Chapter 12

Reducing Emissions in Croatia - the Costs of Mitigation

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Chapter 12 Summary

Reducing Emissions in Croatia – the Costs of Mitigation

In order to avoid dangerous climate change resulting from an increase in temperature of over 2ºC, global GHG emissions must be cut by 50-85% by 2050. Croatia's trajectory for emissions growth in the Business as Usual (BAU) case is estimated to result in 42 million tonnes of CO_2e in 2020 – a significant increase from today. The EU has committed to reducing emissions by 20% by 2020. Croatia has committed to reducing emissions by an average of 5% for the period 2008-2012 from a baseline level of 36 million tonnes under the Kyoto Protocol. Croatia will also share at least part of the EU commitment for 2020, especially with respect to emissions from major point sources such as power plants and industrial sources.

The energy sector is the largest source of GHG emissions in Croatia (73% in 2006). There are many potential measures to reduce emissions from the energy sector by 2020. It is estimated that by implementing the measures in the Energy Efficiency Master Plan, 1% of the national GDP could be saved. Emission reductions from households and the service industry could amount to almost 2 million tonnes by 2020 with a net economic benefit from energy cost savings. Industrial efficiency measures could also have a positive financial impact on companies. Producing electricity from renewable resources, increasing the efficiency of conversion and transmission, and – more controversially – moving to more nuclear power and electricity generated from burning waste, could yield significantly fewer emissions. Reducing fuel consumption in transportation through fuel-efficient vehicles, lower-carbon fuels, using biodiesel or other biofuels, or reducing car travel through better urban planning, public transportation, and traffic systems are also potential areas where emissions can be cut.

The agricultural sector accounts for almost 11% of Croatian emission (2006). Agriculture can play a role in reducing direct emissions from agricultural soils and improved livestock and manure management. Agriculture also has an indirect impact on emissions due to fertiliser production and emissions from transport. Finally, agriculture can have an impact on mitigation due to land use, land use changes and forestry (LULUCF) activities related to converting arable land to grassland or forests, converting drained arable land back to wetlands, or increasing soil in carbon storage management practices.

Industrial processes were responsible for approximately 13% of Croatia's emissions in 2006. Within the industrial processes sector, cement-related emissions reductions can be achieved using measures, such as increasing the amount of clinker in cement to EU standards and through indirect measures, such as incinerating waste materials for energy and building concrete rather than asphalt roadways. Additionally, changing the industrial process for manufacturing nitric acid can also lead to significant reductions. Reducing the emissions from fertilizer and lime production may also be an option, but no information is available on the potential savings in Croatia.

The waste management sector was responsible for a little under 2% of total emissions in 2006. Emissions can be reduced in the sector by utilising landfill methane as a source of energy/ electricity.

LULUCF measures in Croatia also present significant possibilities for reducing net emissions. In 2006, land use changes amounted to an estimated net reduction of 7.5 million tonnes – almost a quarter of Croatia's emissions. However, only approximately 1 million of this can be counted in international negotiations. Further, carbon sequestration in soils due to agricultural practices could have significant impacts, both on soil quality and on the net emissions from Croatia.

According to this chapter's estimate, if all measures are fully and successfully introduced – excluding reductions from land use changes – Croatia could theoretically achieve a 30% cut in emissions by 2020, from the baseline of 36 million tonnes per year. The economic costs of achieving this reduction in 2020 are estimated to be EUR 115-536 million in that year. While this calculation needs further analysis, it shows major reductions are possible with relatively moderate economic costs, given the likely future price of carbon. However, while potential does exist and seems achievable at a relatively low cost, there are many political, institutional, technical, and other considerations that would have to be resolved to reach these reduction levels.

12.1. Introduction

As shown in Section 2, Croatia may face serious consequences from climate change that will affect individual economic sectors and human development as a whole. Croatia will also be required to reduce its emissions of greenhouse gases. In order to avoid dangerous climate change – an increase of more than 2ºC – world experts believe that the CO_2e[I] concentrations

[I] CO_2e is an abbreviation for carbon dioxide equivalent, which includes both CO_2 and other greenhouse gases (by reflecting the relative impact that the other gases have on global warming compared to CO_2). All gases have been expressed in terms of CO_2e for this chapter for the sake of simplicity and to reflect international practice.

[II] The OECD is the Organisation for Economic Cooperation and Development and represents 30 of the largest economies of the world that comprise over 60% of global GDP. See www.oecd.org.

Figure12-1: Windmills on the island of Pag.

Source: Josip Portada.

Box 12-1: Croatia's emissions in comparison to other countries and obligations upon entering the EU

Croatia is somewhere in between the "developed" and "developing" classification in terms of emissions. OECD countries[II] – which can be described as "developed countries" – had an average emissions level of 11.4 tonnes per person in 2005 (10.8 tonnes/ person in 1990).[4] In contrast, developing countries had emissions rates of 2.4 tonnes per person in 2005 (1.7 tonnes/ person in 1990).[5] With a population of 4.44 million people,[6] Croatia emitted 6.94 tonnes per person in 2006 – not including land use changes. When land use changes are considered, Croatia was responsible for 5.26 tonnes per person in 2006 because of the growth of forests.[7] In order to avoid dangerous climate change, Croatia, along with the rest of the world, will have to be a part of the solution. Without a successful global effort to drastically reduce emissions, Croatia and the world will face more severe consequences.

Croatia's obligation once it enters the EU is not yet known. It will probably constitute part of the final accession negotiation. The EU has a new burden sharing methodology for reaching the 20% reduction target collectively. This imposes different individual targets for EU countries, taking into account the economic strength of the country. For sources of GHGs not covered by the European Trading Scheme (ETS) the range of obligation in the EU is +20% to -20% - i.e. some countries will be allowed to increase emissions up to 20% and some will be required to cut emissions by as much as 20%. Croatia will be allowed to increase its GHG emissions in the non-ETS sector by 15-17%, compared to 2005.

In the EU-ETS sector mostly major emitters at one location (such as power plants, oil refineries, etc.) there will be a single EU-wide cap instead of different caps for each member state. In total, a 21% reduction compared to 2005 emissions will be required in the ETS sector. The basic principle for allocation will be auctioning, which will be open to all member states equally. The power sector will have to buy all allocations to emit GHGs through an auction process and industry sources will have some free allocations. Exceptions, possibly higher levels (up to 100%) of free allocation to industries particularly vulnerable to international competition ('carbon leakage') will be determined in 2010.

in the atmosphere must not exceed 450 parts per million (ppm). Currently, the levels are at 380 ppm and rising by 1.9 ppm per year. Pre-industrial levels were approximately 275 ppm.[1]

The IPCC states that, in order to accomplish this, by 2050, global emissions must be cut by 50%-85%. Because of population growth, this will mean that emissions throughout the world must be cut to a maximum of 2 tonnes per person.[2] The Stern analysis, along with the most recent global HDR,[3] outlines two different paths for countries striving to reach this goal. The first path would be taken by "developed countries" – required to reduce emissions by 25-40% by 2020 and by 80% by 2050. The European Union has already committed to reducing emissions by 20% by 2020, but is ready to increase this reduction to 30% if other industrial countries will agree to cut their emissions.

Croatia has already begun the process of reducing emissions – having committed to reducing emissions by 5% compared to 1990 levels by 2012 under the Kyoto Protocol. In 1990 Croatian emissions were 32.527 million tonnes of CO_2e.[8] However, because much of its electricity was imported from other parts of the former Yugoslavia, these were very low emissions rates that did not allow for economic growth. Croatia has therefore negotiated that the base-year level be set at 36.027 million tonnes of CO_2e – 3.5 million tonnes more than the actual levels.[9] This means that Croatia has a target of 34.225 million tonnes for 2012, not including land-use changes.

Croatia's GHG emissions in 2006 (the last year for which data is available) amounted to 30.834 million tonnes CO_2e, (a 14.4% reduction compared to the agreed-upon baseline value under the Kyoto Protocol and a 5.2% reduction in emissions in comparison to actual 1990 emission levels). This number does not include the amount of GHG emissions removed by carbon sinks – mostly increasing forest biomass. For the last five years the average increase in GHG emissions has been 1.7 % per year, the main reason for this being the increase of emissions from the energy sector.[10]

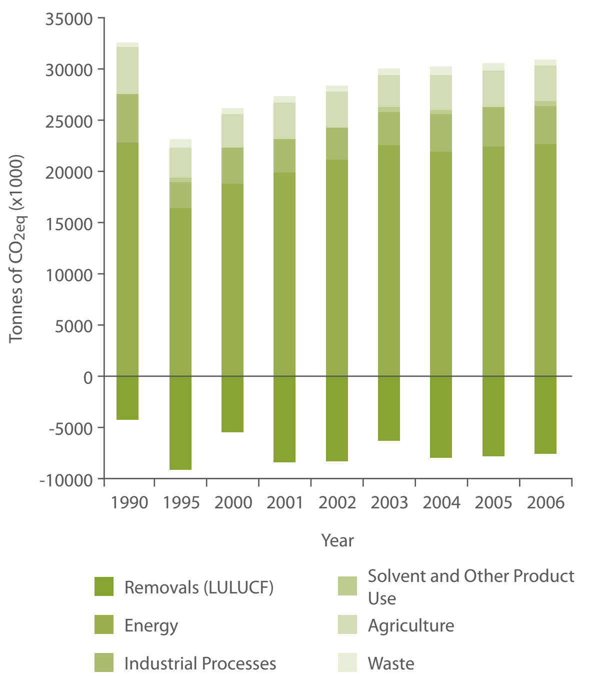
While many different aspects affect Croatia's emissions, the primary sectors are:

- The energy sector (73.13% of 2006 emissions) – including transportation, production of electricity, manufacturing and industry energy production, and fugitive emissions from oil/ natural gas/ coal production.
- The agricultural sector (11.37% of 2006 emissions) – including from livestock, manure management and soil management.
- Industrial processes (12.99% of 2006 emissions) – including mostly cement production, lime production, ammonia production, nitric acid production and consumption of chemicals that are potent GHGs in refrigeration and air conditioning equipment.
- Emissions from waste sites (1.92% of 2006 emissions) – mostly methane gas released from landfills.[III]
- Land use changes (-24.29% of 2006 emissions) – creation of carbon sinks due to the expansion of forests.

However, this is the current situation. In analysing what Croatia can do to reduce emissions by 2020, it is necessary to have a basic idea of what could happen if no steps are taken to reduce emissions – the BAU scenario. Under this scenario, the MEPPPC estimates that emission levels (not counting changes in land use and sinks from forests) would reach approximately 42 million tonnes of CO_2e by 2020 – an increase of 16.6% from the agreed upon 1990 baseline of 36 million tonnes.[11]

[III] These four sectors that emit GHGs represented over 99% of all emissions in Croatia in 2006.

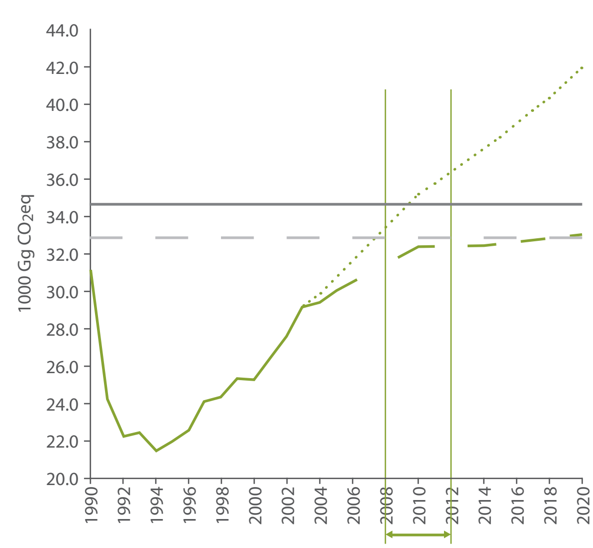
Figure 12-2: GHG emissions from various sectors in Croatia.



Source: MEPPPC 2008b.

Figure 12-3: Likely emissions scenario for Croatia until 2020 – 2008 to 2012 is the period for the Kyoto Protocol.

The dotted line represents the current projections of emmissions under BAU scenario. The dark striped line represents the projections of emmissions if Croatia introduces measures to reduce emmissions and stabilise them by 2020.



Source: MEPPPC 2007: 73.

There are many measures that can be introduced to reduce emissions, and the latest National Communication on Climate Change suggests that emissions can be stabilized by 2020.[12] No estimates are given within this document for how much this stabilization would cost Croatia. Furthermore, no estimate is given for the maximum amount of emissions reductions that would be possible, if the best-case scenario occurred and all reduction measures were introduced successfully.

In order to analyse the economic impacts of mitigation measures, this chapter uses the available information on the likely costs of various emissions reductions in Croatia. Most of this analysis was undertaken using research carried out under the LIFE-funded project, which analysed the marginal costs for various measures to reduce emissions in various sectors.[13] The costs per tonne of reduction represented are derived mostly from Ekonerg's analysis of marginal costs for 2012. Although these costs are likely to change for 2020, this chapter uses those costs to provide a general range of reduction costs, rather than a definitive number (See Box 12-2 for more on the methodology of calculating costs). It is important to note at the outset that for certain measures, there may be other economic benefits from participating in the European Trading Scheme (ETS), which has an average value of EUR 25 per tonne of carbon. There are also other international voluntary schemes where financial resources may be made available for mitigation measures. This would mean that any measure with a marginal cost of less than EUR 25 per tonne of reduction might actually be profitable for actors that implement them if they can sell the credits on the market.

The purpose of this chapter is to give a basic outline of the types of measures that could be introduced to reduce net emissions, how many net emissions could be reduced by 2020 under a "best case scenario," and what the general range of costs for those emissions reductions would be. No single number can answer the question – how much would it cost Croatia to reduce its emissions by 20-30% by 2020. However, this chapter provides suggestions for moving forward that would not overly burden the economy and restrict human development.

Box 12-2: Methodology for calculating emissions reduction potentials and costs

To calculate the likely costs/ benefits of reducing emissions, this analysis focused solely on 2020. The basic concept is to take how much CO_2e can be reduced by a certain measure in that year. Then multiply the total potential reduction by the cost of reduction per tonne of emissions (marginal cost of reduction of CO_2e). If the measure actually has a net benefit – i.e. it is cheaper than carrying out a process that emits more carbon – then the marginal cost of reduction is negative. Energy efficiency measures are a good example of this. Owning a fuel-efficient car or using compact fluorescent light-bulbs (CFLs) saves money over a short time span. On the other hand, if a measure costs extra money – such as replacing coal fired power plants with solar photovoltaic cells – the measure has a positive marginal cost for reduction of CO_2e.

Most of the numbers for potential emissions reductions were taken from Ekonerg's series of top-down models and studies for the LIFE project in 2006 and 2007. In some areas the potential of the reduction measures were only available for either 2015 or 2012. The annual marginal costs of reduction for most measures were calculated in the Ekonerg studies utilizing capital costs, operational costs, and a discount rate of 4%. In those cases, the reduction potentials from previous years were assumed to be the same for 2020 – though they may be larger.

The costs associated with these measures should be considered as rough estimates only. This is because the initial model was based on a timeframe until 2012, whereas this analysis is looking at 2020. Additionally, these estimates did not include the administrative and institutional costs associated with implementation – which may be large in the households and services sector. Because of this and other uncertainties in cost, this analysis took the estimated values plus/ minus EUR 10 per tonne. In certain cases where the initial capital costs would be significant, the timeframe for overall use, once the measure becomes operational, would be more important (such as solar, wind, and nuclear energy production), estimates were taken from the IPCC's most recent assessment of likely costs of mitigation for economies in transition.[14] For the agricultural sector an independent analysis was carried out for the purposes of this Report.

While exact numbers have been calculated for most measures, it is better to provide a range of potential values that reflect the uncertainty of costs – grouping them in terms of whether the measures might have a net economic gain, be close to cost neutral, be economically advantageous in the case of a cost of EUR 25 per tonne, or be more expensive.

All costs are listed in terms of current value, as calculating inflation and Euro or Croatian Kuna values in 2020 is complex and superfluous to the core message of this chapter.

12.2. Reducing emissions due to energy use

The energy sector is the largest source of GHG emissions in Croatia – covering emissions from all activities, including fossil fuel consumption and fugitive emissions from fossil fuel production, transport, processing, storage and distribution (See Figure 12-4).

Energy consumption in general is rising in Croatia, though in 2006 total energy consumption was slightly lower than in 2005. Within the energy sector, there are many important, new developments. First, energy efficiency can potentially play a vital role in Croatian energy policy. One of the goals of energy policy in the Republic of Croatia, defined in the Strategy of Energy Sector Development[15] is to improve the overall efficiency of energy production, central transformation/ conversion, transmission/ transport, as well as energy consumption. However, as no implementation strategy for energy efficiency currently exists, energy savings and improved energy efficiency have not yet been achieved. Consequently, the total primary energy consumption intensity (energy used per Euro of GDP) in Croatia is 20.1% higher than the EU-15 average.[16] This is a burden to both the national economy and physical environment. It is estimated that approximately 1% of national GDP is wasted as a result of low energy efficiency. [17]

As part of the EU accession process, Croatia is swiftly moving forward with its energy efficiency and renewable energy plans. According to the EU Directive,[IV] member states must adopt and aim to achieve an overall national energy savings of 9% in the ninth year of application of the Directive. The Croatian national target is calculated based on the average consumption of energy for 2001-2005. Therefore, Croatia must immediately begin to move forward with energy efficiency measures (See Chapter 13 for more on energy efficiency activities in Croatia).

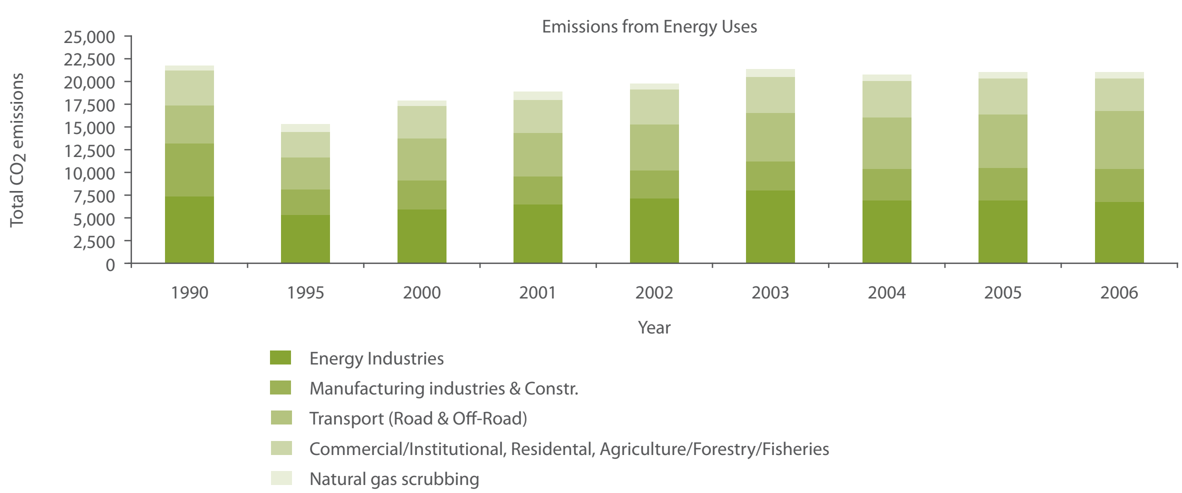
Furthermore, Croatia has committed to producing at least 5.8% of all its electricity from renewable energy sources other than major hydropower plants, by the end of 2010.[18] This begins to put Croatia on the path towards efficiency and greener energy. Croatia's new energy strategy will identify numerous goals for renewable energy production in order to meet predicted 2020 energy requirements. However, at the time of drafting this Report, this strategy had not been finalised. Emissions by energy sub-sectors are presented in Figure 12-4. Many potential measures exist to reduce emissions from the energy sector, which can be divided into the following categories: electricity production, energy use for industrial use, energy used by households and the service sector, and energy used for transport.

[IV] Directive 2006/32/EC on energy end-use efficiency and energy services.

"The energy sector is the largest source of GHG emissions in Croatia

It is estimated that approximately 1% of national GDP is wasted as a result of low energy efficiency"

Figure 12-4: CO_2 emission by sub-sectors from the energy sector in the period 1990-2006 (x 1000 tonnes CO_2)



12.2.1. Measures in reducing emissions from electricity production

Electricity production generates GHG emissions through the burning of fossil fuels. The consumption of energy from electric and heat power production in thermal power plants, public heating plants and public cogeneration plants resulted in approximately one fifth of all emissions in Croatia in 2006. The basic ways to reduce emissions from production are to change the fuel, which drives electricity production, or to increase the efficiency of the production system. Changing the fuel involves shifting some electricity production to sources that do not emit GHGs (such as nuclear fuel), emit less GHGs (such as natural gas), or renewable sources (such as biomass that does not involve cutting down trees, solar electricity, wind energy, etc.). Reductions due to decreased demand are also possible and discussed in section 12.2.2 and 12.2.4. The list of potential emissions reduction measures, their potential for GHG emissions by 2020 and the associated costs per tonne of reduction are listed in Table 12-1. As can be seen, numerous measures can be taken that have net costs close to zero, though this does not include implementation costs.

If all these measures were implemented, it would result in a GHG reduction of 7.848-7.890 million tonnes. However, the majority of this reduction (5,500,000 tonnes) results from the construction of a new 1000 MW nuclear power station. This may not be the most sustainable or politically acceptable option, even if it would result in significant reductions. Where to put a nuclear plant and what to do with the waste are important questions that must be addressed using the principles of fairness and sustainability. Indeed, this is an issue being discussed for the recently proposed Energy Strategy. It should also be noted that the use of biomass for electricity production is very expensive.

Table 12-1: Potential emissions reductions and costs per measure for the year 2020 from changes in electricity production[19]

Emissions reduction measures in electricity production	2020 Potential CO_2e reduction	Cost per tonne reduction (min)	Cost per tonne reduction (max)	2020 Cost per year (min)	2020 Cost per year (max)
Reductions in losses from the distribution grid and potential reductions in emissions of CO_2 (4,5% decrease in losses)	56,300	-EUR 10	EUR 10	-563,000	563,000
Reduction of emissions due to electricity produced from biomass[20]	700,000	EUR 76	EUR 145	53,200,000	101,500,000
Cogeneration potential delivered onto the public electricity grid	297,000	EUR 10	EUR 30	2,970,000	8,910,000
Increasing central district heating systems and cogeneration	39,000	EUR 10	EUR 30	390,000	1,170,000
Reduction of emissions from building small hydropower[21]	71,000 to 113,000	EUR 20	EUR 50	1,420,000	2,260,000
Reductions from usage of wind power[22]	1,125,000	EUR 24	EUR 50	27,000,000	56,250,000
Reductions from usage of nuclear fuel (by building one 1000 MW nuclear power station)[V]	5,500,000	-EUR 14	EUR 14	-77,000,000	77,000,000
Reductions from usage of geothermal[23]	60,000	-EUR 11	EUR 20	-640,000	1,200,000
Total possible emissions reduction from electricity production	7,848,300-7,890,300			6,777,000	248,853,000

[V] Cost estimates from IPCC (Sims et al. 2007) estimate for Economies in Transition for 2030.

12.2.2 Measures in reducing emissions due to energy use in industry

Another area within energy where emissions can be reduced is in industry – by changing the way energy is produced or increasing efficiency. The possible measures are outlined in Table 12-2. If all measures were introduced, the total emissions reduction during the year 2020 would be 1.785 million tonnes. Most of these measures are either cost neutral or would actually have a positive impact on the balance sheets of industries. This is because most use waste as a fuel (which does not have as high a purchase cost as, for instance, natural gas) or involve increasing energy efficiency.

It should be noted that the last measure noted in the table – pumping CO_2 underground for Enhanced Oil Recovery (EOR) purposes or into water, after production – needs further analysis in Croatia, as its use as a long-term solution is questionable: Underground CO_2 might seep out at a later date, essentially a postponement of emissions. However, if this seepage occurs over a few centuries, this would not be a problem, as CO_2 is not toxic if it leaks slowly. Additionally the emissions problem might be solved in the next century. If it is proven as viable, the EOR might be considered a CCS (Carbon Capture and Storage) technology. CCS technology is regarded as one of the most promising in terms of curbing GHG emissions in the future. Reducing GHG emissions to levels that will not cause catastrophic changes will not be possible without breakthrough technologies such as this one. Some of these technologies do not yet exist, while others (including CCS) are available, but need to be tested and become commercially available.

Table 12-2: Potential emissions reductions and costs per measure for the year 2020 from changes in energy use in industry [24]

Emissions reduction measure in industry	2020 Potential CO_2e reduction	Cost per tonne reduction (min)	Cost per tonne reduction (max)	2020 Cost per year (min)	2020 Cost per year (max)
Use of biomass for energy use for industry and construction	100,000	-EUR 45	-EUR 25	-4,500,000	-2,500,000
Increased energy efficiency in industry and construction (including cogeneration)	800,000	-EUR 30	-EUR 10	-24,000,000	-8,000,000
Use of biologically-based waste products for energy use for industry - especially refuse derived fuel (re-used materials) of biological and fossil origin and dried sludge - especially in the cement industry	202,000	-EUR 10	EUR 10	-2,020,000	2,020,000
Increasing the energy efficiency of the process of clinker production	53,000	EUR 0	EUR 20	0	1,060,000
Reduction of emissions of CH_4 by using waste as an alternative source of energy in the production of cement and other industrial goods (removing the source of CH_4)	130,000	Unknown	Unknown	Unknown	Unknown
Pumping CO_2 underground after production (technology unproven)	500,000	Unknown	Unknown	Unknown	Unknown
Total possible emissions reduction from energy use in industry	1,785,000			-30,520,000	-7,420,000

12.2.3. Measures in reducing emissions through changing energy use in households and the service industry

Better energy use within households and the service industry reduces emissions through a variety of mechanisms. The first and most economically advantageous way to reduce emissions is through energy efficiency. Energy efficiency measures can be used in the construction of new buildings, redesigning the building envelopes (e.g. installing more insulation) and roofs, and introducing technology such as efficient light-bulbs (CFLs – compact fluorescent light-bulbs) and appliances, in both offices and in households. Additionally, there are relatively inexpensive (in the long term) measures such as installing solar collectors and biomass heating systems. Finally, the installation of photovoltaic solar systems and advanced solar systems is the most expensive measure, though the potential exists for its implementation.

In total, emissions reductions from this sub-sector could be up to 1.981 million tonnes by 2020, with a net benefit of between EUR 57.8 million and 102.9 million for that year. This is mostly due to savings in energy use. However, while energy efficiency in households may have the significant potential to reduce emissions and be economically advantageous, the associated

Table 12-3: Potential emissions reductions and costs per measure for the year 2020 from changes in energy in households and services [25]

Measures in households and the service sector	2020 Potential CO_2e reduction	Cost per tonne reduction (min)	Cost per tonne reduction (max)	2020 Cost per year (min)	2020 Cost per year (max)
Savings of electricity in households – due to lighting changes (CFLs)	416,000	-EUR 145	-EUR 125	-60,320,000	-52,000,000
Savings of electricity in households – energy efficient appliances	282,000	-EUR 145	-EUR 125	-40,890,000	-35,250,000
Savings of electricity in households due to reduction of consumption of electricity for heat	28,000	-EUR 145	-EUR 125	-4,060,000	-3,500,000
Reduction of heat losses - due to complete reconstruction of building envelopes	26,000	-EUR 40	-EUR 20	-1,040,000	-520,000
Reducing heat losses from roofs	4,000	-EUR 40	-EUR 20	-160,000	-80,000
Reducing heat losses from windows	22,000	-EUR 40	-EUR 20	-880,000	-440,000
Energy Efficiency in offices	461,000	-EUR 25	-EUR 5	-11,525,000	-2,305,000
Reducing heat losses on new buildings	134,000	-EUR 25	-EUR 5	-3,350,000	-670,000
Solar collectors for water heaters	20,000	-EUR 10	EUR 10	-200,000	200,000
Renewable energy use in offices	109,000	-EUR 10	EUR 10	-1,090,000	1,090,000
Use of biomass in small heating systems and households	379,100	EUR 10	EUR 30	3,791,000	11,373,000
Use of fuel cells and Photo-voltaic cells[VI]	39,000	EUR 40	EUR 192	1,560,000	7,488,000
Solar energy - advanced systems	61,000	EUR 250	EUR 275	15,250,000	16,775,000
Total possible emissions reductions from measures in the households and services sector	1,981,100			-102,914,000	-57,839,000

[VI] Cost estimates from IPCC (Sims et al. 2007) estimate for Economies in Transition for 2030.

implementation costs (such as subsidies for CFLs, for construction costs, etc.) make this less economically attractive – though still beneficial. These savings will also rely on policies and energy efficiency standards for appliances and isolation materials, including building codes for new buildings with specific energy efficiency requirements. In addition, public information on energy efficiency will assist people in making the right choices. Product labels that clearly indicate energy consumption (and money saved) is one of the key tools. Most of these measures are underway to some extent in Croatia (see Chapter 13 for more on existing activities related to this).

12.2.4. Measures in reducing emissions through changing energy use in transport

As Croatia develops economically, more people are buying cars and driving. There are also more emissions from air and sea travel. Thus, the transportation sector represents a significant and growing portion of emissions – mostly from road transport. In 2006, transportation emissions were one fifth of all emissions in Croatia. Transportation emissions grew from 4.266 million tonnes per year in 1990 to 6.226 million tonnes in 2006 – which was largest increase for any sub-sector within energy during that period.[26]

Table 12-4: Potential emissions reductions and costs per measure for the year 2020 from changes in the transport sector

Measures in the transport sector	2020 Potential CO_2e reduction	Cost per tonne reduction (min)	Cost per tonne reduction (max)	2020 Cost per year (min)	2020 Cost per year (max)
Using vehicles with less emissions (140 gCO_2/km)	200,000	-EUR 60	-EUR 40	-12,000,000	-8,000,000
Using fuels with less carbon - LPG and CNG versus diesel or gasoline	100,000	-EUR 10	EUR 10	-1,000,000	1,000,000
Using biodiesel	370,000	EUR 90	EUR 110	33,300,000	40,700,000
Using bioethanol and hydrogen cells	270,000	EUR 90	EUR 110	24,300,000	29,700,000
Measures in inter-city passenger transport - improving roads, encouraging railroad travel, sea and intermodal transport, decrease of traffic jams	96,000	Unknown	Unknown	Unknown	Unknown
Measures in city passenger travel-building bike lanes, encouraging public transport, decrease of traffic jams	81,000	Unknown	Unknown	Unknown	Unknown
Measures in goods transport - ensuring efficiency of motors/ low emissions, putting "spoilers" to decrease air resistance on vehicles, encouraging fuel efficient driving	460,000	Unknown	Unknown	Unknown	Unknown
Total possible emissions reductions from measures in the transport sector	1,577,000 (940,000 in the cost analysis)			44,600,000	63,400,000

Reductions in emissions from transport will require using vehicles (including public transportation vehicles and goods transport vehicles) that are more fuel efficient, changing fuels to less carbon intensive fuels, using biodiesel or other biofuels, or by reducing the amount of kilometres travelled by cars in general. Reducing the emissions per kilometre travelled by personal vehicles to 140 gCO_2/ km (from 2003 levels of approximately 164 gCO_2/km)[27] would achieve large cost effective savings.[28] This level 140 gCO_2/km is approximately the emissions for vehicles that use 4.5 litres per 100 km of regular gasoline and 5 litres of diesel per 100 km.

While Croatia does not produce cars, the Government can have significant influence over the type of cars that are bought and sold through fees on carbon and other emissions, requiring better labelling of fuel economy, encouraging fuel efficient driving habits, etc. Additionally, there is a large level of potential emissions savings by switching fuels from gasoline or diesel to compressed natural gas (CNG) or liquid petroleum gas (LPG) – both of which are produced in relatively small amounts in Croatia but can be imported. The same is true for biodiesel – for which there is a production capacity of 20,000 tonnes per year in Croatia.[29] It should be noted that in this analysis, the costs for utilising biodiesel, bioethoanol, and other biofuels is considered the same. This is probably not actually the case,[30] but given the level of uncertainty in future price, it is the estimate used in this calculation.

In total, implementing all measures would lead to reductions of over 1.5 million tonnes per year in 2020 (See Table 12-4). It is important to note that the measures for which the cost is unknown are probably good practices for the sustainable development of cities and transportation in general. Encouraging alternative (non-auto) transportation and effective inter-city/ intra-city traffic flows is desirable regardless of climate change.

12.3. Reducing emissions in the agricultural sector

12.3.1. Global GHG emissions from agriculture

One sector where emissions reductions are only just beginning to be examined in Croatia is agriculture. Agriculture is a significant source of nitrous oxide and methane emissions – both GHGs.[31] Agricultural soils and livestock directly emit GHGs, while indirect emissions come from fossil fuel use in farm operations, the production of agrochemicals and the conversion of land from forests to fields.[32] In 2004, direct emissions from agriculture represented 13.5% of all global anthropogenic GHG emissions.[33] The total global contribution of the agricultural sector, including all direct and indirect emissions, is estimated at 8.5-16.5 billion tonnes of CO_2e – 17% to 32% of all global man-made GHG emissions.[34] In the EU (excluding Bulgaria and Romania), agricultural direct emissions contributed to 9.2% of the total GHG emissions in 2004.[35]

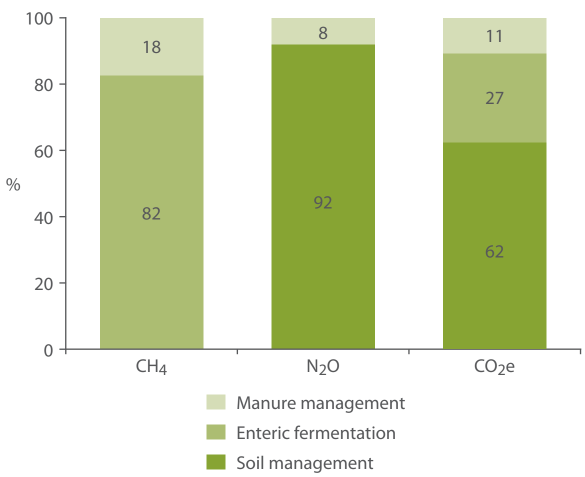
Livestock farming and fertiliser use are by far the two most significant sources of GHGs from agriculture, while enteric fermentation and ruminant livestock (cattle, sheep and goats) produce methane, contributing to about 60% of all global methane emissions.[36] Manure usage, storage and decomposition also produce GHG emissions, of both methane and nitrous oxide, while fertilisers applied on agricultural land emit nitrous oxide, a major direct emission source. Besides livestock farming and fertilisers, agriculture emits GHGs through the production of legume crops, residue burning and land use change (e.g. conversion of carbon-rich grassland soils or forests into farm land).

To date, carbon losses from agricultural soils have not been reported in the national GHG inventories. However, these are substantial and in the EU-15 have been estimated at 10-20 million tonnes of CO_2e per year, adding 4-8% to GHG emissions in the EU-15.[37]

12.3.2. GHG emissions from Croatian agriculture

In 2006, the Croatian agricultural sector emitted 3.5 million tonnes of CO_2e – 11.4% of the country's anthropogenic GHG emissions in that year.[38] In the period 2001-05, livestock farming was responsible for a little over half of the direct GHG emissions from agriculture, while crop production produced the rest.[39] Most methane is produced from enteric fermentation (of which cattle produce the most – see Figure 12-5). The vast majority of nitrous oxide emissions resulted from current soil and manure management practices.

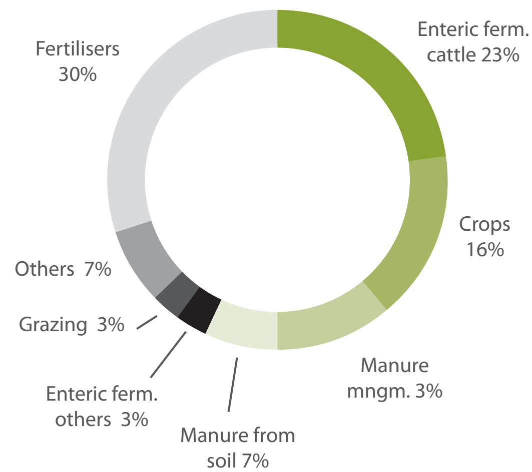
Figure 12-5: GHG emissions by gas and management/natural process.



Source: modified after Znaor 2008.

The biggest single source of GHGs in agriculture was from fertilisers applied to agricultural land, followed by the enteric fermentation from cattle, crops (nitrogen-fixing crops, crop residues and related nitrogen leaching), and manure management (See Figure 12-6 for all of the categories). Besides the emissions presented in Figure 12-6, two additional sources of GHGs result from agriculture: the burning of residues and carbon losses from agricultural soils. Burning agricultural residues is prohibited in Croatia and is thus not included in the national GHG inventory.[40] While some farmers still practise this, these emissions have been estimated at about 1000 tonnes of CO_2e per year – a very small amount. The UNFCCC does not require carbon losses from agricultural soils to be reported in the national GHG inventories. These have been estimated at 1.179 million tonnes per year in Croatia, adding an additional 35% to emissions from farming.[41]

Figure 12-6: GHG emissions by source.



Source: modified after Znaor 2008.

12.3.3. Croatian GHG agriculture emissions forecast

Future GHG emissions from the Croatian farming sector are very difficult to estimate for a number of reasons:

1. Croatian agriculture is still at a crossroads, struggling to accommodate both numerous small-scale family farms and large-scale agricultural companies. Its future development is unclear.
2. In 2000, Croatia had half the livestock of the 1980s.[42] The Government has initiated several programmes aimed at increasing livestock numbers[43] and this policy is likely to continue. Consequently, GHG emissions – notably methane – would increase.
3. The consumption of fertilisers decreased by almost a third during 1999-2006. By subsidising the price of natural gas for fertiliser production[44] and by forcing the sole domestic fertiliser manufacturer (Petrokemija) to sell fertiliser below the market price,[45] the Government has stimulated higher consumption. As this policy will probably continue, fertiliser consumption is likely to remain the same or increase – resulting in similar or increased nitrous oxide emissions.
4. The EU Nitrates Directive forces Croatia to improve its manure management and to reduce nitrogen losses. With the assistance of the World Bank, the Government has already started related pilot projects.[46] It is very likely that in the near future manure management in Croatia will be substantially improved, resulting in lower GHG emissions from manure.
5. The Croatian organic farming sector has expanded rapidly in recent years. During 2000-2007 the area farmed organically increased from 13 to 7,577 hectares, but this still represents only 0.62% of all agricultural land in Croatia. Increasing the practice of organic farming could reduce GHG emissions (See Box 12-3).

Croatia's latest report to the UNFCCC[47] presents an assessment of the mitigation potential for Croatia and GHG emissions scenarios until 2020. Overall, in the BAU scenario, GHG emissions are projected to increase 13% by 2020 – up to around 3.9 million tonnes in agriculture.

12.3.4. Possible mitigation measures

Agriculture can play a role in climate change mitigation through three mechanisms:

1. By reducing GHG emissions from agricultural soils, livestock and manure management (e.g. reduced or more efficient use of fertilisers, prevention of nitrogen leaching from soil, improved manure management, reduction or replacement of ruminants

Box 12-3: Mitigation potential of organic farming

Organic farming contributes to the reduction of greenhouse gas (GHG) emissions because it reduces the consumption of fossil fuels (notably those used in fertiliser manufacturing), reduces emissions of CO_2, methane and nitrogen oxides and reduces the vulnerability of soils to erosion, while at the same time increasing carbon stocks in the soil.[48] Consequently, conversion to organic farming is considered a viable way of reducing GHG emissions. Depending on the commodity produced, organic farming emits 6-31%,[49] 18%,[50] 29-37%,[51] or 48-60%[52] less GHGs than non-organic farming. Average CO_2 emissions per unit area from organic beef are 57% lower than for non-organic production.[53] However, if there are substantially lower yields, organic farming results in higher GHGs per kg of product.

Numerous studies have shown that, despite their reliance on frequent mechanical weed control, organic farming systems can increase soil organic matter stocks.[54] One study[55] also found that besides the total carbon, organic farming results in more particulate organic matter (fine fraction of soil organic matter which is difficult to form) than conventional farming. Various long-term trials have shown that the annual carbon increase in soil from organic farming is 12-28%.[56] Surprisingly, the "biodynamic"[VII] treatment accumulated the most amount of carbon in the soil despite the fact that it was supplied with about 20% lower organic matter in manure than other manure-based treatments.

[VII] The oldest organic farming method, established in 1924 by Dr. Rudolf Steiner- an Austrian philosopher born in Croatia.

with other livestock, a less nitrogen-rich diet for livestock, less burning of crop residues, etc.).

2. By reducing its indirect emissions, notably those arising from fertiliser production, transport and application.
3. By restoring natural vegetation (e.g. converting arable land to grassland or forests or converting drained arable land back to wetlands), or by enhancing carbon storing management practices (e.g. the inclusion of grassland crops in arable rotations, reduced soil disturbance, avoiding bare soil, etc.). This mechanism can be regarded as a change in "Land Use, Land Use Changes and Forestry" which must be officially recognized in international negotiations for Croatia to gain credits for this reduction. However, the analysis in this Report demonstrates the tremendous mitigation possibility of this measure. (See Section 12.6)

In Croatia, all three mechanisms are likely to have a positive mitigation effect. The second measure, however, cannot be regarded as a direct mitigation measure of the agriculture sector, since the mitigation action has to be tackled primarily by the industrial sector and the transport sub-sector of energy.

12.3.5. Possible mitigation scenarios for agriculture

This Report presents seven possible mitigation scenarios. They are based on different approaches and technologies that could theoretically be applied to realise mitigation effects:

1. The "BAU (business as usual)" scenario assumes the continued gradual development of high-input agriculture, resulting in a 20% increase in livestock numbers and a 20% increase in fertiliser consumption by 2020.
2. The "Manure 50%" scenario assumes improved manure management, complying with the requirements of the EU Nitrates Directive by 2020 and emitting 50% less GHGs from manure than in 2005.
3. The "Fert -70%" scenario, envisages a 70% reduction in fertiliser consumption by 2020. This is based on a World Bank assessment suggesting that a 63-78% cut in nitrogen fertiliser use would be required to ensure that nitrate content in Croatian waterways falls below the Maximum Admissible Concentrations (MAC).[57]
4. The "Ruminants reduced 25%" scenario, projecting a substitution of 25% of ruminant livestock with non-ruminant livestock (e.g. swine and poultry) by 2020, but maintaining the same livestock unit value (body weight) as 2005.
5. The "Organic 25%" scenario, assumes the conversion of 25% of agricultural land to organic farming by 2020. It envisages the same crop and livestock mix as in 2005 and the calculation is based on a study commissioned by the UNFAO[58] and a follow-up study.[59] It does not take into account the carbon sequestration effect of organic management.
6. The "Best available technology (BAT)" scenario assumes adopting the best available practice to reducing GHGs by 2020. It assumes the manure management efficiency of the "Manure 50" scenario and fertiliser inputs in the "Fert -70%" scenario. In addition, it assumes a 30% reduction of non-fertiliser related leaching and a 30% reduction of emissions from applied organic manures. It has the same crop and livestock mix as in 2005.

The measures that are evaluated in the cost-benefit analysis are:

- Business as Usual.
- Implementation of the Best Available Technologies including better manure management, decreased fertilizer use, a 30% reduction of non-fertiliser related leaching and a 30% reduction of emissions from applied organic manures.
- Implementation of changes in the livestock mix towards non-ruminant livestock, keeping the same level of total livestock units.
- Conversion to 25% organic farming.

12.3.6. Cost-benefit analysis of agriculture measures

The analysis of the costs and benefits of reducing emissions from the Croatian agricultural sector is difficult to carry out and is currently unavailable. Croatia lacks the standard gross margins for crops and livestock and the data on agricultural investments are scarce and often location-specific. Additionally, there is very little quantitative information on organic matter turnover, its decomposition and humification that specifically relates to the situation in Croatia. As a sound cost-benefit analysis of each mitigation measure is beyond the scope and resources of this Report, we can only present a tentative cost-benefit calculation. Although this gives a likely order of magnitude, it should be treated with caution.

Figure 12-7 shows the average annual net benefits of mitigation measures. "Ruminants reduced 25%" and "Organic 25%" are the only scenarios showing a positive net benefit (= benefits minus costs). The high benefit (low cost) arising from the "Ruminants reduced 25%" scenario is because the gradual replacement of ruminants with non-ruminants does not involve significant costs and because non-ruminants produce a gross value-added nearly two times that of ruminants per Livestock Unit, while at the same time reducing methane emissions by almost 90%. However, a possible repercussion from this shift may be a loss in milk production. The organic farming scenarios benefit from the fact that the organic farming GVA per hectare is comparable with that of non-organic production and because it saves public money invested in fertiliser manufacturing and transport.

Box 12-4: Information on the cost-benefit analysis for agriculture

A cost-benefit assessment must first establish which and whose costs and benefits are to be assessed. Is it only the direct costs linked with the introduction of mitigation measures? And should the assessment also include related public investments and environmental costs arising from GHG emissions. Similarly, it should be known who should pay these costs, why, and to what extent. Should it be society (from public money), the food processing and tobacco industry, consumers or farmers themselves? There are justifiable arguments for and against all of these options, but discussing these is beyond the scope of this Report.

Based on the available data, the following factors were considered to calculate the cost of mitigation:

1. The investment and costs of technological changes required to implement mitigation measures (e.g. purchase of new machinery, livestock, etc.).
2. Lost opportunity costs linked with the introduction of mitigation measures (e.g. lost revenue resulting from the replacement of highly profitable crops with carbon-building grasses/legumes).
3. Public investments – hidden and direct subsidies, legislation and informative/capacity building programmes preventing climate-destructive practices and/or facilitating the adoption of mitigation measures.
4. The costs of implementing the changes.

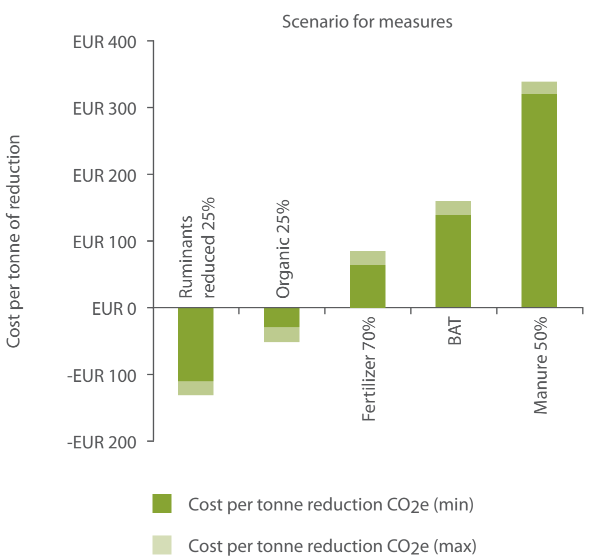
The benefits calculated included:

1. Extra profit generated by the introduction of the mitigation measure (e.g. increased yield, reduced cost of fertiliser use, etc.).
2. Saved public money (e.g. reduced subsidies for fertiliser manufacturing and transport).

The crop and gross-margin calculations are based on the information provided by the Croatian Agricultural Extension Institute[60] and Znaor (2008). Public investments are taken from Znaor (2008). The cost of manure management compliance with the EU Nitrates Directive and subsidies required for the introduction of measures are taken from a World Bank (2008) study on the topic. The soil carbon calculations are based on Znaor (2008) and assume a net sequestration of 0.7 tonnes of carbon per hectare per year.

The "Fert -70%" scenario leads to reduced yields but benefits from the money saved from less fertiliser purchase. The "Manure 50%" scenario involves significant investment and adaptation costs related to stables and manure facilities. The BAT scenario combines the costs and benefits allocated under "Fert -70%" and "Manure 50%", though there would be additional benefits from reduced non-fertiliser induced nitrogen leaching. It should be noted that some form of fertilizer reduction and manure management might be necessary and will probably be implemented under EU regulations, though it is unclear exactly how much.

Figure 12-7: Estimated marginal costs per tonne of CO_2e reduction in 2020.



12.4. Reducing emissions from industrial processes

With the collapse of industry in Croatia in the early 1990s, emissions from industrial processes dropped by more than a third. Since then, industrial processes have increased gradually and were responsible for approximately 13% of Croatia's emissions in 2006.[61] Most of those emissions were from either cement production, lime production, ammonia production (for fertilisers), or nitric acid production. These processes emit CO_2 and other GHGs such as methane and nitrous oxide.

The first industry examined is the cement industry. For each tonne of cement produced, ¾ of a tonne of CO_2 is emitted through the chemical process. This does not include the energy needed to produce and distribute the cement (discussed earlier). There are four manufacturers of cement in Croatia producing mainly Portland cement with a dry process (which leads to fewer emissions).[VIII] In 2006, 3.7 million tonnes of cement were produced, however, this is increasing. Production of cement is expected to grow to 4.43 million tonnes in 2020. The value of the Portland cement sold in 2007 was EUR 225 million.[62] A second type of cement called "Aluminate cement," is also produced, though its emissions are negligible compared to those related to the

[VIII] Dalmacijacement d.d., Holcim Hrvatska d.o.o., Našicement d.d. and Istra Cement d.o.o.

Table 12-5: Potential emissions reductions and costs per measure for the year 2020 from changes in the agriculture sector

Measures in the agriculture sector	2020 Potential CO_2e reduction	Cost per tonne reduction (min)	Cost per tonne reduction (max)	2020 Cost per year (min)	2020 Cost per year (max)
Ruminants reduced 25%	578,000	-EUR 110	-EUR 90	-63,580,000	-52,020,000
Organic 25%	515,000	-EUR 30	-EUR 10	-15,450,000	-5,150,000
Fert -70%	840,000	EUR 65	EUR 85	54,600,000	71,400,000
Best Available Technologies	1,084,000	EUR 140	EUR 160	151,760,000	173,440,000
Manure 50%	303,000	EUR 320	EUR 340	96,960,000	103,020,000
Total possible emissions reductions from measures in the agricultural sector: Ruminants reduced 25% + 25% organic + Best Available Technologies	2,177,000			72,730,000	116,270,000

production of Portland cement. In total, the industry employs a little over 2000 people who are directly involved in the industry.

During cement production, CO_2 is released into the atmosphere as a by-product of clinker production. Clinker production has increased 42.8 % since 1990. According to trends, emissions will increase by 538,000 tonnes CO_2 by 2020 (to 3,100,000 tonnes) if no actions are taken. This emissions projection includes emissions from energy consumption, which is covered in Section 12.2 above. By reducing the amount of clinker in cement to EU standards, it would be possible to reduce emissions significantly in 2020, for a net cost close to zero. This means that it may be economically beneficial to do this for the companies if regulations allow it. Considering the upcoming impact of the ETS system and the current carbon fee in place in Croatia, the option seems particularly economically viable. However, certain legal and technical issues must be resolved before this option can be implemented.

Other potential indirect CO_2 emissions reduction measures in other sectors related to cement production (energy, waste management, transport) include:[63]

- Preventing emissions of GHG at waste collection sites. This means mostly burning fuel from waste materials (already included in Table 12-2) and consequently reducing emissions from the waste that would otherwise lie in the waste storage site.
- Building concrete roadways that uses less energy than asphalt roadways. These roadways emit less CO_2 directly and indirectly. Concrete roads are more enduring and need less maintenance than asphalt roads. Concrete roads also affect fuel savings. Cargo vehicles could save up to 10% of fuel driving on concrete roads. In some EU countries (Germany, Belgium, and Austria) 25% of the roads are concrete, whereas, in Croatia they are rarely built.

A second industry examined is nitric acid production. In the production of this chemical – which is used for a variety of processes – the GHG nitrogen oxide is released. By changing the industrial process that produces nitric acid, it would be possible to decrease emissions significantly. By assuming the same emissions levels and same reduction potential for 2020 as for 2012, the potential reduction would be 820,000 tonnes of CO_2e in 2020. The cost would be minimal, and, similar to changing the amount of clinker production, may actually be economically beneficial (less than EUR 1 per tonne of reduction), which would be worth reducing if those emissions reductions can be sold on the carbon market.[64]

Fertiliser and lime production are also important sources. The fertiliser industry is particularly important: the Petrokemija fertiliser manufacturer alone accounts for 30% of Croatia's natural gas consumption and 5% of Croatia's anthropogenic GHG emissions.

Table 12-6: Potential emissions reductions and costs per measure for the year 2020, resulting from changes in industrial processes

Measures in industrial processes	2020 Potential CO_2e reduction	Cost per tonne reduction (min)	Cost per tonne reduction (max)	2020 Cost per year (min)	2020 Cost per year (max)
Reduction of the share of clinker in cement from 77% on average by max 14% by 2020 because of changes in defined norms and characteristics of cement.	364,000	-EUR 10	EUR 10	-3,640,000	3,640,000
Production of nitric acid – non-selective catalytic production in the process – a chemical reaction to eliminate 80-90% of GHGs by converting N_2O to just nitrogen.	820,000	-EUR 10	EUR 10	-8,200,000	8,200,000
Total possible emissions reductions from measures in industrial processes	1,184,000			-11,840,000	11,840,000

However, no data is available regarding reduction potentials in these industries.

By changing industrial processes, it appears possible to reduce emissions from cement and nitric acid production by over 1 million tonnes in 2020. The economic impacts of these reductions are unclear as the marginal costs of reduction are close to zero. The current air pollution fee assessed by the Croatian Government will become 18 HRK (EUR 2.46) per tonne in 2009. This fee increase will mean that the marginal costs of introducing measures would decrease by EUR 2.46 per tonne for both industries.

12.5. Reducing emissions from waste management

The final emissions source analysed is waste management. The waste management sector was responsible for 591,000 tonnes of CO_2e in 2006 – a little under 2% of total emissions. These emissions are primarily from the escape of methane gas from waste sites after the decomposition of waste material. Therefore, emissions reduction is possible by:

- Reducing the amount of waste that goes to waste sites – either by reducing the actual amount of waste or taking some of the waste and using it as a fuel source in other processes, such as heat generation for industry
- Treating the waste through thermal waste treatment (essentially burning waste), or
- Burning the escaping methane gas – potentially using it as an energy source.

While costs were not available for all these measures, the likely marginal costs for the reduction of emissions by burning methane at the sites is estimated to be close to zero – or between EUR -10 and 10 per tonne.[67] This measure could reduce emissions by 175,000 tonnes per year in 2020 (see Table 12-7). Thus, the net cost-benefit would be somewhere between EUR -1,750,000 million and EUR 1,750,000 per year for 2020.

The costs for the other measures are not available, but are likely to be low – and might result in a net benefit. HEP is already undertaking preliminary planning for a plant which uses waste as the fuel for producing energy – essentially burning waste for fuel.

Table 12-7: Potential emissions reductions and costs per measure for the year 2020 resulting from changes in waste management processes[68]

Measures in the waste management sector	2020 Potential CO_2e reduction	Cost per tonne reduction (min)	Cost per tonne reduction (max)	2020 Cost per year (min)	2020 Cost per year (max)
Reduction of emissions by burning CH_4 from flaring	175,000	EUR -10	EUR 10	-1,750,000	1,750,000
Reduction of emissions of CH_4 by thermal waste treatment – burning waste	180,000	Unknown	Unknown	Unknown	Unknown
Total possible emissions reductions from measures in the waste management sector	355,000 (175,000 estimated for costs)			-1,750,000	1,750,000

12.6. Reducing net emissions due to land-use, land use changes and forestry (LULUCF)

Carbon can also be absorbed by the environment in a number of ways. A major "carbon sink" in Croatia is the changes in land use. Significant portions of Croatian land have gradually become forested and are included as a reduction in CO_2e. In 2006, this amounted to an estimated net reduction of 7,490,000 tonnes – or almost a quarter of all Croatia's emissions. Forests cover 37% of the mainland of Croatia, 81% are owned by the State and the rest are privately owned.[69] Essentially, this means increasing the amount of forests, shrubs, or the thickness of trees in forests. Interestingly, the current level of almost 7.5 million tonnes of reductions has occurred, not as a result of climate change concerns, but rather because of other factors such as abandoned farmland and nature protection measures. The average amount of reductions due to land-use changes from 1990-2006 was 7.75 million tonnes.[70] It is unclear whether this amount of forest biomass growth will continue into the future, but it seems probable.[71]

However, as no cost-benefit analysis is available for these reductions in Croatia, it cannot be included in this analysis in terms of the likely costs of this measure. While cost-benefit analyses are available for other countries,[72] it is unlikely that the results transfer well to the situation in Croatia, where land use changes are contributing to mitigation without specific climate change policies encouraging this. Furthermore, it is likely that only part of the total sink belonging to forest management activity will be counted in the post-Kyoto period. Under the current Kyoto Protocol allocations, Croatia has a cap for what can be counted as a sink - 0.97 million tonnes CO_2e.

An additional change in land use that could have a significant impact is increasing the carbon content in soils. Through changes in farm management – the use of grass-clover crops, the application of green manures/ green cover crops and under-sowing of cereals – carbon can be absorbed by the soil which produces better farming conditions including guarding against water loss (see Chapter 8). An annual carbon sequestration of 700 kg C per hectare over a 15-year period is possible with the right management techniques. A linear annual increase of the agricultural area under this type of management could amount to 943,000 hectares (all arable and land under orchards and vineyards) by 2020.[IX]

This practice is estimated to cost EUR 65-85 per tonne of removal if 700 kg of carbon is mitigated per year per hectare. This calculation is based on the public money (subsidies) envisaged to stimulate farmers to practice this measure – an average annual cost of approximately EUR 101 million. This subsidy is, however, questionable. One could argue that the application of green manure and other carbon/building measures constitutes a good farming practice and as such should not be paid for by public money. If the cost of practising these measures were transferred to farmers, the net cost to the Government would be greatly reduced, though the cost would still exist. Furthermore, there are advantages to increasing the level of carbon in soils related to retaining moisture – which is already a problem in Croatian soils. This estimate of costs deserves further review, as the IPCC estimates that significant reductions through this methodology would be possible for under EUR 13 per tonne.[73]

[IX] Numerous studies report sequestration rates of 400-1,800 kg C per hectare per year in temperate regions (Hepperly, Moyer et al. 2008, Hülsbergen and Küstermann 2008, Pimentel, Hepperly et al. 2005, Raupp, Pekrun et al. 2006, Teasdale, Coffmann et al. 2007). At the USA Rodale Institute's experimental farm for instance, legume-based organic farming systems in 14 years increased soil carbon by 35% (from 1.8% to 2.4%) (Petersen, Drinkwater, et al. 2000).

Table 12-8: Potential carbon reduction and costs per measure for the year 2020 from changes in LULUCF

Land Use, Land Use Changes and Forest Cover	2020 Potential CO_2e reduction	Cost per tonne reduction (min)	Cost per tonne reduction (max)	2020 Cost per year (min)	2020 Cost per year (max)
Soil sequestration of carbon (700 kg per hectare per year)	2,533,000	EUR 65,00	EUR 85,00	164,645,000	215,305,000
Increased forest mass	7,000,000	Unknown	Unknown	Unknown	Unknown
Total possible CO_2e reduction for LULUCF	9,533,000			164,645,000	215,305,000

Currently Croatia only receives "credit" for its international commitments under the Kyoto Protocol of a little less than one million tonnes of CO_2e reduction, due to LULUCF. Since the potential appears to be drastically more than that – up to an astounding 9.5 million tonnes, it is important to further examine the cost/ benefit of implementing these changes and the methodology for accounting for them in international reporting. In the "post-Kyoto" negotiations, these could play an important role in Croatia's position.

12.7. Economic analysis of measures

12.7.1. Measures that are likely to be economically beneficial to Croatia

As a first step in reducing emissions, Croatia should move forward with any project that is likely to yield a negative marginal cost (or a net economic gain).

Table 12-9: Likely "No Regrets" measures for mitigation that will have an economic benefit.

Sub-sector of emissions	Emissions reduction measure	2020 Potential CO_2e reduction	2020 cost per year (min)	2020 Cost per year (max)	Probable responsible stakeholder
Agriculture - changes in farming techniques	Switching to 25% organic farming	515,000	EUR -15,450,000	EUR -5,150,000	MAFRD/ farmers
Agriculture - Livestock changes	25% of ruminants replaced by non-ruminants	578,000	EUR -63,580,000	EUR -52,020,000	MAFRD/ farmers
Energy - for industry use	Use of biomass for energy use for industry and construction	100,000	EUR -4,500,000	EUR -2,500,000	MELE/ MEPPPC
Energy - for industry use	Increased energy efficiency in industry and construction (including cogeneration)	800,000	EUR -24,000,000	EUR -8,000,000	MELE/ MEPPPC
Energy - use for Transport	Using vehicles with less emissions (140 gCO_2/km)	200,000	EUR -12,000,000	EUR -8,000,000	Individual citizens/ MELE/ MEPPPC/ Ministry of Transportation
Energy - use in households and services	Savings of electricity in households – due to lighting changes (CFLs)	416,000	EUR -60,320,000	EUR -52,000,000	Individual citizens/ MELE
Energy - use in households and services	Savings of electricity in households – energy efficient appliances	282,000	EUR -40,890,000	EUR -35,250,000	Individual citizens/ MELE
Energy - use in households and services	Savings of electricity in households due to reduction of consumption of electricity for heat	28,000	EUR -4,060,000	EUR -3,500,000	Individual citizens/ MELE
Energy - use in households and services	Reducing heat losses from roofs	4,000	EUR -160,000	EUR -80,000	Individual citizens/ construction firms/ MELE/ MEPPPC
Energy - use in households and services	Reducing heat loss from windows	22,000	EUR -880,000	EUR -440,000	Individual citizens/ construction firms/ MELE/ MEPPPC
Energy - use in households and services	Reduction of heat loss - due to complete reconstruction of building envelopes	26,000	EUR -1,040,000	EUR -520,000	Individual citizens/ construction firms/ MELE/ MEPPPC
Energy - use in households and services	Energy Efficiency in offices	461,000	EUR -11,525,000	EUR -2,305,000	Individual firms/ MELE/ MEPPPC
Energy - use in households and services	Reducing heat loss on new buildings	134,000	EUR -3,350,000	EUR -670,000	Construction companies/ Individual citizens/ firms/ MELE/ MEPPPC
	Total reduction due to "no regret" options that have a net economic gain once implemented	3,566,000	-241,755,000	-170,435,000	

Table 12-10: Measures that may be neutral in terms of marginal cost per tonne of reduction

Sub-sector of emissions	Emissions reduction measure	2020 Potential CO_2e reduction	2020 cost per year (min)	2020 Cost per year (max)	Probable responsible stakeholder
Energy - electricity production	Reductions from usage of nuclear fuel (by building a 1000 MW nuclear power stations)	5,500,000	EUR -77,000,000	EUR 77,000,000	HEP/ MELE/MEPPPC
Energy - electricity production	Reductions from usage of geothermal	60,000	EUR -640,000	EUR 1,200,000	Individual firms/ MELE
Energy - electricity production	Reductions in loss from the distribution grid and potential reductions in emissions of CO_2 (4.5% decrease in loss)	56,300	EUR -563,000	EUR 563,000	HEP/ MELE
Energy - for industry use	Use of biologically-based waste products for energy use for industry - especially refuse derived fuel (re-used materials) of biological and fossil origin and dried sludge - especially in the cement industry	202,000	EUR -2,020,000	EUR 2,020,000	Individual industries/ waste management companies
Energy - use for transport	Using fuels with less carbon - LPG and CNG versus diesel or gasoline	100,000	EUR -1,000,000	EUR 1,000,000	MELE/ Ministry of the Sea, Transport, and Infrastructure
Energy - use in households and services	Renewable energy use in offices	109,000	EUR -1,090,000	EUR 1,090,000	Individual firms/ MELE
Energy - use in households and services	Solar collectors for water heaters	20,000	EUR -200,000	EUR 200,000	Construction companies/ Individual citizens/ firms/ MELE/ MEPPPC
Industrial processes - cement production	Reduction of the share of clinker in cement from 77% on average by max 14% by 2020.	364,000	EUR -3,640,000	EUR 3,640,000	Cement Companies/ MEPPPC
Industrial processes - nitric acid production	Production of nitric acid - non-selective catalytic production in the process - a chemical reaction to eliminate 80-90% of GHGs by converting N_2O to just nitrogen.	820,000	EUR -8,200,000	EUR 8,200,000	Nitric acid producers
Waste treatment	Reduction of emissions by burning CH_4 from flaring	175,000	EUR -1,750,000	EUR 1,750,000	Waste management companies
	Total reduction of emissions resulting from possible "cost neutral" options	7,406,300	-96,103,000	96,663,000	

These potential measures are outlined in Table 12-9 and would account for just over 3.5 million tonnes of reductions in 2020 if fully implemented – saving EUR 170-241 million in costs. It should be noted that the reductions from changing from ruminant livestock (cattle) to non-ruminant livestock may not be carried out to this extent, but some level of the measure may be effective at reducing emissions and increasing economic gains. Furthermore, many of these measures will depend upon the active involvement of citizens. While public education may help in this arena, it is likely that regulation and prices will have a greater impact.

12.7.2. Measures with minimal cost

Table 12-10 outlines the various measures that are expected to either cost a small amount or save money. Those that are eligible may be profitable for businesses if sold on the carbon market – such as the burning of CH_4 from landfills or the non-selective catalytic production of nitric acid. In total, these measures could reduce emissions by 7.4 million tonnes of CO_2e in 2020 for a minimal marginal cost. However, it should be noted that the majority of these reductions (5.5 million tonnes) result from building new nuclear facilities – which is problematic in terms of environmental sustainability and political feasibility.

12.7.3. Measures that are unlikely to cost more than EUR 25 per tonne of CO_2e reduced

The next group of measures may not have a net economic benefit but might be economically cost-effective when considering the costs of the EU ETS and other carbon offset programmes – including the voluntary market. For the purposes of this estimation, the price of CO_2e per tonne is assumed to be EUR 25, thus

Table 12-11: Measures which might cost something but which may be profitable with carbon offsets through either the ETS or voluntary emissions reduction schemes, at EUR 25 per tonne of reduction

Sub-sector of emissions	Emissions reduction measure	2020 Potential CO_2e reduction	2020 Cost per year (min)	2020 Cost per year (max)	Probable responsible stakeholder
Energy - for industry use	Increasing the of energy efficiency of the process of clinker production	53,000	EUR 0	EUR 1,060,000	Cement industry/ waste management companies/ MELE/ MEPPPC
Energy - electricity production	Cogeneration potential delivered onto the public electricity grid	297,000	EUR 2,970,000	EUR 8,910,000	HEP/ MELE/ MEPPPC
Energy - use in households and services	Use of biomass in small heating systems and households	379,100	EUR 3,791,000	EUR 11,373,000	Individual citizens/ MELE
Energy - electricity production	Increasing central district heating systems and cogeneration	39,000	EUR 390,000	EUR 1,170,000	City governments/ MELE/ energy producers/ MEPPPC
Energy - electricity production	Reduction of emissions from building small hydropower	71,000 to 113,000	EUR 1,420,000	EUR 2,260,000	Individual firms/ MELE
Energy - electricity production	Reductions from usage of wind power	1,125,000	EUR 27,000,000	EUR 56,250,000	HEP/ MELE/ MEPPPC
	Total emissions reductions due to options that are justifiable with a carbon cost of EUR 25 per tonne	881,100	8,571,000	24,773,000	

any measure which has a probable marginal cost below EUR 25 would be cost-effective, if it can utilise reduction funds or prevent Croatia and Croatian businesses from having to spend money buying credits elsewhere. The sum of all of these measures has the potential for reducing emissions by an additional 881,100 tonnes in 2020.

In examining the possible measures that would either have a net positive economic impact or that may have a price for reduction less than the cost of buying credits on the open market, the total amount of reductions possible would be 11.85 million tonnes of CO_2e. If taken from the projected emissions of 42 million tonnes, this leads to an emissions total of 30.15 million tonnes – which would mean a significant reduction (16%) from the baseline levels of 36.03 million tonnes. This assumes a relatively high price of carbon (EUR 25). However, much of this reduction (5.5 million tonnes) would result from nuclear power production, which may not be viable for environmental and/ or social acceptability reasons.

12.7.4. Measures that are more expensive for reducing emissions

The next level of emissions reduction measures are likely to be more expensive than the market price of carbon but may be good to implement regardless. This is because these measures may:

1. Be required to meet EU obligations – such as the use of biodiesel and bioethanol and the implementation of Best Available Technologies in agriculture;
2. Be more acceptable to the public – such as solar power – or;
3. Have alternative benefits to the sectors that implement the measures. Increasing carbon

[X] This measure would need approval within international negotiations to be included in the national emissions statistics.

Table 12-12: More expensive measures for reducing emissions

Sub-sector of emissions	Emissions reduction measure	2020 Potential CO_2e reduction	2020 Cost per year (min)	2020 Cost per year (max)	Probable responsible stakeholder
Energy - use in services	Use of fuel cells and Photo-voltaic cells	39,000	EUR 1,560,000	EUR 7,488,000	MELE/ MEPPPC
LULUCF in agriculture	Soil sequestration of Carbon (700 kg per hectare per year)[X]	2,533,000	EUR 164,645,000	EUR 215,305,000	MAFRD/ farmers/ MEPPPC
Energy - electricity production	Reduction of emissions due to electricity produced from biomass	700,000	EUR 53,200,000	EUR 101,500,000	HEP/ MELE/ MEPPPC/ MAFRD
Energy - use for transport	Using biodiesel	370,000	EUR 33,300,000	EUR 40,700,000	MAFRD/ biodiesel producers/ MELE/ MEPPPC/ retail sellers
Energy - use for transport	Using bioethanol and hydrogen cells	270,000	EUR 24,300,000	EUR 29,700,000	MAFRD/ biodiesel producers/ MELE/ MEPPPC/ retail sellers
Agriculture - changes in farming techniques	Implementation of Best Available Technologies - reducing fertilizers and better manure management	1,084,000	EUR 151,760,000	EUR 173,440,000	Farmers/ MAFRD/ MEPPPC
Energy - use in services	Solar energy - advanced systems	61,000	EUR 15,250,000	EUR 16,775,000	HEP/ MELE/MEPPPC
	Total emissions reductions due to options that are more expensive, but may have additional benefits/ be popular	5,057,000	444,015,000	584,908,000	

content in soils, for example, would not only be a mitigation measure, but may also help agricultural actors in reducing problems with the lack of moisture in soils.

In total, these measures could account for an additional 5.06 million tonnes of reduction – though at a significant cost of EUR 444 – 585 million for the year 2020 (See Table 12-12). This is equivalent to EUR 100 to 132 per person in Croatia per year.

12.7.5. Measures that should be economically feasible but have unknown costs

The final measures that could be taken to reduce emissions by 2020 are those for which data is currently unavailable, in terms of cost of emissions reduction per tonne. Some of these measures may not be politically popular – such as building a waste incinerator plant. Some measures will require significant cross-sector cooperation and public involvement – such as mea-

Table 12-13: More expensive measures for reducing emissions

Sub-sector of emissions	Emissions reduction measure	2020 Potential CO_2e reduction	2020 Cost per year (min)	2020 Cost per year (max)	Probable responsible stakeholder
Energy - electricity production	Reductions from switching to lower carbon content fuels (natural gas, etc) - unmeasured, but, says, 5% reductions	Unknown	Unknown	Unknown	HEP/ MELE/MEPPPC
Energy - use for Transport	Measures in city passenger travel - building bike lanes, encouraging public transport, decrease of traffic jams	81,000	Unknown	Unknown	Individual citizens/ city governments/ Ministry of Sea, Transport and Infrastructure/ MEPPPC
Energy - use for Transport	Measures in goods transport - ensuring efficiency of motors/ low emissions, using "spoilers" to decrease air resistance on vehicles, encouraging fuel efficient driving	460,000	Unknown	Unknown	Individual firms/ Ministry of Sea, Transport and Infrastructure/ MEPPPC
Energy - use for Transport	Measures in inter-city passenger transport - improving roads, encouraging railroad travel, sea and intermodal transport, decrease of traffic jams	96,000	Unknown	Unknown	Individual firms/ Ministry of Sea, Transport and Infrastructure/ MEPPPC
Waste treatment	Reduction of emissions of CH_4 by using waste as an alternative source of energy in the production of cement and other industrial goods (removing the source of CH_4)	130,000	Unknown	Unknown	Cement industry/ waste management companies/ MEPPPC
Waste treatment	Reduction of emissions of CH_4 by thermal waste treatment	180,000	Unknown	Unknown	HEP/ Waste management companies/ MEPPPC
Energy - for industry use	Pumping CO_2 under ground after production (technology unproven in Croatia)	500,000	Unknown	Unknown	HEP/ MELE/MEPPPC
Land use changes	Increasing forest cover and growth of forests	7,000,000	Unknown	Unknown	Farmers/ landowners/ forest managers/ Croatian Forests/ MAFRD
	Total emissions reductions resulting from options that could be economically viable, but which do not have cost information available	8,447,000			

sures to increase public transportation and decrease transportation emissions. Others will require a better understanding of the technology (such as pumping carbon underground in the oil production sector) or the introduction of a better methodology for measuring the offsets and its acceptance by the international community – such as credit for land-use changes. The potential exists to reduce CO_2e emissions by a tremendous 8.45 million tonnes by 2020. Most of this reduction comes from continuing the reductions associated with forest cover and the growth of forests – though such a large amount is not likely to be recognised in international negotiations.

12.8. Conclusions and recommendations

As the Government of Croatia decides the commitments it can make in terms of reducing emissions, the above type of analysis is critical. According to these estimates, if all the measures mentioned here are implemented, the total emissions reduction for Croatia for 2020 would be approximately 16.9 million tonnes. The costs for this reduction are estimated to be between approximately EUR 114.7 million and 535.9 million for that year – equivalent to 0.31-1.43% of 2007's GDP.

If the final set of measures – including land use changes, were implemented, the total emissions reduction potential would be approximately 25.36 million tonnes – 7 million from land use changes in forestry if current growth patterns continue. Thus in 2020 from a total of 42 million, the total net emissions from Croatia would be a little over 16.6 million tonnes – or approximately 3.81 tonnes per person per year, if the population decreases to 4.37 million.[74] However, this reduction is unrealistic for a number of reasons.

- First, the numerous carbon sinks created by land use change are not expected to be implemented or counted fully.
- Second, many programmes require public action and involvement. This will require major institutional engagement.
- Third, many emissions reductions measures are controversial such as building nuclear power plants, incinerators, and reducing clinker requirements in cement.

Figure 12-8: Reductions for 2020 and level of emissions sorted by level of costs of the measures

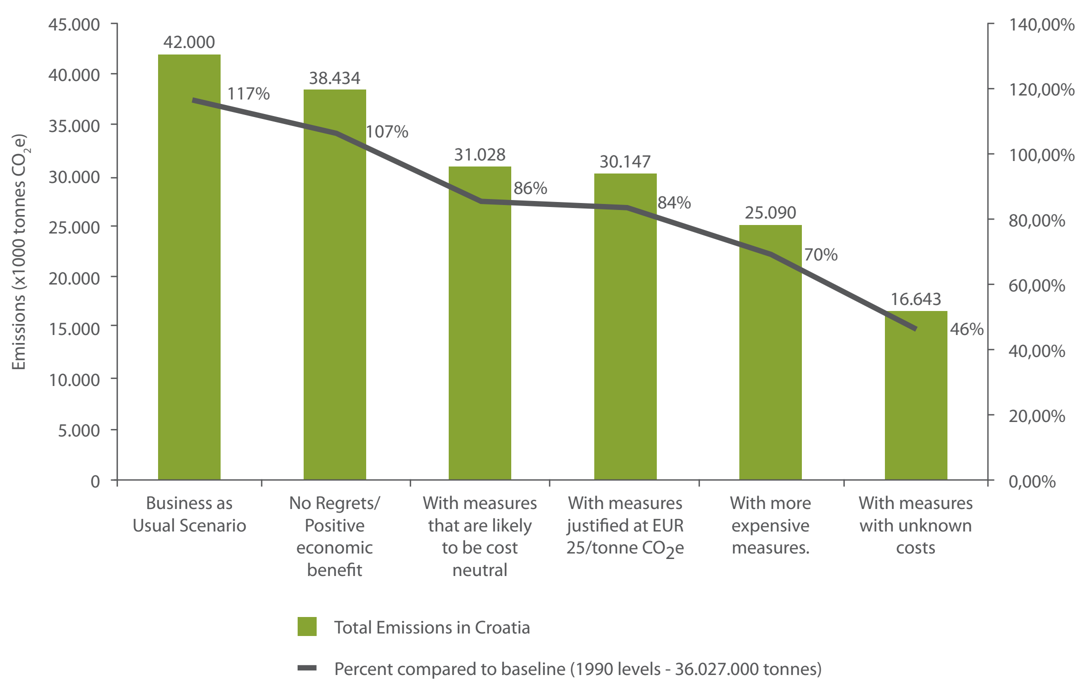
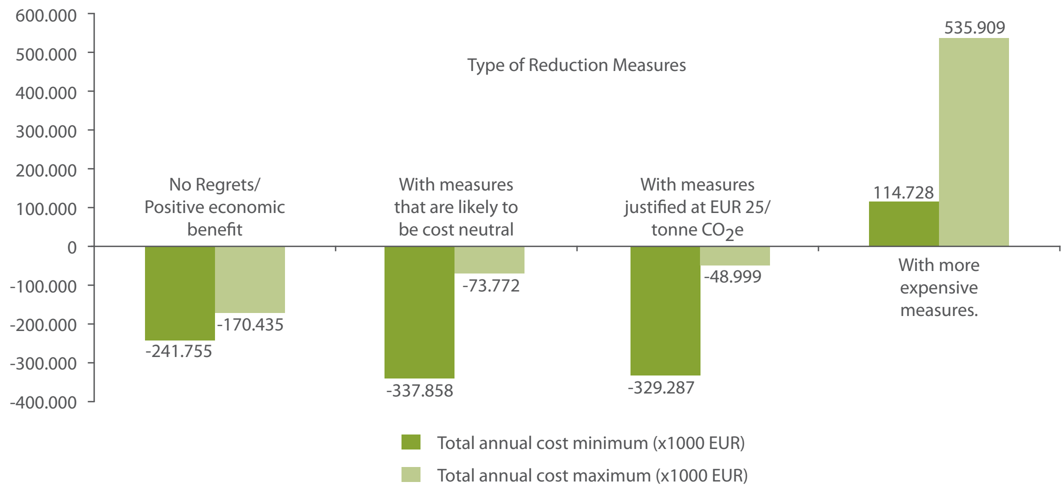


Figure 12-9: Projections for total costs for various types of measures for 2020



In order to achieve the 'absolutely best case scenario' described above, a number of issues must be addressed:

- The public and businesses must play a large role in implementing energy efficiency measures. This is the most economical way to reduce emissions in transportation, the households and services sector and in many industrial areas.
- All public and private institutions – especially in the energy, industrial, and agricultural sectors – need to streamline processes for ensuring that carbon emissions are reduced where possible and in a non-controversial manner.
- A number of outstanding technical issues will have to be resolved – for example the amount of cement in road construction, the amount of fertilisers that farmers should use, the crop rotations for agriculture that might include carbon sequestration, the amount of ruminants versus non-ruminants kept on farms, the placement of small hydro plants, and many others.
- A number of questions about potentially socially-unpopular measures which account for major portions of carbon reduction would need to be addressed.
- The use of bio-fuels needs further discussion – especially as biodiesel has come under fire in the past year because of the possibility that it leads to food shortages and price increases.
- Issues related to the thermal processing of waste – or incineration – need to be resolved. They could potentially lead to political conflict among communities near any waste treatment plant.
- Building nuclear plants instead of coal or gas fired plants accounts for 5.5 million tonnes of reductions. However, nuclear power is not the most popular investment and it is questionable because of its social acceptance. Participatory decision-making must occur and proper precautions must be taken.

In conclusion, this analysis shows that the theoretical potential for reductions in emissions in Croatia is high, if the price of GHGs is set at EUR 25 per tonne. However, while this potential does exist and seems to be achievable at a relatively low cost, the actual capacity of various actors to implement all the measures is much less certain. There are many political, institutional, technical, and legal considerations that must be taken into account before moving forward with any of the measures. These are discussed in more detail in Chapter 13. However, numerous measures have been identified as no-regrets measures that can have a significant impact. These are primarily oriented towards the following:

1. Improving energy efficiency in the households and services sector,
2. Increasing efficiency and decreasing emissions in industrial processes,
3. Burning methane from landfills for energy,
4. Encouraging organic farming,
5. Continuing land use changes that promote the sequestration of carbon in forests, along with improving the monitoring and calculation of carbon stock change
6. Increasing the efficiency of transport systems, including the fuel efficiency of cars, the efficiency of traffic flows, and alternative transportation (walking, biking, carpooling, public transport).

Additionally, there are many other measures that may become cost-effective with a higher price on GHGs. Finally, there are measures that may have a net positive economic cost but are potentially helpful in addressing other problems, such as increasing the carbon content of soils to retain moisture and decreasing the use of fertilisers to protect water quality.