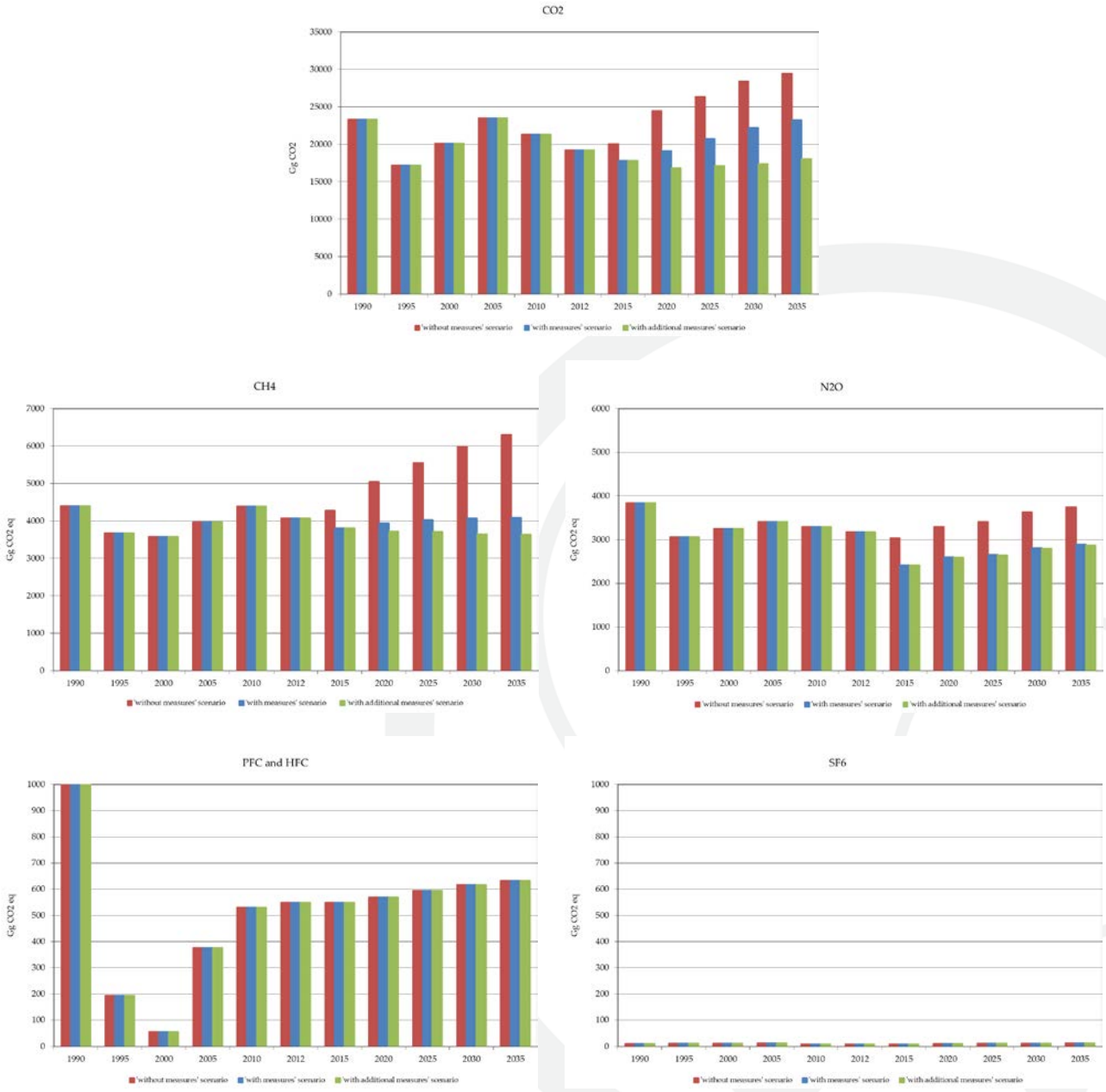


Source: [7.], EKONERG

Figure 2-4: Historical and projected removals by sinks in the LULUCF sector, 'with 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 all three scenarios, in the period from 1990 until 2035 are shown in Figure 2-5.



Source: [7.], EKONERG

Figure 2-5: Projections of greenhouse emissions by gases

Historical emissions and projections of greenhouse gas emissions CO_2, CH_4, N_2O, HFCs and PFCs, SF_6, for all three 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 CO_2, CH_4, N_2O, HFCs and PFCs, SF_6, $GgCO_2$ eq

CO2	1990	1995	2000	2005	2010	2012	2015	2020	2025	2030	2035
'without measures' scenario	23,339.56	17,213.76	20,099.51	23,501.38	21,330.41	19,233.20	20,011.68	24,443.93	26,370.83	28,432.30	29,450.79
'with measures' scenario	23,339.56	17,213.76	20,099.51	23,501.38	21,330.41	19,233.20	17,834.01	19,154.22	20,738.63	22,180.44	23,256.17
'with additional measures' scenario	23,339.56	17,213.76	20,099.51	23,501.38	21,330.41	19,233.20	17,834.01	16,824.30	17,118.12	17,397.43	18,039.47
CH4	1990	1995	2000	2005	2010	2012	2015	2020	2025	2030	2035
'without measures' scenario	4,400.65	3,674.80	3,582.40	3,968.02	4,389.04	4,074.50	4,278.25	5,044.75	5,557.50	5,984.50	6,295.25
'with measures' scenario	4,400.65	3,674.80	3,582.40	3,968.02	4,389.04	4,074.50	3,803.50	3,935.00	4,030.50	4,068.25	4,094.75
'with additional measures' scenario	4,400.65	3,674.80	3,582.40	3,968.02	4,389.04	4,074.50	3,803.50	3,726.50	3,711.00	3,648.00	3,636.25
N2O	1990	1995	2000	2005	2010	2012	2015	2020	2025	2030	2035
'without measures' scenario	3,838.83	3,059.47	3,255.62	3,406.76	3,298.46	3,170.72	3,036.62	3,295.88	3,412.10	3,629.64	3,751.82
'with measures' scenario	3,838.83	3,059.47	3,255.62	3,406.76	3,298.46	3,170.72	2,416.78	2,601.54	2,658.16	2,810.14	2,890.60
'with additional measures' scenario	3,838.83	3,059.47	3,255.62	3,406.76	3,298.46	3,170.72	2,416.78	2,589.62	2,643.26	2,795.24	2,878.68
PFC and HFC	1990	1995	2000	2005	2010	2012	2015	2020	2025	2030	2035
'without measures' scenario	1,086.77	192.84	55.71	376.31	531.01	548.76	549.85	569.10	595.17	616.76	633.31
'with measures' scenario	1,086.77	192.84	55.71	376.31	531.01	548.79	549.85	569.10	595.17	616.76	633.31
'with additional measures' scenario	1,086.77	192.84	55.71	376.31	531.01	548.79	549.85	569.10	595.17	616.76	633.31
SF6	1990	1995	2000	2005	2010	2012	2015	2020	2025	2030	2035
'without measures' scenario	10.45	11.62	11.12	13.03	8.89	9.16	9.36	10.39	11.34	12.22	12.91
'with measures' scenario	10.45	11.62	11.12	13.03	8.89	9.16	9.36	10.39	11.34	12.22	12.91
'with additional measures' scenario	10.45	11.62	11.12	13.03	8.89	9.16	9.36	10.39	11.34	12.22	12.91
TOTAL	1990	1995	2000	2005	2010	2012	2015	2020	2025	2030	2035
'without measures' scenario	32,676	24,152	27,004	31,265	29,558	27,037	27,885	33,365	35,948	38,675	40,145
'with measures' scenario	32,676	24,152	27,004	31,265	29,558	27,037	24,614	26,271	28,034	29,687	30,888
'with additional measures' scenario	32,676	24,152	27,004	31,265	29,558	27,037	24,614	23,719	24,079	24,469	25,202

The energy sector has the most significant anthropogenic sources of CO_2 emissions, with maximum value from 19.762 $GgCO_2$ (for the 'without measures' scenario) to 9,642 $GgCO_2$ (for the 'with additional measures' scenario) in 2035.

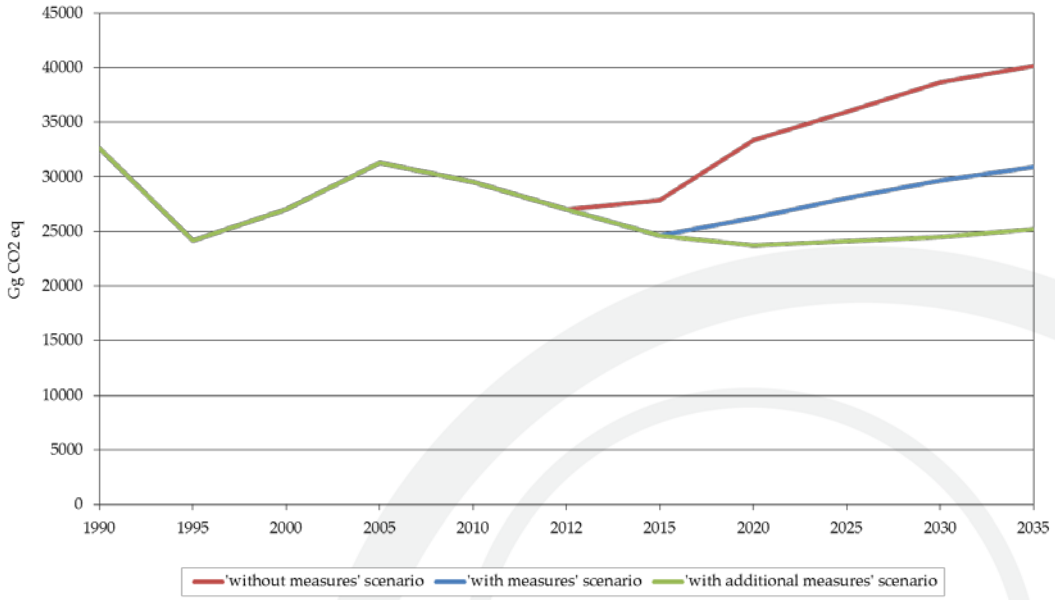
The main sources of CH_4 emissions are fugitive emissions from energy sector, waste management sector and agriculture sector. Projections indicate an increase by 43% in CH_4 emissions by 2035 compared to 1990 for the 'without measures scenario, while in scenarios 'with measures' and 'with additional measures' there is a decrease ranging from -7% (for the 'with measures' scenario) and -17.4% (for the 'without measures' scenario).

The most important source of N_2O emissions is agriculture sector, which projections in 2035 have the maximum of 2,536 $GgCO_2$ eq for the 'without measures' scenario, or 2,495 $GgCO_2$ eq for the 'with additional measures' scenario.

The sources of HFCs and PFCs and SF_6 emissions are in the industry sector. Although their emissions in absolute terms are not large, due to the large global warming potential (GWP), their contribution is significant.

2.3. TOTAL PROJECTIONS

Total projections of greenhouse gas emissions (without LULUCF) for all three scenarios, for the period until 2035 are shown in Figure 2-6 and Table 2-2.



Source: [7], EKONERG

Figure 2-6: Total projections of greenhouse gas emissions (without LULUCF) for period until 2035

Table 2-2: Historical emissions and projections of greenhouse gas emissions, $GgCO_2$ eq

'Without measures' scenario	1990	1995	2000	2005	2010	2012	2015	2020	2025	2030	2035
Energy	18.969	14.036	15.115	17.262	15.312	13.471	14.523	18.769	20.205	21.811	22.324
Transport	4.101	3.471	4.599	5.684	6.038	5.710	5.563	5.933	6.390	6.845	7.283
Industry	4.007	2.233	2.814	3.505	3.383	3.041	3.092	3.385	3.665	3.922	4.124
Waste management	708	775	886	1.003	1.272	1.316	1.605	1.854	2.098	2.314	2.498
Agriculture	4.891	3.638	3.591	3.811	3.554	3.499	3.101	3.423	3.589	3.783	3.916
TOTAL	32.676	24.152	27.004	31.265	29.558	27.037	27.885	33.365	35.948	38.675	40.145
'With measures' scenario	1990	1995	2000	2005	2010	2012	2015	2020	2025	2030	2035
Energy	18.969	14.036	15.115	17.262	15.312	13.471	12.436	13.673	14.759	15.703	16.292
Transport	4.101	3.471	4.599	5.684	6.038	5.710	5.403	5.475	5.940	6.403	6.846
Industry	4.007	2.233	2.814	3.505	3.383	3.041	2.377	2.523	2.717	2.896	3.040
Waste management	708	775	886	1.003	1.272	1.316	1.353	1.245	1.103	981	876
Agriculture	4.891	3.638	3.591	3.811	3.554	3.499	3.044	3.355	3.515	3.704	3.833
TOTAL	32.676	24.152	27.004	31.265	29.558	27.037	24.614	26.271	28.034	29.687	30.888
'With additional measures' scenario	1990	1995	2000	2005	2010	2012	2015	2020	2025	2030	2035
Energy	18.969	14.036	15.115	17.262	15.312	13.471	12.436	11.450	11.227	11.009	11.202
Transport	4.101	3.471	4.599	5.684	6.038	5.710	5.403	5.145	5.518	5.879	6.250
Industry	4.007	2.233	2.814	3.505	3.383	3.041	2.377	2.523	2.717	2.896	3.040
Waste management	708	775	886	1.003	1.272	1.316	1.353	1.245	1.103	981	876
Agriculture	4.891	3.638	3.591	3.811	3.554	3.499	3.044	3.355	3.515	3.704	3.833
TOTAL	32.676	24.152	27.004	31.265	29.558	27.037	24.614	23.719	24.079	24.469	25.202

Projections show that compared to 1990, in 2035 the emission suddenly increases by 22,9% in the 'without measures' scenario. In the 'with measures' scenario, the emission in 2035 remains approximately the same as in 1990, while in the 'with additional measures' scenario emission is reduced by 22,9% compared to 1990.

In the 'with measures' scenario projections show continuous downward trend in emissions by 2015, primarily due to economic downturn and implementation of measures to encourage the use of renewable energy sources and energy efficiency. In the period from 2015 to 2020, the increase in emissions affects the expected increase in installed capacity in thermal power plants using fossil fuels to reduce the import of electricity. After 2020, this scenario shows a slight increase due to expected increase in economic activity and new power plants.

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

In 'with measures' scenario, in relation to the 'without measures' in 2035, the greenhouse gas emissions will be reduced by 23%, while in the scenario 'with additional measures' by 37%.

In scenario 'with additional measures' in relation to the scenario 'with measures' in 2035, greenhouse gas emissions will be reduced by 18,4%.

2.4. TOTAL EFFECTS OF POLICIES AND MEASURES

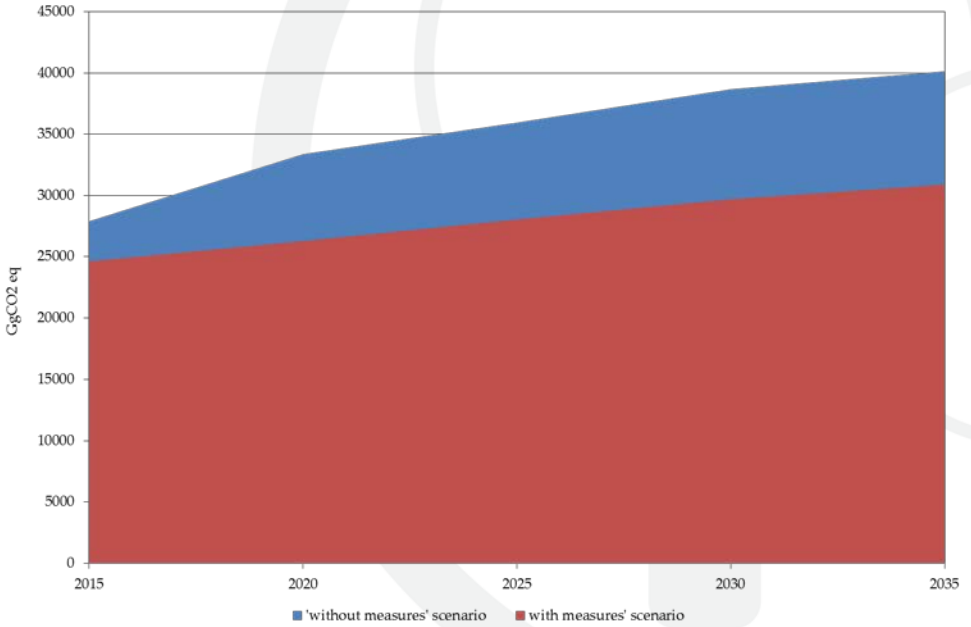
Total effects of applied policies and measures to reduce greenhouse emissions are shown in Table 2-3.

Table 2-3: Total effects of policies and measures, $GgCO_2$ eq

	2015	2020	2025	2030	2035
'Without measures' scenario	27,885	33,365	35,948	38,675	40,145
'With measures' scenario	24,614	26,271	28,034	29,687	30,888
TOTAL	3,271	7,093	7,914	8,988	9,257

Source: EKONERG

By comparing the 'without measures' scenario with scenario that includes the application of relevant policy and measures which implementation is already in progress, or application of policy and measures that have already been adopted ('with measures' scenario), total effects of applied policies and measures have been determined. Emission is reduced by 3,271 $GgCO_2$ eq in 2015 to 9,257 $GgCO_2$ eq in 2035 (Figure 2-7).



Source: EKONERG

Figure 2-7: Total effects of policies and measures

2.5. EMISSIONS OF ETS AND NON-ETS SECTORS

Historical emissions and projections of greenhouse gas emissions in ETS and non-ETS sectors for three scenarios are shown in Table 2-4.

Table 2-4: Historical emissions and projections of greenhouse gas emissions in ETS and non-ETS sectors, $GgCO_2$ eq

	2010	2015	2020	2025	2030	2035
'Without measures' scenario	29,558	27,885	33,365	35,948	38,675	40,145
ETS	10,759	10,770	14,526	15,841	17,332	17,792
non-ETS	18,798	17,115	18,839	20,107	21,343	22,353
'With measures' scenario	29,558	24,614	26,271	28,034	29,687	30,888
ETS	10,759	8,523	9,819	10,759	11,612	12,085
non-ETS	18,798	16,091	16,453	17,275	18,075	18,803
'With additional measures' scenario	29,558	24,614	23,719	24,079	24,469	25,202
ETS	10,759	8,523	8,426	8,394	8,402	8,683
non-ETS	18,798	16,091	15,293	15,685	16,067	16,519

Source: [7.], [27.], EKONERG

Emissions within the ETS in 2010 encompassed 36.4% of total emissions, amounting to 10,759 GgCO2 eq. Projections indicate that in 2015 the ETS will cover, depending on the scenario, between 34.6% (scenarios 'with additional measures') and 38.6% (scenario 'without measures') of total emissions, while in 2035, according to the 'with additional measures' scenario, 34,5% of emissions will be included, 39.1% of emissions will be included according to the 'with measures' scenario and 44,3% of total emissions will be included in the 'without measures' scenario.

In the 'without measures' scenario, compared to 2010, emission projections show an increase in emissions of 0,1% in 2015 up to 65,4% in 2035. The reason of this increase is primarily in the expected construction of new power plants using fossil fuels.

In the 'with measures' scenario, the continuation of downward trend in emissions is expected until 2015 due to economic downturn as well as subsequent increase of emissions by 12,085 GgCO2

eq in 2035, an increase of 12,3% compared to 2010. A slow growth of emissions is due to expected increase in economic activity [19.] and new power plants.

In the 'with additional measures' scenario, projections show a steady light downward trend, primarily due to planned actions to promote usage of renewable energy sources and energy efficiency.

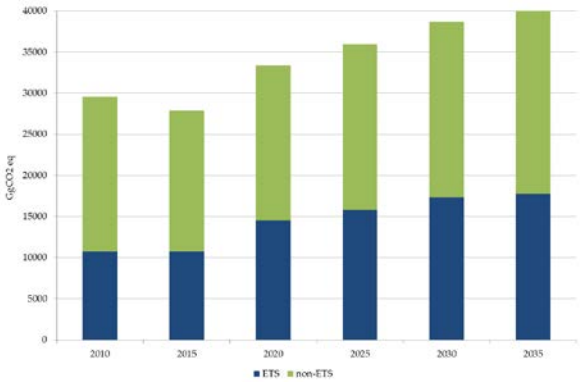
In 2010, emissions outside the ETS amounted to 18,798 GgCO2 eq, which represents 63.6% of total emissions.

In the scenario 'without measures', projections indicate an decrease in emissions in non-ETS sector until 2025 and an increase in emissions until 2035 (18,9% in 2035 compared to 2010).

In the 'with measures' scenario, increase in emissions is expected in the whole observed period from 2015 to 2035, and it is expected that in 2035 the emission will be at the 2010 level.

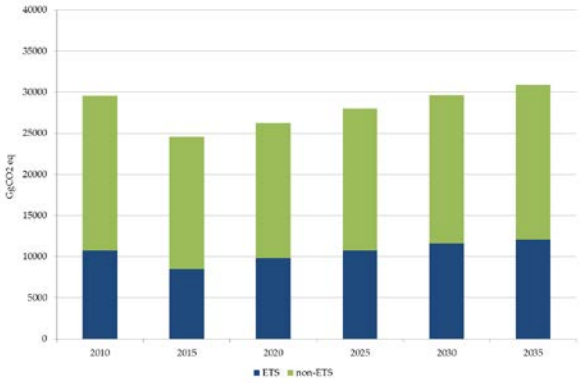
In the 'with additional measures' scenario, further reduction of emissions is expected.

Historical emissions and projections of greenhouse gas emissions in ETS and non-ETS for three scenarios are shown in Figures 2-8 to 2-10.



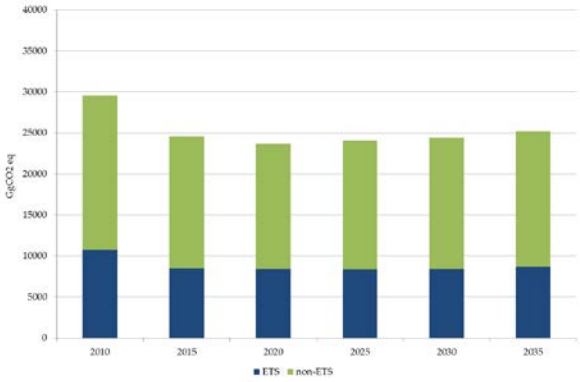
Source: [7.], EKONERG

Figure 2-8: Historical emissions and projections of emissions within ETS and non-ETS, scenario 'without measures'



Source: [7.], EKONERG

Figure 2-9: Historical emissions and projections of emissions within ETS and non-ETS, scenario 'with measures'



Source: [7.], EKONERG

Figure 2-10: Historical emissions and projections of emissions within ETS and non-ETS, scenario 'with additional measures'

III 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 'without measures', 'with 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 projections after 2020 are approximated and without detailed analytical background since the preconditions for economic development and other key parameters for this period are within a wide range of uncertainty.

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 characterized 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).

The preparation of the National Strategy for Low-carbon Development is in progress in Croatia. A range of possible measures and scenarios for achieving this objective will be closely considered in it.

3.1. ENERGY

The projections of greenhouse gas emissions in the energy sector are based on assumptions, objectives, measures and guidelines provided by the Energy Strategy (Official Gazette 130/09).

The Strategy of Energy Sector provided projections for the final energy consumption and gross final energy consumption until 2020, with a view of 2030, for the baseline scenario and additional energy efficiency scenario (Sustainable scenario). The Strategy was based on assumption of stable economic growth of Gross Domestic Product (GDP) of 5% per annum, as a logical result of the trend at that time (2006, 2007 and 2008).

However, the economic and financial crisis resulted in a GDP decrease. Instead of planned GDP growth of 21.5 % in the period from 2009 to 2012, a negative rate of -9.0 % was achieved, which represents the difference of 30.5%. Decrease in industrial production and general social standards reduced the energy demands. Therefore, it was necessary to correct the scenarios of the Strategy of Energy Sector and adapt them to the new situation and plans.

A revised projection of final energy demand was adopted in the National Action Plan for Renewable Energy Sources by 2020, published in 2013. For these projections, the last historic year was 2010, and according to then actual macroeconomic forecasts, GDP growth was predicted from 2013, which affected the growth of energy consumption projections. In reality, there has been a continuation of the economic and financial crisis and there was a decline of GDP in 2013 and 2014. This negative trend was reflected in reduction of energy consumption in the period from 2010 to 2012, which led to significant differences between the actual situation and the one in updated projections from 2013.

For these reasons and because of new EC guidelines on the usage of harmonized basic macroeconomic parameters for all Member States under the Regulation, for the purposes of this report new projections of final energy consumption were made. They take into account recent historical data up to 2012 and projections are based on macroeconomic parameters and EC guidelines for the Member States in accordance with the Regulation.

In the 'without measures' scenario, the emission increases, particularly in the electricity generation sub-sector. The reasons for increase are increased energy demands, reduced dependency on electricity imports and assumption that all new electricity demands in this scenario are being covered by fossil fuel power plants, about 50% coal-fired and 50% gas-fired.

In electricity generation, the renewable energy sources are at the same level as during 2010, with generation mostly from the existing large hydropower plants. After 2015, liquid fuel will no longer be in use for electricity generation. It is also planned that after 2020, Croatia will no longer import electricity, which significantly increases the generation in Croatian power plants since import amounted to 25 - 35%.

Emissions in the industry sub-sector is growing along with economic recovery, but growth is moderate as in other sub-sectors considering a decreasing dependence of energy consumption on GDP growth and assumption that there will be no construction of major new energy-intensive industries.

In the services sub-sector, projections show an increase in the final energy consumption because of the GVA growth of the service sector. As the share of electricity in total energy consumption in the services sub-sector in 2012 was 64% and projections show a continuous trend of increasing the share of electricity in energy instead of fossil fuels in this sub-sector, thus greenhouse gas emissions show only a slight increase. The increase ranges from 2015, with an anticipated economic recovery.

The increase in energy consumption and greenhouse gas emissions by households in the 'without measures' scenario has the greatest influence from increase in living standard and increase of the number of flats, while the emission reduction is affected by trend of population decline and reduction in usage of fuel oil in favour of natural gas, biomass and electricity. In this scenario, the projections show a significant increase in energy consumption for electrical appliances and cooling, a slight increase in energy consumption for heating and stagnation in consumption of energy for cooking, hot water preparation and lighting. The final impact of all factors led to a rise of 1.1% in greenhouse gas emissions in households.

In the sub-sector of energy consumption in agriculture, fisheries and forestry, projections show a reduction in energy intensity and despite the increase in GDP, there is a reduction in energy consumption and greenhouse gas emissions.

The 'with 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. Measures included in the scenario are:

- cogeneration
  - promotion of cogeneration construction,
- renewable energy sources in accordance with the National Renewable Action Plan until 2020 (2013):
  - promotion of the use of renewable energy sources for electricity generation,
  - promotion of the use of renewable energy sources for heat generation,
  - promotion of the use of renewable energy sources and energy efficiency through the Croatian Bank for Reconstruction and Development (CBRD),
  - promotion of the use of renewable energy sources and energy efficiency through the Environmental Protection and Energy Efficiency Fund (EPEEF),
- energy efficiency in accordance with the Third National Action Plan for Energy Efficiency of Croatia for the Period 2014 - 2016 (2014):
  - the application of measures using best available technologies (BAT) for new power,
  - encouraging the use of renewable energy sources and energy efficiency by the Fund for Environmental Protection and Energy Efficiency Fund (the Fund),
  - encouraging the use of renewable energy and energy efficiency through the Croatian Bank for Reconstruction and Development (HBOR),
  - energy efficiency projects with repayment through savings (ESCOs),
  - increase energy efficiency in buildings
  - energy audits in the industry,

  - encouraging energy efficiency in households and the services sector through project activities,
  - labeling the energy efficiency of household appliances,
  - metering and informative billing of energy consumption,
  - Eco-design of energy using products,
- change of fuel shares in final consumption
- revitalization of nuclear power plant Krško/extend lifetime up to 2043.

The 'with additional measures' scenario is based on the application of the above 'with measures' scenario and shows the effect of additional measures that are planned:

- an increase in renewable energy policy after 2020, according to the guidelines and objectives set out in the Energy Development Strategy (Official Gazette 130/09).
- continued support to energy efficiency after 2020, with the same dynamics as to 2020 and increase of support to energy efficiency by introducing the energy efficiency obligations for energy distributors as defined by the Law on Energy Efficiency (Official Gazette 127/14) and the Third National Action Plan for Energy Efficiency [10].

3.2. TRANSPORT

In total final energy consumption, the transport sector accounts for approximately 33% [25.], the largest share of energy consumption is in the road transport with almost 90%. In the area of road transport, about 60% of energy consumption refers to passenger cars and 37% for the light and heavy duty vehicles[1].

The 'without measures' scenario implies a development of final energy consumption in line with market trends and consumers' habits, without government interventions, but assuming the usual application of new, technologically advanced products that over time appear on the market. In this scenario, the increase in energy consumption affects growth in the number of passenger and goods transport, which is caused by increase in GDP based on historical relations. In addition, the increase affects increasing number of vehicles, increased distance travelled per car and fewer passengers per car. A decrease in energy intensity is a result of technological improvements and increased efficiency of cars on the market.

The 'with measures' scenario includes measures to reduce greenhouse gas emissions arising from existing regulations and the transfer of the EU acquis:

- energy efficiency in accordance with the Third National Action Plan for Energy Efficiency of Croatia for the Period 2014 - 2016:
  - introducing the obligation to provide information on fuel economy and CO_2 emissions of new cars,
  - encouraging the replacement or purchase of new energy-efficient vehicles,
  - financial incentives for the purchase of hybrid and electric vehicles,
  - development of infrastructure for electric vehicles in urban areas,
  - development of sustainable transport systems in urban areas,
  - encouraging turnover of vehicles to LPG and CNG,

[1] ODYSSEE database: http://www.indicators.odyssee-mure.eu/energy-efficiency-database.html

  - increasing the efficiency of new vehicles, including a significant proportion of hybrid vehicles,
  - labeling obligation on fuel economy and CO2 emissions of new cars,
- renewable energy sources in accordance with the National Action Plan for Renewable Energy Sources by 2020:
  - obligation to place biofuels on the Croatian market,
  - obligation to purchase or lease vehicles that can use biofuels in public transport and public sector,
  - encouraging the production of biofuels,
- electric vehicles
  - financial incentives for the purchase of hybrid and electric vehicles,

The 'with additional measures' scenario assumes the following measures:

- energy efficiency
  - continued support to energy efficiency after 2020, with the same dynamics as to 2020 by introducing the energy efficiency obligations for energy distributors as defined by the Law on Energy Efficiency (Official Gazette 127/14) and the Third National Action Plan for Energy Efficiency,
- renewable energy sources
  - support for biofuels even after 2020,
- change of vehicle structure and fuel for cars
  - enhancing the attractiveness of rail transport,
  - use of inland waterway transport,
  - encourage the use of bicycles.

3.3. INDUSTRY

Industry sector contributes to total greenhouse gases emission with about 11% in 2012 [7.], of which 94% comes from the key emission sources: production of cement, nitric acid, ammonia and consumption of hydrofluorocarbons in refrigerating and air-conditioning equipment. The solvent use sector, which is observed within the framework of industry sector, contributes to total greenhouse gas emission with about 0,6%.

In the period until 2035, greenhouse gas emission reduction in industrial processes could be achieved by implementing the measures in production of cement and nitric acid and in the solvent use sector.

The 'without measures' scenario assumes that production in industrial processes will reach planned, maximum values until 2035.

The 'with measures' scenario includes implementation of cost-efficient greenhouse gas emission reduction measures in production of cement and nitric acid as well as solvent use. The scenario includes the following measures:

- reducing the clinker factor in cement production,
- N_2O emission reduction in nitric acid production (catalytic decomposition),
- reduction of volatile organic compounds emission in solvent use sector.

The scenario comprises process emission. Emission from fuel combustion is included in the energy sector.

3.4. AGRICULTURE

The agriculture sector in total greenhouse gas emissions has a share of about 12,9% in 2012 [7]. The most important sectoral emissions are emissions of CH_4 with 30% of total emissions and N_2O with 70% of total emissions. Emissions are caused by different agricultural activities. The CH_4 emission source is animal husbandry (enteric fermentation), which accounts for about 83% 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.

The 'without measures' and 'with measures' scenarios assume that there will be an increase in agricultural areas and sustainable consumption of fertilizer.

The 'with measures' scenario assumes implementation of the following measures:

- effective manure management, which includes proper and timely usage of manure and proper storage of manure. It is assumed that this measure can reduce greenhouse gas emissions from agriculture by 15% until 2020 in relation to the 'without measures' scenario.

3.5. WASTE MANAGEMENT

The waste management sector contributes to total greenhouse gas emission with about 4,9% in 2012 [7.], of which 70% comes from the municipal solid waste disposal at landfills, which is the key source of this sector.

In the period until 2035, greenhouse gas emission reduction in waste management could be achieved by implementing the measures, which are defined by the waste management priority order.

The 'without measures' scenario includes projections of greenhouse gas emissions from municipal solid waste disposal, wastewater handling and waste incineration. The scenario assumes a continuous increase of municipal solid waste as a result of higher living standards.

The 'with measures' and 'with additional measures' scenarios include projections of greenhouse gas emissions from municipal solid waste disposal, as in the other two activities measures to reduce greenhouse gas emissions are not planned. The scenarios assume implementation of measures defined by the Law on Sustainable Waste Management (OG 94/13), Waste Management Strategy of the Republic of Croatia (OG 130/05) and Waste Management Plan of the Republic of Croatia for 2007 - 2015 (OG 85/07, 126/10, 31/11):

- 'with measures' scenario:
  - prevention of and reducing the amount of municipal waste,
  - increasing the amount of separately collected and recycled municipal waste,
  - reducing the amount of disposed biodegradable municipal waste,
  - methane flaring,
  - use of biogas to generate electricity and heat,
  - processing of waste for the use in the cement industry.
- 'with additional measures' scenario:
  - thermal processing of municipal waste and sludge from wastewater treatment.

The CH_4 emission reduction could be achieved by applying the prevention of and reducing the quantity of municipal waste, increasing the quantity of separate collected and recycled municipal

waste, decreasing the disposed biodegradable municipal waste and methane flaring. Implementation of other measures included in 'with measures' and 'with additional measures' scenarios contributes to the CO_2 emission reduction, which is included in the energy sector.

3.6. LULUCF

In the LULUCF sector, projections were made according to sectoral categories: 'Forest land', 'Cropland', 'Grassland', 'Wetland', 'Settlements' and 'Other land'. The projections were done for the 'with measures' scenario. The 'without measures' and 'with additional measures' 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), Decision 529/2013 / EC of the European Parliament and of the Council of May 21, 2013 on the rules for calculation of emissions and removals of greenhouse gases arising from activities related to land use, changes in land use and forestry, and information on the measures in respect of those activities. The projections were made based on statistical analysis of the trend of activity data and average implied emission factors for the past ten years, which included measures that were in force in 2009. These measures are prescribed by the Forest management plan of Croatia for the period 2006-2015 for forests and forest land. Based on this document, 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 1.88 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.

IV 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, industry, agriculture, waste management and LULUCF), in accordance with Annex XII of Implementing Regulation.

The 'with 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 package LEAP (eng. Long-range Energy Alternatives Planning System)[2] was used, in which was created a model of the energy sector in Croatia. Output data are structured in accordance with the structure of inventory of the United Nations Framework

[2] More information available at http://www.energycommunity.org/default.asp?action=47

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 by sector – energy and transport

<table>
<tr><td colspan="2">ENERGY</td></tr>
<tr><td colspan="2">The projections of greenhouse gas emissions are based on projections of final energy consumption that have been updated for the purpose of this report. In the sector related to energy transformation, management of energy resources and import and export of energy, processes are simulated using the software package with regard to assumptions and measures envisaged by scenario. Below is a more detailed description of the methodology.</td></tr>
<tr><td>1. Final energy demand</td><td>Final energy demand is projected in different sectors - industry, transport, services, households and agriculture, fisheries and forestry. In the 'without measures' scenario, projections are based on projections of activities that lead to energy consumption and projection of energy intensity for each activity. The bases for projections of activities are macroeconomic parameters and guidelines provided by the EC to Member States to harmonize the key parameters. For the projections of energy intensities, a development of technology and changing of lifestyles was taken into account. The scenarios 'with 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 fuel used
– services – by type of fuel used
– households – by purpose (heating, water heating, cooking, cooling, electrical appliances and lighting) and by type of fuel
– agriculture, fisheries and forestry - by type of fuel</td></tr>
<tr><td></td><td>Demographic trends - assumes a scenario of average fertility and average migration, in accordance with the guidelines of the EC.</td></tr>
</table>

ENERGY	
1.1. 'Without measures' scenario	
1.1.1. Energy demand in industry	Assumptions: – development of industrial production will not be based on energy-intensive industries, – market mechanisms will direct the balanced development to the less energy-intensive industry where Croatia is not in need of resources, – trends in gross value added in industry is based on harmonized parameters for projection given by the EC [21].
1.1.2. Energy demand in transport	Assumptions: – for passenger and freight transport, an increase in passenger and goods transport in the GDP growth in line with the historical relation has been assumed, – existing road infrastructure was mainly built – the transport of passengers will have fastest growth in air traffic.
1.1.3. Energy demand in general consumption	Assumptions: Households: – living area will grow slowly with the recovery of economic activity. Most of the new surfaces will refer to a block of flats in urban areas, – reduction of the share of electricity and liquid fuels for heating, – consumption of electricity to power household appliances and devices for cooling (air conditioning) will grow, – specific energy consumption for cooking in households will stagnate. Services: – change in the structure, used forms of energy – increase of electricity consumption, decrease in the usage of petroleum products and their replacement with natural gas, – on the islands and parts of Croatia not covered with a natural gas grid, the share of liquefied petroleum gas will be increased. Agriculture, forestry and fisheries: – share in final energy consumption will decline, – there will be no increase in energy consumption.
1.2. 'With measures' scenario	
1.2.1. Energy efficiency improvements	Energy efficiency in line with the National Action Plan for Energy Efficiency for the Period 2014-2016: – supporting the use of renewable energy sources and energy efficiency by the Environmental Protection and Energy Efficiency Fund (the Fund), – encouraging the use of renewable energy and energy efficiency through the Croatian Bank for Reconstruction and Development (HBOR), – energy efficiency projects with repayment through savings (ESCOs), – increasing energy efficiency in buildings – energy audits in the industry, – promoting energy efficiency in households and the services sector through project activities,

ENERGY	
	– labelling the energy efficiency of household appliances, – metering and informative billing of energy consumption, – eco-design of energy using products.
1.2.2. Increase of share of renewable energy sources	The goal is to achieve 20% share of renewable energy in final energy consumption by 2020, according to the National Action Plan for renewable energy sources by 2020.
1.3. 'With additional measures' scenario	
1.3.1. Energy efficiency improvements	Continued support to energy efficiency even after 2020, with the same dynamics as to 2020 and an increase of support to energy efficiency by implementing the energy efficiency obligations for energy distributors as defined by the Law on Energy Efficiency (Official Gazette 127/14) and the Third National Action Plan for Energy Efficiency (2014).
1.3.2. Increase of share of renewable energy sources	Increase of renewable energy policy even after 2020, according to the guidelines and objectives set out in Green book for the Croatian Energy Development Strategy (Official Gazette 130/09).
2. Energy transformations and resources	
2.1. 'Without measures' scenario	
	Assumptions: – all electricity needs will be met from domestic sources, starting from 2020, – no new capacity of renewable resources, – all new electricity demands and replacement of old capacity are settled by production from fossil power plants; 50% high-efficiency combined cycle power plants with gas and 50% coal plants so called 'clean coal technology', – emission intensity of new capacity is at the level of the existing one, – Nuclear power plant Krško continues delivering 50% of energy to Croatia and operates up to 2043.
2.2. 'With measures' scenario	
	Assumptions: Energy efficiency in energy transformation and use of resources in accordance with the Third National Action Plan for Energy Efficiency: – supporting the development and increasing the efficiency of cogeneration plants, – supporting the reduction of losses in transmission and distribution of energy. Achieving the goal of 20% share of renewable energy sources in final energy consumption by 2020, in accordance with the National Action Plan for Renewable Energy Sources by 2020.
2.3. 'With additional measures' scenario	
	Assumptions: Continued support to energy efficiency after 2020, with the same dynamics as to 2020 and an increase of support to energy efficiency by implementing the

ENERGY	
	energy efficiency obligations for energy distributors as defined by the Law on Energy Efficiency (Official Gazette 127/14) and the Third National Action Plan for Energy Efficiency. Extension of renewable energy policy after 2020, according to the guidelines and objectives set out in the Green Paper on Strategy for the Energy Development of Croatia (OG 130/09).

Industry

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 production units, 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 calculates CO_2, CH_4, N_2O, HFCs, PFCs 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 by sector – industry

INDUSTRY	
	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 2012 (annual growth rate of gross domestic product and gross value added and decrease in population) and the results of sector analysis and studies (cement and nitric acid production). Assumptions for 'without 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 "real scenario", in 2020, the achievement of level of the volume of industrial production in 2008 is assumed, when the highest level of development of the Croatian economy is reached.

	Assumptions for 'with measures' scenario: – the application of cost-effective measures in the cement and nitric acid production, – reduction of volatile organic compounds emission in solvent use sector. 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 management

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 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 management

WASTE MANAGEMENT	
	The projections were carried out based on expected development and future state of the parameters for projections (amount of waste produced, organic fraction of municipal solid waste, amount of waste disposed at landfills). Emission projections start from the situation and projections of macroeconomic parameters in 2012 (annual growth rate of gross domestic product and gross value added and decrease in population), which includes the goals by 2035. The objectives are defined by sector strategic documents - Strategy and Plan of the Waste Management in the Republic of Croatia and the Law on Sustainable Waste Management. Assumptions for 'without measures' scenario: – included projections for solid waste disposal on land, wastewater handling and waste incineration, – continuous growth of the quantity of municipal solid waste is expected as a result of higher living standard. Assumptions for 'with measures' and 'with additional measures' scenarios: – included projections for solid waste disposal on land, – continuous growth of the quantity of municipal solid waste will be slowed down due to application of the measures defined in the strategic documents, – quantitative targets for the amount and composition of municipal waste and other parameters in the model for estimating CH_4 emissions from landfills, which are not defined by the strategic documents, are estimated by expert judgment.

	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 measures' scenario, for all sectoral components, the Projections Guide (A: General Guidelines and B: Sectoral Guide, [23]) was used. Six sub-categories of this sector in the Report of the National Inventory of Croatia for 2014 have been recognized as the key ones, whether the trend or level. These are: 'Forest land remaining forest land', 'The land converted to forest land', 'Cropland remaining cropland',' The land converted to Cropland', 'Land converted to Grassland' and 'Land converted to Settlements'. 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 20-year basis and average superior implied emission factor for the past 10 years for each sink (ground and underground biomass and soil). Alternative 1 was used, whereat the activity data for the period from 2013 to 2035, in this case the size of the sub-categories of land, were received using the average annual rates of change from the chain indices within the past ten years, from 2003 to 2012. In cases where the average annual rate of change had unrealistic extreme values, the arithmetic mean of information on specific activity for the past ten years ('Land converted to Grassland') was used, i.e. expert assessment to predict the annual volume of reforestation ("Land converted to forest land').

Assumptions and input parameters used in the preparation of projections are presented 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 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 same annual level (1.88 kha / year) – There will be a decrease in areas of 'Cropland' and 'Grassland'.

4.2. PARAMETERS ON PROJECTIONS

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

Parameter		2012	2015	2020	2025	2030	2035
GDP – annual growth rate	%	-2.2	0.2	1.9	1.9	1.7	1.7
Population	million people	4.268	4.245	4.199	4.145	4.087	4.024
Coal prices	Euro/GJ	2.5	2.3	3.5	3.7	3.7	3.9
Oil prices (1% S)	Euro/GJ	9.3	11.9	13,7	13.8	14.4	14.8
Gas prices	Euro/GJ	5.9	7.7	9.5	9.1	10	10.2

Source: [16.], [19.], [28.]

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

Parameter		2012	2015	2020	2025	2030	2035
Total energy consumption							
Coal	PJ	28.4	24.1	40.7	45.7	48.7	42.1
Oil	PJ	134.2	106.5	110.0	116.7	123.8	129.6
Gas	PJ	101.8	105.9	96.0	104.2	112.7	133.0
Renewable	PJ	51.2	54.1	63.8	64.1	64.5	64.1
Total electricity generation							
Coal	TWh	NE	NE	NE	NE	NE	NE
Oil	TWh	NE	NE	NE	NE	NE	NE
Gas	TWh	NE	NE	NE	NE	NE	NE
Renewable	TWh	NE	NE	NE	NE	NE	NE
Electricity imports	TWh	7,60	5,80	2.78	2.78	2.78	2.78

Source: [9], [10.], EKONERG

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

Parameter		2012	2015	2020	2025	2030	2035
Final energy consumption							
Industry	PJ	41.56	40.41	41.13	41.99	42.49	42.78
Transport	PJ	84.02	81.59	86.42	93.01	99.54	105.82
Households	PJ	77.11	76.13	74.90	76.91	78.93	81.01
Agriculture, forestry and fisheries	PJ	9.61	8.94	8.80	8.74	8.63	8.55
Services	PJ	30.09	25.69	29.20	33.87	35.45	35.45

Source: [9], [10], EKONERG

Table 4-9: Parameters on projections – weather parameters

Parameter	
Heating degree days	2,226
Number of days of heating	167
Cooling degree days	NE

Source: [16.]

Table 4-10: Parameters on projections – industry

Parameter		1990	2010	2015	2020	2025	2030	2035
Production index for industry*								
Cement industry	%	2,642,764 t	5	-12	-2	7	15	21
Nitric acid industry	%	332,460 t	1	-11	-2	7	16	22
CO_2 and N_2O emissions**								
Solvent use	%	117 Gg CO_2 eq	29	34	42	53	62	72

*,** the percentage change in relation to 1990

Source: Manufacturers of cement and nitric acid, [7], [19], [21]

Table 4-11: Parameters on projections – transport

Parameter		2012	2015	2020	2025	2030	2035
Number of passenger kilometres, land transport	10^9 pkm	31.21	31.39	32.94	35.31	37.68	39.78
Transport of goods	10^9 tkm	136.66	136.09	140.25	145.19	150.20	155.36
Energy consumption in road transport	PJ	74,30	72.99	77.48	83.65	89.78	95.65

Source: [16]

Table 4-12: Parameters on projections – agriculture

Parameter		1990	2010	2015	2020	2025	2030	2035
Livestock numbers								
Dairy cattle	1000 heads	488	209	150	180	195	210	225
Non-dairy cattle	1000 heads	370	262	230	280	305	330	355
Sheep	1000 heads	751	629	650	690	700	710	720
Goats	1000 heads	172	75	65	80	88	95	103
Horses	1000 heads	39	21	20	22	23	24	25
Mules/asses	1000 heads	17	4	4	5	5	5	5
Swine	1000 heads	1573	1231	850	1200	1288	1375	1463
Poultry	1000 heads	17102	9469	9900	10290	10485	10680	10875
Production of crops								
Wheat	t	1,602,435	681,017	864,865	879,847	1,002,001	1,042,030	1,178,645
Maize	t	1,950,011	2,067,815	2,551,245	2,187,640	2,205,554	2,239,040	2,256,114
Potatoes	t	610,236	178,611	313,056	203,239	160,630	132,738	104,879
Sugar beets	t	1,205,928	1,249,151	1,847,208	1,428,948	1,408,317	1,471,355	1,497,069
Tobacco	t	12,394	8,491	14,166	11,766	12,041	12,794	13,712
Sunflowers	t	52,982	61,789	112,321	92,333	109,745	114,592	129,556
Rape seed	t	33,200	33,047	79,103	70,866	70,933	90,782	99,821
Tomatoes	t	54,742	33,648	44,265	44,884	41,278	50,494	53,804
Barley	t	196,554	172,359	280,698	228,296	243,098	250,955	278,746
Oats	t	62,287	48,190	57,647	61,295	76,089	74,009	82,453
Cabbages and other brassicas	t	135,637	45,654	80,057	61,109	57,412	63,091	63,099
Garlic	t	11,830	3,659	6,359	4,912	4,534	5,288	5,757
Onions	t	40,309	26,704	38,380	33,438	33,475	40,069	44,763
Rye	t	15,840	2,507	381	0	0	0	0
Sorghum	t	2,185	1,000	1,298	1,554	1,891	2,357	2,761
Watermelons	t	20,938	23,313	42,913	32,599	31,346	33,683	35,274

Soybeans	t	55,461	153,580	141,488	153,926	174,867	185,521	190,140
Beans, dry	t	18,437	1,641	1,110	0	0	0	0
Cabbages and other brassicas	t	1,790	1,197	1,374	2,210	3,050	3,903	4,708
Lentils	t	219	29	38	13	0	0	0
Peas, dry	t	535	340	908	356	98	0	0
Vetches	t	1,888	1,838	2,239	1,923	1,585	1,512	1,462
Clover	t	225,466	119,968	170,218	147,241	143,473	148,600	157,171
Alfalfa	t	252,563	177,652	228,802	226,824	247,731	283,849	317,840
Mineral fertilizers								
Applying nitrogen	kg	107,413,402	99,526,430	107,868,673	114,578,604	114,578,604	114,578,604	114,578,604

Source: [16], [17], [23], [6], [7]

Table 4-13: Parameters on projections – waste management

Parameter		1990	2010	2015	2020	2025	2030	2035
Waste generation per head of population	t/ per cap	0.209	0.380	0.394	0.412	0.437	0.459	0.479
Organic fraction of municipal solid waste ('without measures' scenario)	%	67	68	68	68	68	68	68
Organic fraction of municipal solid waste ('with measures' scenario)	%	67	65	52	24	24	24	24
Municipal solid waste disposed to landfills ('without measures' scenario)	t	590,000	1,587,291	1,622,462	1,679,246	1,756,190	1,819,879	1,868,715
Municipal solid waste disposed to landfills ('with measures' scenario)	t	590,000	1,587,291	1,137,800	1,004,441	815,016	797,653	770,878

Source: [7], [13], [14], [18], [19], [22]

Table 4-14: Parameters on projections – LULUCF

Parameter	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035
⇒ **Area in kha**										
Forest land	**2,302.47**	**2,303.57**	**2,304.51**	**2,307.65**	**2,323.64**	**2,343.29**	**2,358.38**	**2,373.58**	**2,388.87**	**2,404.27**
Forest land remaining Forest land	2,298.93	2,299.80	2,300.35	2,299.89	2,298.69	2,304.66	2,311.66	2,321.96	2,345.76	2,366.57
Land converted to Forest land	3.54	3.78	4.16	7.76	24.94	38.62	46.73	51.62	43.11	37.70
Cropland	1,623.77	1,595.62	1,591.81	1,570.14	1,548.47	1,527.04	1,505.99	1,485.24	1,464.77	1,444.58
Cropland remaining Cropland	1,616.44	1,589.61	1,587.11	1,561.53	1,535.06	1,509.09	1,482.08	1,460.31	1,439.41	1,416.89
Land converted to Cropland	7.33	6.01	4.70	8.61	13.42	17.95	23.91	24.93	25.36	27.69
Grassland	**1,210.53**	**1,221.12**	**1,231.71**	**1,225.52**	**1,219.32**	**1,213.15**	**1,207.03**	**1,200.93**	**1,194.86**	**1,188.83**
Grassland remaining Grassland	1,179.49	1,184.61	1,188.36	1,180.42	1,157.71	1,143.48	1,130.73	1,112.91	1,108.25	1,102.26
Land converted to Grassland	31.03	36.50	43.35	45.10	61.62	69.67	76.29	88.02	86.61	86.56
Wetland	**72.32**	**73.27**	**74.21**	**74.28**	**74.34**	**74.41**	**74.48**	**74.54**	**74.61**	**74.67**
Wetland remaining Wetland	70.06	70.06	70.06	71.19	72.32	73.28	74.23	74.29	74.36	74.41
Land converted to Wetland	2.26	3.21	4.16	3.09	2.02	1.13	0.25	0.25	0.25	0.26
Settlements	**212.98**	**218.54**	**224.11**	**237.40**	**250.70**	**264.58**	**279.50**	**295.25**	**311.89**	**329.47**
Settlements remaining Settlements	190.89	197.72	203.43	209.14	214.09	221.79	228.97	244.72	261.37	276.29
Land converted to Settlements	22.09	20.83	20.68	28.26	36.61	42.79	50.53	50.53	50.53	53.19
Other land	**237.34**	**247.28**	**233.05**	**244.41**	**242.92**	**236.93**	**234.02**	**229.86**	**224.39**	**217.58**
Other land remaining Other land	237.34	247.28	233.05	244.41	242.92	236.93	234.02	229.86	224.39	217.58
Land converted to Other land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CROATIA Total	5,659.40	5,659.40	5,659.40	5,659.40	5,659.40	5,659.40	5,659.40	5,659.40	5,659.40	5,659.40

Table 4-15: Parameters on projections – LULUCF - continued

Parametar	Biomass	Soil
⇒ ***Average 10-year Implied emission factor (Mg C/ha)***		
Forest land	**1.023**	**0.005**
Forest land remaining Forest land	1.026	NO
Land converted to Forest land	0.657	0.713
Cropland	**-0.004**	**-0.008**
Cropland remaining Cropland	-0.005	0.000
Land converted to Cropland	0.230	-1.081
Grassland	**-0.023**	**0.048**
Grassland remaining Grassland	NO	NO
Land converted to Grassland	-0.516	1.097
Wetland	**-0.002**	**-0.086**
Wetland remaining Wetland	NE	NE
Land converted to Wetland	-0.062	-2.474
Settlements	**-0.103**	**-0.390**
Settlements remaining Settlements	NE	NE
Land converted to Settlements	-0.791	-2.952
Other land	**NO**	**NO**
Other land remaining Other land	NO	NO
Land converted to Other land	NO	NO

Source: [7.]

V 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,
- Volume of imports / exports,
- Variability due to electricity generation from hydropower plants.

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 tCO2 / MWh, tN2O / 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 period of war, transition to a market economy and economic crisis are powerful factors that prevent reliable correlation of emissions with historical data. It is assumed that energy consumption will grow along with the GDP, but the correlation of GDP and energy consumption will be reduced.

The impact of changes in the GDP growth rate on overall projections for 'with measures' scenario is analysed below.

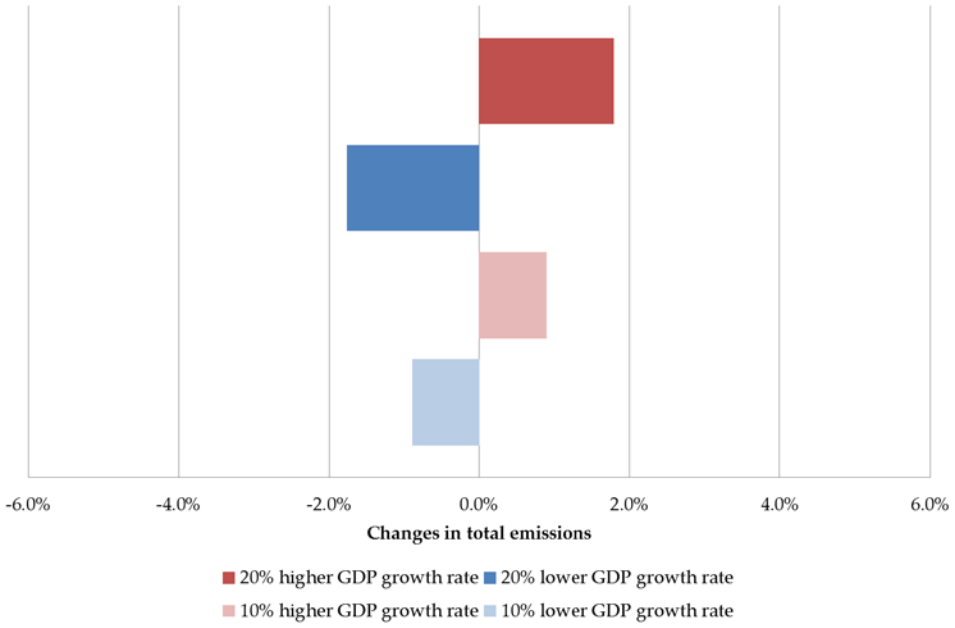
Four cases of changes in the GDP growth rate compared to the baseline scenario were analysed, as follows:

- Increase in the GDP growth rate by 10%,
- Decrease in the GDP growth rate by 10%,
- Increase in the GDP growth rate by 20%,
- Decrease in the GDP growth rate by 20%.

In Table 5-1 the parameters used for the sensitivity analysis are shown.

Table 5-1: Parameters used for the sensitivity analysis

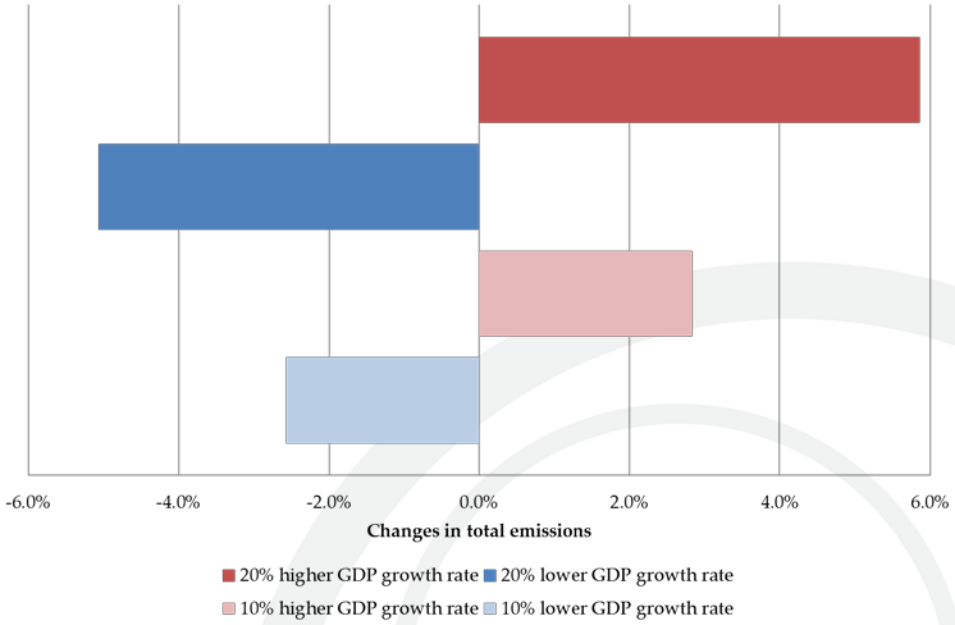
Parameter		2012	2015	2020	2025	2030	2035
GDP – annual growth rate, the base case	%	-2.2	0.2	1.9	1.9	1.7	1.7
GDP – annual growth rate, 10% higher	%	-2.2	0.2	2.1	2.1	1.9	1.9
GDP – annual growth rate, 10% lower	%	-2.2	0.2	1.7	1.7	1.4	1.4
GDP – annual growth rate, 20% higher	%	-2.2	0.2	2.3	2.0	2.0	2.0
GDP – annual growth rate, 20% lower	%	-2.2	0.2	1.5	1.5	1.4	1.4



Source: EKONERG

Figure 5-1: Sensitivity analysis – impact of changes in GDP growth rate on total GHG emissions, 'with measures' scenario in 2020

The results of analysis for 2030 are shown in Figure 5-2.



Source: EKONERG

Figure 5-2: Sensitivity analysis – impact of changes in GDP growth rate on total GHG emissions, 'with measures' scenario in 2030

Sensitivity analysis showed that in case of 10% lower annual GDP growth rate, emissions in 2020 in the 'with measures' scenario were by 0.9% lower, while in 2030 by 2.6% lower than calculated in the basic 'with measures' scenario. In case of a 10% higher annual GDP growth rate , emissions in 2020 in the 'with measures' scenario were by 0.9% higher, while in 2030 by 2.8% higher than calculated in the earlier shown basic 'with measures' scenario.

In case of 20% lower annual GDP growth rate, emissions in 2020 in the 'with measures' scenario were by 1.8% lower, while in 2030 by 5.1% lower than calculated in the basic 'with measures' scenario. In case of 20% higher annual GDP growth rate , emissions in 2020 in the 'with measures' scenario

were by 1.8% higher, while in 2030 by 5.9% higher than those calculated in the basic 'with measures' scenario.

Imports and exports, mainly related to electricity, but can be important for other activities as well, for example the production of petroleum products, construction materials and, over a period of several years, agriculture. The higher imports, the lower own generation and the lower are emissions. Imports depend on market prices, demand and opportunities of own generation, and in a short term may be a result of unplanned shift in economic policy. For instance, the import of electricity in Croatia has an increasing trend, with very expressed annual fluctuations. During the last five years, imports accounted for over 30% of total electrical energy. Import of electricity partly cancels the impact of electricity generation from hydropower. The Energy Strategy sets a target of reducing electricity imports, since 2020, it is assumed that all needs will be covered by sources from the Croatian territory and Nuclear Power Plant Krško.

Variability due to electricity generation from hydropower plants. Croatia is among the countries which emissions significantly depend on generation from hydropower. Generation from hydropower can vary from 4.4 TWh to 6.5 TWh, sometimes even more, up to 8 TWh. These variations result in increased generation from thermal power plants, usually the difference covers generation from thermal power plants with fuel oil. Emissions due to this influence can vary ± 1.5 MtCO2 eq, which is almost 10% of total emissions. Deviations from the average may last for several years, in cases of dry periods or wet periods. Projections are made with normalized hydropower generation, with fifteen years of average.

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