

The Norwegian scenario and action plan presented by NITO

Future Climate - Engineering solutions



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Preface

Future Climate - Engineering Solutions is an international project involving engineer associations from all over the world. The project was initiated by the Danish Society of Engineers, IDA. The Norwegian Society of Engineers and Technologists (NITO) is one of the originators of the project, in cooperation with IDA, The Swedish Association of Graduate Engineers and The Association of German Engineers, VDI.

The Future Climate project is based on national action plans for reduction of greenhouse gas (GHG) emissions, developed by project partners. Participating associations develop their own national climate action plans. The plans give a technical evaluation of the national possibilities for reducing climate gas emissions to a level matching IPCC's¹ best case scenario.

13 associations of engineers from 12 different countries worldwide participate in the Future Climate project.

NITO has, with assistance from Institute of Transport Economics, TØI and Centre for international Climate and Environmental research - Oslo, CICERO made plans for engineering solutions in Norway. The methodology is based on status, technological ideas, calculation charts and graphics to present sustainable climate scenarios up to 2050. The purpose is to reduce the emission of GHG to a sustainable level. The Norwegian statistics for energy consumption and figures for GHG emissions are collected from the Norwegian Low Emission Commission² (LEC), where CICERO had the function as secretariat.

The tools and calculation charts are used by NITO internally, and in the national public debate on energy and climate. The data of the climate plans will be used in the overarching project report that will be presented before the UN climate summit, COP 15, in Copenhagen 2009.

Across the economy, we have searched for solutions that are already available, or on the verge of becoming so. We have analyzed findings from both scientific publications and various reports prepared by industry and environmental organizations. NITO is certainly not the first to undertake such an effort; numerous studies have been published by academics, think-tanks, environmental organizations and governments alike. But few have shown how the needed reductions in GHG emissions can be achieved by 2050.

¹ The Intergovernmental Panel on Climate Change

² NOU 2006:18 A climate-friendly Norway

Summary

Norway is a nation rich in both renewable and fossil energy. We have large hydropower capacity and production, and electricity accounts for almost 50 percent of our energy consumption. In addition there is great potential in wind energy, biomass energy, thermal energy and other renewable energy sources. Norway is one of the largest exporters of oil and gas in the world. Most of our fossil energy is exported, and the utilisation of these resources is not taken into account in the national emission accounts. However, fossil energy used to produce oil, gasoline, diesel and natural gas is included in the national accounts.

Norwegian annual GHG emissions, as defined by the Kyoto regulations, are currently 53 Million tonnes CO₂ equivalents per year. The main contributors to GHG emissions in Norway are the following four sectors - almost equal in emissions:

- Fossil energy production - oil and gas
- Industry - power consuming production
- Transport
- Heating, waste and agriculture

Following the Kyoto Protocol, Norway's emissions target has been that the country's average GHG emissions for the period 2008–2012 shall not increase by more than one percent compared to the emission level in 1990. Compared with today's level, this would mean a reduction of greenhouse gas emissions by about 7 percent. The target will be met by reducing emissions both nationally and in other countries, using the Kyoto emissions quota trading mechanisms, "Clean Development Mechanism" (CDM) and "Joint Implementation" (JI). The Climate White Paper presented in June 2007, entails that Norway must exceed the Kyoto target by 10 percentage points. The climate compromise of January 2008 suggested that Norway would become carbon neutral by 2030, and reduce GHG emissions by 30 percent within 2030³.

Before these targets were set, LEC presented in 2006 two scenarios involving a 50 or 80 percent reduction in domestic emissions to be reached by 2050, relative to the emissions level in 1990. The scenarios of 50 or 80 percent reductions are related to a reference scenario with increased energy consumption and related increased GHG emissions based on assumptions of continued high economical growth and increasing consumption of energy. The Reference scenario created by LEC is based on the government's long term economic outlook. Reduced GHG emissions from expected future reduction in Norwegian fossil oil and gas production are included in the reference scenario.

The political idea of unbroken welfare-growth has until the breakout of the present world economic crisis not been disputed. There is now, however, growing debate about possible political actions and whether the notion of everlasting economic growth ought to be replaced by the more moderate goal of achieving an acceptable standard of living.

³ About 2/3 of our total emission reductions must come from national sources.

The challenges connected to reductions in GHG emissions are transitions to more efficient use of energy and increased use of renewable energy. The important economic significance of fossil energy production and oil related activities, represent a challenging barrier to Norway's efforts to reduce emissions.

There is great potential both in the short term as well as the long term, towards 2050, for reducing Norwegian GHG emissions. Efficient technology is within reach, and can be used for business development, as well as for the actual reduction in GHG emissions. In addition, there is also a potential in Norway for large electricity surpluses that may be used for transport and industry purposes, or be exported abroad. The NITO strategy and the NITO scenario for reduced GHG emissions and a sustainable society by 2050 is based on a bottom-up approach. The purpose is to reduce the emissions of GHG to a sustainable level, defined as the best case scenario of IPCC in which the increase in global temperature does not exceed 2° C.

The NITO bottom-up approach for reducing GHG emissions in the four Norwegian sectors is based on:

- Fossil energy production: In 2050 NITO expects close to zero GHG emissions from almost empty oil wells, and very limited emissions from production of natural gas. With renewable on-shore electric power production it is possible to substantially reduce GHG emissions from production of fossil energy in 2050.
- Industry: NITO estimates higher efficiency within Norwegian industry. For large industrial activities Carbon Capture and Storage (CCS) is expected to reduce process related GHG emissions by 50 percent.
- Transport: The national transport sector may be almost independent of fossil fuels by 2050, with gradual increase in the use of electric energy, new batteries and second generations of bio-fuels. Ships may increasingly use methane as fuel and reduce emissions by new sail technology. Optimising speed in relation to goods with different urgency will reduce the speed related energy consumption from ships. The emissions from transport of goods may also be reduced by transition to electric railway.
- Heating, waste and agriculture: Will heating, waste management and farming gradually reduce GHG emissions by 75 percent. The means by which to do so are heat pumps, bio-energy and highly isolated buildings to reduce energy consumption/increase energy efficiency. Collection and efficient use of methane from landfills and deposits will also reduce GHG emissions.

The measures mentioned above results in a scenario allowing for a 74 percent reduction in domestic GHG emissions⁴.

⁴ Excluding use of the flexible mechanisms under the Kyoto protocol.

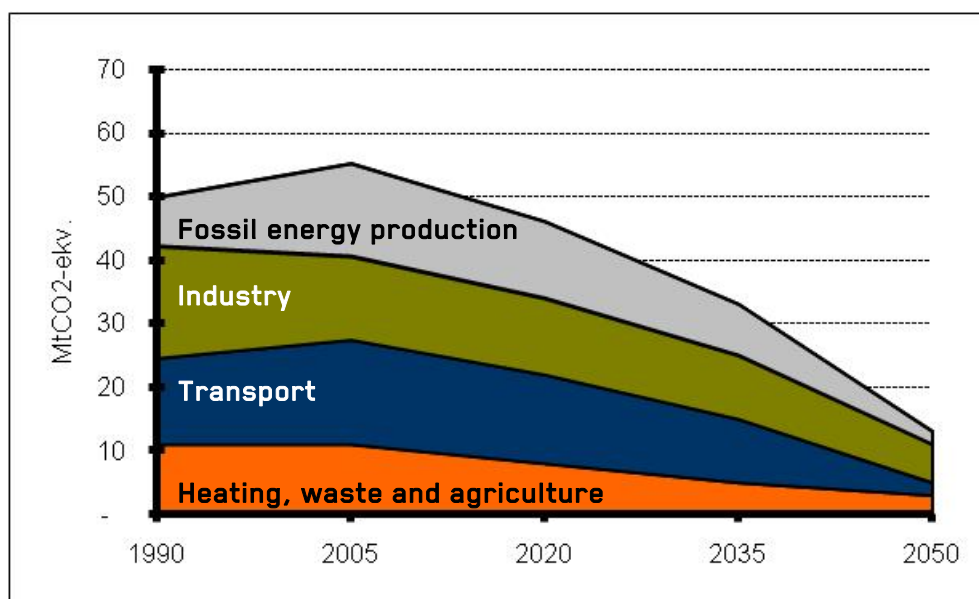


Fig 1: NITO scenario with 74 percent GHG emission reductions for Norway

Possible future export of Norwegian renewable energy as a result of increased renewable energy production and increased energy efficiency is not included in the Kyoto regime. However, export of renewable energy has the potential to contribute to reduced emissions in the importing countries. If GHG emissions reductions from possible future export of renewable electric energy were taken into account in the Norwegian scenario, this may imply a possible reduction in Norwegian GHG emissions of about 95 percent in 2050.

Recommendations

In general, NITO strongly emphasizes the importance of supporting energy efficiency in all sectors and parts of society. NITO also strongly advocates improving conditions under which growth in renewable electricity production may take place.

Fossil Energy Production

- New production should, when technology permits, take place from subsea facilities.
- New production should use electricity from renewable sources.

Industrial Sector

- Hydropower and other renewable sources of energy should be considered an asset of great value for future industry in Norway.
- The authorities should hire and educate "Energy Hunters", making them available free of charge for companies wanting to identify possible energy efficiency projects.
- Active energy management with certification requirement should be mandatory for companies using more than 50 GWh annually.
- Utilizing the potential of surplus heat from the industry.

Transport

- Norwegian industry must have competence and production methods to meet the needs of a new generation of cars.

- The "Plug-in Hybrid" concept must be supported and given priority by the government.
- The production of fuel from Norwegian renewable biomass must be supported by the government.
- Ship owners must be given incentives to extend their use of methane.
- New sail technology should be used to optimize speed and fuel consumption related to the weather and the urgency of the goods they carry.
- Infrastructure must be built to accommodate an effective transfer of heavy duty transport from road to electric railway and ships.

Heating, waste and agriculture

- Norway must adapt and adhere to the EU target of 20 percent increase in energy efficiency in buildings.
- Renovation of old buildings must be increased by 4/5 times.
- All new houses should be built with technology for "passivehouses" by 2020.
- Heating systems in public buildings must be changed to flexible systems that run on energy from different renewable sources by 2020.
- Use of livestock manure for production of biological gas.
- More efficient production of milk and beef.
- Reduce use of nitrogen in the agricultural sector.

Future Climate – the project

There is a strong need for reductions in GHG emissions to a sustainable level. Overcoming climate changes is a huge challenge, and might well be the number one challenge for engineers and society in the 21st century.

The core of the Future Climate project is national climate plans that outline a sustainable climate scenario. The climate plans are developed by each of the associations involved in the project for their home country.

The climate plans are developed on the basis and know-how of the associations and their members, and a common goal of all plans is to contribute to reduction of GHG emissions to a sustainable level. In the project, a sustainable level is defined as the best case scenario of IPCC where the increase in global temperature does not exceed 2° C. Within each plan, each participating association estimate realistic and yet ambitious reduction target for their country.

The purpose of the project is to develop climate plans and display sustainable energy technologies, as well as the corresponding measures needed to develop these technologies, in order to support an ambitious agreement at the UN Climate Change Conference in Copenhagen 2009.

Besides being an input to decision makers on national and international level, the climate plans offers opportunities for the participating associations to display the proficiency of their members, both towards a national and international audience.

Consequences of a 2 degree target

This project does not specify GHG emission reductions targets that individual countries must meet. Instead, it is the responsibility of each participating association to develop a sustainable climate scenario that contributes to reach the 2 °C target. The project has appointed an expert group (advisory board) which will consider the plans as a whole in the context of the 2 degrees target. Below, an illustration of the challenges ahead is displayed.

In its latest reports from 2007, IPCC estimate that if the concentration of CO₂-equivalents in the atmosphere is kept within the range of 445-490 ppm⁵, the global average temperature will increase by 2,0-2,4° C compared to pre-industrial level. As total GHG concentration already amounted to 445 ppm CO₂-equivalent in 2005, IPCC estimate that the emission of GHG will have to peak not later than 2015, and that global emissions of GHG should be reduced by 50-85 percent in 2050 compared to 2000.

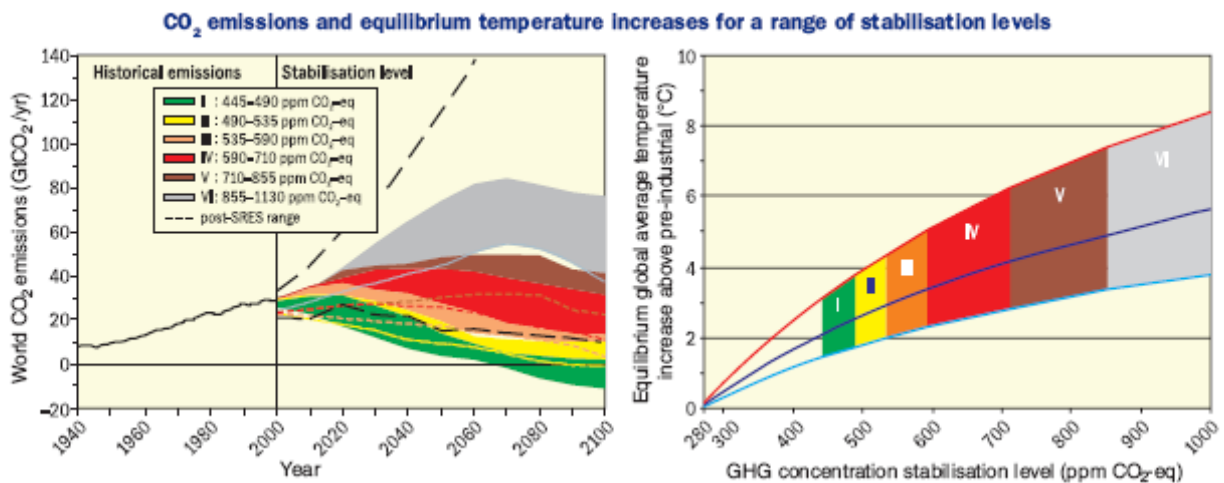


Fig 2: The CO₂ emission pathways and associated equilibrium temperature increases for a range of GHG stabilisation levels.

There is no doubt that all countries sooner or later must find ways of reducing the emissions of GHGs. However, there will be differences in the extent of emissions reductions related to the size of the current emissions, the trends of emissions and the economic ability of the individual countries.

If we, for the illustration, suggest that the emissions of GHG should be considered on a per capita basis, it is clear that developed countries will need to stabilise the emissions of GHG within the next couple of years, followed by a reduction of GHG emission above the average reduction level of 50-85 percent by 2050. For emerging economies, stabilization of GHG emissions followed by a reduction can be postponed some years. However reductions will have to take place in all regions of the world. In 2000 the total emissions of CO₂-equivalents was approximately 45 GT per year (IPCC, Working group 3), corresponding to 7.4 tonnes CO₂-equivalents per capita. UN forecast that the population will be approximately 9 billion by 2050,

⁵ Parts per million (ppm)

which means that the emission of CO₂-eq should be reduced to between 0.8-2.5 tonnes per capita per year. The current CO₂ emission per capita is displayed in figure 3.

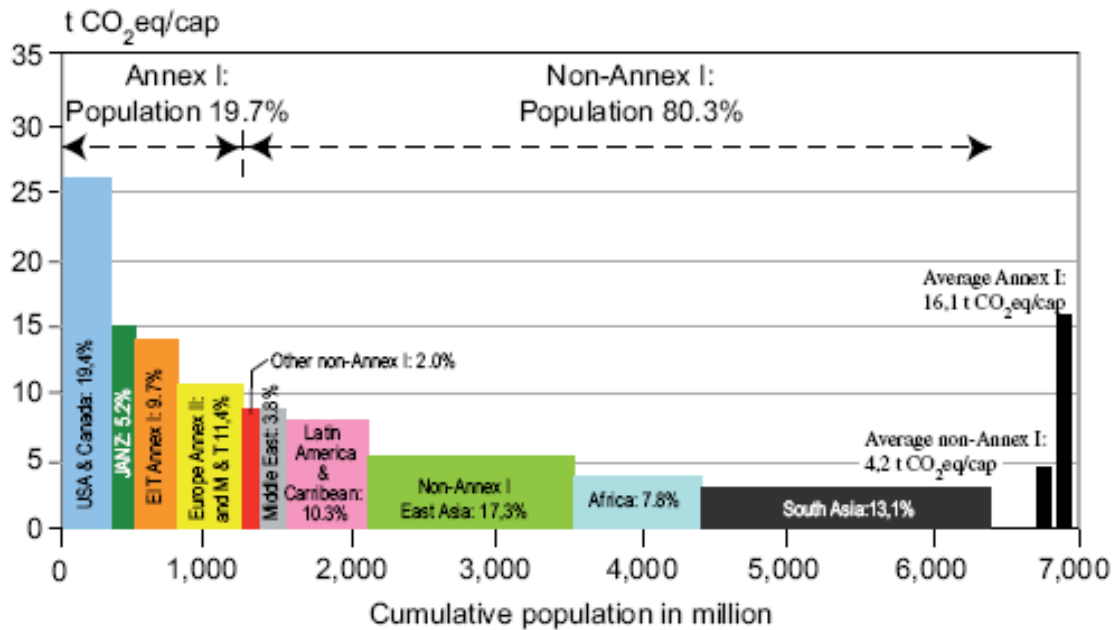


Fig 3: CO₂ emissions per capita from different parts of the World

The Norwegian energy system and energy production

Norway is a nation with rich hydropower capacity. Generated electric energy production is about 600 PJ, or 125 TWh per year. The other two important primary energy sources are crude oil and natural gas, with 721 PJ respectively 221 PJ per year (2007). Around 50 percent of the end consumption of energy is electricity. Hydropower accounts for about 98-99 percent of the total electricity production. The end consumption of energy in 2008 was about 819 Petajoule (228 TWh), which is 17 percent more than in 1990.

The current hydropower electric energy consumption is equivalent to about 28 000 kWh per capita, which corresponds to the heat value of 2.4 tons fossil mineral oil, or 3 200 litre of gasoline. Norway has with its renewable energy resources the potential to be self sufficient with energy, and could probably do well without additional fossil energy sources.

Unexploited and not protected hydropower sources are in the range of 40 TWh. The potential for renewable biomass energy in Norway is estimated to be about 50 TWh by 2050. In addition there is potential for wind energy, thermal energy and some other renewable energy sources.

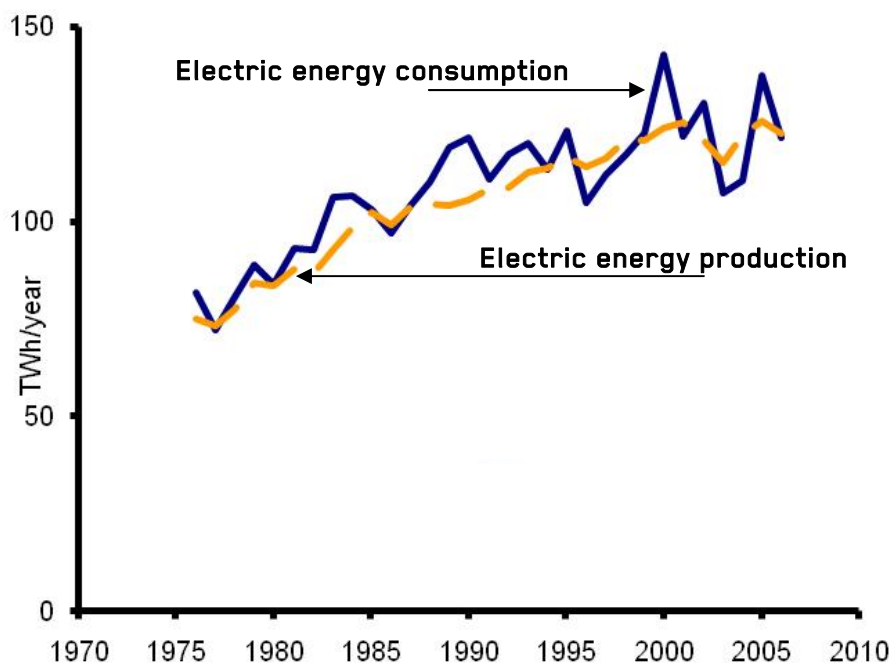


Fig 4: Norwegian electric energy production and consumption

Historically Norway had a surplus of inexpensive hydropower electric energy that was used to build up power intensive industry like aluminium production, iron, steel and ferro silisium production as well as pulp and paper production. NITO expect renewable electric energy to be a high valued export product in the future. If Norway does not increase production of new renewable energy, it might be a dilemma in the future whether "clean Norwegian electric energy" in the future shall be exported and replace "Euromix" electric energy or be used by the Norwegian industry.

Electricity prices have increased considerably since 2000. Norway has traditionally had low electricity prices compared to other countries, but since 2003 the electricity prices for households have been at about the same level as the average price in OECD.

New wind energy, thermal energy and other renewable energy sources may be used to create energy related industrial production and economical growth, but the costs for this electric energy is today in many cases expected too be to high to make the industrial production profitable.

Potential

Norway has substantial supplies of timber and a great potential for using logging waste and other bio products waste for **bio energy**. The potential for renewable biomass energy in Norway is estimated to about 50 TWh by 2050. Phasing in bio energy can contribute to reduced GHG emissions in Norway, but requires a major effort on the development of infrastructure. It

is important that an increase in production capacity for bio energy is planned in a sustainability perspective.

Wind power and hydropower are well matched because the water can be stored in the magazines when the wind is heavy. If wind power production is reduced, this can quickly be compensated by increased hydro power.

The potential for development of hydropower is large, and includes power plants of varying size, rearmament projects and expansions of existing plants. NVE (Norwegian Water Resources and Energy Directorate) estimates the potential outside the protected waterways to about 40 TWh.

Norway has developed a substantial proportion of its rivers, and this has had some negative consequences for the natural values and outdoor activities. A portion of the projects have been controversial and created debate and disagreement. At the same time, pointing to the climate challenge, we need more renewable energy to replace our fossil fuel consumption. New hydropower can make a significant contribution in this context.

NITO is working for increased modernization, expansion and continuous upgrading of existing hydropower plants, as well as gentle development of new hydropower where environmental considerations are emphasized.

Norway is the country in Europe that have the most natural favourable conditions to exploit wind power, at the same time Norway has some of the worst schemes to develop it. Wind power has so far played a modest role in the Norwegian power generation. Statistics for 2007 show a yearly production of 0.9 TWh - just below one percent of Norway's total production of electricity. Wind power is considered to have a considerable potential as a contribution to the country's total power generation. The development pace of wind power will largely be determined by the funding authorities, because wind power is not yet commercially profitable, and therefore depends on public support. NITO finds it unlikely that the Parliament's goal of 3 TWh from wind power by 2010 will be reached. Many stakeholders have withdrawn, and wind power projects are being shelved due to poor profitability.

Good wind conditions along the Norwegian coast makes offshore wind turbines interesting and challenging. Tough, cold climate and deep ocean technology represents challenges. In addition, the infrastructure for the transmission is challenging at sea. The benefits of putting wind turbines at sea is that the wind is heavier, less inconvenience (out of sight) and it may contribute to the electrification of the continental shelf (supplying oil platforms with clean power). Several companies are pushing to develop technology for both fixed and floating wind turbines. StatoilHydro is starting its first offshore floating wind turbines in 2009, and is planning to have a small mill park established by 2013.

On assignment from Enova, SWECO Groner in cooperation with ECON and Cellar Vindteknikk has estimated the potential for marine energy in the Norwegian system. The study includes a survey of resources and technology, and a discussion of the future for ocean energy. The aim of this study was to describe the energy potential, challenges, problems and possibilities of a phase-in of ocean energy in the Norwegian energy system. It was particularly emphasized to analyze the distance between the existing cost and revenue potential for various technological solutions. The study has been limited to wind, wave and tidal power.

The physical potential for offshore wind power (down to 300 meters depth) is estimated to 14.000 TWh. That is more than one hundred times the entire Norwegian hydropower production. First and foremost, there are financial constraints that determine the amount of floating wind power that can be developed.

The physical potential for wave power is estimated to 600 TWh, of which 12 to 30 TWh is assumed to have potential for development. The potential for tidal power is estimated to be approximately 1 TWh, but the potential for development is expected to be significantly less.

All reviewed technologies for wave and tidal power is today considered as pre-commercial. Costs are substantially higher than for conventional power plants, and most of the concepts are technically immature. Also when it comes to offshore wind power, costs are today to high, given the current framework conditions.

However, it is difficult to assess the possible earnings potential for the less mature technologies. There are indications that the profitability assessments of several studies are to "conservative" - not taking into account that the price of CO2 will make power more expensive.

To develop offshore wind power in Norway, there is a need for:

- Funds for research to develop the technology
- Framework conditions that make development economically feasible
- An overall commitment to increasing the skills base in wind power and establish a Norwegian wind power environment.

NITO is working to improve the framework conditions and increased funding for renewable energy.

Sources of GHG emissions

Norway is a nation rich with fossil energy. Most of the fossil energy is exported, and the utilisation of these resources does not count in the national emission accounts. However, the fossil energy used to produce oil, gasoline, diesel and natural gas is included in the national

accounts. The Norwegian GHG emissions defined by the Kyoto regulations are 53 Mt CO₂ equivalents of CO₂-equivalents per year. The contributors to the GHG emissions from Norway are four nearly equal sectors.

- Fossil energy production
- Industry
- Transport
- Heating , waste and agriculture

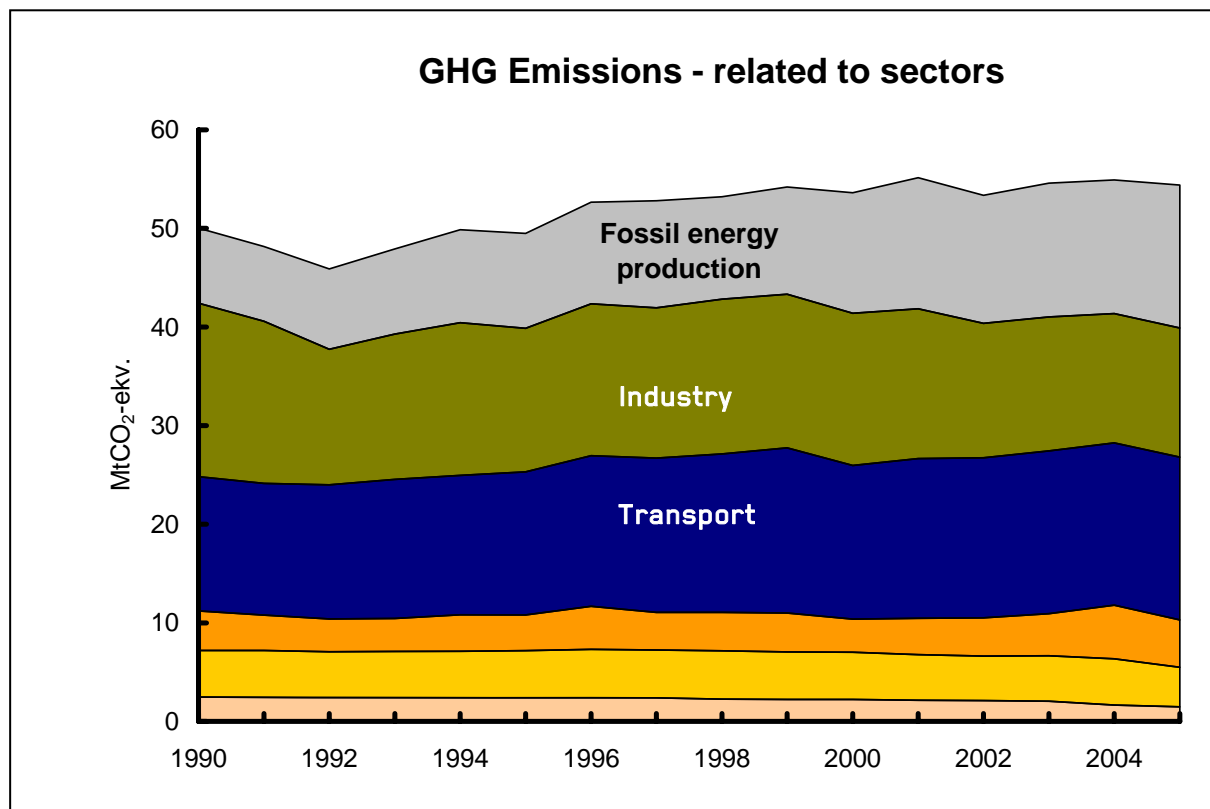


Fig 5: Historical Norwegian GHG emissions

The Norwegian Reference scenario

The Norwegian Low Emission Commission (LEC) in 2006 presented a low emission scenario with approximately 70 per cent reductions to be reached by 2050, related to the emissions in 1990. A Reference scenario with continued increase in energy consumption and related increased GHG emissions was based on political assumptions of continued high economical growth and increasing consumption of energy.

The Reference scenario created by the LEC is based on the conventional economic outlook as presented by the government. Reduced GHG emissions from expected future reduction of Norwegian fossil oil and gas production are included in the Reference scenario.

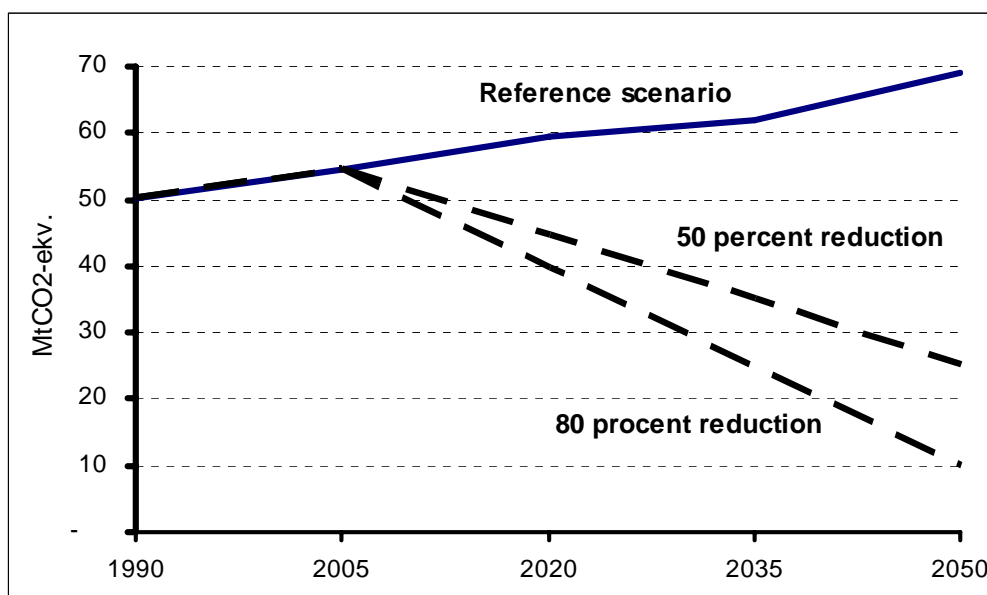


Fig 6: Norwegian Reference scenario and targets for reductions according to the Low Emission Commission.

The challenges related to GHG emission reductions are transitions to more efficient use of energy and increased use of renewable energy. The current economical important fossil energy production represents a challenging barrier to reduce GHG emissions for Norway. Fossil energy production and export creates economical welfare but also contributes to global warming.

Abatement Costs

Actions to reduce GHG gas emissions have different costs. Figure 7 shows that a number of actions have negative costs, i.e. are economic profitable. Efficient technology is within reach, and can be used for business development as well as for the actual reductions of GHG emissions.

On the other hand, the GHG emissions from oxidation/reduction processes in the Norwegian power intensive process industry can probably only realistically be reduced by Carbon Capture and Storage (CCS). Carbon Capture and Storage technology is not today a mature technology and is also expected to be an expensive way to reduce GHG emissions in the future. For middle size and small process industry CCS might be economically unrealistic.

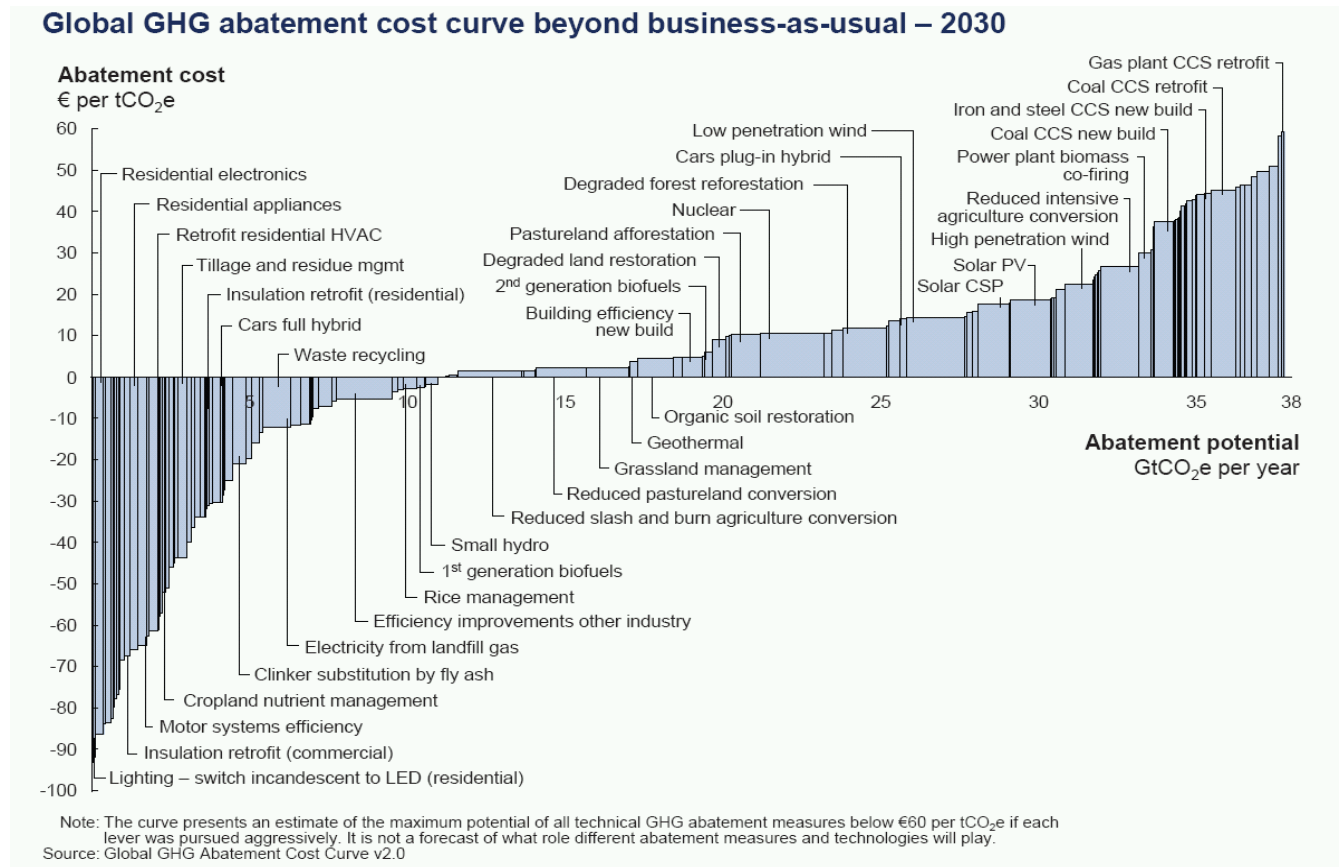


Fig 7: Costs for actions to reduce GHG emissions. Source: McKinsey

Potential and actions for the four emission sectors

All of the four main sources of Norwegian GHG emissions have energy efficiency and GHG reduction potential. NITO is in this project focusing on engineering solutions mainly related to industry, transport and heating/waste, where NITO engineers have the possibility to influence and actively reduce emissions.

Actions for the fossil energy sector

Norway is a nation rich in fossil energy. Most of our fossil energy is exported, and the utilisation of these resources does not count in the national emissions account. In 2006 Norway was ranked the fifth largest oil exporter and the tenth largest oil producer in the world. Correspondingly, Norway is the third largest gas exporter and the fifth largest gas producer in the world. Production of oil and natural gas contribute to Norwegian Kyoto protocol specified GHG emissions. Extraction and production of fossil oil and gas is however supposed to be done in the most efficient way compared with other fossil energy producers. The argument for continued high oil and gas production is that the world needs fossil energy and that the fossil energy carriers are produced with the least amounts of GHG emissions by Norway.

In 1991, Norway was one of the first countries to introduce a substantial CO₂ tax. This tax has led to development of technology and triggered initiatives that led to considerable emissions

reductions. The strict regulation of flaring through the Petroleum Act contributes to a low general level of flaring on the Norwegian continental shelf, compared to other countries.

There are also concrete, practical measures on the shelf, and Norwegian oil industry leads the way when it comes to applying environmentally friendly solutions. But although much is done to develop environmental competence and technology, there are huge challenges when it comes to GHG emissions. The developments on the Norwegian continental shelf towards more mature fields, movement of activities towards the north and longer distances for gas transport all reinforce a trend of higher emissions per unit. In the next few years, CO₂ emissions from the petroleum activities are estimated to about 14 MT CO₂ per year.

The emissions will be high until the reserves of oil declines substantially. Production of oil and gas will decrease as these resources are depleted. NITO assume that there in 2050 will be only small amounts of oil left on Norwegian territory, and that the production of oil practically will be shut down. In 2050 there will probably be substantial natural gas resources left in Norway. NITO assume that the world eagerly will demand natural gas in 2050, and that the production will continue, but with strict arrangements to minimise GHG emissions.

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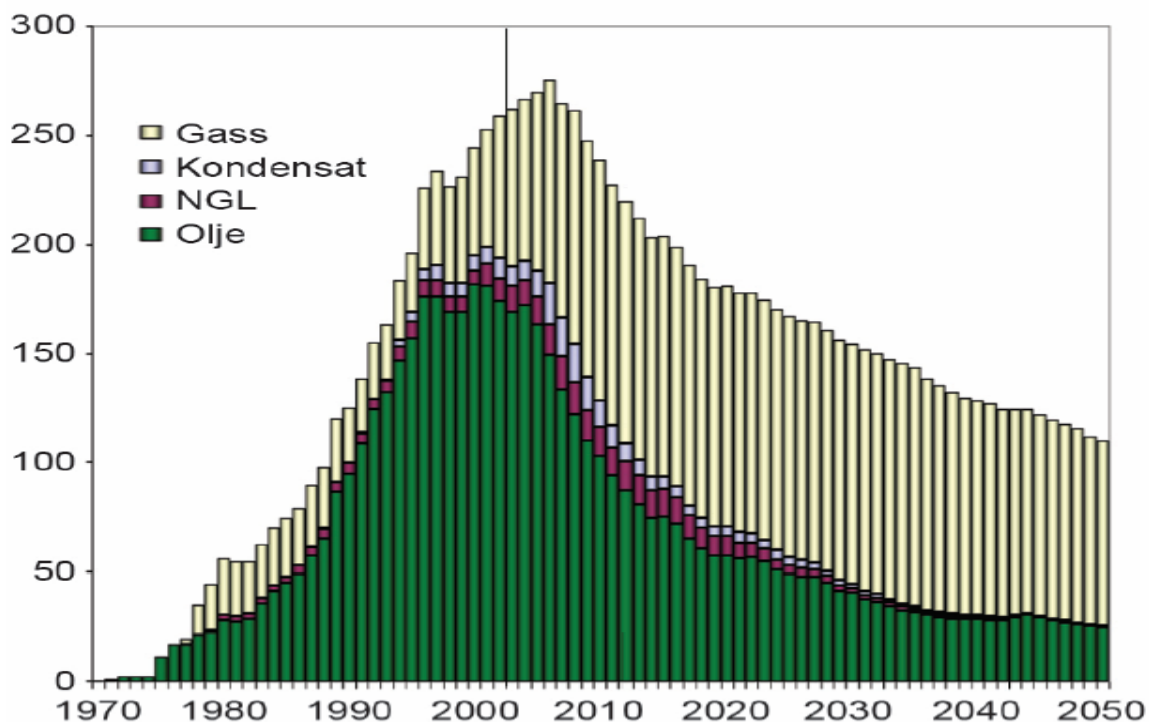


Fig 8: Expected Norwegian oil and gas production

In 2050 NITO expect almost zero GHG emissions from almost empty oil wells, and very limited emissions from production and export of natural gas.

NITO recommends:

- The work on emission-free power in the petroleum sector must be intensified.

- New production is anticipated to be from sub sea facilities for small or medium size oil and gas fields.
- NITO believe the oil companies should develop plans for how they can now at least 85 per cent emission-free hydropower energy by 2050.

With renewable electric power supply from on shore power stations with no or small GHG emissions, it is possible to substantially reduce GHG emissions from new production of fossil energy by 2050. As of today, several fields already receive all or parts of their power supply from land. For example, the Troll and Ormen Lange facilities use power from the grid, while Walhall redevelopment and the Gjøa field will be developed using power from land.

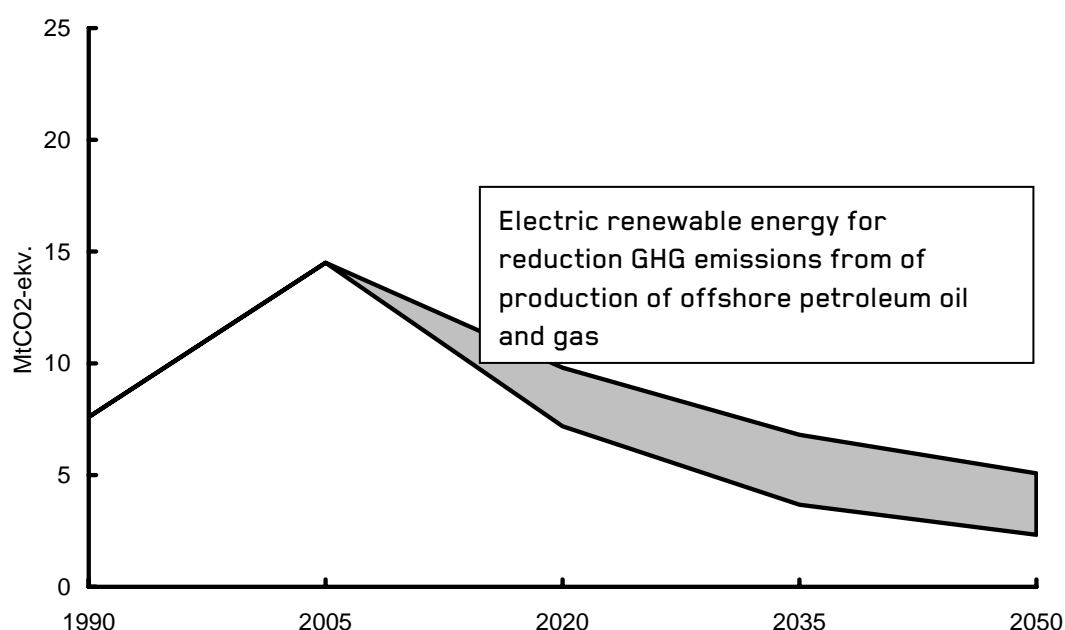


Fig 9: Norwegian Reference scenario and reduction of GHG emissions from production offshore oil and gas with renewable electric power from the shore

Actions for the industrial sector

In a historical perspective Norway's surplus of inexpensive hydropower electric energy enabled us to create power intensive process industry and energy consuming activities like aluminium production. With actions taken to reduce energy consumption and increase production of renewable energy, there will still be renewable energy left for industrial activities in 2050. New wind energy, bio energy and other renewable energy sources may be used to create energy related industrial and economic growth.

Energy intensive industries like aluminium production may however struggle with high electricity prices. Since this industry is highly exposed to international competition, energy reduction actions are continuously invented, implemented and evaluated. The alternative to high energy consumption is to shut down, and as such to reduce the international supply of the commodity.

Norwegian companies are at the highest technological level of emission reduction activities. Through voluntary agreements, the onshore industry has reduced direct GHG emissions by more than 20 percent from 1990 to today. During the past five years, the industry, in cooperation with ENOVA, has delivered nearly 3 TWh worth of energy-saving measures. There are many promising distinct projects. Elkem is working to develop carbon technical aluminium, a technology solution that will reduce energy consumption and CO₂ emissions dramatically. Norske Skog is working to produce biodiesel from wood waste, which will make fuel available without taking resources from the world's food production. In the Grenland area, the industry is working on promising projects for the management of CO₂. There are many more examples.

One of the Norwegian industry's competitive advantages has been clean and cheap hydropower. By concentrating on energy efficiency, the industry has contributed to improving its competitiveness. Norwegian industry is among the world's cleanest, but may still be better. Competitiveness may be ensured through strict environmental standards, which will serve as an incentive to the development of the industry, based on ample supply of high expertise and world leading technology. To prevent migration of industry to countries that exhibit fewer/lower environmental standards, and thus have more polluting industries, it also serves as a contribution to curbing global warming.

NITO recommends:

- New production must be based on more environmentally friendly technologies and products, as well as facilitation for rational use of energy and heat.

The potential for energy efficiency and reduced emissions of GHG

Both larger studies and specific projects reveal a considerable potential for reducing energy usage in industry and manufacturing. The same studies also show that a substantial proportion of energy efficiency projects are commercially viable and profitable. There is a wide range of possible efficiency measures, i.e. energy efficiency in the industry is feasible by using more efficient tools and equipment, such as electric engines, boilers, pumps and improving processing integration.

Many energy efficiency measures provide positive returns due to the cost savings effects from reduced energy consumption. A number of major Norwegian industrial companies have already implemented internal programs to improve energy efficiency. This is achieved by using systems for energy management, energy saving campaigns and the appointment of so-called "energy hunters", who are staff dedicated to identify opportunities for energy efficiency.

However, many energy efficiency measures are not realised in spite of the potential financial gains involved. This is often related to non-technical barriers, such as lack of attention from corporate management, lack of clarified responsibilities for implementation of measures, or uncertainty about future operations. There are also measures with a positive but small individual savings potential, and as such are not large enough to attract attention.

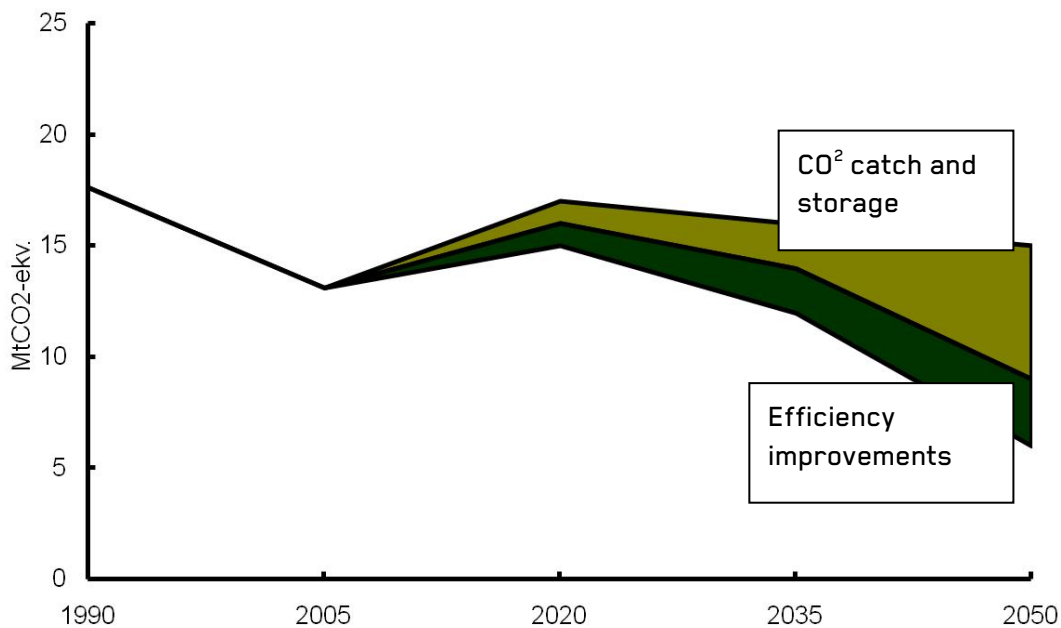


Fig 10: Reference scenario for Norwegian GHG emissions and actions to reduce GHG emissions from the industrial sector

The Norwegian Pollution Control Authority (SFT)⁶ has found that in the industry, a reduction of 0.2 MT CO₂ may be achieved through energy efficiency measures by 2020. A report written by Bellona and Siemens from 2007 identified an energy surplus potential of about 3.5 TWh from efficiency measures involving electric motors and process automation. The total potential for energy efficiency is higher when the heating process and overall system improvements are included.

A study⁷ conducted in 2009 estimated the potential for surplus heat from the Norwegian industry to 19 TWh. 7 TWh of the surplus heat has a temperature of over 140 °C, making it possible to exploit the energy to generate power. 3 TWh have a temperature of 60-140 °C which, in part, can be used for power generation, but first and foremost for district heating systems. The remaining potential is located in the lower temperature ranges, but may be appropriate for the exploitation of low-temperature district heating, heating of water for fish farming, or as a heat source for heat pumps.

Energy intensive industry

Energy intensive industries⁸, together with the wood industry, accounted for 75 percent of the total energy consumption in the industry in 2007. Other major consumers of energy are refineries, the mineral industry and other chemical industries. These industries used about 13 percent of the energy consumed by the Norwegian industry in 2007.

⁶ SFT's analyses of measures

⁷ Norsk Energi og Nepas. Utnyttelse av spillvarme fra norsk industri - en potensialstudie

⁸ which includes the metal industry and manufacturers of chemical raw materials.

There is a considerable potential for increased energy efficiency in the energy intensive industry. The industry itself has undoubtedly an interest in continuing improving energy efficiency considering the fact that energy costs make up a significant proportion of their overall costs.

"Emissions of greenhouse gases for the production of aluminium in Norway have fallen by 62 percent. This means that the industry has gone beyond the requirements established in an agreement signed with the Ministry of the Environment. The goal of this agreement was a reduction in emissions of greenhouse gases per tonne of aluminium produced in Norway by 50 percent by 2000 and 55 percent by 2005. Figures from SFT show that the emissions in 2005 were 62 per cent below the 1990 level per tonne produced. Total emissions are reduced by 39 percent. The production of aluminium has increased by 61 percent during the same period. The reason for the reduction of GHG is the reorganization and improvement of production. These improvements mean that Norway has the world's cleanest aluminium production. In addition, cleanliness of the national industry is also helped by the fact that Norwegian electricity is based on 100 percent pure water power." Source: Norsk industri

A significant reduction in GHG emissions from oxidation processes in the Norwegian process industry is only possible to achieve through Carbon Capture and Storage (CCS). Carbon Capture and Storage technology is not a mature technology today, and is also expected to be an expensive way to reduce GHG emissions in the future. For middle size and small processing industry companies it might even be economically unrealistic.

IPCC estimates that capture and storage of CO₂ will represent 20-30 percent of the cuts involved in meeting the climate challenge. According to the International Energy agency (IEA) CCS could reduce CO₂ emissions by 20-80 percent by 2050.

Norway introduced first-generation technology in this area in the North Sea more than ten years ago. Norway has for years stored CO₂ under the Sleipner gas field off the coast of Norway. What is new is the ambition to adopt the technology in new areas in the larger scale. In the longer term, we need to develop a technology to capture CO₂ from gas-and coal-fired power plants. For a technological breakthrough that will provide lasting value, the costs must be lowered significantly. Norway is in the process of establishing pilot projects - at Mongstad and Kårstø - aimed at capturing and storing CO₂ from gas-fired power plant in full scale. It is extremely challenging projects, both technologically and economically.

NITO recommends:

- Continued government support of CCS efforts

Cooperation between the industry and the national authorities is important in relation to energy saving.

Eks.: Cooperation on energy efficiency between the national authorities and Norske Skog
 Norske Skog is a multi national manufacturer of lightweight coated and uncoated newsprint and magazine paper. In order to produce newsprint, biomass from spruce is used. The manufacturing of mechanical mass is very energy intensive. The production capacity of its manufacturing plant at Skogn is 560,000 tonnes newsprint paper per year, and the power consumption is approximately 1.2 TWh per year.

In 1991 Norske Skog and the Ministry of Environment started a partnership aimed at solving the challenges concerning use of recycled paper, i.e. newspapers and magazine. An agreement was signed, in which Norske Skog committed itself to build recycled paper plants with a capacity of 100,000 tonnes per year. The cooperative venture between Norske Skog and the Ministry led to the decision to build a plant to remove ink from recycled fibre at Skogn in February 1998. The total investment was 500 million Norwegian kroner, and the capacity was 140,000 tonnes per year. This result was an energy reduction of 266 GWh per year. In addition to the energy reduction, newspapers and magazines are recycled.

In 2006, an agreement was signed between Enova and Norske Skog activating a grant of 50 million to a project on fillers at Skogn, with a total cost of 330 million NOK. The project involves adding lime to the newsprint. As a result of the increased proportion of fillers, the factory will reduce the need of electric energy by 17 percent when the project is completed. This corresponds to a reduction in energy usage of 250 GWh. To illustrate the scale of the energy saving measures, this is equivalent to the energy consumption of 25,000 households.

Challenges

A number of measures that may be implemented in order to reduce energy consumption are profitable, but they are not implemented even if the gains are measurable and benefitting the bottom line. It seems that a lot of companies within the Norwegian industry operate with a short planning horizon. High-quality efficiency measures are not implemented unless there is a clear focus on energy consumption in the company's management.

- The industry, particularly SMEs, lack the skills to identify opportunities for energy efficiency and qualified personnel to implement and follow up the efficiency measures.
- Energy efficiency loses out in competition for industry investment.
- Lack of mechanisms between energy customers and suppliers that motivate reduced energy consumption.

There are still some "simple" measures that ought to be considered, which upon realization may well provide obvious business opportunities.

I.e.:

- Control Systems - SD plants
- Optimization of electric motors - energy-efficient drives
- Optimization of air systems - optimization and leak sealing
- Insulation of pipe systems and buildings
- Efficient lighting

- Energy efficiency of processes/systems
- Fuel saving processing
- Increased efficiency/reduction in energy consumption in the transport chain

NITO recommends:

- Hydropower and other renewable sources of energy should be considered as an asset of great value for future industry in Norway.
- The authorities should hire and educate "Energy Hunters", making them available free of charge for companies wanting to identify possible energy efficiency projects.
- Active energy management with certification requirement should be mandatory for companies using more than 50 GWh annually.
- Utilize the potential of surplus heat from the industry.

Actions for the transport sector

The transport sector in Norway contributed in 2000 with emissions of 16 Mt GHG. The reference scenario indicates a growth to 18 Mt GHG by 2050. A transport sector with fossil fuel emission of 5 Mt CO₂-equivalents is within reach by 2050. The fossil fuel emissions can be even lower with an intensive change to synthetic biofuels from Norwegian forests and so called CO₂-neutral GHG emission. Small cars and light duty vehicles with electric drive will contribute with the largest part of the reductions.

Norwegian vehicle industry should adapt to development and production of systems and components attractive to the new generations of vehicles.

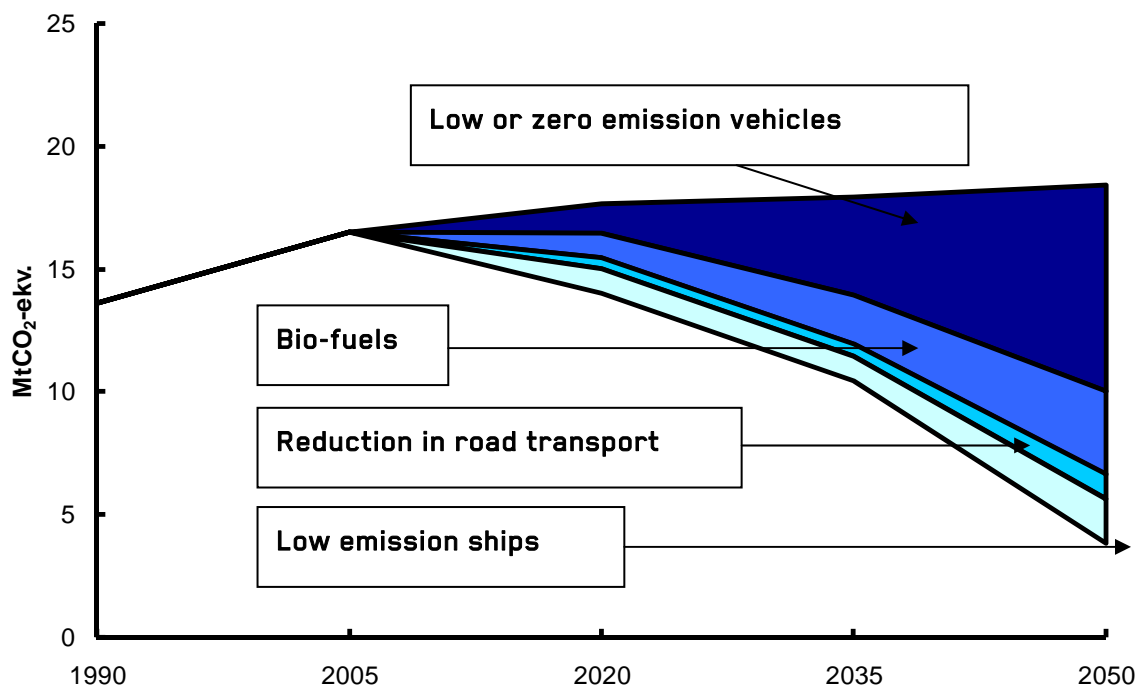


Fig 11: Scenario for Norwegian GHG emissions and actions to reduce GHG emissions from the transport sector in relation to the Reference scenario

Light duty vehicles

The internal combustion engine, fuelled by petrol or diesel, is currently the totally dominant technology for vehicle propulsion. New light vehicles with combustion engines have energy efficiency from tank to wheel in the order of 18-25 percent in real life driving. Today's compression ignition diesel engine is about 20-25 percent more efficient than the spark ignition petrol engine. Direct fuel injection has been practiced for heavy-duty diesel engines since the 1950s. The introduction and development of injection systems for small diesel engines for light vehicles since 1990 has led to great improvements in performance and efficiency.

In Europe, light diesel vehicles have captured an increasing share of the market for new cars compared to light petrol vehicles. The climate change driven focus on efficiency and market's demand for a robust power source favours diesel engines.

Electric power and electric motors are superior to combustion propulsion in every way. Electric drive has the advantage of zero emissions and high efficiency from the hydropower or wind electric generator (energy efficiency of about 75 percent "Well to the wheel"). Energy for electric drive can be stored in batteries, or stored as hydrogen for conversion to electric power in fuel cells. The superior efficiency in converting electric energy to useful power to the wheels is a strong argument for electric drive.

For future fuel cell vehicles and hybrid vehicles the average "Well to Wheel" efficiency (in real life driving) will be in the range of 30-40 percent. Fuel cells may in the future even make it possible with even higher efficiency than 40 percent. For ordinary light vehicles with diesel and gasoline engines the efficiency is at its best in the range of 30-40 percent, respectively 20-30 percent. These high efficiencies, for vehicles with combustion engines, require best engine load and best rpm (rotations per minute). The energy efficiency with electric drive, fuel cell vehicles and hybrid vehicles is high at low as well as at high driving loads. For vehicles equipped with traditional combustion engines the efficiency is, as shown in fig 12, acceptable at high loads but very poor at low engine loads.

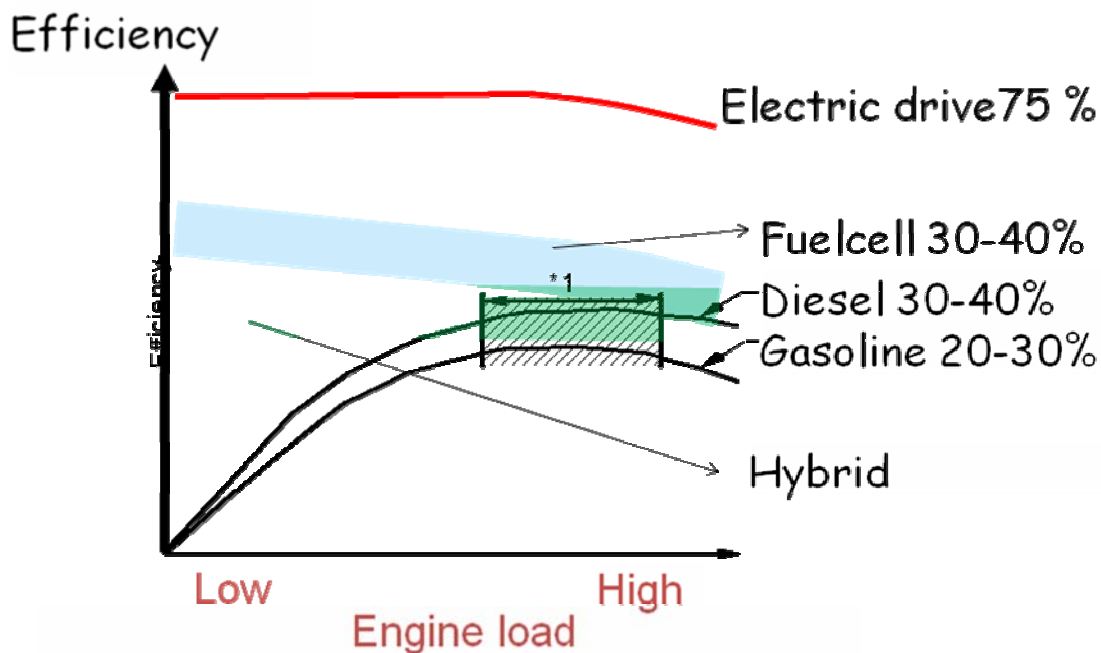


Fig 12: Energy-Efficiency for personal cars in a "Well to Wheel" perspective

Low or zero emission vehicles

Challenges with storage of electric energy and the technological and economical challenges with fuel cells have for long been major barriers to their commercialization. New battery technology has however in the recent years made small electric battery vehicles and plug-in hybrid vehicles promising solution for commuting and short distance travelling respectively family cars.

A realistic approach to improve efficiency and reduce GHG emissions from future vehicles is introduction of hybrid technology with combined electric propulsion and efficient small combustion engines. The hybrid concept, where the transmission includes a combustion engine and an electric motor plus batteries for energy storage, is commercially available from at least two international vehicle producers. Others major producers are preparing to introduce hybrid technology in their new models. Mild hybrid vehicles produced in large numbers with low production costs are with increased oil prices expected to become a profitable choice for ordinary customers.

There are different ways for configuring hybrid functions in vehicles. Basically, the combustion engine powers a generator, which provides electric power for a motor that drive the wheels. The hybrid passenger car model, Toyota Prius, has a complex energy management system that makes it possible to combine the best features from combustion engines and electric drive. The Honda Civic hybrid with Integrated Motor assist System (IMS) is an efficient mild hybrid vehicle. With mild hybrid systems the electric power contribution is relatively small compared with the combustion engine, and may be produced from a combined flywheel-starter-generator and a battery.

Battery electric vehicles may in principle move towards hybrid propulsion with a small combustion engine or small fuel cells as range extenders and to charge the batteries. The GM prototype models Volt and Ampera are examples of vehicles that combine battery electric drive with range extenders.

Hybrid Electric Vehicles offer several advantages. The combustion engine may run at optimum speed and load to yield maximum efficiency. Locally harmful exhaust emissions can be significantly reduced during harsh transient driving and be totally eliminated during short periods of electric urban driving. Brake energy is recovered and stored in the battery. The engine can stop and restart according to the need for power. Idling is unnecessary and extra power for acceleration and climbing can be drawn from the battery. "Well-to-Wheel" studies and life cycle assessments of CO₂ emissions indicate that electric drive, hybrid drive and plug-in hybrid vehicles are the future.

The plug-in Hybrid concept

Increased national energy efficiency and reduced use of Norwegian electric power in industry and for heating will together with wind and other new electric power sources make it feasible to allocate a substantial amount of electric energy to the transport sector. The plug-in hybrid concept and small battery electric personal cars are expected to dominate the Norwegian market from 2020 and might be expected to be the only personal cars options from 2040.

The life cycle emission perspective

In a life time perspective production and use of hydro power generated electric energy as energy source for light vehicles and personal cars has superior GHG emissions figures compared with all other options. Fig 13 shows CO₂ emissions for production and use of cars in life cycle perspective. Emissions from production are higher with hybrid vehicles than from production of traditional vehicles, and will become even higher from production of battery electric cars.

The figure also shows that it is a necessity for GHG emission reductions that the electricity for use in electric cars is renewable or produced in a CO₂ free way. If the electricity is produced in a coal power plant a hybrid gasoline vehicle is a better alternative than a battery electric car.

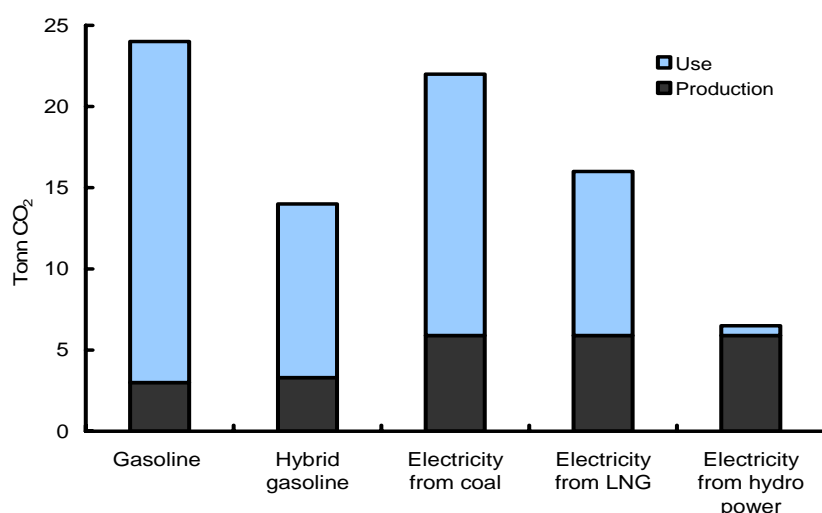


Fig 13: CO₂ emissions for production and use of cars, in life time perspective. Source: Tahara et al. 2001

Renewable fuels

Renewable fuels and biofuels are produced from renewable energy sources. CO₂ released by the combustion of biofuel and biomass is regarded as CO₂-neutral, since most of the carbon from biomass will be circulated back, and not increase the CO₂ concentration in the atmosphere. Carbon in biological compounds will anyway be released as CO₂ and methane emissions in the short term perspective as a result of natural fermentation and decomposition.

Two politically popular liquid biofuels that often (without taxes) can be sold to competitive prices are rapeseed oil methyl ester (RME) and ethanol. They are often called first generation biofuels and can be distributed as additives (up to 5 percent blend with fossil fuels) and in some markets they are available as pure biodiesel or high blend ethanol.

Other fuels that may replace fossil petrol and fossil diesel can be produced from renewable energy as well as from fossil energy sources. It may be somewhat confusing with renewable hydrogen, methane or DME (DiMethylEther). These fuels are regarded to be CO₂-neutral, but exactly the same energy carriers can be produced from fossil energy sources. If hydrogen for transport however is produced with CO₂ capture and storage (CCS) the GHG effects are removed, but we have to pay for these extra costs.

In countries with high taxation of fossil fuels, as is the case in the Nordic countries, approximately 70 percent of the retail price is taxation. High taxes on fossil fuels make it possible to support the sale of alternative fuels by freeing them from taxes. Freedom from fuel taxes is a more direct incentive than economical support for purchase of vehicles dedicated for special alternative fuels or purchase of cars that may drive with alternative fuels as well as fossil fuels. However in many cases economical support is a necessity for both the alternative fuels and the vehicles to make a new environmental friendly concept attractive to the market.

Not only GHG emissions but also low energy consumption is essential for cars that shall contribute to reduced global warming. Vehicles designed to run on for example E85 (85 percent ethanol) should preferably meet the same energy challenges and emission levels as petrol passenger cars.

The Swedish initiative for extended use of bio-fuels and ethanol in particular seems to encourage the use of vehicles with high energy consumption and CO₂ tail-pipe emissions exceeding the average for new cars.

Alternative fuels are likely to gain increased popularity with the future expected shortage of petroleum oil and increased concern about global warming. Emissions from vehicles, "Tank to Wheel" is a result of the choice of fuel, the conversion process of chemical energy to motion and the clean-up process.

Technology and fuel neutral vehicle criteria should be combined with ambitions to increase use of renewable fuel in countries with high taxes on fossil fuels. Exemption from taxation can be a sufficient advantage regime in the short run, but in the long run renewable fuels have to meet economical as well as environmental "Well to Wheel" competition.

Synthetic fuel is a concept that was introduced by Shell and their owned company Choren and refers to a fuel, produced from natural gas in the short term and from biomass or other renewable bioenergy sources in the longer term. Synthetic fuels or GTL from natural gas are pure hydrocarbon compounds, in liquid form, and are universally applicable. When Gas to Liquid (GTL) fuels are produced from biomass or biogas they are classified as CO₂-neutral energy carriers and for purposes of distinction they are then referred to as Biomass to Liquids, BTL fuels.

Norwegian forestry and Norwegian forests is the feedstock for serious plans to produce large quantities of synthetic diesel. The company Xynergo is a company owned by one of the world's biggest paper producers, Norske Skog. Xynergo has with Choren technology plans to step by step build up synthetic diesel production in Norway.

Heavy duty vehicles

It is possible, but in praxis it has in Norway been shown to be difficult, to transfer heavy duty vehicle transport to ships and rail. Norway is a country with low population density and new railways are expensive in comparison with new roads for district locations.

Synthetic diesel from Norwegian forests is likely to be the future alternative to fossil diesel for the heavy duty transport sector. Hybrid technology and electric drive is beneficial for urban buses but to a less extent beneficial for other forms for heavy duty transport.

Ships

The shipping sector has developed solutions and efficient engines for the use of methane as a ship fuel. Norwegian ships are already using natural gas and will to an increasing extent use methane as fuel to reduce GHG emissions. New sail technology is an option that may reduce GHG emissions from shipping. Finding and optimising best speed to minimising GHG emissions

from ships in relation to goods with different urgency can reduce the speed related energy consumption of ships.

Railway

The GHG emissions from the transport of people and goods can be reduced by transition to electric railway. However in low density populated country like Norway, electric railway passenger transport is only expected to increase in the most populated areas.

The rail infrastructure in Norway is not good enough for significant increase in the transport of goods. With simple means and limited small costs the capacity may however be extended to transfer some of the heavy duty road transport to railway.

High speed trains and new infrastructure for these trains is expensive and a controversial theme in Norway. The parliament has decided to further assess the feasibility of very large investments in tracks for high speed rail for passenger and freight transport.

Actions for heating, waste and agriculture

Most of the measures aimed at energy efficiency are considered to be cost-effective. A number of studies indicate that energy efficiency measures may imply less demand for energy both in industrial economies, as well as in developing and transition economies. The potential of increased energy efficiency in both commercial and residential buildings is by far one of the most promising areas in which to make fast and cost effective reductions in global GHG emissions. Today, building infrastructure is responsible for a third of the global energy related CO₂ emissions⁹. There is a variety of measures that may be implemented in the area of residential and commercial buildings.

In Norway, direct electric heating has traditionally been inexpensive, and as such make up a lot of the electric energy consumption. Energy consumption by Norwegian households is 38 TWh per year, and in commercial buildings it amounts to 30 TWh. About 55-65 percent of the consumption is used for heating and hot water. The potential for increased energy efficiency in buildings is huge in Norway. With well insulated buildings, it is possible to reduce energy consumption by 50 -75 percent in old buildings.

⁹ D. Ürge-Vorsatz, A Novikova, Potentials and costs of carbon dioxide mitigation in the world's buildings, Department of environmental sciences and policy, Central European University.

Energy consumption in Norwegian buildings 2006. TWh

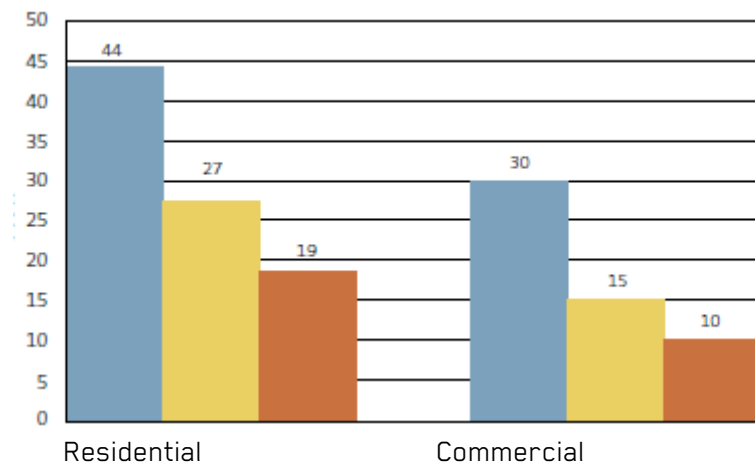


Fig 14: Energy use for Norwegian residential and commercial buildings; Stables are total consumption, consumption for heating and heating by electricity Source: Enova's construction statistics 2007

In addition, direct electric energy heating may also be substituted by geothermal energy, solar energy, energy from heat pumps and bio energy. The use of oil must also be replaced by more environmental friendly technologies (renewables). Surplus electric energy from more efficient heating of buildings may in the future be used in the transport sector, perhaps also in the national industries or even exported to other parts of Europe.

NITO supports EUs target for the building sector, and recommends a 20 percent increase in energy efficiency by 2020. This will reduce energy consumption by 15 TWh. By 2050 the target must be a 50 percent increase in energy efficiency, or about 37 TWh.

NITO advocates that all new buildings should have efficient insulation and low energy consuming heating systems. About 60 percent of all energy consumption in buildings is used for the heating of air and water today - approximately 15 percent for water and 45 percent for air¹⁰. The rate of new buildings is just 1-2 percent every year. Old buildings have the highest consumption of energy. To reduce energy consumption it is therefore necessary to renovate old buildings. Energy for heating should then be based on climate friendly sources/renewables, and the use of direct electricity for heating should be minimized.

Solar energy is hardly used for heating in Norway today. Approximately 6000 square meters of solar heating arrays have been installed, and contributes to about 1.5 GWh. A realistic potential for solar heating of the existing building infrastructure is 3.6 TWh. Solar arrays may be built directly on to rooftops, and linked to in-house heating systems, hot water tanks or a larger heating system. There is enough solar heat to cover large amounts of our energy consumption during spring, summer and autumn. A moderately sized plant can deliver 5000-7000 kWh a year¹¹.

¹⁰ Source: Enova's construction statistics 07

¹¹ Source: www.solenergi.no

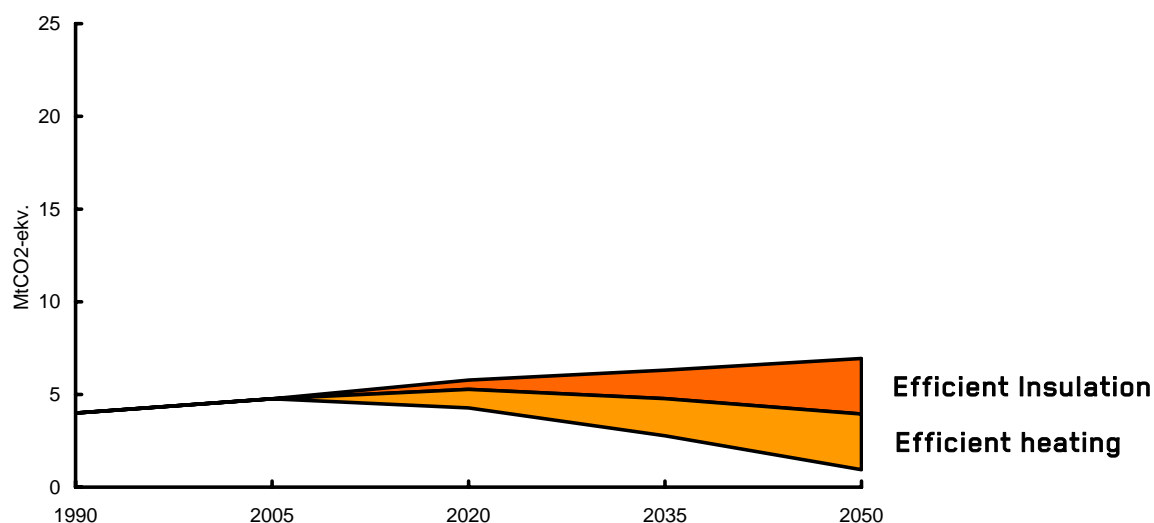


Fig 15: Norwegian Reference scenario for GHG from households and heating of buildings and the reduction effects of more efficient insulation and alternative heating

New buildings, passivehouses

NITO recommends:

- All new houses should be built on so-called passivehouse technology¹².

A passivehouse is an extreme energy-saving house, even when compared to conventional new buildings. A passivehouse has energy consumption below 65 kWh / m² per year for residential buildings, and 80 kWh / m² per year for commercial buildings. The first passivehouse, constructed as a multifamily residence, was built in Germany in 1999. A 79 percent primary energy saving (including electrical power) without sacrificing comfort is proven possible, at 7 percent extra cost compared to the cost of a conventional new building. Due to reductions in annual energy expenditures, the full return on the initial investment can be expected within 10-20 years time¹³.

In Norway, the passivehouse standard would save 0.67 TWh each year compared to today's standard (TEK). The savings would be 0.45 TWh per year compared to the new standard (TEK07). Accumulated, with a constant growth, this will add up to a saving of 26 TWh by 2050 (related to TEK97).

The following measures are necessary to reach passivehouse standard:

- Well balanced ventilation
- Closed building structure and good insulation.
- Windows and doors have to be of good quality, with low heat loss.

¹² Definition at www.passiv.de

¹³ (Passivehouse "Wohnen & Arbeiten"; <http://www.passivhaus-vauban.de/idee.en.html>)

- New lighting technology, LED-technology.
- Low energy white electrical products
- Monitoring and control of ventilation, light and technical equipment via SD plants.
Central computer facilities
- Solar energy for heating
- Separate power plants using solar energy, small wind turbines or small power plants.

These measures can of course help to reduce energy consumption in buildings more than the passive standard, and with plenty of energy production the building may be a net supplier of energy (so called Plus house).

Old/existing buildings

The main bulk of the building infrastructure consists of existing/old buildings. The rate of new buildings raised is only about 2 percent per year. Existing/old buildings thus constitute about 98-99 percent of the building infrastructure. Measures directed towards existing/old buildings are therefore of vital importance to achieve an energy efficient building infrastructure.

NITO recommends:

- Rehabilitation of buildings from a situation with high heat consumption to passivehouse standard. The objective of renovations must be changed from only changing the façade to full passivehouse standard. This measure will on the whole reduce energy consumption in relation to heating (of air and water) by more than 50 percent for each building¹⁴.
- The pace of renovation of buildings must be increased by 4 or 5 times, involving renovation aimed at achieving passivehouse standard. This measure is necessary to achieve the goal of 15 TWh reductions of energy consumption in buildings by 2020.
- Replacement of old lighting with new, with automatic sensors detecting the presence of people or sunlight, has a potential in commercial buildings equalling 4.5 TWh, which corresponds to 45 percent of current consumption. The period for recovering the costs is estimated to 1-3 years¹⁵.
- Taking advantage of LED - technology in buildings.
- Installation of automatic monitoring and control of heating, ventilation, lighting and other technical installations via central computer (SD-plants). In commercial buildings, this can help to reduce consumption by 10-30 percent depending on the building and use. A 10 percent reduction may constitute 8 TWh through installation in all buildings¹⁶. The effect decreases with improved building standard.

¹⁴ Source: Husbanken, <http://www.husbanken.no/>

¹⁵ Source: Lyskultur

¹⁶ Source: Fact Sheet from Nelfo

Myhrenenga housing cooperative - Norway's first passivehouse renovation



The housing cooperative consists of 168 one or two bedroom apartments in seven housing blocks that are situated just outside of Oslo. The housing blocks are built in the 1960s, and needed extensive rehabilitation of the building structure. The cooperative has, in cooperation with SINTEF Byggforsk and the architect firm "Arkitektskap", agreed to renovate buildings with the view to achieve passivehouse standard. Energy consumption before the rehabilitation was 300 kWh/m² per year, and is estimated to be 80 kWh/m² per year after the rehabilitation. Total energy consumption will be reduced by at least 75 percent, and energy consumption for heating will be reduced by 90 percent. In the project there are also plans to install solar collectors for heating water, and heat pumps. The old boilers will no longer be used. The extra cost for renovating the buildings to passivehouse standard is recovered within 8-9 years. In addition, one can expect a relatively large value increase of the houses, perhaps up to 2 000

Heating of buildings

NITO recommends:

- Development of near and district heating based on bioenergy, geothermal heat and heat pumps.
- All heating by oil must be phased out and replaced by bioenergy, heat pumps and geothermal heat. Figures from 2002 show a consumption of about 3.4 TWh of oil for heating, which constitutes 3 MTCO₂¹⁷.
- Facilitate for the installation of active solar heating in homes and commercial buildings. This measure may make up at least 3 TWh of renewable heat.
- Conversion of heating systems in buildings to flexible systems that may run on renewable energy sources. It is important that the different efficiency measures are implemented at the same time, in order to prevent too much use of energy.

Heat pumps for geothermal energy

NITO recommends:

- Transition from direct electricity to heat pumps and bioenergy

¹⁷ Source: Low Emission Commission 2006

Waste

The amount of waste is rising sharply, and constitutes a large climate problem. In 2007 Norway generated 429 kg of garbage per capita. In 1995 the equivalent figure was 269 kg. Higher consumption generates more energy, waste and emissions.

Emissions from the waste sector in Norway today constitute 1.5 million tonnes of CO₂ equivalents. The majority of emissions come from methane emissions from waste depots. Therefore, a ban on the disposal of wet-organic waste has been introduced from July 1st 2009.

Waste handling today, with the exception of methane emissions from old landfills, generates a net emission of 350 000 tonnes of CO₂ equivalents each year. The greater parts of these emissions originate from continued disposal of wet-organic waste and the incineration of plastic. Recycling of waste and biogas production from wet-organic waste can reduce emissions from the waste sector by 1.1 MT CO₂¹⁸.

NITO recommends:

- Stricter requirements with regards to the collection and recycling of paper, cardboard, glass, metal and plastic must be introduced in all the municipalities in Norway. Reduced emissions: 700 000 tonnes of CO₂
- Stricter requirements with regards to the collection of wet-organic waste and biological treatment of waste for biogas production must be introduced. Biogas must be used for generating electricity or as peak loads in district heating systems. Reduced emissions: 400 000 tonnes of CO₂
- Methane gas from old landfills must be captured. It is possible to reduce emissions by 900 000 tonnes of CO₂ equivalents over the next 20-30 years without large investments¹⁹.
- Measures to increase recycling of waste and building materials should be introduced.

Agriculture

Agriculture currently generates greenhouse gas emissions in the form of methane from livestock and manure and nitrous oxide from agricultural soils. Nitrous oxide make up the lion's share of these emissions. While there are no technical 'quick fix' to reduce agricultural emissions, improved agricultural practises, such as restoring cultivated organic soils and improving cropland management, may enable emission reductions, at least if compared to status quo, by 2050. However local farm methane capture and local use of this energy source for electricity production will make it possible to reduce CO₂ emissions from waste and agriculture by 2 MT CO₂ equivalents by 2050 as shown in fig. 16.

60 percent of all emissions from the primary industry come from agriculture and forestry. It is possible to reduce emissions from agriculture and forestry, while at the same time increase the production of food. The world's population will reach 9 billion by 2050, and the average life expectancy level will be higher in large parts of the world. In 2050 food production need to be

¹⁸ Source: Klimaregnskap for avfallshåndtering. Østfoldforskning 2009

¹⁹ Low Emission Commission

doubled from the present levels. The emissions from agriculture will thus rise. It is however possible to reduce emissions from the sector and make the agricultural industry more efficient.

NITO recommends:

- Norway must increase its food production, and preserve its fertile land. This will reduce transport, and contribute to improve the global distribution of food.
- The use of livestock manure for the production of biological gas may reduce emissions of methane by 340 000 tons CO₂ equivalents²⁰.
- More efficient production of milk and beef may help reduce emissions by 250 000 tons of CO₂ annually.
- Reduced use of nitrogen in the agriculture sector. More effective use of fertilizer and precision fertilization may reduce emissions by 170 000 tons CO₂. The use of straw for energy production may also help to reduce emissions by 140 000 tons CO₂ equivalents. This also generates energy that may be used for heating building
- Increased use of bioenergy.

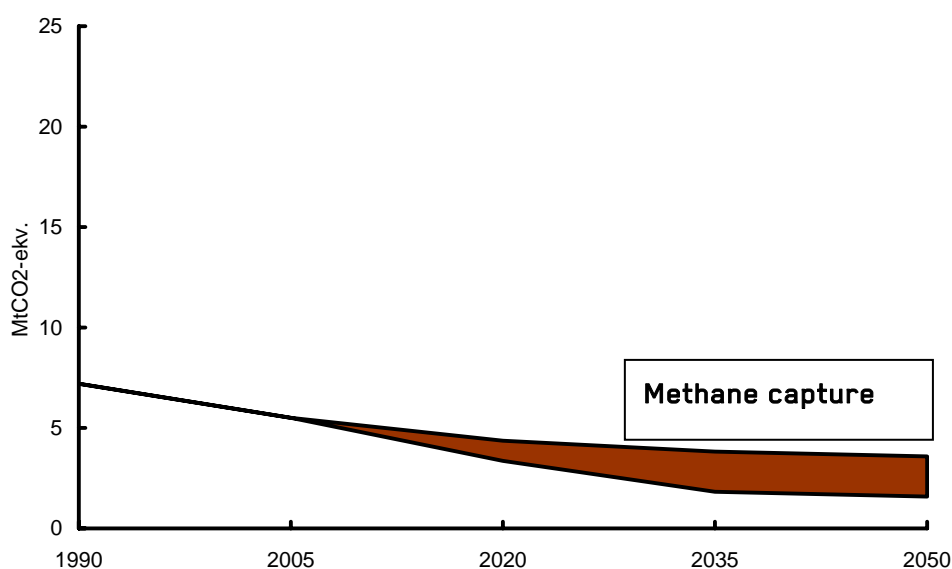


Fig 16: Norwegian Reference scenario for GHG from Agriculture, waste and landfills and the reduction effects of methane capture

Emissions of GHG from Agriculture waste and landfills are expected to decrease in the Reference scenario. In addition, capture of methane emissions are expected to be mandatory. NITO suggests distributed and intensive capture of all methane emissions.

²⁰ Source: Klimaregnskap for avfallshåndtering, Østfoldforskning

Plans and the NITO scenario for Norway

The NITO plans and the NITO scenario for reduced GHG emissions and a sustainable society in 2050 are primarily based on a bottom-up perspective. Norway is producing a substantial amount of renewable hydro power energy and has the potential of increasing its energy production with wind and biomass. Efficiency and economize with the available resources from a bottom-up perspective are adequate actions especially for the two sectors "Heating, waste and agriculture" and "Transport". Efficient technology is in reach and can be used for business development as well as for the actual reductions of GHG emissions.

The potential for new sustainable Norwegian energy production for the industrial sector and the fossil energy sector can be related to the world markets supply and demand, and the potential for cost efficient production. The costs for development and production of new sustainable energy sources like wind, geothermal and bio energy are justified when the market is willing to pay the price in a long time perspective.

A planned reduction to 74 percent of the GHG emissions in 1990 will not come easy. The transition to new energy efficient and GHG lean technology is first expected to successful towards 2035 and 2050. The reason is that research and development of crucial technology will require substantial resources, and the market penetration must to some extent be cost efficient and compete with not environmentally sustainable technical solutions. Society or the individual customer will have to invest in environmentally friendly technical solutions that first will pay off in the long run.

Business and industrial opportunities for Norway related to reducing CO₂ emissions are amongst others development and production of new batteries for energy storage in vehicles, and efficient technology for Carbon Capture and Storage, CCS. Increased heat and electric power generation based on Norwegian renewable energy resources represents a potential to export high value renewable energy to a world with future shortage of energy.

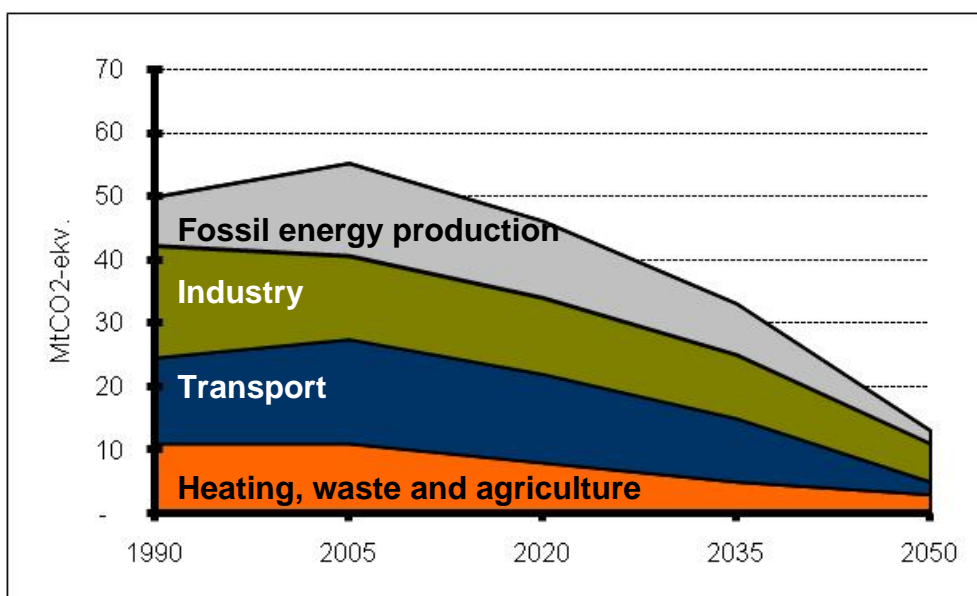


Fig 17: A NITO plan for a Norwegian GHG emission reduction with 74 percent

The NITO bottom-up approach scenario up to 2050 for GHG emissions from the four Norwegian sectors consists is based on the approach:

Fossil energy production - oil and gas

Production of petroleum and natural gas contribute to Norwegian Kyoto protocol specified GHG emissions, but this industry also contributes to Norwegian welfare and to fulfil an international demand for fossil energy. The emissions from production of petroleum and natural gas will be high until the production of oil start to decline substantially. In 2050 we expect almost zero GHG emissions from almost empty oil wells and very limited emissions from production and export of natural gas. With renewable electricity power from the shore it is possible to substantially reduce GHG emissions from production of fossil energy in 2050. Carbon Capture and Storage, CCS in the empty gas and oil wells will be expected at the production sites.

Industry - power intensive manufacturing

With actions taken to increase energy efficiency in all sectors and increased production of renewable energy, there will be renewable energy available for industrial activities in the future. For the industrial sector, NITO estimate increased energy efficiency and that the supply of energy will be sufficient. However Carbon Capture and Storage, CCS, is seen as the only way to reduce CO₂ emissions from the processes at the Norwegian process industry. The reason is that the process industry produces CO₂ in its oxidation/reduction processes. Energy reduction actions are feasible, and for large industrial facilities CCS is expected to reduce process GHG with 50 %.

Transport

The national transport sector can, with gradually increased use of electric energy, new batteries and second generations of bio-fuels from Norwegian forests in 2050, be almost independent of fossil fuels. Low weight plug-in hybrid light vehicles and electric small cars will be able to run on renewable electric energy and bio-based liquid fuels as synthetic diesel or ethanol. Heavy duty road transport will have the possibility to become CO₂ neutral with future synthetic liquid fuels from Norwegian forests. Norwegian coastal ship transport can increasingly use methane as fuel and reduce emissions by new sail technology. Optimising ships speed in relation to goods with different urgency will reduce the speed related energy consumption and GHG emissions from ships. The emissions from personal transport can in the dense populated areas of Norway be reduced by transition to public transport and electric railway. The emissions from heavy duty transport of goods can also be reduced by transition from roads to electric railway.

Heating, waste and agriculture

Heating, waste management and agriculture will gradually reduce GHG emissions by 75 percent up to 2050. In a country with cold climate, improved insulation of buildings and alternative sources for heating has a substantial potential. The means are heat pumps, bio-energy and highly isolated buildings that will reduce energy consumption/increased energy efficiency. The increased energy efficiency in buildings will release electric energy that can be

used in the transport sector and in the industry. Collection and efficient use of methane from landfills and deposits will reduce the GHG emissions.

Non Kyoto regime opportunity

When the energy carrier is free of carbon, i.e. electricity or hydrogen, energy efficiency will only have an indirect effect on emission, because using these energy carriers does not lead to emissions of CO₂. The effect of these measures on the climate must be considered in relation to what they supplant.

Possible future export of Norwegian renewable energy due to new electric energy production and increased energy efficiency is not included in the Kyoto regime, and is not a positive asset on the Norwegian account. However export of renewable energy must not be forgotten since it has the potential to contribute to reduced emissions of GHG gases in the importing countries. If a possible CO₂ reduction from possible future export of electric energy was counted a Norwegian scenario, this could imply that it is possible to reduce Norwegian GHG emission by about 95 percent in 2050. The Norwegian scenario could - if export of renewable energy was included in the Kyoto regime look like indicated by the green line in figure 18.

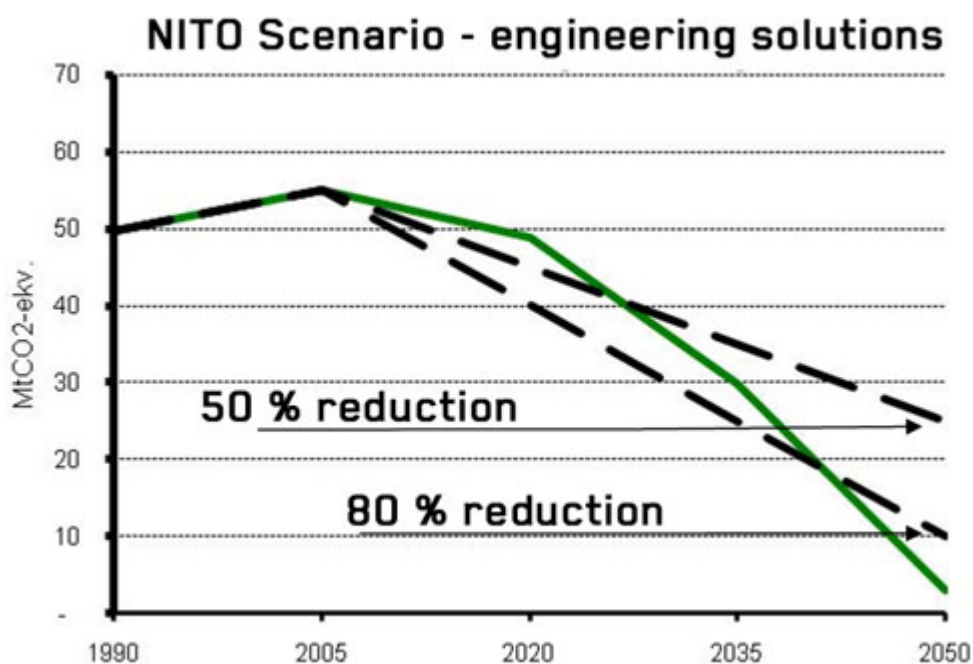


Fig 18: Possible 95 percent Norwegian reductions - including international GHG reductions from future new energy production, increased energy efficiency and export of renewable electric energy

Norwegian report in action

NITO has with assistance from Institute of Transport Economics, TØI and Centre for international Climate and Environmental research - Oslo, CICERO made plans for engineering solutions in Norway. The methodology is based on status, technological ideas, calculation

charts and graphics to present sustainable climate scenarios up to 2050. The Norwegian statistics for energy consumption and figures for GHG emissions are collected from "Low emission Commission", 2006 where CICERO had the function as secretariat.

NITO would like to thank Rolf Hagman, (TØI) and Knut H. Alfsen (CICERO) for the assistance in making the plans for engineering solutions in Norway.

NITO would also like to thank the Norwegian engineers who contributed to the project with valuable knowledge and opinions through surveys, different gatherings and working groups.

The tools and calculation charts are being used by NITO internally, and in the national public debate on energy and climate.

The NITO scenario shows that the solutions necessary to tackle global warming are available in Norway. Courageous political leadership is the key to implementing the scenario. When world leaders gather at the United Nations Climate Change Conference in Copenhagen in December 2009, they need to develop a global policy framework that features:

- A pledge to reduce emissions by 85 percent by 2050, and a plan for how to achieve it. This essentially means setting a global cap on emissions and a schedule for tightening it.
- A radical increase in public funding for developing and demonstrating new climate-friendly technologies. While the necessary technologies already exist, substantial efforts are needed to reduce costs and speed their implementation at large scale.
- A change in market conditions to make it financially attractive to protect the climate. In essence essentially means giving climate-friendly technologies and advantage by putting a price on emissions and making the polluter pay.

NITO will market the Future climate – engineering solutions initiative by

- Stressing that the sustainable climate scenario should be developed within available energy resource and should not risk sustainable food production.
- Stressing the bottom – up approach and the need for action
- Stressing the industrial dilemma

NITO is taking necessarily measures needed to support the solutions

Necessarily measures needed to support the development of the technologies and solutions within the sustainable climate scenario are:

- Actions to influence the members
- Internal creative processes
- Lobby the political system with engineering knowledge
- Influence media
- Promote this project and get attention

Data Sheet of the Sustainable Climate Scenarios

			Baseline	Climate plan		
			2000	2015	2030	2050
GHG emissions (CO ₂ -equivalent)	CO ₂	42 Mt	40	25	10	
	Methane	5 Mt	4	3	2	
	Nitrous oxide	5 Mt	4	2	1	
	CFC	2 Mt	1	0	0	
	Total	54 Mt	49	30	13	
GHG emissions by sector (CO ₂ - equivalent)	Power stations	0,2 Mt	0	0	0	
	Industrial processes	15,4 Mt	14	10	6	
	Transportation fuels	15,6 Mt	15	8	2	
	Agricultural byproduct	4,8 Mt	4	3	1	
	Fossil fuel retrieval processing, and distribution	12,2 Mt	11	5	1	
	Residential, commercial and other sources	3,4 Mt	3	2	1	
	Land use and biomass burning					
	Waste disposal and treatment	2,2 Mt	2	2	2	
Total	53,8 Mt	49	30	13		
Energy consumption by use (PJ)	Transport	188	180	150	120	
	Agriculture, forest and fishing	32	32	30	30	
	Industry, construction, wholesale, private and public service	307	300	250	250	
	Housing	259	250	200	100	
	Energy sector (production and distribution)	215	210	180	150	
	Total	1001	972	810	700	
Primary energy supply (PJ)	Crude Oil	721	700	500	50	
	Gas	221	250	300	250	
	Coal (Coke)	28 (29)	30	0	0	
	Nuclear	0	0	0	0	
	Waste, biomass, etc	55	60	100	150	
	Biomass					
	Geothermal	0	10	50	100	
	Solar heat	0				
	RE-electricity:	Wind		5	50	100
		Photo Voltaic		1	10	10
Hydropower		603	610	620	650	
Wave & tidal						
Total	1 628	1 666	1 530	1 260		
Installed effect						
Degree of RE of the total energy supply (%)	(EU calculation method)	47	50	60	90	
Energy import (PJ)	Oil	43	0	0	0	
	Gas	-	0	0	0	
	Coal (Coke)	26 (29)	0	0	0	

	Biomass	0
	Electricity	5
	Uranium	-
	Total	74 (103)

0	0	0
0	0	0
0	0	0
0	0	0

Energy export (PJ)	Oil	5822
	Gas	1960
	Coal	16
	Biomass	0
	Electricity	74
	Uranium	-
	Total	7872

5500	3000	500
2000	2500	2500
0	0	0
0	0	0
75	100	200
7 575	5 600	3 200

Energy efficiency (BNP/primary energy supply)		130 (2000) US\$/PJ
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164	240	426
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