

Intermediate report

Nordic Energy Perspectives



Nordic perspectives on the EU goals relating to CO₂, renewable energy and energy efficiency

- results from the MARKAL model

March, 2009



Preface

Nordic Energy Perspectives (NEP) is an interdisciplinary Nordic energy research project with the overall goal of demonstrating means for stronger and sustainable growth and development in the Nordic countries.

NEP analyses the national and international political goals, directives, and policy instruments within the energy area, as well as their influence on the Nordic energy markets and energy systems and the infrastructures and institutional structures. NEP aims at clarifying to decision-makers the consequences of political and strategic decisions for politicians, energy actors and the public. The project is to promote a constructive dialogue among researchers, politicians, authorities and actors on the energy markets. For further information about the project, please visit: www.nordicenergyperspectives.org.

This series of reports are the second reporting from the second phase of the project. The following intermediate and final reports are now presented:

Synthesis report, March 2009:

- Second NEP2 synthesis report (*Responsible: Peter Fritz, Håkan Sköldbberg, Bo Rydén*)

Final reports, March 2009:

- Widened view of energy efficiency and the resource management (*Responsible: Bo Rydén*)
- Technology options for a low CO₂ energy system (*Responsible: Tiina Koljonen*)
- Wood markets and the situation of the forest industry in the Nordic countries (*Responsible: Per Erik Springfeldt*)

Intermediate reports, March 2009:

- Reference and policy scenarios (*Responsible: The NEP model group*)
- Global scenarios (*Responsible: Janne Niemi*)
- Biomass market and potentials (*Responsible: Tiina Koljonen*)
- Nordic perspectives on the EU goals relating to CO₂, renewable energy and energy efficiency (*Responsible: Thomas Unger, Bo Rydén*)
- Prominent strategies for environmental sustainability in the stationary energy sector (*Responsible: Anders Sandoff*)
- The future of the Nordic district heating (*Responsible: Monica Havskjold, Håkan Sköldbberg*)
- Trade within the RES directive and related power interconnection issues (*Responsible: Berit Tennbakk*)
- Natural gas in the Nordic countries (*Responsible: Peter Fritz*)

Our intention in NEP is to present all reports in English. Due to lack of time, some of the texts in some of the reports are at this stage still in Scandinavian languages. We apologize for this. These texts will as soon as possible be translated into English. The translated texts/reports will be available on the project's web site, www.nordicenergyperspectives.org, soon after the Oslo conference.

Oslo, March 2009, *The NEP Research Group*

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1. Introduction

A common aspiration in the EU's and the Nordic countries' policies is to develop the society in a sustainable direction. The future energy system is an important part of such a society. In the NEP project we have a general view of a sustainable development of the society, but our focus is directed to the demands that such a society puts on the energy system

Since 2001 the EU has a general strategy for sustainable development¹. A key element in the strategy is that environmental protection, social cohesion and economic prosperity must go hand in hand. The strategy should, according to its aims, found a basis for reviews and development of EU policy within different areas during the coming years. The EU's climate and energy policy package could be seen in this perspective.

The EU's climate and energy policy package (here named "the EU's green package") has been viewed by us as an operational expression for an energy policy for the EU, which is based on the general strategy for sustainability. Our analysis in the project is based on the targets of the package.

1.1 The EU's green package

On January 23 2008 the EU Commission presented its climate and energy package and in December 2008 an agreement with the EU Parliament was reached. The goal for the policy package is to reduce emissions of greenhouse gases by at least 20 % compared to 1990 and to increase the renewable share in the EU energy mix from 8.5 to 20 % until the year 2020.

The target for CO₂ emissions reduction of 20 % compared to the 1990 level corresponds to a reduction of 14 % compared to the 2005 level. The reduction should be reached partly within the system for emission trading and partly through measures in other sectors. The trading system will be expanded and the number of emission allowances will gradually be reduced in a way that the emissions covered by the system decreases by 21 % until 2020, compared to the 2005 level.

Within the sectors not included in the emission trading system the emissions should, as an average, be reduced by 10 % compared to the 2005 level. For these sectors a burden sharing has been applied, taking each country's specific prerequisites into account.

In order to reach the 20 % target for increased use of renewable energy until 2020 the EU Commission has assigned individual and mandatory targets for all EU countries.

The policy package also includes the target that at least 10 % of all fuels in the EU's transport sector should be biofuels. The EU Commission has also issued new guidelines for governmental support to environmental protection which should help the member states to develop a sustainable European climate and energy policy.

¹ A Sustainable Europe for a Better World: A European Union Strategy for Sustainable Development. COM(2001)264 final

1.2 The aim of this report

The aim of this report is to illustrate the effects of the EU's climate and energy package on the development of the Nordic energy system. The identified effects have been analysed both as consequences of the whole package and as consequences of specific targets. We have also analysed how the stationary energy system interacts with the transportation system in the response to the policy targets.

The analyses presented in this report are based on the same research questions and focus as in the NEP report "Nordic perspectives on the EU goals relating to CO₂ emissions, renewables and energy efficiency" (May 2008). The most important differences between the two studies relate to the scope which is being addressed, as well as model methodology. In the current study, we have also included the transport sector and international electricity trade between the Nordic countries and Continental Europe (Germany and Poland). Furthermore, important input data has been updated and the model implementation of the three investigated EU targets has been improved since the former report from May 2008.

2. Calculated main scenarios

In this intermediate report we present results from model calculations of the development of the Nordic energy systems. The MARKAL-Nordic model has been used for the calculation and the focus has been on the EU green package, with the 20 % targets for CO₂ reduction and use renewables. Alternative policies and targets have also been analysed.

The following scenarios have been calculated:

- The reference scenario
Includes existing policy instruments such as energy and CO₂ taxes and selected support schemes such as the Swedish electricity-certificate and direct subsidies in the other Nordic countries. Furthermore, the EU emission trading scheme (EU ETS) is included as an exogenously given EU emission allowance (EUA) price of 25 EUR/t.
- The green package
Includes the same policy instruments as the reference scenario but, in addition, also a requirement to reach the renewable target defined for the Nordic countries in accordance with the EU energy and climate package.
- The extended green package.
Includes the same policy measurements as the "green package" scenario but, in addition, also the target of increasing energy efficiency by 20 percent until 2020 adapted to the Nordic countries.
- Alternative scenarios
Relate to what the transportation sector achieves regarding the 20 % CO₂ reduction target and the 20 % renewables target (with the assumption that this could increase the targets for the stationary energy system).

In order to get a good understanding of the presented results and to understand their implications it is important to be aware of how the scenarios are defined. In appendix 1 we therefore make quite an extensive description of how different policy targets have been modelled.

3. The Nordic electricity production

In this chapter we present the MARKAL-NORDIC results for the development of the Nordic electricity production. The presentation starts with the green package case.

3.1 The EU target for 20 % renewables

The EU target for 20 % renewables in the energy mix by the year 2020, and its resulting target for the Nordic countries, influences the development of the energy system in a number of ways. According to the MARKAL-NORDIC calculations the electricity production based on coal decreases rapidly. During years with normal hydropower production, the fossil fuels that are used for electricity production are primarily used for combined heat and power production (CHP). Wind power and CHP production based on biomass expands significantly. In Norway hydro power also expands. (This option is more or less non-existing in Sweden and Finland due to political decisions.) Nuclear power also expands, partly due to capacity increases in existing Swedish plants and due to a fifth and a sixth Finnish reactor (which MARKAL-NORDIC identifies as profitable investments²). After the year 2030 the nuclear production decreases as a consequence of the assumed 60 years life length for the Swedish reactors.

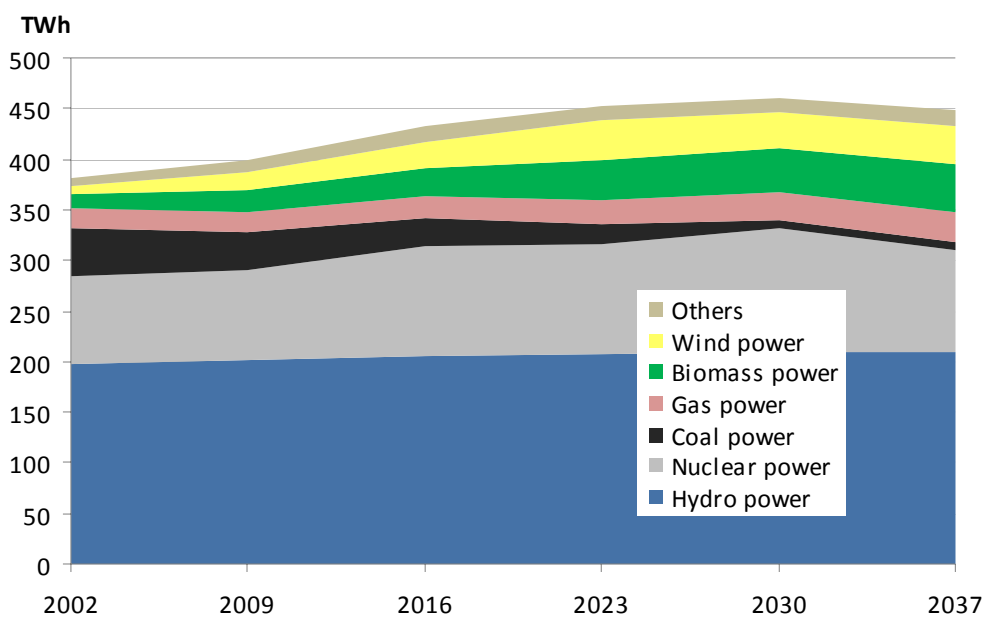


Figure 1 The EU green package has a great impact on the development of the Nordic electricity production. Almost all new power production which is built in the Nordic countries will be based on renewable or nuclear energy (“Others” in the figure is CHP production based on municipal waste or peat.)

Almost all new electricity will be based on renewable or nuclear energy

As mentioned above the dominating sources for increased electricity production in the MARKAL calculations assuming the EU’s green package (the 20 % renewable target and the 20 % CO₂ reduction target) is nuclear, wind and biomass. In figure 2 the changes in Nordic electricity production compared to the situation 2005 is shown. By the year 2023 the Nordic nuclear electricity production has increased by 20 TWh through the Swedish capacity increases and a

² Here we have assumed investment costs of around 2200 €/kW for new nuclear power.

fifth Finnish reactor. In 2030 the sixth reactor increases nuclear production even more. Wind power increases even more, more than 25 TWh, until the year 2023. The increase in the use of biomass for electricity production in CHP plants (district heating and industry) is of the same magnitude as the wind power increase. A large part of the renewable electricity production is introduced as a result of the EU green package. (This can be seen by comparing figure 1 and figure 3 below.) A small but significant increase in electricity production based on natural gas fired CHP can also be identified. Hydro power in Norway also increases, as mentioned above. The only source of electricity production which is phased out as a consequence of the economical conditions, partly created by the EU green package, is coal. By the year 2023 more than 20 TWh coal based electricity production will be phased out.

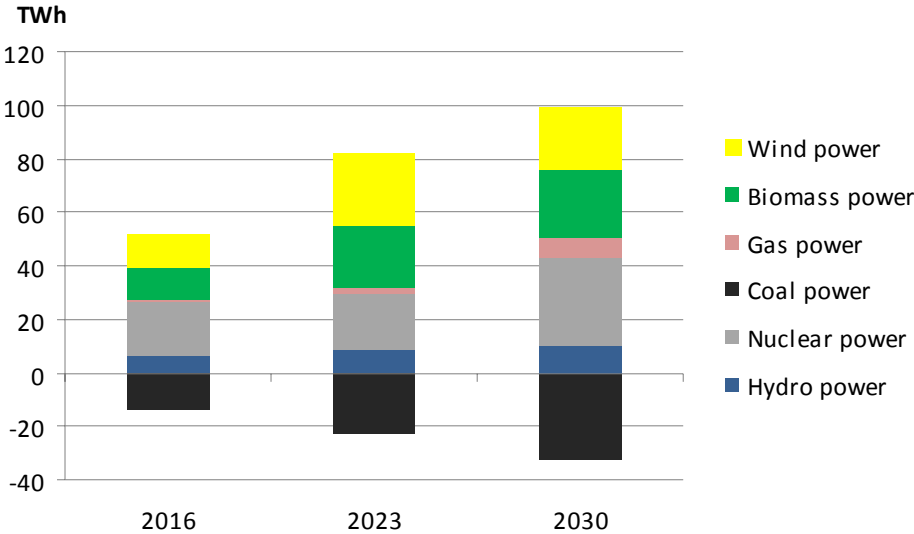


Figure 2 Change in electricity production in the Nordic countries if the EU’s green package is implemented, compared to the 2005 situation.

3.2 The reference case

Figure 3 below shows the development of the Nordic electricity production in the reference case assuming only the presently applied policy instruments. The increase in electricity production based on nuclear and hydro is identical to the one calculated for the EU’s green package. This increase is thus not a consequence of the incentives created by the green package, nor is it eliminated through the expansion of wind and biomass electricity in the EU green package case. The reference case shows increases also in wind power and biomass CHP. Already the present policy instruments leads to increased renewable electricity production. However the increase is considerably smaller than in the green package case. The wind power increases by less than one third of the increase calculated for the green package case, 8 TWh to the model year 2023 instead of 27 TWh. The existing EU emission trading scheme (EU ETS) contributes to the phasing out of coal based electricity production already in the reference case. Natural gas based electricity production increases however slightly more in the reference case than in the green package case, by 6 TWh instead of 3 TWh to the model year 2023.

Another difference between the cases is that the future total electricity production is smaller in the reference case. Both cases show significant increases, but the increase is larger in the

green package case. As shown in a section below the production difference is not due to differences in electricity demand in the Nordic countries. The development in electricity demand is more or less identical in the two cases. Instead the differences in electricity production can be related to differences in export/import.

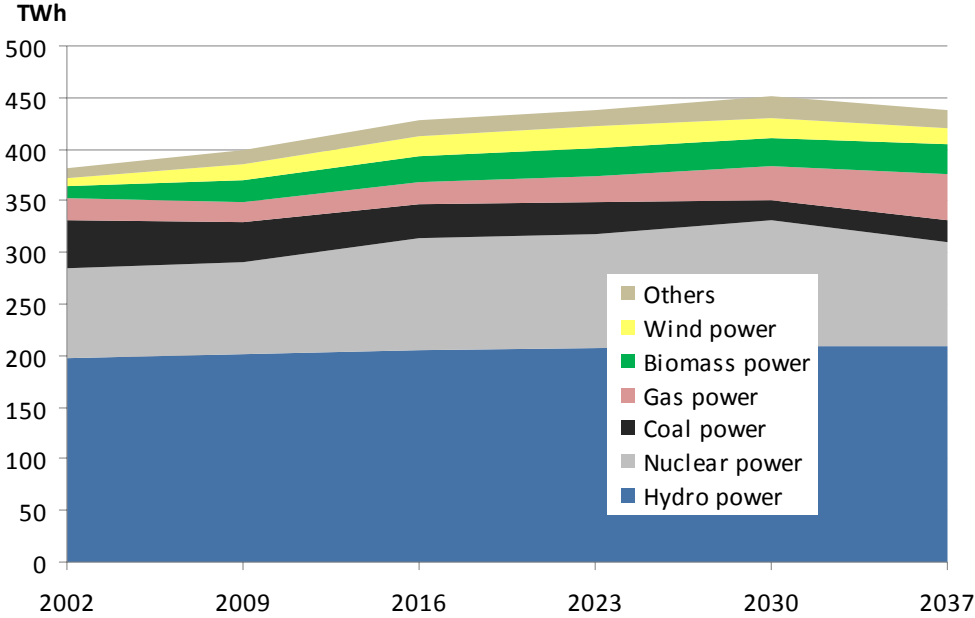


Figure 3 The development of the Nordic electricity production in the reference case.

The development of the Nordic electricity production in the case with all three EU 20 % targets is presented in chapter 5.2 below.

4. Nordic electricity export/-import

Figure 4 shows Nordic electricity export and import, both historical data from statistics and results for the years 2016, 2023 and 2030 from the MARKAL-NORDIC calculations. Results for two future scenarios are shown.

As indicated above the net export is larger in the green package scenario than in the references scenario, especially for the year 2023. The large electricity export in the green package case is caused by the large introduction of renewable energy in the Nordic electricity production (as a result of the 20 % renewable energy target). This leads to a surplus of electricity in the Nordic area and relatively low electricity prices compared to Germany/Poland. This electricity-price difference between the areas results in the export.

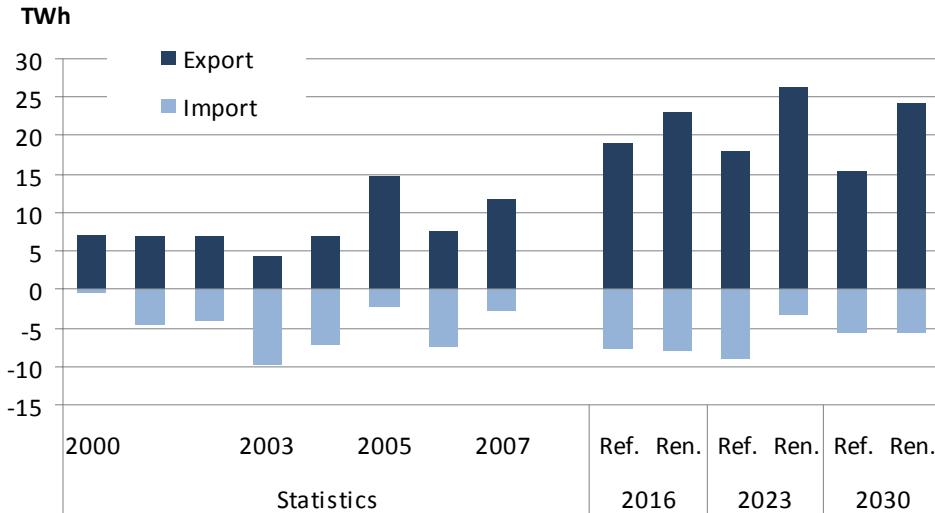


Figure 4 Nordic electricity export/import, historical and results for the development in two different scenarios. (Electricity import to Finland from Russia is not included in the figure.)

In order to get a better feeling for the development over time figure 5 shows Nordic export and import for the period from the model year 2016 to the year 2044. The green package case is chosen. (Most results in this report are shown for a period until 2030 or 2037. Here we have added results for an additional model year, 2044, in order to show the long term trend for Nordic electricity export/import, which is strongly influenced by the assumed Swedish nuclear phase-out after 60 years lifetime.)

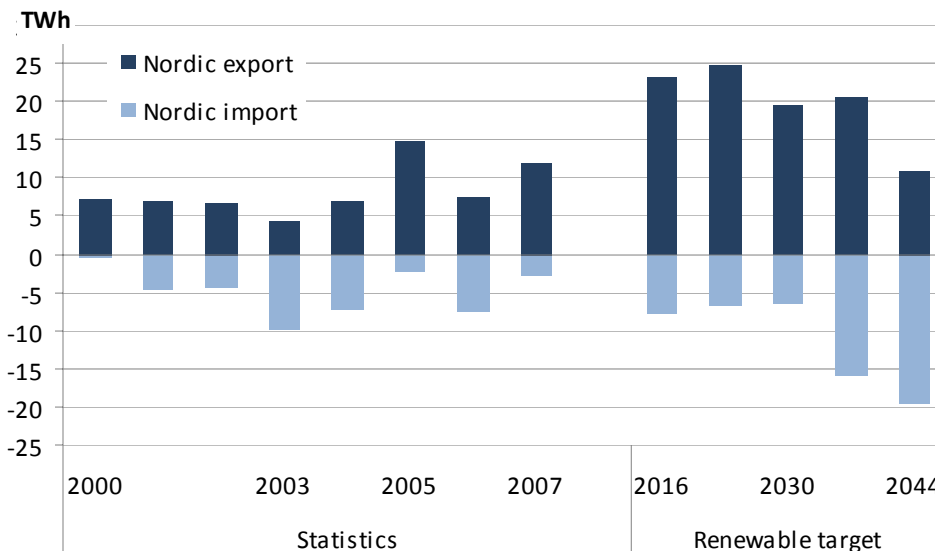


Figure 5 Nordic electricity export/import, historical and results for the development in the green package scenario. (Electricity import to Finland from Russia is not included in the figure.)

The figure shows the large net export of electricity during the coming 20 years. After the year 2030 the assumed phasing out of nuclear power in Sweden leads to decreasing net export and eventually a situation where the Nordic countries become net electricity importers. This is due

to the assumption that new large-scale (fossil) power plants are somewhat cheaper in Continental Europe (economies of scale) than in the Nordic countries where plant sizes, generally, are smaller.

5. Development of the Nordic electricity demand

During the years following the year 2000 the long term trend of increasing Nordic electricity demand was broken. Some people interpreted this as the start of a long period of decreasing electricity use. However, this did not happen. The Nordic electricity use started to grow slowly again in 2003, by approximately one (1) % per year. The MARKAL-NORDIC calculations indicate a similar development in the reference and in the green package scenarios, at least during the next 15-20 years. As shown in figure 6 below the development of the Nordic electricity demand is almost identical in the two scenarios. This is partly explained by the limited price flexibility on the demand side in the model, but also by the fact that electricity prices do not seem to differ in any significant respect between the two scenarios.

5.1 Nordic electricity demand remain more or less constant if the 20 % increased energy efficiency target is added

By adding the target for 20 % improved energy efficiency to the EU’s green package, i.e. all EU 20 % goals (the “extended green package” scenario), there will be a significant effect on the Nordic final electricity use, see figure 6. We would then get a situation where the electricity demand remains more or less constant at the present level for 10 – 15 years. After 2020, which is the year that the target aims for, the demand may grow slightly. The increase is however small and may soon turn into stagnation or even a slight decrease in electricity demand. From the year 2020 the electricity demand is 25 – 30 TWh/year lower in the extended green package scenario than in the references scenario or the green package scenario.

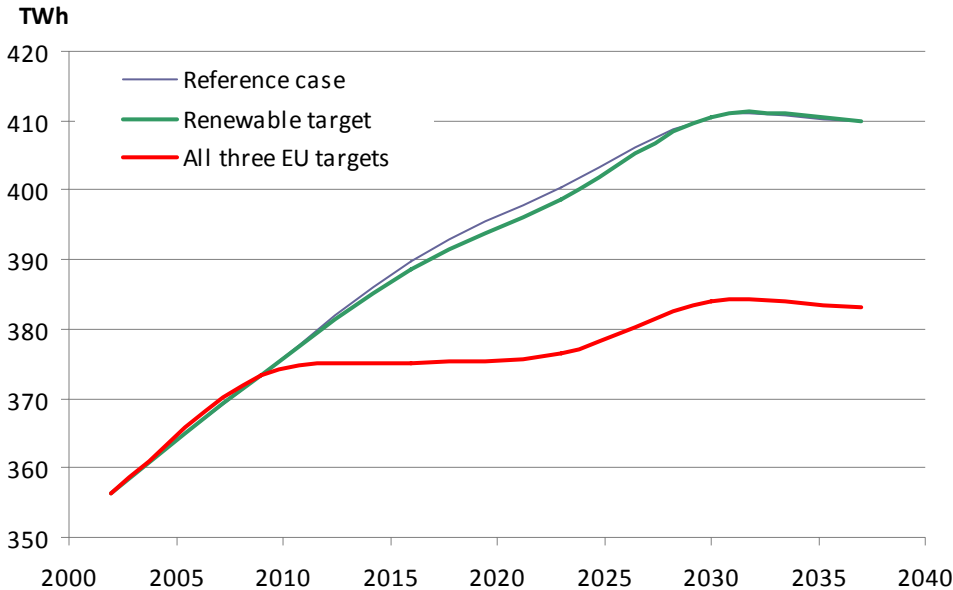


Figure 6 Development of Nordic electricity demand (excluding distribution and transmission losses) in different scenarios. If the 20 % increased energy efficiency target is added the Nordic electricity demand remains more or less constant.

Primary energy weighting

Since the EU’s target for increased energy efficiency relates to the primary energy use the primary energy weighting is of great importance in order to achieve synergies with the energy conversion sector. All energy supply has been weighted by the factor one (1), with the exception of “free heat” for heat pumps which is weighted at zero (0). When it comes to nuclear power we have chosen to weight the electricity from nuclear power plants by the factor one (1). Thus, we have not weighted the energy content of the uranium fuel to the reactors. There is an ongoing debate within the EU regarding the weighting of nuclear power.

If nuclear power instead would be weighted through the uranium energy content as primary energy, the phasing out of nuclear power would be a profitable efficiency improvement measure. Our judgement is that elimination of nuclear power is not the intended purpose of the target.

5.2 Nordic electricity production if all three EU 20 % targets are applied

The target for increased energy efficiency also has a significant effect on the Nordic electricity production. If all three EU 20 % targets are applied the MARKAL-NORDIC calculations show a development according to figure 7. This could be compared to the development in the reference and green package scenarios shown in figures 3 and 1.

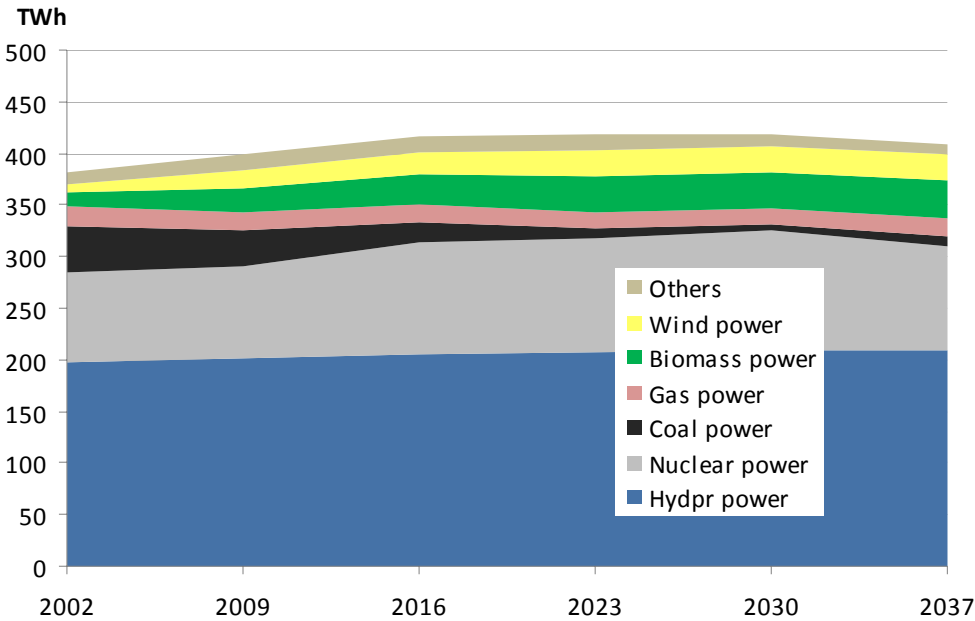


Figure 7 The development of the Nordic electricity production in the case with all three EU 20 % targets (the extended green package scenario)

The development for nuclear power and hydro power is identical to the development in the other two cases, but all other production alternatives show smaller production volumes than in the green package case. Electricity production based on fossil fuels decreases a lot compared to today. During years with normal hydro power production electricity production based on fossil fuels can almost entirely be found in CHP plants, whereas condensing plants are only

marginally used. Wind power and biomass based CHP production expand but less than in the green package case. The lower electricity demand is of course reflected in the production figure (although there is no strict connection between demand and production, due to the Nordic electricity export/import).

6. Renewable energy

As described in chapter 1, the European Commission in December 2008 accepted a wide-ranging energy package, called the climate and energy package with measures and goals for the work of increasing the share of renewable energy in the EU countries' energy mix. The package also includes a goal for decreasing emissions of greenhouse gases in the EU by 20 %. In parallel with this is the EU's goal of improving energy efficiency by 20 %. This policy package will have a clear influence on the development of the energy system in the Nordic countries³. The analysis focuses on the stationary energy sector and therefore no results regarding the transport sector is presented in this section. (An analysis of how the different targets influence the transport sector and how this is connected to the development of the stationary energy system is presented below in another section of this report.)

6.1 The reference case

As mentioned above a point of departure for the analysis has been a calculation of the energy system's development with today's policy instruments, the reference case. This case does not, therefore, include the goal of increased use of renewable energy. (Examples of policy instruments that already today stimulate the use of renewable energy are high taxes on fossil fuels, the emission-rights trade system for carbon dioxide⁴, investment and operation support for diverse renewable alternatives, and the Swedish electricity-certificate system.) Figure 8 shows the increase of the Nordic use of renewable energy for this reference case. The figure reveals that present costs for different renewable kinds of energy, together with today's policy instruments, leads to a strong growth in the use of biomass. The increase happens in spite of the fact that the calculations assume a constant level for the size of Nordic forest industry. This means that no increased biomass use within the forest industry contributes to the expansion of the use of biomass in the Nordic countries. Wind and hydro power increase too, but relatively little.

The heading "Other" in the figure covers other types of energy which is regarded in the green package as renewable, primarily heat from heat pumps⁵, but also industrial waste heat and solar heat.⁶

³ By the Nordic countries we refer to Denmark, Finland, Norway and Sweden.

⁴ The emission-rights trade system is illustrated with a CO₂ price corresponding to approximately 25 €/ton within the trading sector.

⁵ For heat pumps we make, based on the green package, the following assumption: the free energy that heat pumps render useful, together with the renewable share of the electricity input is seen as renewable.

⁶ Even though not specifically addressed in the Directive Proposal, we assume here that industrial waste heat is included in the renewable portfolio.

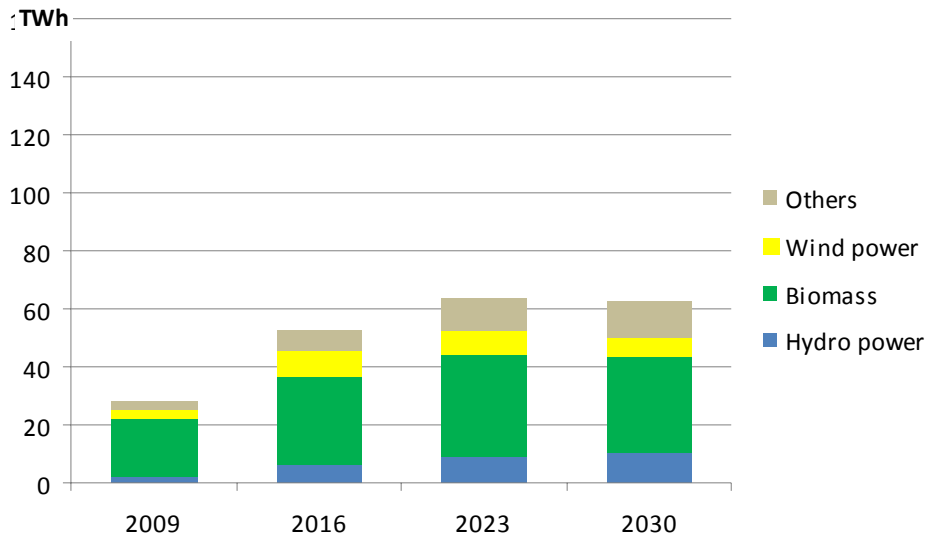


Figure 8 Increase of renewable energy in the Nordic countries in the reference case relative to 2005 (with no new goals from the EU, but keeping current emission trading system and national policy instruments)

6.2 The target of increased use of renewable energy, i.e. the green package

We then add the goal of increased use of renewable energy to the reference case and thus we reach the green package scenario. In the directive regarding increased use of renewable energy quantified goals for the share of renewables in each country can be found. The goal is expressed as the share of renewables in final energy use. Our point of departure for the analysis is that the transport sector only meets the Biofuel Directive which corresponds to 10 percent of total fuel use. Thus, the stationary energy sector is, in this case, assumed to bear a larger share of the burden than 20 percent. For the stationary energy system, the goals (at the final energy use levels) for each country⁷ imply that a further amount of just over 120 TWh renewable energy must be added to the stationary energy system in the Nordic countries from 2005 to 2020. For the period after 2020 a moderate increase in the renewable target has been assumed in the calculations.

The analysis of the effects of the target for increased use of renewable has been made in this introductory analysis by inserting in the model a condition that imposes this total amount of renewable energy on the Nordic energy system. Thus, we have not imposed the amount of renewables for each country, but instead allowed the total amount to be produced in the most cost-effective way in the Nordic countries as a whole (more on this in Appendix 1).⁸

In the calculation case with the target for increased use of renewable energy the overall assumption for the Nordic countries as regards renewable energy has been inserted as a condition. Hence, this calculation shows the effects for the Nordic countries of the renewable target

⁷ Since Norway does not belong to the EU there is no specific EU renewability goal for Norway. We have assumed that Norway is given a goal corresponding to the average value of the goals for the other three countries.

⁸ However, a certain bias away from the most cost-efficient solution is deliberately maintained. For instance, the Swedish electricity-certificate scheme and a few other selected existing support schemes for renewables are included also in the green package (and the extended green package) scenarios.

on promotion of renewable energy; see Figure 9. The calculation shows that the use of renewable energy increases dramatically in the Nordic countries. If one views each type of energy by itself, one can see that hydro power is virtually unaffected, since it is limited by the possible expansion that we have stipulated in the model. The increased use of biomass is doubled in comparison with the reference case. Most of the biomass is used for electricity and heat production in the district heating systems and in industry. One reason for not reaching an even larger increase of biomass use is the size of the total demand for district heating and process heat. Moreover, the biomass price is described with a “step-wise supply curve”, where the biomass range becomes gradually more expensive as the amount used increases.

A strong growth due to the target for increased use of renewable energy is obtained also for wind power. In the reference scenario the growth of wind power stops at less than 10 TWh, whereas the green package scenario entails a wind power expansion on the order of 30 TWh in the Nordic countries. Most of this is built already within 10 – 15 years. Also other renewable electricity production is expanded somewhat more than in the calculation case with today’s policy instruments (the reference case). The growth can primarily be attributed to heat pumps. Thus, with the renewability goal’s definition of renewables, stimulation is given to heat pumps as well.

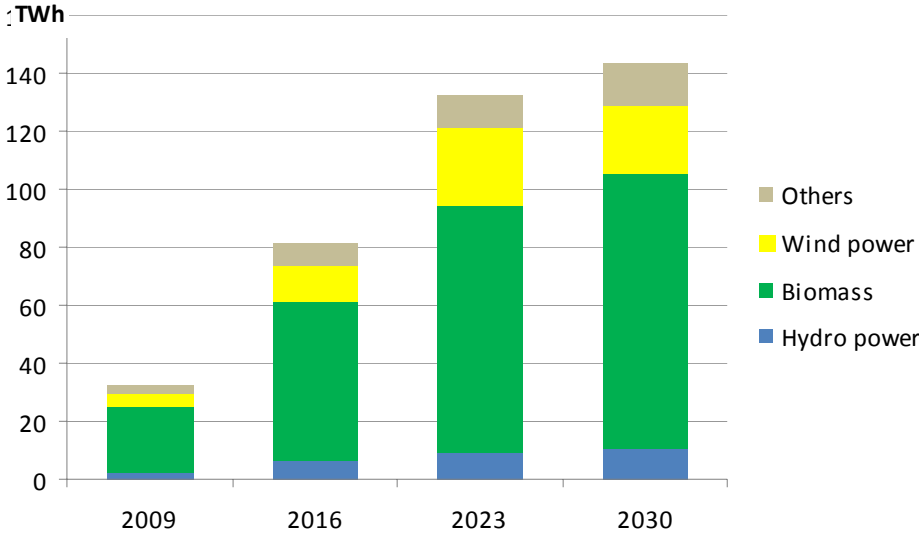


Figure 9 Increase of renewable energy in the Nordic countries relative to 2005, when the EU target for increased use of renewable energy is applied (also keeping current emission-rights trade and national policy instruments)

In sum, the EU target for increased use of renewable energy clearly increases the amount of renewables used in the Nordic countries. By 2023, the increase in use is doubled compared to the case with today’s policy instruments (without the renewability goal). Still, it is worth noting the strength in today’s instruments – which, without being strengthened, increase the use of renewable energy in the Nordic countries by more than 60 TWh between 2005 and 2023.

Renewable energy, country by country

How does the use of renewable energy develop in each of the Nordic countries? Figure 10 shows for each country, and sector by sector, where the calculated increase in the use of re-

newable energy can be found in the year 2020, for the case with the renewable target (the green package case). As can be seen, the differences are relatively great between the countries. These differences are to a large extent attributable to the countries' dissimilar energy systems. For example, district heating in Norway is assumed to play a minor role also in the future. The only result that can clearly be considered as common for all the countries, is the significant expansion of wind power.

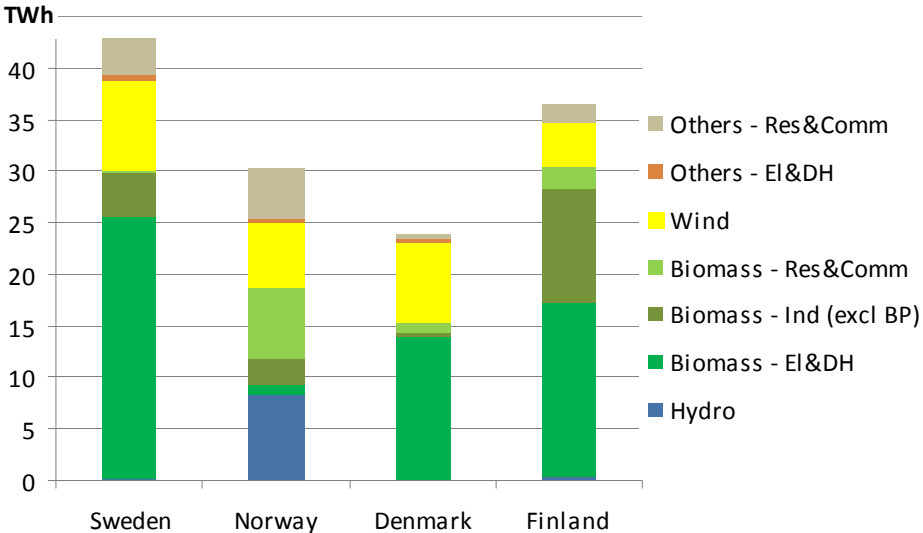


Figure 10 Increase of renewable energy in the Nordic countries from 2005 to 2020, assuming the EU's increased renewable target

Calculated in TWh, however, biomass is the renewable type of energy that increases the most (compared with 2005), both in the industry of Finland and Sweden and, especially, in the electricity and district heating sector of Sweden, Denmark and Finland. A certain share of the increase in industrial use of biomass is related to the assumed (modest) increase in economic activity in the pulp and paper industry. The increase of heat production from heat pumps (most of "Others" in the above figure) is also large, mainly in Norway and Sweden, but in Finland as well. The heat pumps are to a great extent used for phasing out electrical heating for reasons of "renewability".

6.3 All three EU 20 % targets

What, then, happens when the EU's 20 % goal for increased use of renewable energy is combined with the EU's other 20 % goals, i.e. the extended green package scenario? Here we analyze how the use of renewable energy is influenced by the effectivization goal (-20 % energy use) and the greenhouse gas goal⁹ (-20 %). First, something will be said about how we have expressed these goals in the model calculations.

The goal of decreased energy use focuses on a decrease of primary energy. Since our model contains no savings measures in the final use stage (e.g. increased insulation or more efficient appliances), we have – based on data about savings potentials etc. – assumed that approxi-

⁹ In our analysis we study only reduction of carbon dioxide emissions, which we have assumed are to be decreased by 20 %. As described above we have not applied a Nordic cap for the emissions, but instead we have chosen an EUA price that we assume leads to an EU emission reduction of 20 %.

mately 8-9 % of the goal is fulfilled by a decreased demand for useful energy. Neither does the model contain the transport sector, which we assume takes its part of the energy efficiency goal. The rest of the increased energy efficiency target, 20 % - (8-9 %), is optimized through the MARKAL calculations. The result shows, see figure 11, that around 6-7 % efficiency measures are found as “substitution in the residential and commercial sector and in industry” (e.g. change from electrical heating to heat pumps in small houses) and 5 % as efficiency measures in “measures in the large-scale energy conversion” (e.g. more electricity produced in cogeneration plants instead of production in condensing plants).

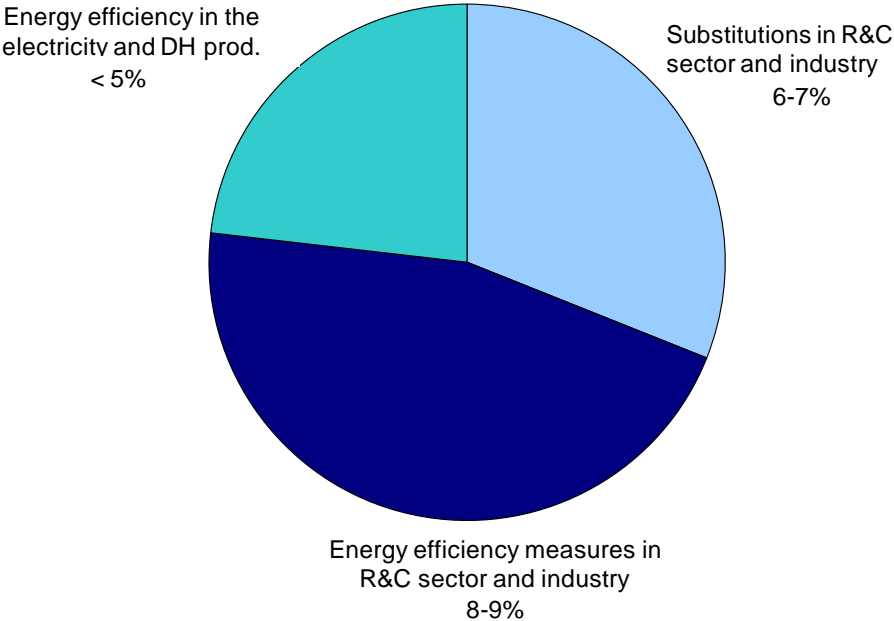


Figure 11 The menu to achieve 20 % improved energy efficiency in the Nordic countries

The goal of carbon dioxide reduction in reality focuses on the total EU level. It is therefore not feasible to directly apply this at the Nordic level. Instead we analyse how the emission of CO₂ is influenced by the other targets. Moreover, today’s climate control instruments, e.g. the emission allowance price and the carbon dioxide tax, are included in the calculation. In many cases the emissions of CO₂ from the stationary energy system decreases by more than 20 %. If, however, the CO₂ reduction is small we make additional “what if” scenarios where we apply a Nordic ceiling for the total carbon dioxide emissions that lies 20 % lower than the 1990 level. This has only been necessary in scenarios where the stationary energy system carries parts of the targets of the transport sector.

All three 20 % goals are assumed to remain in principle at this level also during the period after 2020, i.e. no major additional strengthening of the targets is assumed during the studied period.

When the three 20 % goals are applied simultaneously (the extended green package scenario), we obtain a result for the use of renewable energy according to Figure 12. The decreased general energy use is clearly evident also in the use of renewable energy. Another consequence is strong stimulation in the use of heat pumps. This is because the waste heat which is utilized in the pumps’ heat production is not included in the energy amount that is to be reduced. The

quantity of biomass decreases instead, partly due to the design of the effectiveness goal. For example, expansion of certain biomass boilers may be omitted because heat pumps and even natural-gas boilers with higher efficiency are chosen instead. (The target for improved energy efficiency makes no distinction as to whether fossil fuels or renewables are reduced.) The use of biomass also decreases due to a lower demand of district heating (and thereby less production of district heating, which consists largely of biofuel-based production). The use of wind power, too, decreases when the effectiveness goal is applied, due in large degree to less use of electricity. (It decreases compared to the development in green package scenario, not compared to the present level.)

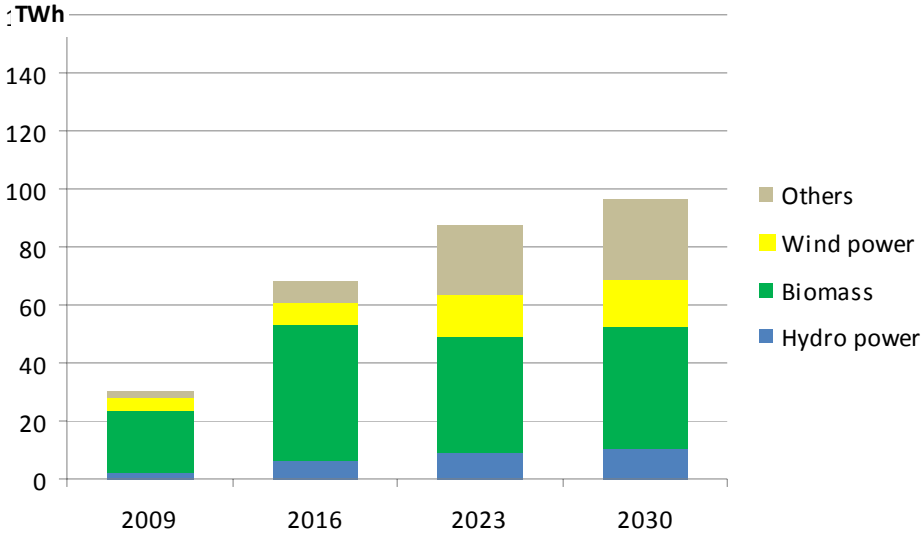


Figure 12 Increase of renewable energy in the Nordic countries relative to 2005, when the EU goals of renewability, greenhouse gas reduction, and effectiveness are applied simultaneously (also keeping current emission-rights trade and national policy instruments)

One may also conclude that especially the extended green package scenario, but also the green package scenario, implies that CO₂ emissions from the Nordic stationary energy system are reduced by significantly more than 20 percent relative emissions in 2005, see figure 13. Thus, the result of applying the EU targets for renewables and energy efficiency to the stationary energy system of the Nordic countries lead to an outcome where emissions from that system are reduced significantly more than the overall percentage target of the EU. Thus, given that 20 percent reduction is somewhat of a target level also for the Nordic countries as a whole, this enables a burden redistribution from the transport sector to the stationary energy sector (more on this in subsequent chapters).

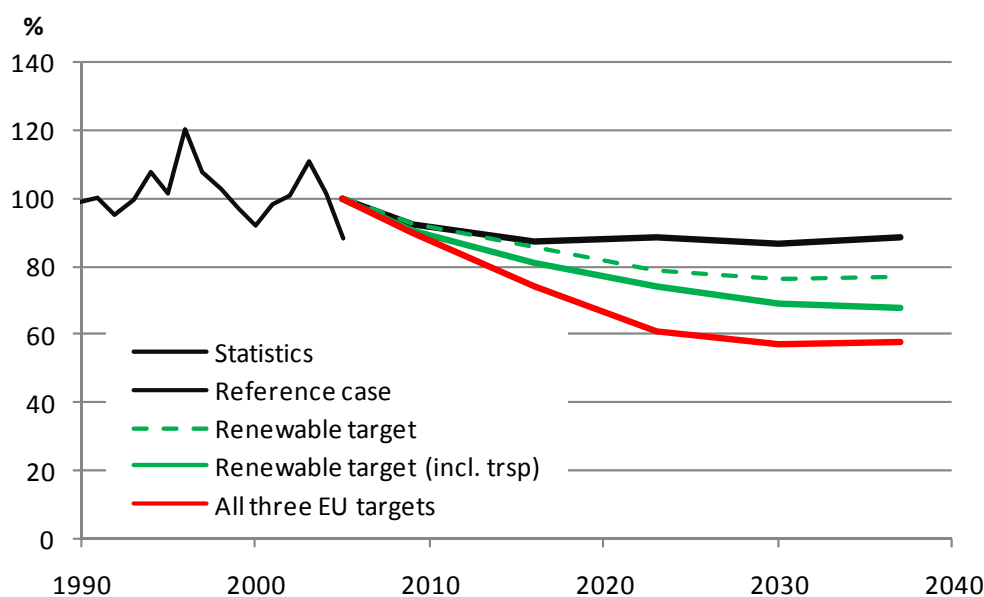


Figure 13 CO_2 emissions from the Nordic stationary energy system in different scenarios

In the extended green package scenario, the total use of renewable energy in the Nordic countries becomes clearly greater than in the reference case where only today's policy instruments are exploited. However, the use of renewable energy becomes noticeably less than when only the renewability goal (together with today's instruments) is applied, i.e. the green package scenario. It is mainly the use of biomass that decreases when the energy effectiveness goal is added to the renewability goal. The use of biofuel becomes however larger than in the calculation cases with today's instruments (the reference case).

6.4 Total use of renewable energy in the different cases

In the sections above we have primarily discussed the increased use of renewable energy in the different scenarios. In order to get an impression of the calculated future total use of renewable energy in the Nordic countries we present in figure 14 the use of different types of renewable energy for the model year 2023. The figure shows the three calculated cases, together with the present situation, 2005.

The figure shows that renewable energy already plays an important role in the Nordic stationary energy system. This means that the increases in the use of renewable energy discussed in chapters 6.1 – 6.3 relates to a starting point with a large amount of renewable energy.

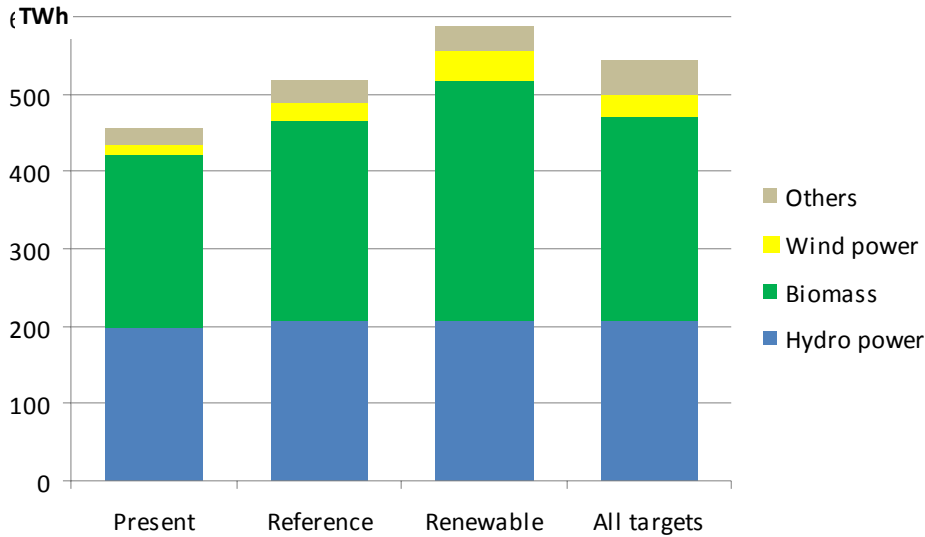


Figure 14 Total use of renewable energy in the Nordic stationary energy system for three different cases in the model year 2023, compared to the present situation

7. District heating

Since many of the effects examined in the above analysis are found in the area of district heating, we analyse below the difference between the calculated district heating production with today's policy instruments (the reference case) and that with the EU's three 20 % goals (the extended green package scenario). Figure 15 shows the calculation results for the development of district heating production in Sweden in the case with today's policy instruments (without the three new EU goals).

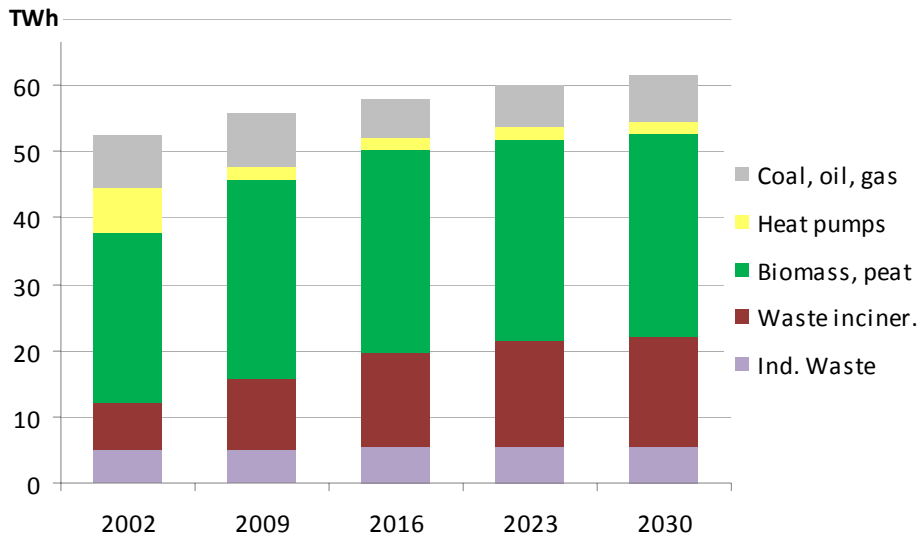


Figure 15 Total district heating production in Sweden in the reference case (without any new goals from the EU, but keeping current emission-rights trade and national policy instruments)

The figure indicates continued moderate growth in district heating deliveries. District heating to new buildings, and conversion to district heating, are thus clearly larger than the decrease

of district heating deliveries due to reduced specific heating needs among present customers. The production mix implies that heat production based on waste and biomass increases, while the use of fossil energy sources and electricity-driven heat pumps is somewhat decreased.

If we add all three of the EU's 20% goals to today's policy instruments, the development of district heating production becomes partly different, as shown by Figure 16. The target for improved energy efficiency leads to intensified energy savings, with a considerably slower growth in the use of district heating, which stagnates or even slightly decreases after 2023. At the same time, the three 20% goals entail a decrease in the competitiveness of district heating production based on fossil energy sources. Waste incineration maintains its competitiveness, largely thanks to the bans on deposition and growing quantities of municipal waste. Nevertheless, the effectivization and renewability goals' definitions have the effect that heat pumps increase their competitiveness and regain their share of the production mix after a short decline. For biomass, all this means that after a rapid expansion until some years after 2010 (largely driven by the electricity-certificate system) the use of biomass for district heating production decreases slightly. This suggests that some of the biomass based district heating plants which are now being built rapidly may, in the long run, face decreasing utilization times.

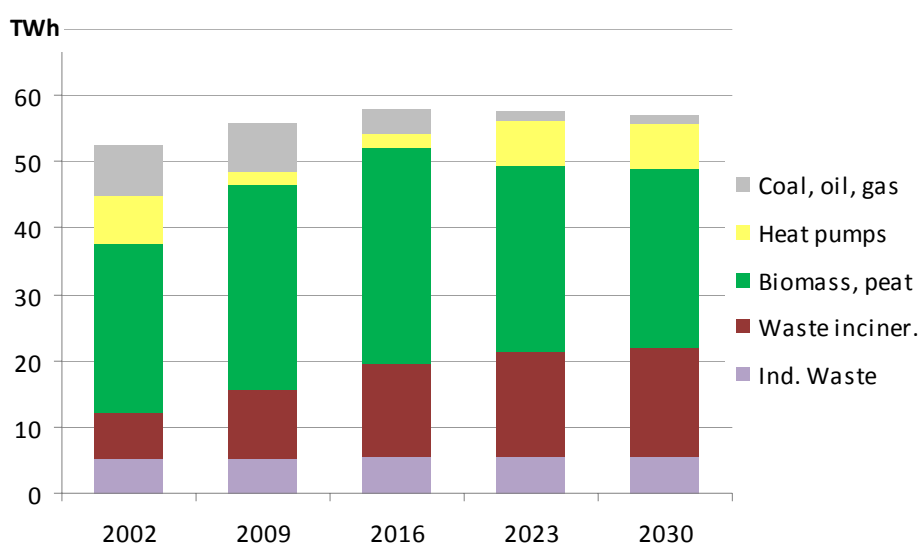


Figure 16 Total district heating production in Sweden in the extended green package scenario, i.e. the EU goals of renewability, greenhouse gas reduction, and energy effectivization are applied simultaneously (also keeping the current emission trading system (EU ETS) and national policy instruments)

8. The connection between the development in the transport sector and the stationary energy system

This chapter is still in Swedish. In later version of the paper the text will be developed further and translated

Vi har analyserat transportsektorns utveckling separat, i tre scenarier (sc. 1, 2, 3). Denna analys beskrivs i appendix 2. I detta avsnitt integrerar vi analyserna för transporter och energi.

Tillvägagångssätt:

- MARKAL omfattar det stationära energisystemet och inte transportsektorn.
- Transportsektorns utveckling ges i tre scenarier (sc. 1-3 i appendix 2). För vart och ett av scenarierna beräknar vi hur mycket av de tre 20 %-målen som transportsektorn inte för-
mår att uppfylla (av sin andel). Detta belastar vi den stationära sektorn med i MARKAL. Låt oss kalla detta en ”indirekt” påverkan på den stationära sektorn från transportsektorn.
- Vi inkluderar också i MARKAL det som direkt påverkar energisystemet, t.ex. en ökad elanvändning när elfordon införs.
- Vi kör sedan MARKAL, med randvillkoren att EU-målen skall nås.
- Det MARKAL-scenario vi utnyttjat flitigast heter ”EU:s gröna paket” (som omfattar CO₂-målet och förnybarmålet), och vi startar med att analysera det förnybara målet.
- Det som är resultat i denna PM är den påverkan transportsektorn har på det stationära energisystemet, direkt + indirekt.

Nedan visar vi CO₂-utsläppen i de tre transportscenarier vi analyserat. I samtliga är inkluderat minst 10 % biodrivmedel (2020) och en hel del ”effektiviseringsåtgärder”. I scenario 2 är också inkluderat en elbilsintroduktion (i hela Norden) i proportion till Elforsks/IVAs vision (som är 600.000 fordon i Sverige till 2020). I scenario 3 är denna elbilsvision ökad med 50 % (mot-
svarande 900.000 fordon i Sverige). I scenario 3 når transportsektorn en 20 %-ig CO₂-
reduktion räknat från 1990.

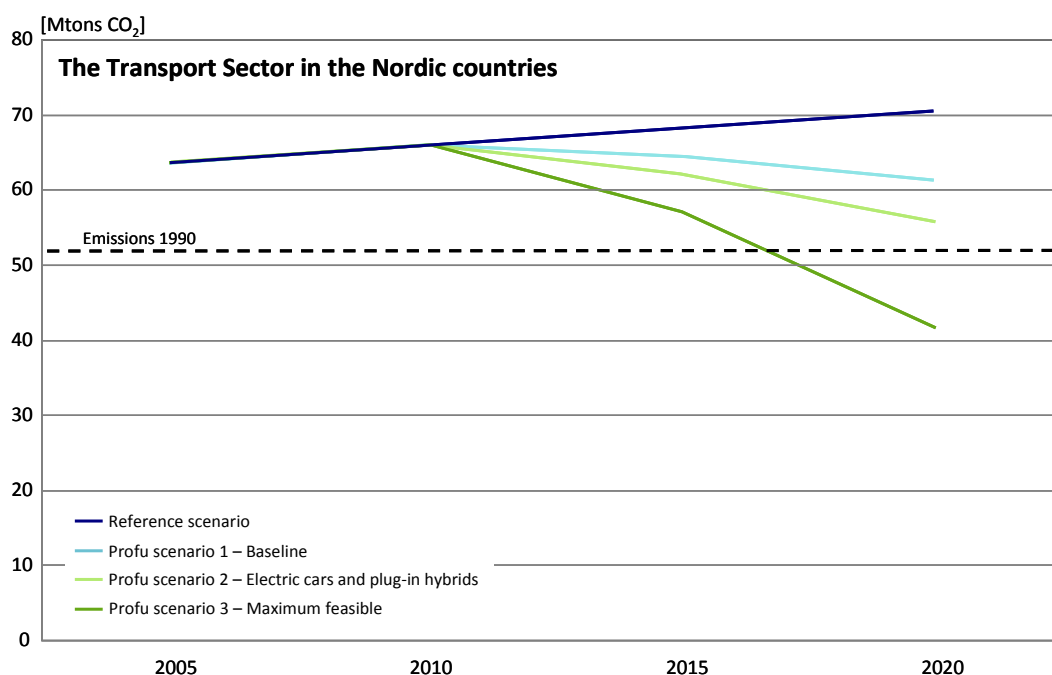


Figure 17 CO₂ emissions from the transport sector in the Nordic countries in Profu scenario 1, 2 and 3 compared to emissions 1990 and emissions in the reference scenario.

8.1 Resultat för EU:s gröna paket och transportsenario 2

Nedan redovisas resultat och slutsatser från analyserna medkombinationen:

- MARKAL-scenariot ”EU:s gröna paket” – för det stationära energisystemet
- och transportsenariot 2 (som innehåller relativt långtgående åtgärder i hela transportsektorn, inklusive en mycket stor elbilsintroduktion i Norden).

Generell slutsats

Stationära sektorn i Norden kan, med en måttlig ”ansträngning”, klara av också den del av transportsektorns CO₂- och förnybarmål, som transportsektorn inte klarar själv i transportsscenario 2.

Förnybarmålet

Vi analyserar först hur förnybarmålet nås, och utgår först från transportsscenario 1. I biodrivmedelsdirektivet anges ett 10 %-igt biodrivmedelsmål för transportsektorn, vilket är inkluderat både i transportsscenario 1 och 2.

Transportsscenario 1

I vårt transportsscenario 1 har vi antagit att detta 10 %-mål uppfylls, men ingen ytterligare förnybar energi används i sektorn. Det innebär att man i transportsektorn når hälften av den 20 %-iga nivån för förnybart som EU formulerat för all energianvändning inom unionen. Återstår 10 %, vilket motsvarar cirka 30 TWh (för år 2020). Detta ansvar tas av den stationära sektorn.

I alla analyser för den stationära sektorn ovan (avsnitt 1-7) har vi låtit den stationära sektorn ta ansvaret för dessa 30 TWh (genom att öka förnybarmålet i MARKAL för energisektorn från 510 TWh till 540 TWh). Det är dock intressant att här analysera hur dessa 30 TWh omsätts i det stationära energisystemet. MARKAL visar att ungefär 45 % av ”ansvaret” hamnar på elmarknaden och 55% på värmemarknaden och att vindkraft och biomassa ökar i enligt figuren.

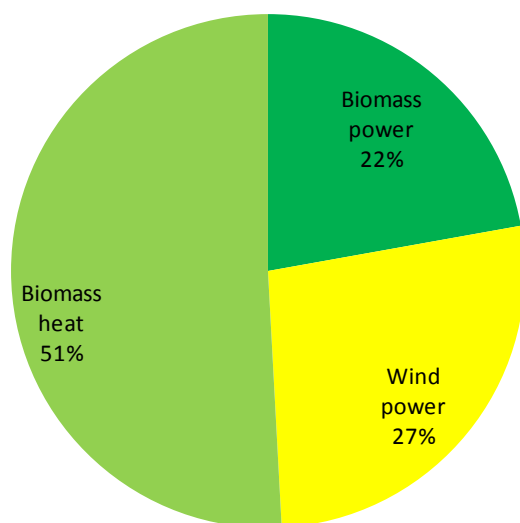


Figure 18 The distribution of additional renewable energy in the stationary sector when parts of the transport sector's responsibility for the renewable target is transferred (only 10 % bio-fuel)

Transportsscenario 2

Ovan har vi utgått från transportsscenario 1. Om vi istället använder transportsscenario 2, med en elbilssatsning, täcks en del av det förnybaransvar som stationära sektorn tar, genom att förnybar el till elbilar räknas frikostigt i direktivet (räknas 2,5 gånger). Det gör att cirka 5 TWh av de 30 TWh:na, täcks av denna ”extra tilldelning till elbilar”. Samtidigt ökar dock elefterfrågan med 3-3,5 TWh år 2020, vilket belastar energisektorn. Motsvarande bild som ovan ser nu ut som följer (obs elbilarnas ”extra” förnybar-el är inritad i figuren separat):

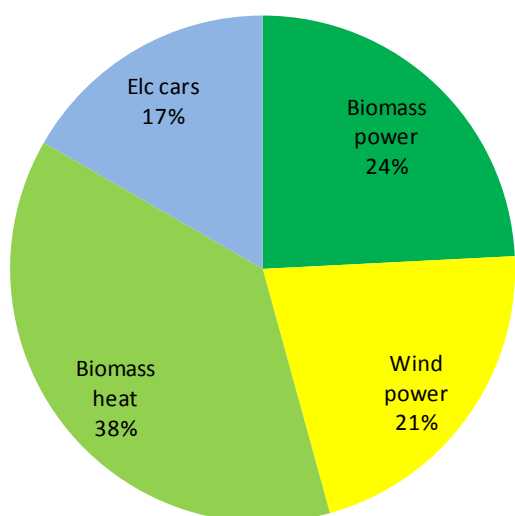


Figure 19 The distribution of additional renewable energy in the stationary sector when parts of the transport sector's responsibility for the renewable target is transferred (10 % biofuel + electric cars)

Skillnaden mellan denna figur och den ovan förklaras alltså av:

- El till elbilar ges en extra tilldelning i förnybara direktivet.
- Att elbilselen tar en del av "kakan" leder till en viss omfördelning av de "åtgärder" som MARKAL väljer för att uppfylla direktivets mål, men balansen mellan åtgärder på el- och värmemarknaden bibehålls ungefär oförändrat.

Elen till elbilarna

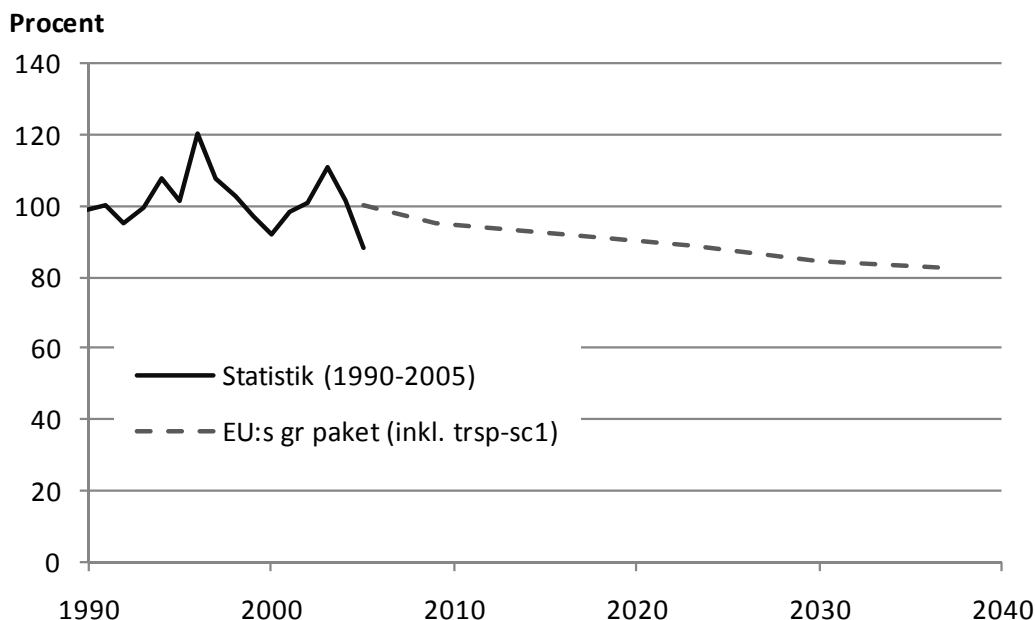
I MARKAL-analyserna klarar det nordiska elsystemet av att möta den ökade elanvändning som elbilarna leder till, genom att minska elexporten (som annars vuxit, eftersom utbudet av nordisk el på den nordeuropeiska elmarknaden ökat till följd av förnybarmålet - och lett till konkurrenskraftigare nordisk el). Enligt MARKAL krävs alltså ingen extra elproduktion i Norden för elbilarna, men exporten minskas.

(I ett marginales-resonemang är då elen till de nordiska elbilarna, lika med marginalproduktionen i det nordeuropeiska elsystemet, vilken till relativt stor del är fossilbränsle-kondensel. CO₂-utsläppen för denna el skall dock ses i det vidgade EU-resonemang vi för nedan, som utgår från ett gemensamt åtagande inom EU, med målet att reducera utsläppen med 20 % till 2020.)

CO₂-målet

Vi för i detta avsnitt ett principiellt resonemang om "ansvaret" för Nordens koldioxidreduktion mellan transportsektorn och den stationära sektorn. Syftet är endast att försöka förstå de mekanismer som påverkas, när vi går från sektorsansvar till ansvaret för helheten. Diagrammen nedan med de "justerade" nivåerna på koldioxidutsläpp i stationära sektorn, skall därför endast ses som underlag för detta principiella resonemang. Korrekta utsläppsdiagram för de samlade utsläppen från transportsektorn och stationära sektorn ges i avsnitt 9 nedan.

I transportscenariot 1 bryts den nuvarande stadiga ökningen av CO₂-utsläppen, se figur 20 ovan, och utsläppen år 2020 hamnar ungefär på 2005 års nivå. Det är dock långt ner till en 20 %-ig reduktion räknat från 1990, som är EU:s mål¹⁰. I absoluta tal cirka 20 Mton för Norden som helhet. Gör vi räkneexemplet att addera denna mängd CO₂ till den stationära sektorns utsläppsansvar, får vi en utveckling enligt nedanstående schematiska bild. Vi kan då konstatera att målet om 20 % CO₂-reduktion till 2020 inte nås.



Figur 20 CO₂-utsläppen i stationära sektorn plus den CO₂-del som transportsektorn inte tar

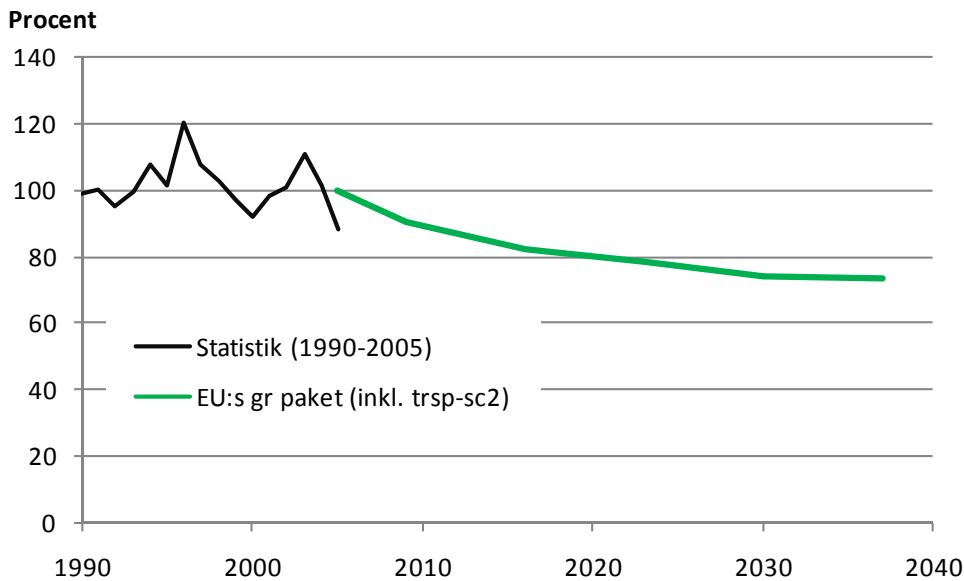
Transportsektorns CO₂-mål ur ett EU-perspektiv

Låt oss anta att transportscenariot 1 är representativt för hela EU (jämförelser med resultat från Pathways-projektet indikerar det; se appendix 2). Då måste alltså den stationära energisektorn i EU ta en del av transportsektorns CO₂-ansvar. Det ger en extra ansträngning för den stationära sektorn. I vår nordiska MARKAL-modell kan vi illustrera detta med en höjning av CO₂-priset.

Transportscenariot 2

Vi har då utnyttjat den MARKAL-körning vi ovan gjorde, kopplad till transportscenariot 2 (med elfordon) och höjt CO₂-priset med 10-15 Euro/ton. CO₂-utsläppen (från stationära energisystemet plus de 20 Mton som vi "fört över ansvaret för" från transportsektorn) reduceras då och målet om 20 % reduktion nås. Det illustreras i figuren nedan.

¹⁰ Vi har i MARKAL hanterat handlande och icke-handlande sektorerna gemensamt. I analyser i andra delar av NEP gör vi dock en noggrann genomgång av betydelsen av den handlande och icke-handlande sektorn.



Figur 21 CO₂-utsläppen i stationära sektorn plus den CO₂-del som transportsektorn inte tar själv. Anpassningar inom den stationära sektorn har gjorts för att klara utsläppsmålet.

Man kan sammanfatta slutsatsen om CO₂-reduktionen så här:

- Den ökade användningen av biobränslen och vindkraft (som vi får när delar av transportsektorns förnybaransvar måste tas av stationära sektorn) ger en viss CO₂-reduktion, men den räcker inte för att nå ner till målet: 20 % CO₂-reduktion.
- För att nå ner till 20 % CO₂-reduktion krävs ytterligare ”ansträngning” för stationära sektorn (se figur nedan, som visar att MARKAL reducerar CO₂-utsläppen i stationära sektorn plus den CO₂-del som transportsektorn inte tar själv. 20 %-målet nås 2020.) Om man vill ”mäta” denna ökade ansträngning i ”X Euro/ton CO₂-prisökning”, visar MARKAL att den är i storleksordningen 10-15 Euro/ton år 2020. (Det är främst modellåret kring 2020 som är kritiskt i vår analys för Norden.)

Ökad elexport (och ökad elproduktion)

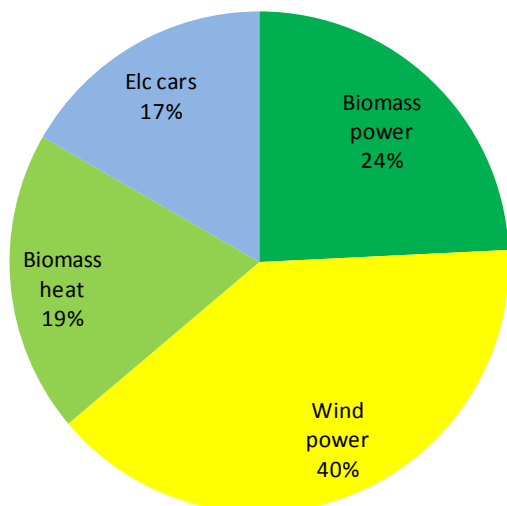
Att CO₂-priset ökas när stationära sektorn får ta en del av transportsektorns CO₂-ansvar leder också till en ökad konkurrenskraft för nordisk el. (Detta visar också analyserna med NEP:s kraftmarknadsmodeller, se NEP-rapport ”Reference and policy scenarios”.)

Den nordiska elproduktionen och elexporten ökar med upp till 15 TWh (för modellår 2030) när CO₂-priset ökas 10-15 Euro/ton, enligt MARKAL-modellens resultat.

Förnybarmålet igen

Den ökade drivkraften för ökad elproduktion, som orsakas av det högre CO₂-priset, påverkar också fördelningen av ansvaret mellan el- och värmemarknaden för att uppfylla det förnybara åtagandet. Elmarknaden tar en större del.

Figur 22 nedan illustrerar detta väl (att jämföra med figur 19 ovan).



Figur 22 The distribution of additional renewable energy in the stationary sector when parts of the transport sector's responsibility for the renewable and CO₂ reduction targets are transferred (10 % biofuel + electric cars)

Elen till elbilarna

Liksom i fallet ovan är elen till elbilarna marginaelen på den nordiska elmarknaden. (Angående påverkan på CO₂-utsläppen, se resonemanget ovan.)

9. Total CO₂ emissions in the Nordic transport and stationary energy sectors

In this chapter we present the total CO₂ emissions from both the stationary energy system and from the transport sector in the different calculated scenarios. In the reference scenario, see figure 23, the total emissions remain more or less on the same level as 1990. Although emissions from the stationary energy sector decrease, the increased emissions from the transport sector, in principal, balances this.

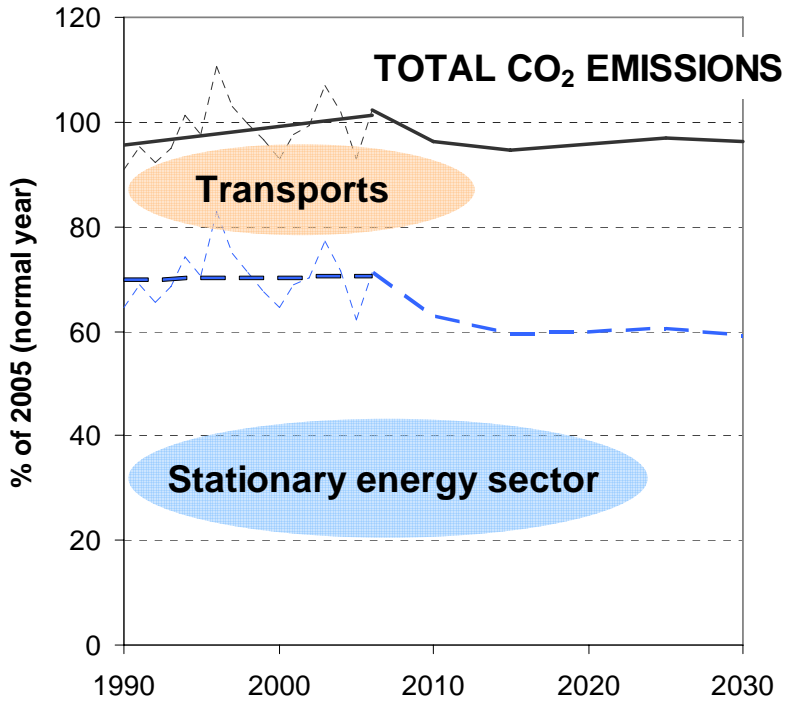


Figure 23 Total Nordic CO₂ emissions in the reference scenario

When the renewable target is added, the green package scenario, the total emissions decrease, see figure 24.

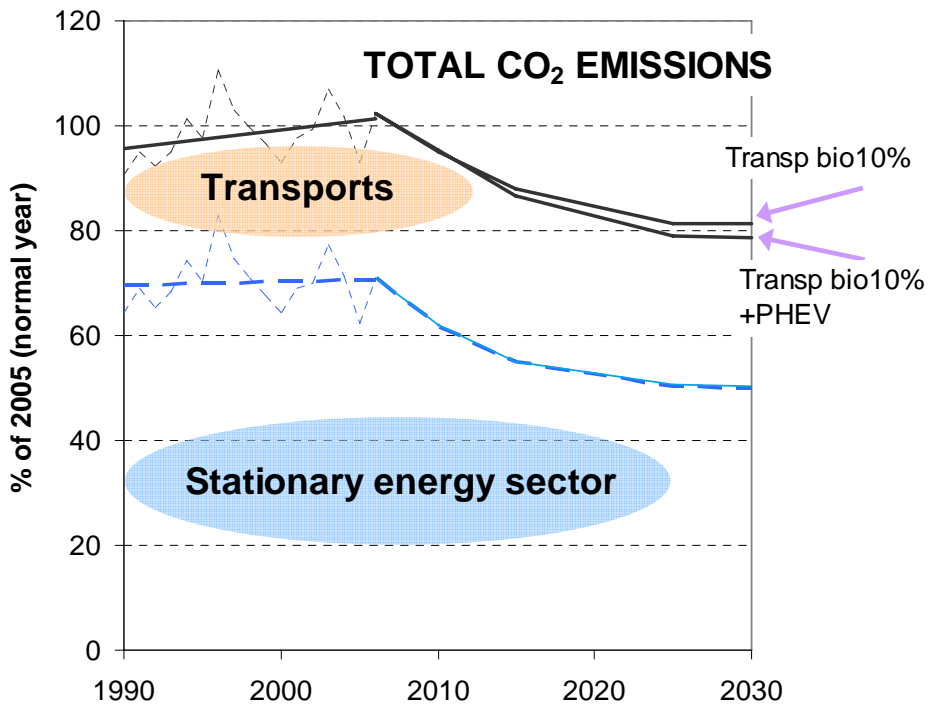


Figure 24 Total Nordic CO₂ emissions in the green package scenario

Here the emissions from the stationary energy sector decreases considerably more than in the reference scenario, due to increased use of renewables. At the same time the emissions from the transport sector increases at a slower rate due to the 10 % renewable transport fuel target. If plug in electric vehicles (PHEV) are added the transport emissions will be even smaller.

An even more drastic decrease in CO₂ emissions can be found in the extended green package scenario, where improved energy efficiency contributes considerably to the emission reduction, see figure 25. Here the total Nordic CO₂ emissions decrease by 35 % to the year 2030, compared to the present situation.

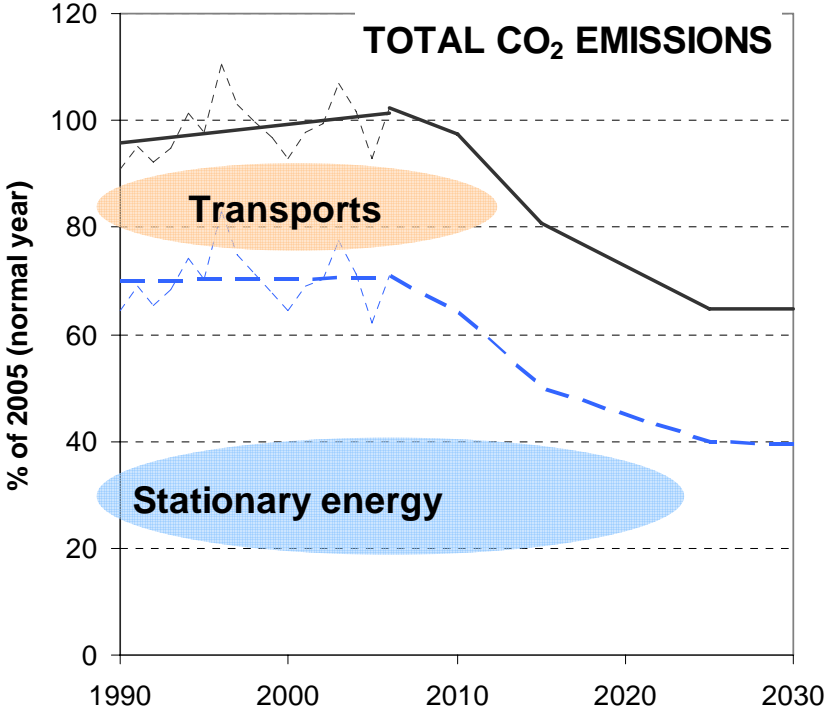


Figure 25 Total Nordic CO₂ emissions in the extended green package scenario

Appendix 1 Model-implementation of the three EU policy targets

The appendix is not included in this version of the report. It is presented in a separate document.

Appendix 2 CO₂ emissions from the transport sector in the Nordic countries

The appendix is not included in this version of the report. It is presented in a separate document.