This Chapter is still a draft version. Minor changes will be introduced in the final version

Appendix 1 Model-implementation of the three EU policy targets

This chapter briefly describes the model implementation of the analyzed EU targets relating to the 20-20-20 goals. For additional input assumptions we refer to the NEP report "Policy scenarios" (2009). [X]

The model – A very brief description

The MARKAL-NORDIC model includes a highly detailed description of the stationary energy systems of the four Nordic countries Sweden, Norway, Denmark and Finland. The stationary energy system includes supply and use of electricity and district heating, and other energy use in industry and the residential and commercial areas. Transports are not included in the model. Furthermore, a somewhat simplified description of the electricity-production systems in Germany and Poland are included. Thus, electricity trade both between the Nordic countries themselves and between the Nordic countries and Germany and Poland is modelled. The objective of the model is to meet demand for energy at the lowest cost possible given a very large number of constraints concerning e.g. policy issues, energy markets and technological development. Demand can be met through existing technology stock and/or through new investments choosing from a basket of a large variety of technologies. The time horizon of the model stretches from today and 2050.

An extended description of the model may be found in the NEP report "Policy scenarios" [X] (in that report the option to include Germany and Poland was, however, ruled out).

The scenarios

In this model analysis, three main scenarios have been investigated. Within each scenario, selected sensitivity analyses have also been carried out but are only to a limited extent addressed in this report. Instead, they have mainly been as a qualitative input when assessing the main scenarios. The three scenarios differ from each other in terms of to what extent the EU energy and climate package is included. The scenarios are summarized in Table 1. The model implementation of each of the three EU targets, i.e targets for CO_2 emissions, renewables and energy efficiency, is explained in the following sections. Furthermore, the main scenarios have also been adapted to reflect the impact of the transport sector. The MARKAL-NORDIC model only includes the stationary energy system of the four Nordic countries used. Hence, to reflect the impact of transports we have made a specific analysis of that sector in parallel with the use of the model. The methodology for that is explained in [X].

Table 1 Scenario description

Scenario	**“CO_2-target”**	**Renewable target**	**Energy-efficiency target**
Reference	25 EUR/t	Not included	Not included
Green Package	25 EUR/t	Included	Not included
Extended Green Package	25 EUR/t	Included	Included

In all the main scenarios, the most important of the existing policy instruments in the Nordic countries are included. This includes energy and CO_2 taxes, the EU ETS and selected support schemes such as the Swedish electricity-certificate scheme.

The CO_2-reduction target

The EU climate target implies that GHG emissions will be reduced by 20 percent by 2020 based on the emissions in 1990. Furthermore, Member-State targets for reducing CO_2 emissions have been defined for the sectors outside the EU ETS as a percentage to be achieved by 2020 based on emissions in 2005, while all sectors included in the EU ETS are to reduce their emissions collectively by 21 percent based on emissions in 2005.[1]

The non-EU member Norway is included in the EU ETS through the EEA (European Economic Area) agreement.

In this model analysis, the European CO_2-reduction target affects the Nordic countries through an EUA price of around 25 EUR/t throughout the modelling period. This assumption reflects the average EUA price between the policy scenarios that are assessed in the NEP report “NEP policy scenarios”[X]. Thus, we have NOT specifically set a reduction target for the Nordic countries but, instead, introduced an extra cost on CO_2 emissions (the EUA price) which, in turn, is what we assumed to be the result of the EU ambition to reduce its emission by 20 percent y 2020.

[1] Commission of the European Communities (2008), “Proposal for a Decision of the European Parliament and of the Council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community’s greenhouse gas emission reduction commitments up to 2020”, COM (2008) xxx final, January 2008.

The model distinguishes between the ETS sector and the non-ETS sector only in the case of Sweden. This means that the EUA price also affects the non-ETS sectors of the three countries Finland, Denmark and Norway. Thus, a driving force to reduce emissions in the non-ETS sectors of these three countries is guranteed in excess of what is achieved through existing taxes and so on, which also is included. However, this simplification means that the non-ETS sector in Sweden is subject to less "CO_2-reducing" pressure than the corresponding sectors of the other three countries, everything else being equal. On the other hand, existing CO_2 and energy taxes are significantly higher in Sweden than in the other countries. Hence, in the end the non-ETS sector in Sweden is still likely to face larger carbon costs than the non-ETS sectors in the other countries in the current model formulation.[2]

The included electricity-supply sectors in Germany and Poland are also affected by the assumed EUA price in the model calculations.

The renewable target

The EU renewable target stipulates that the share of renewables in the Union has to be 20 percent of total final energy use by 2020.[3] This includes all sectors and a large variety of renewable options.

For the Nordic countries belonging to the EU, country-specific targets have been defined by the Commission. In the present analysis, we have assumed that a corresponding target for Norway equals the average of Finland, Sweden and Denmark. Thus, the target for the Nordic countries as a whole equals, as a percentage, the weighted average of the targets of Sweden, Denmark and Finland (see Table 2).

In this analysis we have chosen to define the target as a supply target in TWh in 2020 for the Nordic countries as a whole. Thus, we do not assess country-specific targets nor do we assess a target expressed as a percentage. Following the outline in Table 2, this means that the target corresponds to 540 TWh of final energy in 2020 in the stationary sector given the fact that transports manage to meet the biofuel Directive. Thereby, the share of renewables in the whole energy system equals 47 percent given the energy-demand projections that we assume here.

[2] Model runs for the reference case indicate that CO_2 emissions in the residential and commercial areas in Sweden are reduced by at least 50% by 2020 compared to the base year 2005. This is by far more than the EU Directive's 17 % (which, however, also includes transports and the non-ETS part of the industry).

[3] Commission of the European Communities (2008), "Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources", January 2008.

Table 2 The assumed transformation of the EU Directive into an all-Nordic target for renewables

	Swe		Nor		Den		Fin		Nordic	
	2005	**2020**	**2005**	**2020**	**2005**	**2020**	**2005**	**2020**	**2005**	**2020**
Gross final energy consumption (TWh)[1)]	409	446	227	248	189	207	302	329	1127	1231
Renewables' share (%)[2)]	40	49	56	66	17	30	29	38	37	47
⇒ Renewables (TWh)	164	219	127	164	32	62	88	125	411	570
Final energy consumption in transports (TWh)[3)]	101	110	57	63	61	69	56	60	275	302
Renwables' share in transport (%)[4)]	~0	10	~0	10	~0	10	~0	10	~0	10
⇒ Renewables in stat. energy sector (TWh)	164	208	127	158	32	55	88	119	**411**	**540**
⇒ Renwables' share in stat. energy sector (%)	53	62	75	85	25	40	36	44	**48**	**58**

[1)] EUROSTAT for 2005. Own assumption on growth based on baseline MARKAL-NORDIC calculations for 2020. Figure also includes assumptions on losses in energy conversion based on EUROSTAT data.
[2)] EUROSTAT data and Directive
[3)] EUROSTAT data for 2005. Own assumption on growth based on trends between 2000 and 2005.
[4)] Under the assumption that the EU Directive on biofuels in transport is reached.

In the model used here, the renewable target involves renewables in electricity and district heating supply, and final use of renewables in industry and the residential and commercial areas. Table 3 shows the renewable alternatives and to what extent they are included in the renewable target in the model (in certain cases, where the information in the text of the Directive has been inadequate, we have made our own assumptions. This applies to e.g. industrial waste heat).

Table 3 Renewables included in the renewable target

	Comments
Biofuels	Both commercial biofuels and biofuels for internal use, e.g. waste liquors are included in the target (but NOT peat)
Wind power	
Hydro power	
Solar power and solar heat	
Industrial waste heat	
Heating pumps	Only the amount of “free energy”, i.e. heat from the heat source (air, ground or sea), is included in the target
Refuse	Only the biodegradable share (60 percent is assumed here) is included in the target
Wave power	

No specific renewable target for the included electricity-supply sectors of Germany and Poland has been introduced in this analysis. Thus, wholesale electricity prices in these countries are affected only to the extent that electricity-trade patterns with the Nordic countries are changed as a consequence of the implementation of the renewable target in the Nordic countries.

The energy-efficiency target

The EU energy-efficiency target states that total primary energy use in the EU in 2020 shall be reduced by 20 percent from an estimated baseline level also in 2020.[4] The baseline itself already contains efficiency measures such as autonomous measures but also measures arising from existing policies. These efficiency measures shall, however, not be included in the 20 percent target according to the proposed Action plan. This leaves, of course, significant room for uncertainties concerning what to include and exclude in the baseline.

In Figure 1 the definition of the energy-efficiency target is shown according to the Action Plan. This is also the foundation on which we have built our analysis. Hitherto, there still remain large uncertainties on the implementation of this target and how to achieve the goal. Therefore, we have been forced to make several own assumptions in order to sufficiently assess the impact of such a European target on the Nordic countries.

[4] Commission of the European Communities 2006, ”Communication from the Commission – Action plan for energy efficiency: Realising the potential”, COM(2006)545 final.

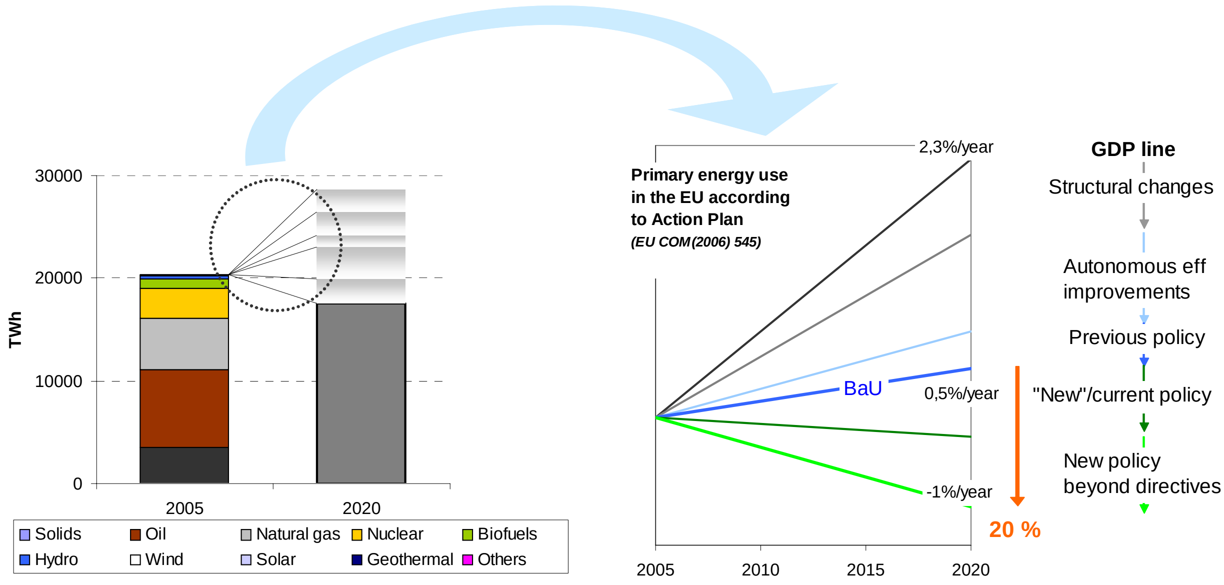

Figure 1 Primary energy use in EU-25 and the definition of the Energy-efficiency target (Source: EUROSTAT and EU COM(2005) 545).

Figure 2 shows the historical development of the total primary energy use in the stationary energy sector of the four Nordic countries together with four different scenarios for the future development. Since overall demand for energy services is expected to slightly increase in the future in our reference case, the total primary energy consumption also increases. However, in our reference case a number of measures are included which are not included in the baseline on which the target level is related (cf. Figure 1, “BaU”). This relates, for instance, to a number of “new” and current policy instruments. Therefore, a scenario without any existing policy measures at all, the “No policy” scenario, was run in the model and used as baseline to which the energy-efficiency target is related. This means that the used baseline somewhat underestimates the contribution from efficiency measures that actually should be included in the baseline according to the definition in Figure 1 On the other hand, the cost-minimizing feature of the model tends to generate energy-efficient solutions, e.g. a certain amount of combined heat and power instead of condensing power, also in the “No policy” scenario. Thus, the “No Policy” scenario tends to overestimate the role of efficiency measures, everything else being equal, when comparing it to the “baseline” definition in Figure 1. Therefore, when weighting it altogether we believe that the “No Policy” scenario is the best and most appropriate “baseline” proxy considering the model approach that has been used here. The primary energy use in the “No Policy” scenario in 2020 has been normalized to 100 percent since this is the starting point to which the target level is related. Thus, the target level is set to 80 percent in 2020 (corresponding to a reduction of 20 percent).

In the “Extended Green package” scenario, *i.e.* including also the energy-efficiency target, we assume that transports take their share of the burden, *i.e.* a reduction in energy use of 20 percent (as for the stationary energy system) in relation to a baseline outcome in 2020.

Since the model only has a limited price-sensitivity and flexibility on the demand side, the model itself is not capable of fully endogenously capture a reduction of 20 percent in primary energy use. Thus, the demand reductions that will be necessary to reach that goal have been exogenously estimated (see NEP report “Widened view of energy efficiency”, March 2009).

The model takes, endogenously, care of efficiency measures at the supply side (e.g. combined heat and power instead of condensing power, wind power instead of fuel-based power generation and fuel conversions at the demand side such as switching to heating pumps or district heating).

In Figure 2 it is shown that the Reference scenario, with existing policy instruments, implies a reduction of total primary energy use by around 6 percent in relation to the baseline outcome in 2020. An additional reduction of around 7 percent is obtained by reducing energy demand according to the exogenously assessed demand-side efficiency measures (cf. “Demand-side efficiency only” scenario in Figure 2). The remaining share, 7 percent units, is managed by the model which, thus, includes efficiency measures at the supply side (including measures in the supply of electricity and district heating as well as in the supply of useful energy at the demand side).

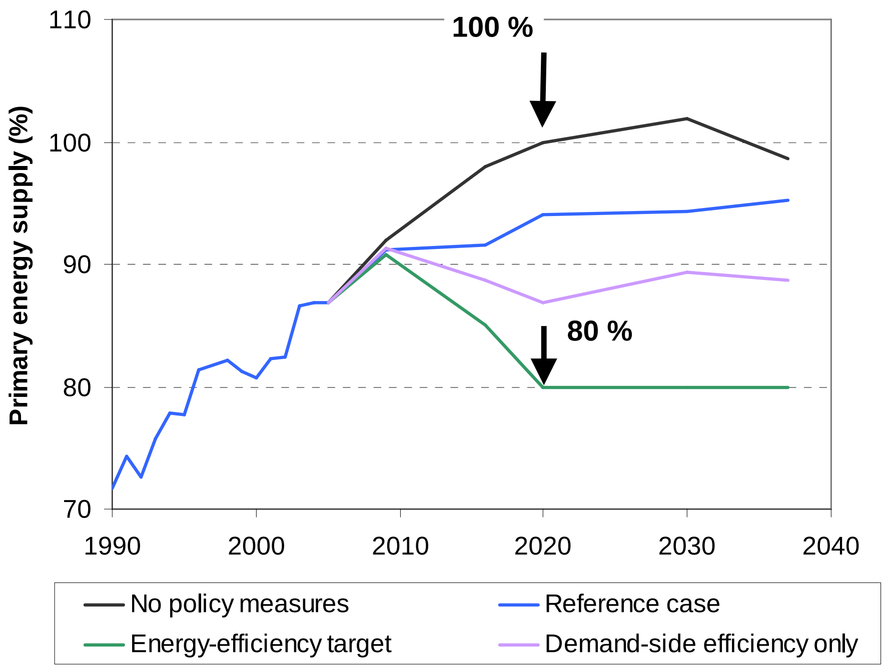

Figure 2 Primary energy use in the four Nordic countries normalized to a model-generated level in 2020 from a “No policy measures” model run (Source: EUROSTAT and MARKAL-NORDIC model runs).

In our analysis, all use of energy is included in the target for primary energy use (PEU) in 2020. For thermal energy conversion this implies that the used amount of fuel is included in the PEU target. The exception concerns nuclear power that has been assigned a primary-energy factor of unity. This means that only the produced volume of electricity is included in the PEU target rather than the actual amount of nuclear fuel being consumed.[5] Furthermore, wind power, solar power, hydro power and industrial waste heat are also assumed to have a primary-energy factor of unity.

[5] If, instead, a primary-energy factor of 3 is assigned to nuclear power (corresponding to the actual amount of nuclear fuel being used), model runs indicate that the premature phasing out of nuclear power would be one cost-efficient solution to reach the PEU target. We believe, however, especially in a European perspective this to be rather unlikely.

In the analysis of the energy-efficiency target, we have assumed that the electricity demand in Germany and Poland is reduced by roughly 10 percent compared to the reference scenario in 2020. Furthermore, since primary energy use in these two countries is not included in the model-description of the energy-efficiency target, electricity trade between the Nordic countries on one hand and Germany and Poland on the other hand, has been set exogenously to a level corresponding to an average between the modelled outcome of the Reference scenario and the “Green Package” scenario (this is the level of trade that we have estimated to be realistic under the given circumstances). If such a boundary for electricity trade would have been omitted, the model would use electricity trade as an unrealistic measure, within the given boundaries for new exchange capacity, to fulfil the energy-efficiency target in the Nordic countries at the lowest cost possible. Furthermore, in order to balance the exogenously specified electricity trade with the Nordic PEU target, it is here assumed that the primary-energy weighting of electricity export *to* the Nordic countries is 2.2 (corresponding to an electric efficiency of 45 percent) and that the primary-energy weighting of electricity export *from* the Nordic countries to Germany and Poland is -2.2. This means that Nordic electricity export relaxes the PEU target while Nordic electricity import tightens the target as it is formulated in the model.

The inclusion of the transport sector

[X] Text will be inserted in the final version