CLIMATE CURE 2020

MEASURES AND INSTRUMENTS FOR ACHIEVING NORWEGIAN CLIMATE GOALS BY 2020

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Summary

CLIMATE CURE 2020 – TASKS AND WORK

In Report to the Storting No. 34 (2006–2007) *Norsk klimapolitikk* (White Paper on Norwegian climate policy[1]), the government stated that it would present an assessment on Climate Policy and the need for new instruments to the Storting in 2010. This report contains the basic material for such an assessment.

This report has been commissioned by the Ministry of the Environment. It has been written by an expert group – Climate Cure 2020 – consisting of the Norwegian Water Resources and Energy Directorate, the Norwegian Petroleum Directorate, the Norwegian Public Roads Administration, Statistics Norway and the Climate and Pollution Agency, which has led the work. The Norwegian Maritime Directorate, the Norwegian National Rail Administration, the Norwegian Coastal Administration and Avinor have all contributed to the work of investigating measures and instruments. The report has also drawn on the expertise of other agencies, research institutions and experts. We have strived to achieve an open process, with several conferences and seminars and input from many others along the way.

The analysis is based on the target for a national emissions cut that was laid down in the agreement on the Climate White Paper, known as the Climate Agreement, which received majority backing in the Storting in 2008. The aim is to reduce emissions in Norway by 15 to 17 million tonnes of CO_2 equivalents by 2020 in relation to the reference path presented in the National Budget for 2007, the effect of forests included. Forestry measures are estimated to give a net uptake of 3 million tonnes of CO_2. Domestic emissions shall therefore be reduced by 12 to 14 million tonnes of CO_2 equivalents, so that they do not exceed 45 to 47 million tonnes of CO_2 equivalents by 2020.

Our assignment has been to present the various options the national authorities have for achieving the target for national emissions reductions by 2020 and the consequences of these, without giving recommendations as to how this can be done. This has been done by means of a sector by

1 The Storting is the Parliament of Norway.

sector analysis of measures and instruments, as well as macroeconomic analyses that also show the effects on the Norwegian economy. In addition, we have put together menus of instruments, in order to illustrate different ways of achieving the national target for emissions reduction.

In line with our mandate, the main focus has been on solutions for achieving the emissions reductions nationally by 2020. We also briefly discuss possible global emissions effects of the measures and instruments in Norway. We also indicate whether the effect of measures and instruments will increase or decrease over the course of time, and whether they could help decrease emissions in the longer term by promoting technological development and structural change.

The transition from fossil fuels to renewable energy sources is central to many of the climate measures we have investigated. As an effect of the greenhouse gas measures, we have assessed the need for domestic production of renewable energy. If the increased demand for renewable energy is to be met nationally, production must increase.

GREENHOUSE GAS EMISSIONS IN NORWAY

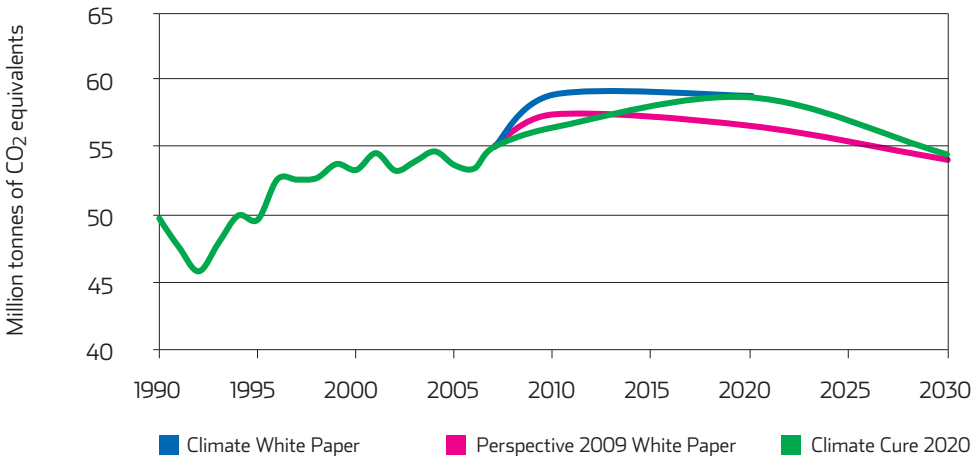
During the period 1990 to 2008, the total emissions of greenhouse gases in Norway increased by 8 per cent, from about 50 million tonnes of CO_2 equivalents in 1990 to 54 million tonnes in 2008. The three largest sources of greenhouse gas emissions in Norway are the transport sector (32 per cent of total emissions), the petroleum sector (27 per cent) and the industrial sector (26 per cent).

The target for national emissions cuts is based on the emissions projections that were presented in the National Budget for 2007. The projections include the effect of measures and instruments that have been adopted. Climate Cure 2020 has taken the projections given in the Perspective 2009 White Paper as its starting point, with adjustment for new information in the Revised National Budget for 2009 and emissions accounting for 2008. It is this updated emissions projection that has been used as the reference path in Climate Cure 2020.

Climate Cure 2020's emissions projection shows emissions of about 59 million tonnes of CO_2 equivalents in 2020. This is the same level as the projection in the National Budget for 2007. For the transport sector, continued growth in emissions is anticipated for the entire period up to 2030. For the petroleum sector, emissions are expected to increase until 2020; then start to decline as a result of an anticipated drop in production. Emissions from the industrial sector are expected to remain relatively stable.

The projections include the emissions reducing effects of measures and instruments that have already been adopted.

Historical emissions and projections for greenhouse gases in Norway in tonnes of CO_2 equivalents. Source: Statistics Norway, Climate and Pollution Agency and the Perspective 2009 White Paper.



Climate Cure 2020 has actualised these as much as possible, so as not to investigate measures whose emissions reduction has already been included in the projection. For example the projection assumes an anticipated efficiency improvement in all industries (1 per cent per year in the transport, industrial and petroleum sectors). Certain specific measures and instruments are also assumed (for example carbon capture and storage from the heat and power cogeneration plant at Mongstad from 2014). If these do not contribute as assumed, then emissions may increase more than is indicated by the projections.

The measures that have been investigated by Climate Cure 2020 are in addition to the measures included in the reference path. Comparisons across sectors must be assessed in the light of the potential that has already been taken out in the different sectors.

METHODOLOGY AND INTERNATIONAL REGULATORY FRAMEWORK

Methodology

Climate Cure 2020 has carried out a sector

by sector analysis of possible measures and instruments for reducing emissions and made a macroeconomic assessment of the total costs to society of achieving the target. We have also grouped the results in menus of instruments in order to identify different ways of achieving the national target. For each of the menus of instruments, we have also made an assessment of the need for energy and the consequences for other important societal goals.

The strength of the sector by sector analysis of measures and instruments is that this approach provides a high level of detail. The weakness is that the analysis is partial, that is to say it does not take into account the macroeconomic knock on effects of measures and instruments. Using the MSG TECH macro model, macroeconomic analyses have also been carried out to study the consequences of the use of instruments for the Norwegian economy. An advantage of this approach is that it captures the knock on effects for the economy. A weakness is that the classification of measures and instruments here will be less detailed than in the sector by sector analysis. The analyses cover different selections of measures and quantify their different cost aspects. The differences between the two approaches mean that they complement each other.

The Norwegian emissions accounting includes all emissions that occur within Norway's borders. This emissions accounting has been taken as the basis for Climate Cure 2020. This means that emissions as a result of transport and trade between Norway and other countries are not included. Neither are emissions in the manufacturing countries for goods that are imported into Norway or emissions in other countries as a result of using goods produced in Norway.

In the sector by sector analysis, socio-economic costs are calculated in accordance with the Ministry of Finance's guidelines for socio-economic analysis. The cost of measures includes the additional costs of implementing them. The cost estimates have as far as possible taken into account the anticipated investment, operational and maintenance costs, costs associated with lost and/or postponed production, changes in consumers' surplus (including time based costs) and external costs.

Socio-economic costs differ from corporate costs in that they also include the effects the measures have on others in society. The costs may rest with one sector, while the benefit comes to another. An example would be reduced local atmospheric pollution as a result of reduced energy consumption by a company. In socio-economic accounting, the value this has for those other than the company itself is deducted from the cost of the measure. The socio-economic costs of measures are also calculated without value added tax or other fiscal taxes.

Standardisation of calculation methods in analysing the measures may overlook important differences between measures as

regards risk and assessment criteria that are used by potential users of measures. This may for example be the reason why the requirement for return on investments is higher than that which forms the basis for the socio-economic analyses. Private or company economic assessment of the costs of measures may be higher than in the socio-economic calculations.

International regulatory framework

Climate Cure 2020 has published two interim reports during the course of the process. One of the reports describes the international regulatory framework that may be of significance for devising instruments in Norwegian climate policy. The other report gives an assessment of possible future carbon prices.

At present there is no new mandatory international treaty on climate change which is sufficiently stringent or detailed to provide guidelines for the use of instruments in Norway. Furthermore, it appears unlikely that there will be any emission trading scheme embracing all countries by 2020. This means that the carbon leakage[2] issue will remain towards 2020, since it is highly unlikely there will be any agreement imposing the same regulatory framework on all sectors globally by 2020.

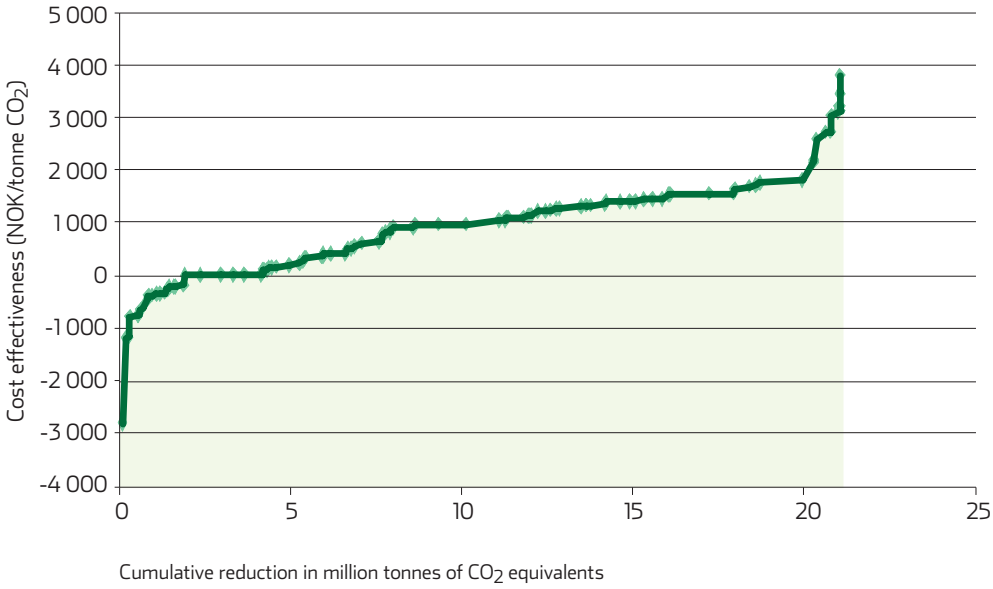
The EU's climate and energy package will be central in the years up until 2020. The main elements of the package are the papers of legal procedure on the continuance of the Emission Trading Scheme (EU ETS), renewable energy and vehicles. Many of the EU's measures are aimed at reducing electricity consumption, but such instruments will have little effect on Norway's greenhouse gas emissions. The EU regulations will affect emissions from vehicles, but there will be a need for supplementary instruments to achieve a transition to other forms of transport and to reduce the need for transport. There are also several sectors which in Norway are not covered by the EU regulations, such as agriculture and waste.

The climate and energy package shows that the EU ETS will be an important instrument. Currently, the petroleum sector and parts of the industrial and energy sectors are covered by the EU ETS Directive. This represents about 40 per cent of our national emissions. It has been decided that aviation and a greater proportion of industry will be included in 2012 and 2013 respectively. Then over 50 per cent of emissions will be included. The carbon price will decide how great the emissions reductions will be as a result of the Emission Trading Scheme within these sectors. We have estimated that the carbon price in 2020 will be about 40 Euros (about NOK 350) per tonne of CO_2 equivalents. A number of the measures that have been investigated have a higher cost and will therefore not be realised by the Emission Trading Scheme alone if the carbon price is at this level in 2020.

Companies covered by the EU ETS that carry out measures with a cost higher than the carbon price, will either liberate

2 Carbon leakage in this context refers to the situation in which implementation of the Kyoto Protocol in Norway could lead to increased emissions of greenhouse gases in countries that have not assumed the protocol's obligations – for example through companies moving from Norway to countries where there are no such obligations.

Cost curve – non-overlapping measures



allowances that they can sell on the market (one allowance gives the permission to emit one tonne of CO_2) or they could reduce their demand for allowances. Given a well-functioning market, the allowances an organisation does not need will be purchased for use by another organisation. Reduced domestic emissions in sectors regulated by the EU ETS will therefore only lead to emissions being moved inside the EU market and not to a reduction on total emissions within the EU ETS. One way of compensating for this is for the authorities to retain (cancel) a volume of allowances corresponding to the emissions that one wishes to cut, over and above the carbon price. The motivation for introducing additional instruments to the Emission Trading Scheme could be to stimulate technological development, that would also benefit others, and to establish the infrastructure necessary to achieve greater emissions reductions in the future.

AGGREGATED FINDINGS FROM THE SECTOR BY SECTOR ANALYSIS

In total, we have identified about 160 potential emissions reducing measures that are described with their potential for reducing emissions and their costs.

All the measures described in the sector by sector analysis give emissions reductions over and above those assumed in the reference path. Several of the measures investigated overlap. If we only look at measures that do not overlap, the analyses show a potential emissions reduction of about 22 million tonnes of CO_2 equivalents by 2020.

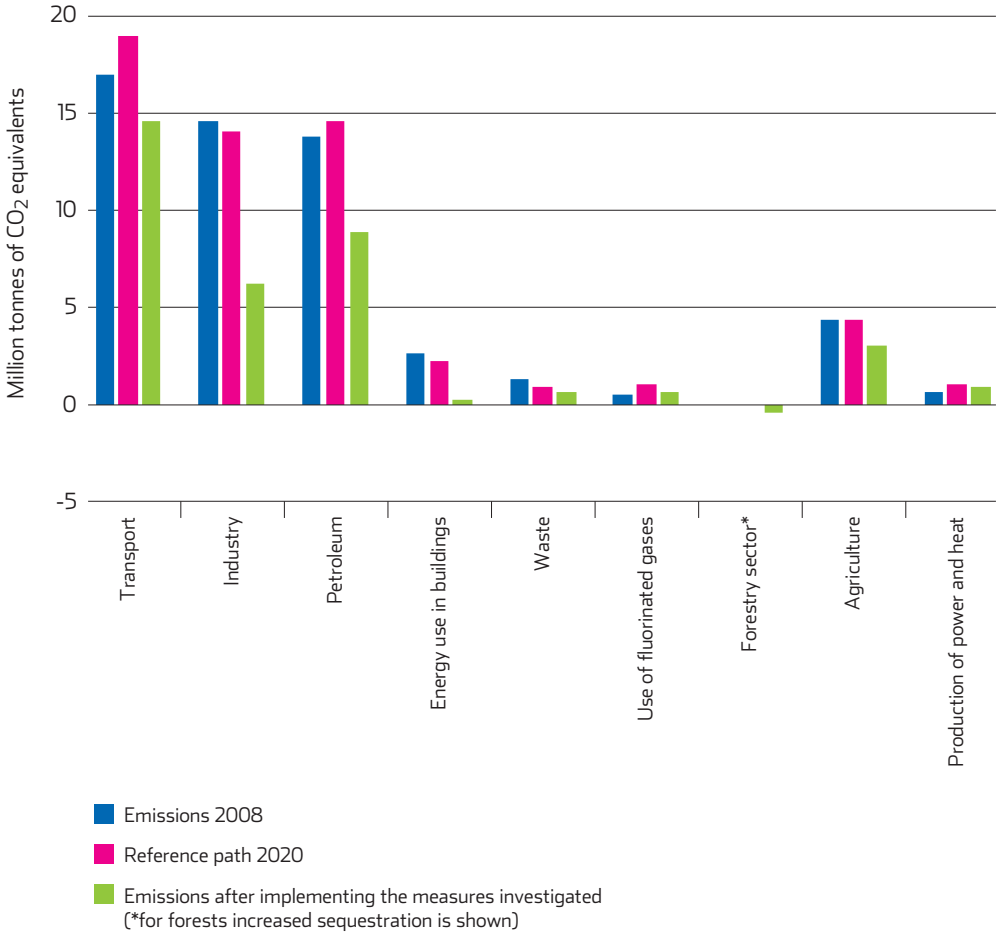
The socio-economic costs calculated for the measures range from economically profitable for companies to very high socio-economic costs per tonne of CO_2 equivalents reduced. Although the sector analyses are based on the same methodological principles, there are differences in the levels of detail as well as uncertainty in the cost estimates. For a number of measures, the applicable technology is already known and available. In addition, we have investigated measures that assume technological development. Even though the analyses are very thorough, the cost estimates involve considerable uncertainty.

Combined, the sector-by-sector analyses give a cost curve that indicates that it is possible to achieve an emissions reduction of 12 million tonnes of CO_2 equivalents by 2020 compared with the reference path by implementing all the measures with a cost up to about NOK 1,100 per tonne of CO_2 equivalents. The cost curve is illustrated in the figure above.

30 of the measures that have been investigated appear to be socio-economically profitable. Together these represent a potential reduction of 3 million tonnes of CO_2 equivalents. That these measures have not already been implemented may partly be due to incorrect cost estimates in the past. Another explanation could be that the corporate costs are higher than the socio-economic costs. Moreover, the organisation using the measure would not receive the whole benefit for example for measures that reduce atmospheric pollution.

The figure on page 12 shows emissions by sector in 2008 as well as emission projections with and without implementation of investigated measures by sector. We have used a high estimate for reduction potential for transport. This involves the most ambitious alternative of biofuel, other technical measures for vehicles, doubling fuel prices, doubling road tolls, halving public transport fares and extending intercity train development. For industry, we have included carbon capture and storage (CCS) measures for nine point sources.

The grouping shows that there is a need to implement measures in many sectors. The sector analyses show that the present instruments will not be sufficient to trigger a great part of these measures. The macro



analysis includes an assessment of the anticipated effects of the present regulatory framework, as well as anticipated increases in carbon prices. This gives an emissions reduction of only 3 million tonnes above the reference path for 2020.

The basis for assessing the measures has been that it must be technically possible to implement them by 2020. However, there may be limitations in capacity that would

make it difficult to implement all these measures at the same time. Therefore, for some sectors, we have assessed a possible implementation tempo. For example, all the CCS measures investigated cannot be implemented at the same time.

Most decisions on instruments and measures need to be taken shortly if their effect is to be achieved by 2020. This applies for example to the introduction of a number of measures in the building, transport and industry sectors, as well as CCS. These are measures that demand time consuming planning and implementation. Delaying decisions could therefore lead to a smaller reduction in emissions.

For a number of measures, the reduction potential increases towards 2030 and beyond, owing to technological development, availability on the market and/or falling costs. For the petroleum sector, the reduction potential will decline due to reduced production. Many of the major investments that are made today, for example in energy supplies, building, road and rail, have a long lifespan. Such investments will be of great significance for future emissions and our opportunities for limiting them. Decisions on investments and instruments that are made today must have a long term perspective beyond 2020 and must consider the need for even further emissions reductions and the anticipated increase in the price of emissions.

THE INDIVIDUAL SECTORS

Transport

The sector analysis for transport covers road traffic, civil aviation, shipping, railways and other mobile sources such as tractors and motorised equipment. The analysis shows that it is possible to achieve a total emissions reduction of 3 to 4.5 million tonnes of CO_2 equivalents by 2020. The lowest estimate is without increased taxation on car traffic or halved public transport fares.

The greatest emissions reductions can be achieved by increasing the use of biofuels and by introducing more vehicles with lower emissions per kilometre (electrification, increased efficiency). The reductions have been calculated to 1.8 to 1.9 and 0.8 million tonnes respectively. In calculating CO_2 benefits from biofuels it has been assumed that all the fuel is imported and that the biofuel is certified. CO_2 emissions linked to production of the fuel will thus occur in the country of origin. However, transport costs to Norway have been included. Whether access to first generation biofuels will be limited as a result of conflict with food production and considerations of sustainability is an issue for debate.

Measures and instruments for changing the distribution of means of transport and/or reducing the extent of transport are often mutually dependent on each other. We have therefore used transport model calculations to estimate the effect of alternative packages of measures. The measure

packages include development of public transport alone or in combination with significant tax increases on road and/or air transport. Doubling of fuel prices for cars, doubling of road tolls in the largest towns and cities, enhancing intercity rail infrastructure, increasing the frequency of long distance buses and halving public transport fares would give an estimated reduction potential of up to 1.2 million tonnes of CO_2 equivalents. Doubling air fares would increase the potential to 1.4 million tonnes. The social consequences of such a large increase in taxes, for example as regards effects on housing, commerce and distribution, have not been assessed.

Other measures, such as doubling the use of bicycles by developing a main network of bicycle paths, funding to improve public transport in the largest towns and cities, eco-driving, gas ferries, reorganising air traffic in Eastern Norway (Oslo Advanced Sectorization & Automation Project (ASAP)), off the land power for ships and energy efficiency measures for ships, are estimated to have a potential for reducing greenhouse gas emissions by about 0.8 million tonnes of CO_2 equivalents a year.

Estimated costs of the measures assessed are for the most part below NOK 1,500 per tonne of CO_2 equivalents, but for some the costs are considerably higher. According to the calculations, some of the measures are socio-economically profitable.

Several measures and instruments in the transport sector would have a considerably larger effect in the longer term. The potential in the more widespread use of biofuels increases greatly, as larger volumes of second generation biofuels come onto the market at a competitive price. Various raw materials and techniques are used to produce second generation biofuels. This gives a substantially higher climate benefit than today's biofuels and less risk of conflict with food production. It is also estimated that the potential from technical measures for vehicles will be considerably greater in 2030 than in 2020, because it takes time to introduce new technology.

Petroleum

The petroleum sector includes all petroleum facilities offshore and the onshore plants at Kollsnes, Sture, Nyhamna (the Ormen Lange field), Melkøya LNG plant (the Snøhvit field), Mongstad and Kårstø. The measures that give the largest emissions reduction are the electrification of existing offshore fields and the capture, transport and storage (CCS) of CO_2 at onshore plants. The estimated costs of the measures range from NOK 400 to NOK 4,000 per tonne of CO_2. The investment costs for individual measures vary from approximately zero to NOK 17 billion. We have calculated measures with a total reduction potential of about 5.5 million tonnes of CO_2 equivalents by 2020, when CCS is included. The present fields have a limited lifespan, thus the measures that have been investigated are expected to have little effect in 2030. This is

because emissions in 2030 are mainly expected to come from any new petroleum fields that have not been discovered or exploited yet. In 1996 the Storting decided that power supply from onshore facilities should be investigated for all new fields.

Possible instruments to realise the measures that have been investigated are increased taxes, a climate fund, agreements between the authorities and the industry on emissions reductions and support for research and development.

Industry

For the industrial sector, we have calculated a total emissions reduction potential of 4.3 million tonnes of CO_2 equivalents by 2020, excluding CCS measures. Measures that would have a considerable effect in reducing emissions in industry include changing from fossil consumables and fuel to bio-coal and bio-mass, energy efficiency measures and certain individual process improvement measures. The use of consumables based on bio-coal is relevant for metal production, while changing to bio-based fuel is relevant for a number of industry sectors. Some more comprehensive measures such as reducing electricity consumption in industry have also been included in the analysis, even though these do not give any reduction in national greenhouse gas emissions.

The measures that have been identified have a total investment cost of about NOK 15 billion. The costs per tonne of reduction vary a great deal from measure to measure. Several measures have been calculated to be socio-economically profitable. The most expensive measures that have been investigated have a socio-economic cost of at least NOK 3,000 per tonne of CO_2 equivalents.

Some of the measures that have been investigated could be realised by extending the Emission Trading Scheme from 2013, as the emissions projection does not take the effect of this extension into account. This would be in line with the EU's revised EU ETS directive. Possible instruments for implementing the other measures that have been investigated are increased taxes, increased public support, regulations such as a general ban on the use of fossil energy carriers for stationary furnaces in industry, and requirements for greenhouse gas reducing measures aimed directly at individual companies through technology requirements as conditions for emission permits. A possible agreement between the authorities and industry is also discussed, whereby industry agrees to future emissions obligations and at the same time undertakes to establish a climate fund to finance measures and support the development and testing of climate friendly processes. Possible compensation for the effects of the increased costs for the industry are also discussed, so as to reduce the risk of carbon leakage.

Capture, transport and storage of CO_2 (CCS)

CCS has been investigated for the petroleum plants at Melkøya, Mongstad and

Kårstø. If all these measures are implemented, they could reduce CO_2 emissions by up to 2.5 million tonnes. The combined heat and power plant at Mongstad and the gas power plant at Kårstø have not been included in the analysis, because reduced emissions from these installations have been allowed for in the emission projections.

The cost of the CCS measures at the petroleum plants has been calculated to NOK 1,300 to NOK 2,250 per tonne CO_2, given that they are built as first generation full scale plants. The estimates are based on coordinated transport and storage solutions.

In addition to the petroleum plants, the capture and storage of CO_2 from nine onshore plants has been investigated. If all nine measures could be implemented by 2020, they would reduce greenhouse gas emissions by around 3.6 million tonnes. However, implementing them all by 2020 is not considered feasible. Estimated costs of the measures range from NOK 1,000 to 1,900 per tonne of CO_2. This presumes that they are built as first generation full scale plants. The maturation of technology over time could reduce these costs. Plants built after 2020 will benefit from the experience of building the first plants. The costs of the measures presume coordinated transport and storage solutions where several industrial plants are close to each other. If the measure is implemented by a single company, the costs per tonne will be higher.

It may be possible to facilitate CCS at more industrial plants than have been investigated in Climate Cure 2020. The examples chosen are in different industries and with different technical bases. There are still technological challenges to be overcome and developing CCS is a major activity because it involves the carbon capture plant, pipeline and sea transportation and geological storage.

The cost estimates for the petroleum plants are based on investigations made by the companies, e.g. the Masterplan for the Mongstad plant. The degree of detail is therefore different from the estimates for the industrial plants, where more schematic assumptions have been used. This could represent a risk of underestimating costs at the industrial plants.

Possible instruments for realising CCS measures include taxes, agreements, a fund and state support.

Domestic production of power and heat

Norway differs from other countries in that electricity accounts for 70 per cent of stationary energy consumption and that this electricity for the most part comes from renewable sources, especially hydro power. Greenhouse gas emissions from Norwegian production of power and heat for sale in the markets were 0.6 million tonnes of CO_2 in 2007. This represents one per cent of national emissions. These emissions mainly come from gas power stations and district heating production. Emissions from gas power stations are discussed under carbon capture and storage (CCS). What remains

are emissions from district heating production, which are discussed in their own sector analysis. The measures in the district heating sector involve changing from fossil fuels to biofuels and electricity. Full phasing out of fossil fuels could reduce CO_2 emissions by 2020 by about 0.16 million tonnes. Costs of the measures range from NOK 500 to NOK 2,600 per tonne of CO_2 equivalents.

Possible instruments for realising the measures are increased taxes, conditions for public support and the terms of the energy licence of the individual district heating plant.

Buildings

Investigation shows that greenhouse gas emissions from the building sector in the operating phase, that is to say from burning fossil fuels, could go down to 1.3 million tonnes of CO_2 equivalents by 2020. With the aid of conversion and energy efficiency measures, most of these emissions could be eliminated by 2020. The most important measures are converting from fossil fuels by changing to district heating and renewable energy. The costs of the conversion measures range from NOK minus 770 to NOK 3,100 per tonne. Most measures cost NOK 1,000 per tonne or less.

Possible instruments are regulations, economic instruments and raising levels of competence.

Agriculture

Measures have been investigated that add up to an emissions reduction potential of about 1.2 million tonnes of CO_2 equivalents by 2020. The measures include the use of manure to produce bio-gas, improved fertilising of agricultural land, halting new cultivation of marshland, production of bio-coal, storing bio-coal in agricultural land and changing energy sources in greenhouses. The bio-gas measures are estimated to have costs ranging from NOK 1,200 to NOK 3,100 per tonne of CO_2 equivalents, while the other measures are estimated to be cheaper. Measures have also been identified that are profitable for companies. Both bio-gas and bio-coal measures produce energy carriers (gas and oil) that can be used for powering vehicles and/or heating buildings. Some of the measures involve a great deal of uncertainty regarding the effect on greenhouse gas emissions or costs of implementing them. Several of the measures in this sector have been investigated in less detail than measures in other sectors.

Possible instruments include economic instruments (such as climate adjustment of funding for agriculture, a climate fund and a tax on artificial fertiliser), legal instruments, information and research and investigation.

Forestry

Emissions and sequestration of greenhouse gases in forests is an important part of Norwegian greenhouse gas accounting. Because of active forest management the standing volume in Norwegian forests has doubled over the last 80 years. Since

1990 alone, the sequestration of CO_2 has increased from around 14 million tonnes to between 25 and 30 million tonnes per year. The net sequestration probably reached a peak during the period 2003–2007. Because of the age composition of the forests, it is expected that the annual net increment will decline and that annual sequestration will be at a level of about 19 million tonnes of CO_2 by 2020. This reference path forms the basis for assessing measures in Climate Cure 2020.

The Kyoto Protocol does not allow Norway to be fully credited for forest sequestration, as there is a ceiling on how much a country can be credited for sequestration in forests for the first regulation period 2008–2012. The Climate Agreement in the Storting assumes that today's rules under the Kyoto Protocol will be continued until 2020 and that this will give Norway the opportunity to be credited for 3 million tonnes of CO_2 from forest sequestration without new measures. The ongoing climate negotiations include proposals to change the accounting rules for forests. Some of these proposals could mean that Norway will be credited with up to 5 million tonnes of CO_2 per year from forests without further measures.

It is possible to increase forest sequestration beyond the 19 million tonne reference path by planting forest in new areas, forest plant breeding and fertilising. Fertilising is the only forestry measure that has been calculated to achieve maximum effect by 2020. This measure gives about 0.45 million tonnes increased CO_2 sequestration per year. In the longer term (50 to 100 years), forestry measures would give substantially increased CO_2 sequestration (5.9 and 12.3 million tonnes per year).

Reduced felling could give higher net short term sequestration of CO_2 in forests. At the same time, reduced felling could reduce the availability of bio-resources that could replace fossil energy and more energy intensive building materials. Reduced felling could also make the forests less productive in a longer perspective.

Measures that involve more intensive forestry and the use of new areas could affect biological diversity. Environmental registration and impact assessments must therefore be made before these measures are implemented.

Waste

The potential for emissions reduction beyond the reference path is estimated at about 0.1 million tonnes of CO_2 equivalents from measures involving collecting methane from landfills. However measures have also been looked at that will reduce greenhouse gas emissions in other sectors, but where the instruments for realising the measures lie within waste policy. Some examples of such measures are materials recycling and the production of biogas. Including increased recycling of plastic, the total reduction potential for CO_2 from the waste sector is about 0.2 million tonnes.

Fluorinated greenhouse gases in products
An emissions reduction potential of 0.5 million tonnes of CO_2 equivalents by 2020 has been estimated. The measures are based on replacing hydrofluorcarbons (HFCs) with natural refrigerants, using HFCs with less global warming potential in areas where it is difficult to replace HFCs with natural refrigerants and minimising HFC leaks from refrigeration systems.

Local and regional authorities
This sector is in an exceptional position in that the local and regional authorities have the means to influence the emissions of many sectors. The individual measures that the local and regional authorities can help to realise are discussed in the sector by sector reports on energy use in buildings, energy production, waste, transport, agriculture etc. As of 1 January 2010, the regional authorities have an increased responsibility in the transport sector. In the report, the main purpose has been to assess the use of instruments that could strengthen the local and regional authorities' opportunity to engage actively in climate issues, especially as regards planning.

MACRO ECONOMIC ANALYSES

In addition to the sector by sector analyses, macroeconomic calculations have been made of the socio-economic costs of achieving the domestic reduction target. The macro analyses span all sectors and the calculations are made by using the general equilibrium model for the entire Norwegian economy.

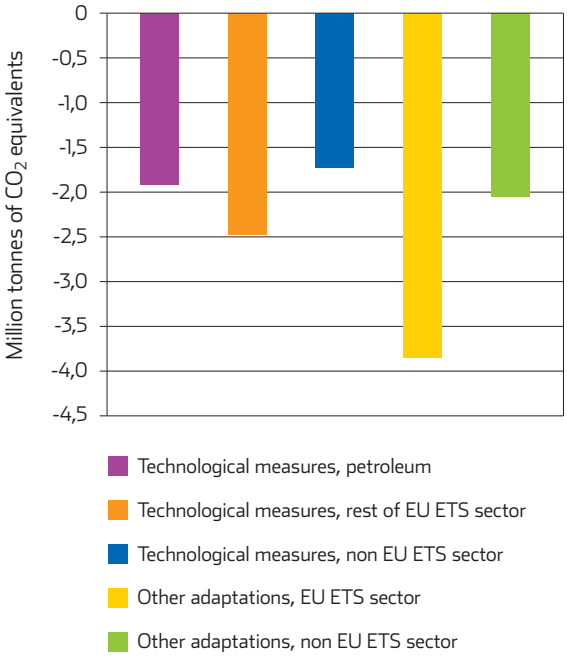
According to the macro analysis, the national target for emissions reduction, excluding the sequestration in forests, of 12 million tonnes of CO_2 equivalents can be achieved with an emission price of about NOK 1,500 per tonne of CO_2 equivalents by 2020. That is to say, the most expensive measure will cost NOK 1,500. However, the average cost would be lower.

The socio-economic annual cost of achieving the national emissions target in this way is estimated to about NOK 5 billion. In addition to the national target, we have taken into account that Norway has international obligations under the EU ETS and the Kyoto Protocol, as well as targets for global contributions in accordance with the climate agreement of the Storting.

Households and organisations in the public and private sectors adapt to the emission price by reducing emissions intensive activities and adapting patterns of production and consumption. Emissions efficiency can be increased by replacing emissions intensive consumables or through more comprehensive technological measures where one invests in eco-friendly technological solutions.

The emissions reductions outlined in the macro analysis are divided almost equally between technological measures and other adaptations. Technology changes in the EU ETS sector amount to about 4.4

Emissions reductions (in CO_2 equivalents) by category of measure; equal price for all sources



million tonnes of CO_2 equivalents. 1.9 million tonnes are generated in the petroleum sector and 2.5 million tonnes from industry. A 3.8 million tonne reduction in the EU ETS sector comes as a result of other adaptations, primarily in reducing activities in the process industry. For some companies, reduced production levels could lead to the whole activity ceasing or moving abroad. The emissions sources not regulated under the EU ETS, e.g. transport activities, reduce emissions by 3.8 million tonnes of CO_2 equivalents in total. Technological measures in road transport account for 1.7 million tonnes of these. Other changes, primarily reduced road transport, other transport, non EU ETS industrial activities and fuel usage in households, account for 2.1 million tonnes. This is illustrated in the figure on this page.

A macroeconomic analysis has also been carried out to show how the domestic

emissions target can be reached, while the EU ETS regulated sector is protected from carbon price increases above the price of EU ETS allowances. Emissions in the EU ETS regulated sector are then reduced by about 3 million tonnes of CO_2 equivalents to about 8 million tonnes, given an equal emission price for the whole economy. Reductions of as much as 9 million tonnes of CO_2 equivalents must then be made in the other sectors if the target for total domestic emissions reduction is to be met. With this alternative, the emission price necessary for the non EU ETS sector is estimated at about NOK 3,400 per tonne of CO_2 equivalents. This kind of differentiated policy between the EU ETS regulated and non EU ETS regulated sources does not ensure that the cheapest measures are realised and the socio-economic costs are doubled, to about NOK 10 billion a year.

MENUS OF INSTRUMENTS

In Climate Cure 2020 we have used two methodological approaches – sector by sector analysis of measures and instruments and macroeconomic analysis – to investigate how Norway can achieve the national climate targets for 2020. We have also tried to see these in context by developing four different menus of instruments so as to illustrate different ways of meeting the national emissions target by 2020.

Please note that the menus are not meant as specific alternative selections or recommendations. They are meant as illustrative examples that clarify individual considerations that might be emphasised in addition to the national climate target. The exact composition of instruments in climate policy will in the end depend on how different considerations are balanced. The different menus presented here are stylised examples that can illustrate the impacts of different approaches to achieving the national emissions target. What all the menus have in common is that they are suitable for reducing national emissions of greenhouse gases by 12 million tonnes of CO_2 equivalents by 2020 compared to the reference path, excluding the effect of forests. We have developed the following four menu examples:

Menu 1: CO_2 tax with supplementary instruments

The purpose of this menu is to illustrate how the national target could be met at the lowest possible cost to society. It is based on introducing a CO_2 tax for all emissions. The CO_2 tax is supplemented with other instruments so as to trigger inexpensive measures that are not brought about by the tax alone. Such a menu would stimulate investment in climate measures, but also involve a significant downsizing and moving of emissions intensive industry. The price of fuel will increase, but the volume of transport will remain largely unaffected. The CO_2 tax would increase government

revenues, thereby allowing for reduction in other taxation or increased public services. The basis for estimating the amount of the CO_2 tax and other instruments and the cost level is uncertain.

Menu 2:
Regulation and support
The purpose of this menu is to illustrate how the national target could be met through a combination of regulation and financial support to bring about technological measures. The costs of meeting the national target with such a menu will be considerably higher than the costs in Menu 1 and the costs will be distributed among a large part of the population by means of financing through taxation or reducing public services rather than making the polluter pay. The focus on technology could have a learning effect and thereby facilitate increased emissions reduction in the longer term. The greatest uncertainty with this menu is that it presupposes technological development and the simultaneous implementation of several large projects.

Menu 3:
Screen the quota regulated sector
The purpose of this menu is to illustrate how the national target could be met without directing new instruments other than the Emission Trading Scheme at the EU ETS regulated sector. The motivation for this is to ensure cost effectiveness within the European system (given a well-functioning EU ETS market, allowances that are excess to requirements because of measures implemented will be purchased and used by others, so that the total emissions within the trading scheme will be unchanged). Such a menu would mean that most of the emissions reductions would have to come from the other sectors. However, the sector analysis for transport shows that emissions in this sector must be reduced beyond what has been assessed as the highest potential, partly because introducing new vehicle technology takes time. The costs of this menu would also be considerably higher than for Menu 1.

Menu 4:
Allowances and supplementary instruments in the EU ETS regulated sector
In order to avoid the most expensive measures in the non EU ETS regulated sector, particularly in transport, supplementary instruments could be introduced to bring about the emissions reductions in the EU ETS regulated sector that are not realised by Menu 3. This could be done by the EU ETS sector entering into an agreement with the government whereby it undertakes to make emissions reductions and by establishing a climate fund along the lines of the Norwegian NOx fund. This would be a less cost effective instrument than emission pricing. It provides some screening of industry compared to Menu 1, but in a more limited way than in Menu 3.

The effect of the menus on demand for energy

The majority of the measures described in the menus above reduce the use of fossil energy carriers, either through increased energy efficiency or by switching to other energy carriers. The sum of all the measures appears to have little effect on demand for electricity, while greatly increasing demand for bio-energy resources.

Depending on which measures in the various menus are implemented, there will be a demand for between 13 and 20 TWh in different forms of bio-energy goods, corresponding to 19 to 28 TWh bio-energy resources depending on production technology. A large part of the bio-energy in demand is liquid bio-energy for use in the transport sector, about 7 TWh, divided about equally between first and second generation bio-fuel. In the short term it is likely that most of the liquid bio-energy will have to be imported. There is also a demand for up to 6 TWh in the form of chippings, pellets or firewood to replace oil used for energy production in industry and buildings. The use of timber to produce bio-coal in the metal industry will represent maximum 6 TWh. There is also a demand for just under 1 TWh in bio-gas in buildings and 2 to 3 TWh for the use of straw in the agricultural sector.

Some key challenges to be faced for the exploitation of Norwegian bio-energy resources in the future will include the tempo of technological development in the production of liquid bio-energy from timber and other plant sources, so-called second generation bio-fuel, the production of bio-coal from timber or straw and the production of bio-gas from wet organic waste and other types of waste. It will also be necessary to develop the end user market for bio-gas and liquid bio-energy, especially as regards logistics and distribution.

UNCERTAINTY AND COMPARISON WITH OTHER ANALYSES

Uncertainty

There are various kinds of uncertainty in an analysis such as the present one. Even though about 160 measures have been investigated in the sector analyses, and the emissions reductions that could occur through changes in commercial structure, input factors and patterns of consumption have been investigated with the aid of macro analysis, there will be other measures and adaptations that have not been included. There may also be measures that prove to have lower emissions reductions than assumed. Comparison with analyses in other countries shows that Climate Cure 2020 has investigated measures to at least the same extent and in some cases in more depth than other analyses.

There will be uncertainty in relation to expectations for anticipated technological development, for example for low emis-

sion vehicles or carbon capture and storage. Faster or slower development could give results other than those assumed in the analysis. New instruments could affect technological development and technological demand. In estimating the cost of measures, there may be systematic uncertainty relating to assumptions that have been made, such as for energy prices or the lifetime of different measures. Different energy prices or lifespans could lead to higher or lower costs. One example is that higher power prices could lead to a reduction in the use of electricity, but also more energy efficiency – while a lower power price could have the opposite effect.

There will also be uncertainty in relation to estimating investment costs of large projects that are complex and require many thorough calculations before the final cost can be determined. More thorough calculations often give a higher cost estimate. On the other hand there could be benefits that have not been estimated and that can bring the costs down.

Another uncertain factor is the instruments' emissions reducing effect, which may be either lower or higher than has been assessed here. This will depend on a number of uncertain assumptions in the reference path regarding economic development, the international regulatory framework and the reaction of the population to the instruments, which in turn depends on an understanding of the climate problem and a willingness to act. There is also uncertainty in respect of the calculation models that have been used in various analyses, for example transport models.

In spite of these uncertainties, overall the analyses give a good general picture of the possibilities for emissions reduction, costs and instruments that could be applied.

Comparison with other sector analyses

In 2007 the Climate and Pollution Agency, at that time the Norwegian Pollution Control Authority, prepared the analysis of measures «Reduksjon av klimagasser i Norge» (Reduction of greenhouse gases in Norway). In this analysis, the costs of measures were divided into three groups (and no marginal cost curve was calculated). The analysis contained no assessment of which instruments would be relevant in order to bring about the measures. The measures were divided into three feasibility categories: high, medium and low. Measures that were considered to require very substantial instruments or technological breakthroughs were assessed to have a low feasibility. Non-valued effects in the form of hidden costs, disadvantages and distribution effects were thereby discussed but not calculated as costs.

Some of the measures from the 2007 analysis are now in the reference path and have therefore not been included in Climate Cure 2020's analysis. In Climate Cure 2020, many of the costs of the measures have been investigated in more detail and more cost elements have been

included. We have also been able to be more precise about speed of introducing measures and learning curves as we are now closer to 2020. Electrification of the continental shelf is also assessed to be more expensive than in the analysis of 2007. In Climate Cure 2020 these cost estimates have been based on more detailed studies, and the remaining lifespan gives higher costs per measure because the overall emissions reduction potential will be lower. Also emissions from the petroleum sector represent a greater proportion of the total in the reference path now than they did in 2007, which also increases costs.

Climate Cure 2020 has considered the extent to which our results from the sector analyses can be compared with results from analyses of other select countries. Norway presupposes certain factors, giving us a different starting point than those of the countries with which we have made comparisons. Compared with other countries, we have very limited potential to reduce emissions from the production of energy, because electricity is largely produced from hydro power in Norway. We have also had a CO_2 tax since 1991, which has already realised the least expensive measures in the petroleum sector.

The total identified potential for emissions reduction is nevertheless at the same level as for the other countries, but the costs of the measures to achieve it are higher in Norway. There is reason to believe that this is because the least expensive measures have already been implemented, and that a considerably larger portion of reduction in emissions (50 per cent more) has been included in the reference path compared to other studies.

CLIMATE CURE 2020

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