Industrial development and export opportunities for Nordic energy industry

A sub-project to Nordic Energy Perspectives,
with funding from Nordic Energy Research

Task 1:
Sustainable development in the Nordic energy system

Areas in sustainable energy sector where companies in the Nordic countries will have both valuable experience and growth opportunities in the homemarkets

Results from the MARKAL-model
Version 1

May, 2008

Nordic Energy Perspectives

Introduction and summary

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. The Nordic energy systems are the point of departure, seen from a European and a global perspective.

This sub-project to NEP, with funding from Nordic Energy Research, is focused on industrial development and export opportunities for Nordic energy industry. The following tasks will be analysed:

1. Sustainable development in the Nordic countries – impact of different energy carriers and energy conversion alternatives, based on model calculations;
2. Sustainability driven strategies and export opportunities for Nordic energy industries and other companies in the energy field;
3. Quantification of the different export markets for knowledge/products in the field of climate change and sustainable development;
4. Transfer of know-how and technologies and problems related to this – with special focus on bio-energy.

This first report from the project focuses on the first item mentioned above. The most important energy carriers and energy conversion alternatives, from a sustainability perspective, have been identified and quantified by means of model calculations using NEP's comprehensive model toolbox, together with more traditional manual analyses. <u>This is still a work in progress and the results should be viewed as preliminary</u>.

Important areas for business development in the sustainable energy sector

In this report we focus on identifying major technologies and energy markets for the development of the Nordic stationary energy system in a sustainable direction. The following four areas have been identified as the most prominent for such a development:

- **Biomass/bio fuels** (see chapter 1 below)
- **Wind power** (see chapter 1 below)
- **Heat pumps** (see chapter 1 and 2 below)
- **More efficient use of energy - energy conservation measures** (see chapter 2 below)

The importance of these technologies and energy markets originates from the assumption that the creation of successful export industries is highly dependent on stiff competition. Conditions for such a competition to come about include mature markets with declining or changing demand or developing markets with a significant profit potential.

These four areas identified above are examples where companies in the Nordic countries have valuable experience and still will be showing a significant development in the years to come.

It is premature to make conclusions about their inherent potential to foster the creation of successful export industries. A lot of circumstances can have effect on such a development. Just to mention a few; the availability of venture capital, the presence of entrepreneurial and intrapreneurial cultures and efficient use of triple helix platforms. However these findings should be regarded as a starting point for further analyses. It more than anything establishes a foundation for the discussion of the roles of these growth areas in relation to possibilities of creating successful export industries.

In the remaining of this report we will give account of how these four areas have been identified and present major assumptions shaping the results.

Model calculations in this task 1

The model calculations, together with the qualitative analyses, have indicated ways in which we can meet the demands for lower carbon dioxide emissions, and described the consequences for the Nordic energy system. The calculations deal with both the effects of the present policy instruments and the consequences of EU's three 20 % goals for the year 2020:

- at least 20 % renewables in the energy mix
- a reduction of the use of energy by 20 % through more efficient use of energy
- reduction of greenhouse gas emissions by 20 %

The results from the energy systems models (here the MARKAL model) will be one of the inputs in the identification of areas where companies in the Nordic countries will have necessary experience and still offer substantial growth potential in order to function as a base for developing export industries..

In this report we also analyse the magnitude of the identified four areas of sustainable energy (bio fuels, wind, heat pumps and efficiency measures) assuming different policy instruments and comprehensive goals. The results are presented in two chapters:

1. The use of renewable energy in the Nordic countries – results from MARKAL calculations
2. Calculation of the potential for energy savings through more efficient use of energy, results for the Nordic countries, with special focus on Sweden

The first chapter includes information regarding bio fuels, wind power and heat pumps, while the second chapter mainly deals with the potential for more efficient us of energy.

Note:
Our intention is to present all reports in English. Due to lack of time, some of the texts 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 will be available on the project's web site, www.nordicenergyperspectives.org, soon after the Helsinki conference, May 14.

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1. Use of renewable energy in the Nordic countries – a summary of results from MARKAL calculations

In the beginning of 2008 came a directive from the EU Commission with measures and goals for the work of increasing the share of renewable energy in the EU countries' energy mix. At about the same time came a proposed directive with the goal of decreasing emissions of greenhouse gases in the EU by 20 %. Parallel with this is the EU's goal of decreasing the use of energy by 20 %. If these directives are adopted, they will have a clear influence on the development of the energy system in the Nordic countries[1]. In order to analyse the consequences for the Nordic countries' energy system, a series of calculations with the energy model MARKAL-NORDIC has been performed. The analysis concerns the stationary energy sector, i.e. not including the transport sector.

As a point of departure for the analysis, a calculation of the energy system's development with today's policy instruments has been carried out. This does not, therefore, include the goal of renewability. (Examples of policy instruments that today stimulate the use of renewable energy are high taxes on fossil fuels, the emission-rights trade system for carbon dioxide[2], investment and operation support for diverse renewable alternatives, and the Swedish electricity-certificate system.) Figure 1 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 biofuel. Also contributing to the use of biofuel is the assumed expansion of the forest industry in the Nordic countries. Wind and hydro power increase too, but relatively little.

The heading "Other" in the figure covers other energy which is regarded in the Directive as renewable, primarily heat from heat pumps[3], but also industrial waste heat and solar heat.

Thereafter we add the goal of renewability. In the proposed directive about increased use of renewable energy are quantified goals for the share of renewables in each country. The goal is expressed as the share of renewables in the total use of energy. Our point of departure for the analysis is that the transport sector takes its share of the introduction of renewable energy. (For the transport area there is also a parallel separate goal that 10 % of the fuels by 2020 are to consist of biofuels.) For the stationary energy system, the goals (at the energy-use levels we assume) for each country[4] imply that a further amount of just over 120 TWh renewable energy must be added to the stationary energy system in the Nordic countries by 2020. For the period after 2020, the same goal level is maintained in the calculations.

[1] By the Nordic countries we refer to Denmark, Finland, Norway and Sweden.
[2] The emission-rights trade system is illustrated with a CO_2 price corresponding to 20 €/ton within the trading sector.
[3] For heat pumps we make, based on the directive, the following assumption: the heat production of heat pumps is calculated as renewable, i.e. not only the free energy that heat pumps render useful, but also indirectly the electricity that is used as operating energy in heat pumps.
[4] 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.

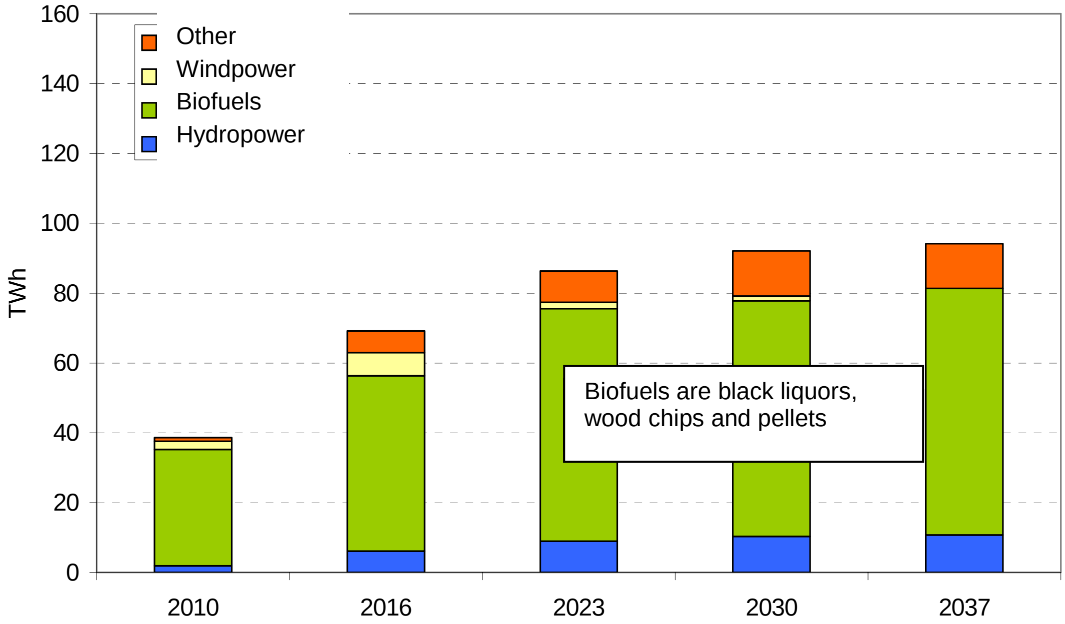


Figure 1: Increase of renewable kinds of energy in the Nordic countries relative to 2005, with no new goals from the EU (but keeping current emission-rights trade and national policy instruments)

The analysis of the effects of the renewability goals 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 effective way in the countries as a whole.

In the calculation case with the renewability goal, 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 EU directive on promotion of renewable energy; see Figure 2. It turns out that the use of renewable energy increases clearly 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 use of biofuel increases somewhat, but not very much. Most of the biofuel is used for heat production in the district heating systems and in industry. Here the size of the heat basis sets limits for how much biofuel heating can be introduced in a profitable manner. Moreover, the biofuel price is described with a "supply stairway", where the biofuel range becomes gradually more expensive as the amount used increases. At the same time, the results show that the use of biofuel is strongly stimulated already with current policy instruments.

A considerably stronger growth due to the renewability goal is obtained for wind power. In the calculation with today's policy instruments, the growth of wind power stops at a few TWh, whereas the renewability goal entails a wind power expansion on the order of 30 TWh in the Nordic countries. Most of this is built already within 10 years. Also other renewable electricity production is expanded somewhat more than in the calculation case with today's policy instruments. 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.

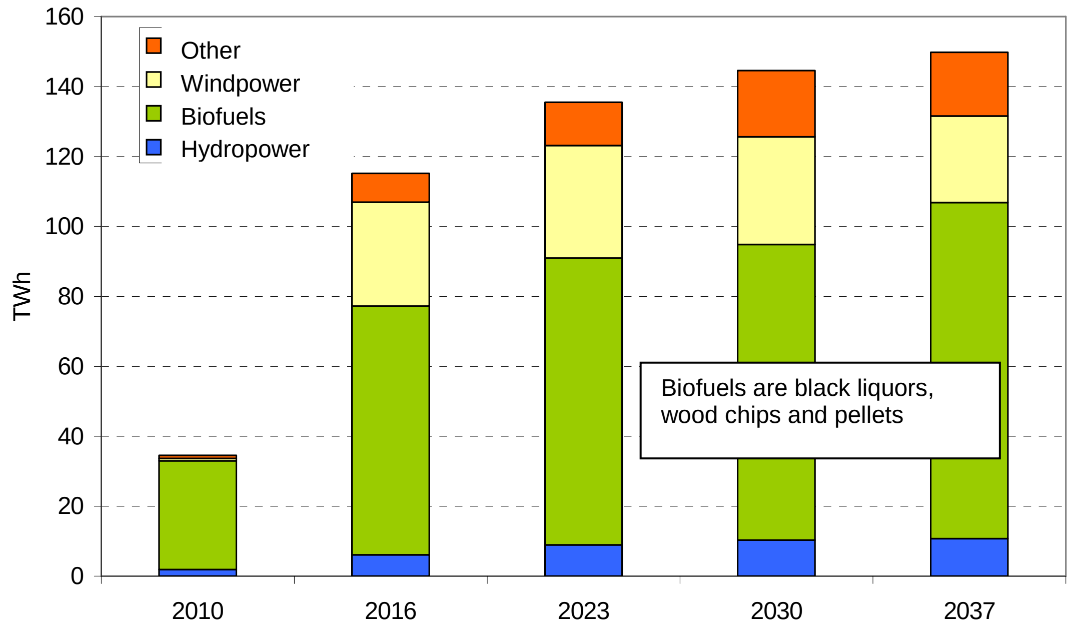


Figure 2: Increase of renewable kinds of energy in the Nordic countries relative to 2005, when the EU renewability goal is applied (also keeping current emission-rights trade and national policy instruments)

In sum, the renewability goal clearly increases the amount of renewables used in the Nordic countries. By 2020, the use is 60 % greater than in 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 nearly 80 TWh between 2005 and 2020.

What, then, happens when the EU's 20 % goal for increased use of renewable energy is combined with the EU's other goals? Here we analyze how the use of renewable energy is influenced by the effectivization goal (-20 % energy use) and the greenhouse gas goal[5] (- 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 community, we have – based on data about savings potentials etc. – assumed that 9 % of the goal is fulfilled by a decreased demand for usable energy. Neither does the model contain the transport sector, which we assume to take its part of the effectivization goal. We also assume, based on supplementary calculations, that the already introduced policy instruments contribute to an effectivization of the energy sector by 5 %. The remaining 6 % decrease in energy use distributes the energy-system model in the most efficient way. (In the initial calculations, the result was invariably that nuclear power would be abolished, due to the plants' low efficiency. Since this result was judged unrealistic, it was avoided by giving nuclear power the primary energy factor of 1 in the subsequent analysis.)

[5] In our analysis we study only reduction of carbon dioxide emissions, which we have assumed are to be decreased by 20 %.

The goal of carbon dioxide reduction is illustrated in the calculation with a ceiling for the total carbon dioxide emissions in the Nordic countries that lies 20 % lower than the 1990 level. Moreover, today's climate control instruments, e.g. emission-rights price and carbon dioxide tax, are included in the calculation.

All three 20 % goals are assumed to remain at this level also during the period after 2020.

When the three goals are applied simultaneously, we obtain a result for the use of renewable energy according to Figure 3. 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 biofuel decreases instead, due to the effectivization goal. For example, expansion of certain biofuel boilers may be omitted because heat pumps and even natural-gas boilers with higher efficiency are chosen instead. (The energy effectivization goal makes no distinction as to whether fossil fuels or renewables are reduced.) The use of biofuel also decreases due to less delivery 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 effectivization goal is applied, due in large degree to less use of electricity.

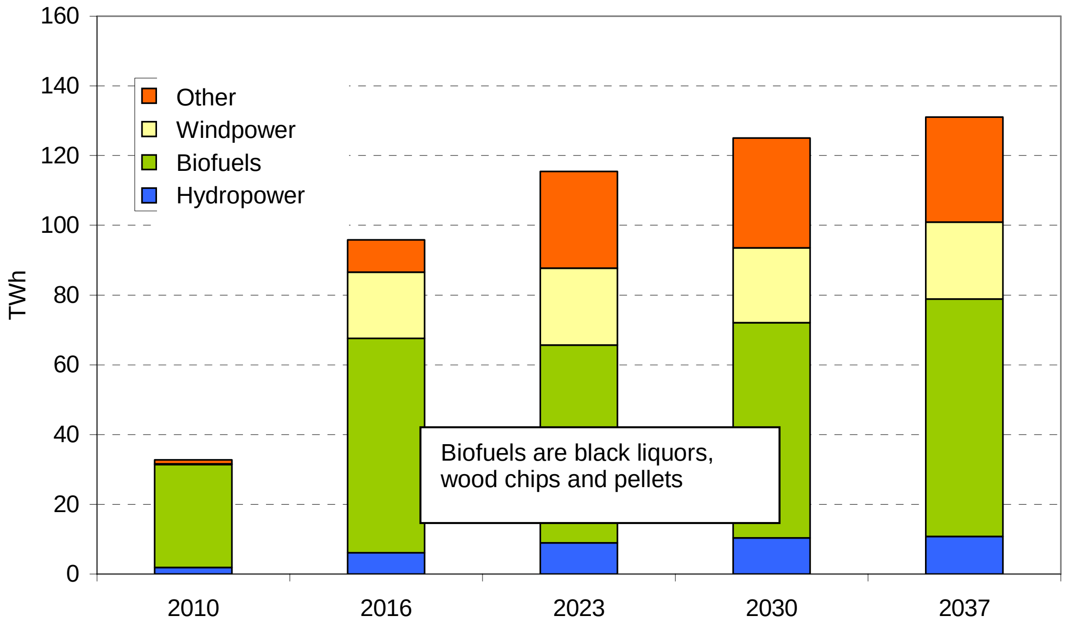


Figure 3: Increase of renewable kinds of energy in the Nordic countries relative to 2005, when the EU goals of renewability, greenhouse gas reduction, and effectivization are applied simultaneously (also keeping current emission-rights trade and national policy instruments)

One can also see that the goal of 20 % reduction of carbon dioxide emissions is not restrictive, i.e. the emissions due to other goals and policy instruments are reduced by more than 20 %. The effectivization and renewability goals are thus clearly stronger than the emission-reduction goal.

When all three 20 % goals are applied, the total use of renewable energy in the Nordic countries becomes clearly greater than in the calculation 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. It is mainly the use of biofuel that decreases when the energy effectivization goal is added to the renewability goal. The use of biofuel becomes even less than in the calculation cases with today's instruments. The opposite trend is shown by heat pump usage, which is greatest in the case where all three 20 % goals are applied simultaneously.

How does the use of renewable energy develop in each of the Nordic countries? Figure 6 shows for each, and sector by sector, where the calculated amounts of renewable energy are used in 2020, for the case when all three 20 % goals are applied simultaneously. 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, Norway is indicated to have very little district heating both today and in the future. The only results that can clearly be observed for all the countries are that wind power expands and that the use of biofuel in the housing and service sectors does not increase.

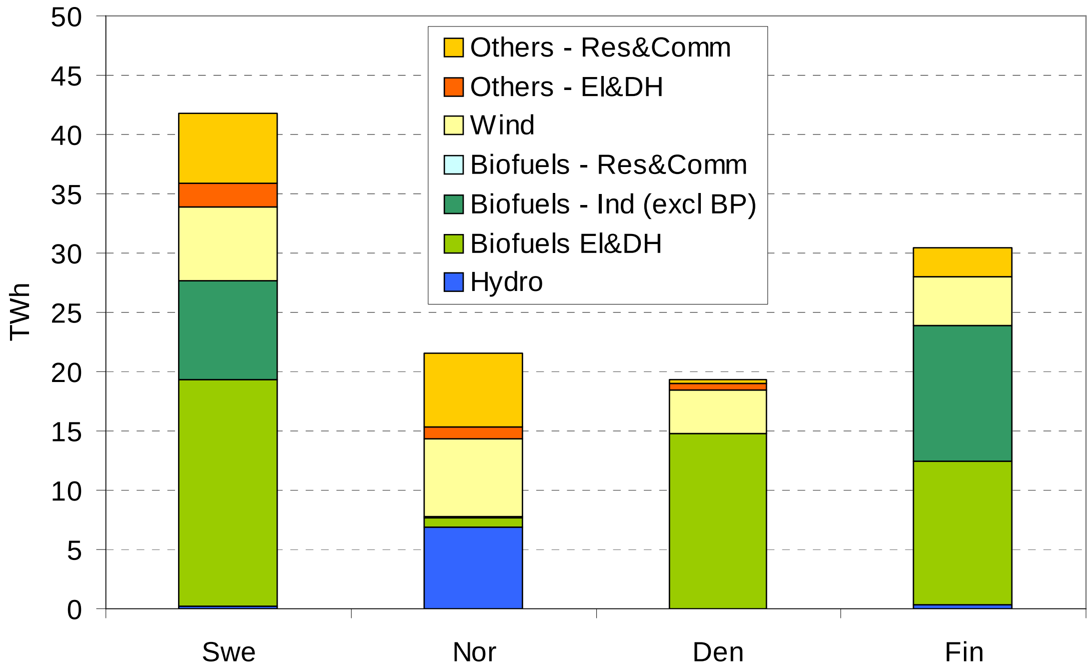


Figure 6: Increase of renewable energy in the Nordic countries by 2020, assuming the EU's 20/20/20 goals (20 % renewables, 20 % less greenhouse-gas emission, 20 % less energy use)

Calculated in TWh, however, biofuel 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. 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 efficiency. In Sweden, and to some degree in Norway and Denmark, the heat production in large-scale heat pumps in the district heating system also increases. This may seem peculiar, since one strength of district heating is considered to be its function as a heat basis for simultaneous production of electricity and heat, with high total efficiency. Here, the district heating is partly given the opposite task of conveying heat based on electricity usage. Thus a focus is placed on the importance of how the efficiency goal is formulated.

Perspectives on district heating in Sweden

Since many of the effects examined in the above analysis are found in the area of district heating, we display in a couple of figures the difference between the calculated district heating production with today's policy instruments and that with the EU's three 20 % goals. Figure 4 shows the calculation results for the development of district heating production in Sweden in the case with today's instruments (without the three new EU goals). The figure indicates continued 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 biofuel increases, while the use of fossil energy sources and electricity-driven heat pumps is somewhat decreased.

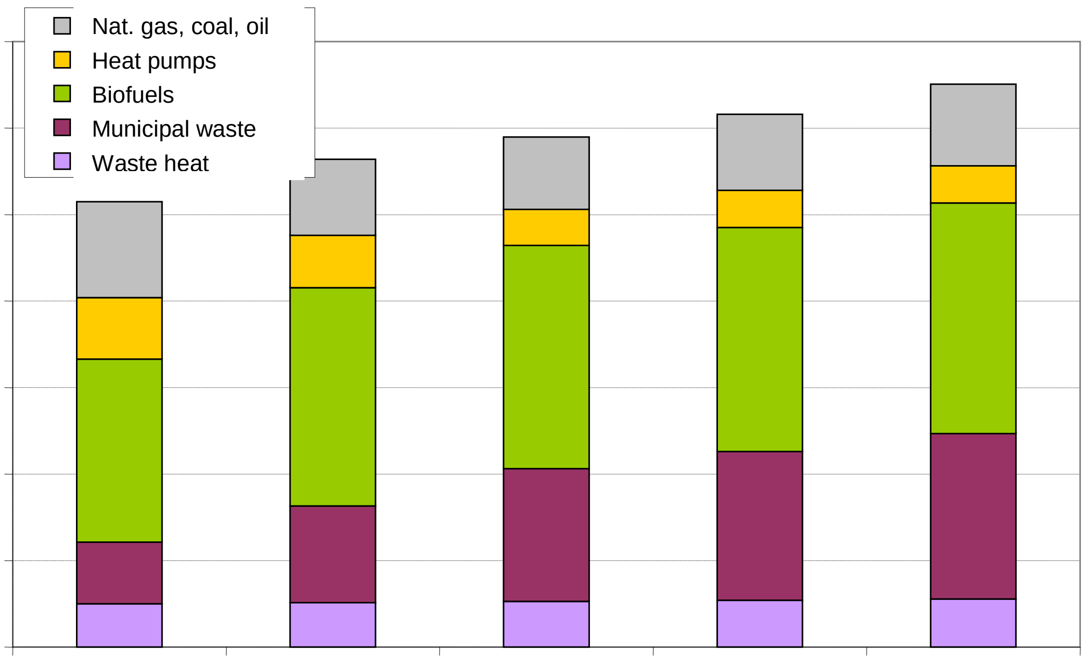


Figure 4: Total district heating production in Sweden, without any new goals from the EU (but keeping current emission-rights trade and national policy instruments)

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 5. The effectivization goal leads to intensified energy savings, with a considerably slower growth in the use of district heating, which stagnates or even slightly decreases after 2016. 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. Nevertheless, the effectivization and renewability goals' definitions have the result that heat pumps acquire greater competitiveness and increase their production strongly. For biofuel, all this means that after a rapid expansion until some years after 2010 (largely driven by the electricity-certificate system) the use of biofuel for district heating production decreases substantially. This suggests that certain of the biofuel district heating plants which are now being built rapidly may, in the long run, face decreasing operation times.

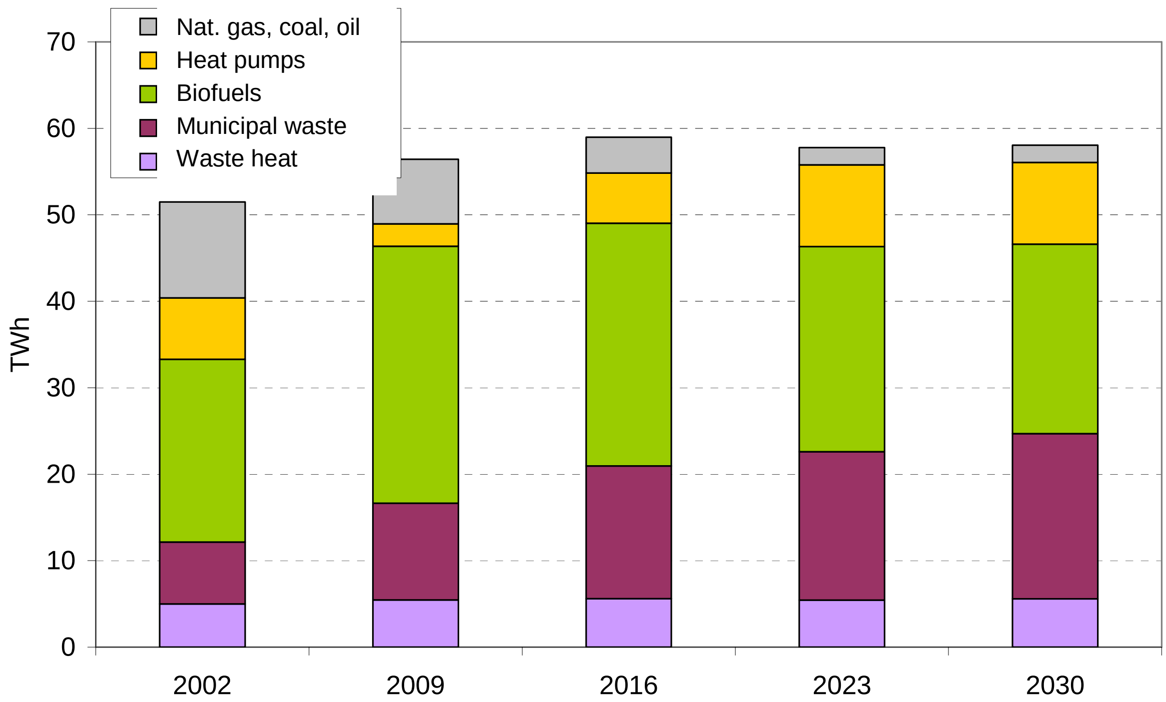
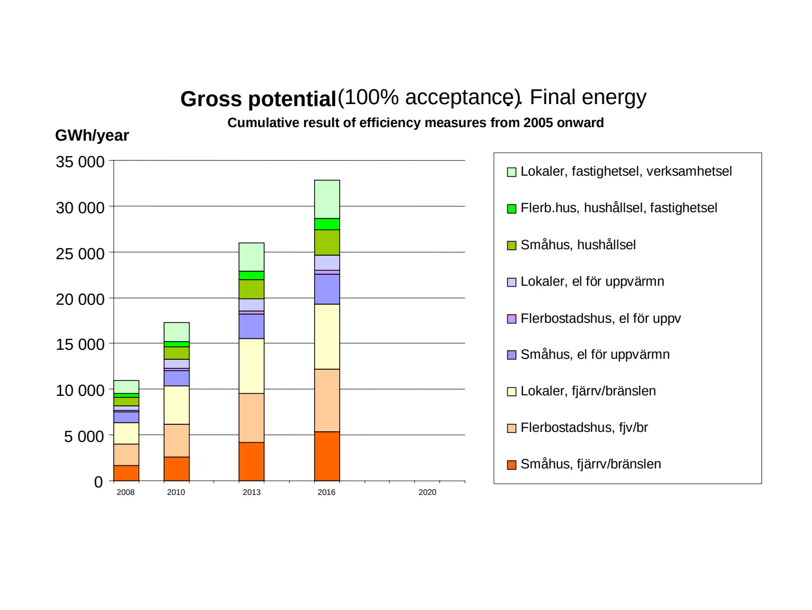


Figure 5: Total district heating production in Sweden, when the EU goals of renewability, greenhouse gas reduction, and effectivization are applied simultaneously (also keeping current emission-rights trade and national policy instruments)

2a. Measures for improved energy efficiency

The figure below, from the Swedish EnEff inquiry, shows the private economic *"gross potential"* in buildings. In this case, the gross potential for the year 2016 is about 22% of the total final energy use. The concept "gross potential" refers to what is private-economically profitable in a present-value calculation, with 6% calculation interest rate and 2% real energy price increase. The potential includes all types of measures (supplementary insulation, ventilation, change of electrical equipment, etc.), both as separate measures and ongoing in connection with replacements and repairs that must be done anyway. Changes of heating method (conversions) are not included. The implementation is distributed over time according to usual lifetimes for apparatuses, building parts etc.



The "gross potential" shows an ideal situation where all house owners make a correct calculation and then implement everything, and it becomes the starting point for calculation of a realistic level of implementation (see below).

This type of calculation often gives rise to objections and scepticism. It may be questioned whether the basis is correct in purely technical terms (are there really so many possibilities for energy efficiency?). In particular, discussion arises over whether this can be called "profitable". Since it is an ideal cases where everyone has complete knowledge, has time to carry out measures, etc., in reality only a portion of them will be implemented; only what is really done reflects what the actors find "profitable", according to the objection.

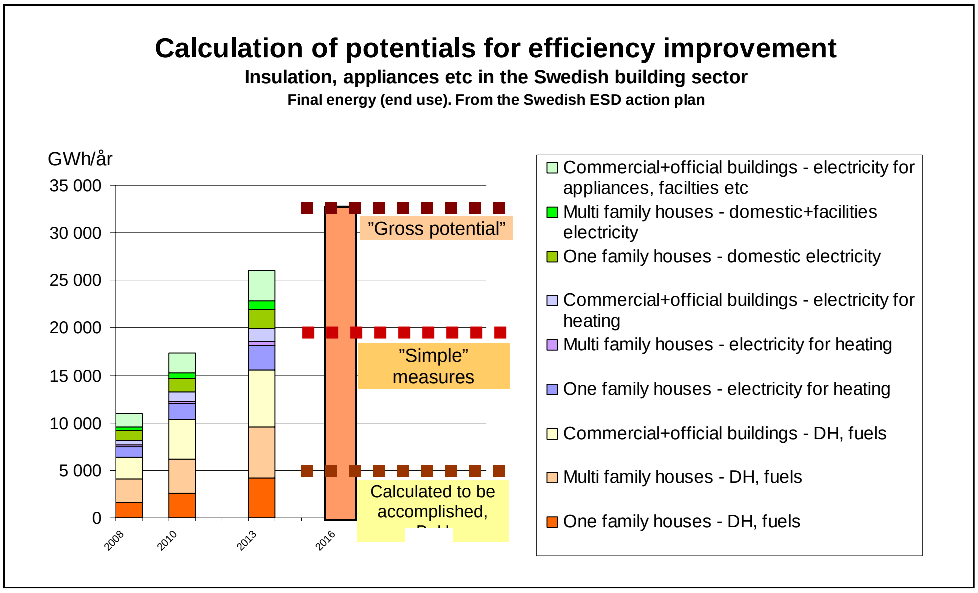
Regardless of this conceptual discussion, we think that the charting of the ideal gross potential is valuable. It provides a point of departure for continued analysis, and a quantification of the "possibilities" to start with. But it is important that one gives this calculation a correct presentation. One must also be careful with concepts such as "technically feasible" potential, or "technical-economic" potential, and then explain clearly what they mean.

Another comment: We are speaking above of how the end users/actors calculate and act.

A *socio-economic analysis* needs to be done in a different way. There, for example, the real variable costs for energy may be different from what tariffs and price lists say.

How much of the "gross potential" is implemented?

Only a part of the gross potential is implemented in reality. This has been established and described in a large number of contexts and inquiries. The Swedish EnEff inquiry judges that *only about 15%* of the house measures (excluding conversions) will be implemented[6] in the business-as-usual case (level ca. 5 TWh in year 2016; see figure below).



In the figure, the concept "acceptance" is used for the part that is implemented. The fact that only a part is implemented has sometimes been described as "the energy efficiency gap/paradox", or as the result of "transaction costs" or "barrier effects" for energy efficiency.

Obstacles to implementation

There are many reasons why not everything is implemented. One may have deficient knowledge that improved efficiency possibilities exist, one may doubt the suitability of certain measures, one may have stricter profitability requirements or problems with financing, one perhaps calculates profitability too narrowly or short-sightedly, one may doubt whether the business will last in its present form, one lacks time to handle this type of issue or produces an inadequate basis, the organization does not have sufficient competence or is focused on other issues, etc.

The description of these implementation problems may need to be deepened. Here we emphasize two rather troublesome obstacles:

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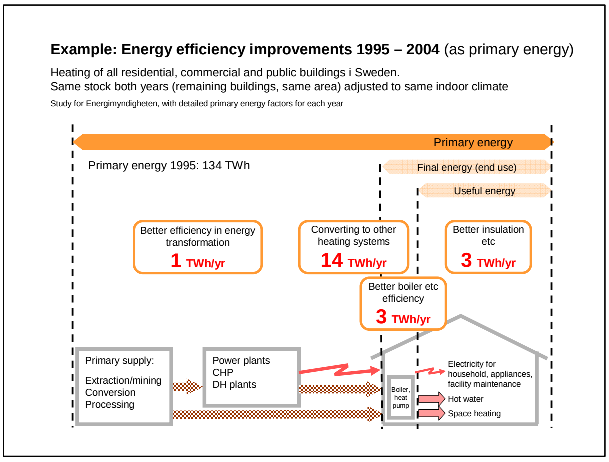
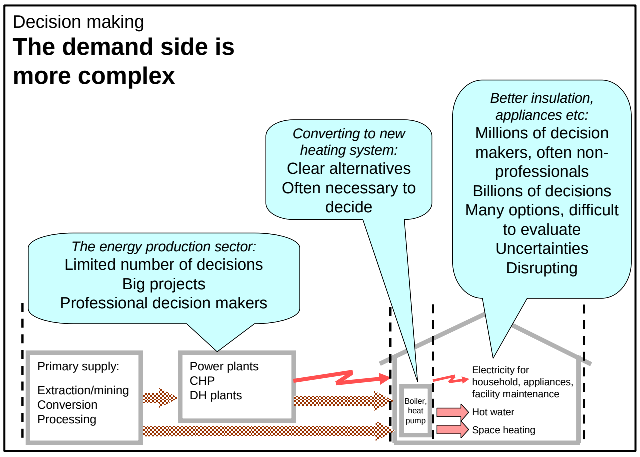
[6] This judgement builds on a Chalmers report from 2005 which analyzed the real trend of energy use during 1993 – 2003. The conclusion was that the real implementation of efficiency measures had been much less than the most cautious assessment of realistic implementation which the 1995 energy commission made for this period, even though the economic preconditions had been more advantageous. The Chalmers report judged that the "acceptance" in the future may lie in the interval 10 to 30% depending on how policy instruments etc. are designed, where the higher level would require strongly sharpened instruments compared with today.

- *Organization and "split incentives"* for premises and multi-residential buildings. For most public and commercial premises, the distribution of roles between owner and users often leads to an unfavourable structure of incentives. The owner must pay for most of the energy measures but the tenant reaps the profit, at least in the case of basic rent. Even with total rent (including heating) there are problems – the tenant has no incentive to behave energy-efficiently. Moreover, the trend that whoever runs a business sells the building where the business is run, and perhaps also outsources the building's administration, leads to a more complex structure which can make measures harder to implement. In multi-residential buildings, the owner normally pays for the investment in e.g. white goods, while the tenant pays the electricity bill. An ECEEE study has analyzed the residential sector in several countries and shows that ca. 25% of all energy there has what are called "principal agent problems", i.e. that those who cause the use of energy are not those who have access to the efficiency measures, or do not get any price signal about their energy behaviour.

- *"The investor market"*. This concept is sometimes used of large owners where the ownership is governed to a high degree by financial motives. About 1/3 of the area of Swedish buildings with premises is owned by such owners who, crudely expressed, focus on refining the use (to extract higher rent) or buy and sell buildings rather than lowering their operating costs.

Different "decision power" in different parts of the energy system
Generally it is easier to get measures and decisions implemented on the side of energy supply, distribution, and large-scale conversion, than on the user side in houses. Construction of power plants, heating plants or power lines is handled by professional organizations in a limited number of (rational) decisions. To realize the efficiency improvement potential on the user side requires millions of decisions by millions of small-house owners, tenants, and people in owner and administrator organizations, for whom energy is often only a fraction of all the issues they must deal with.



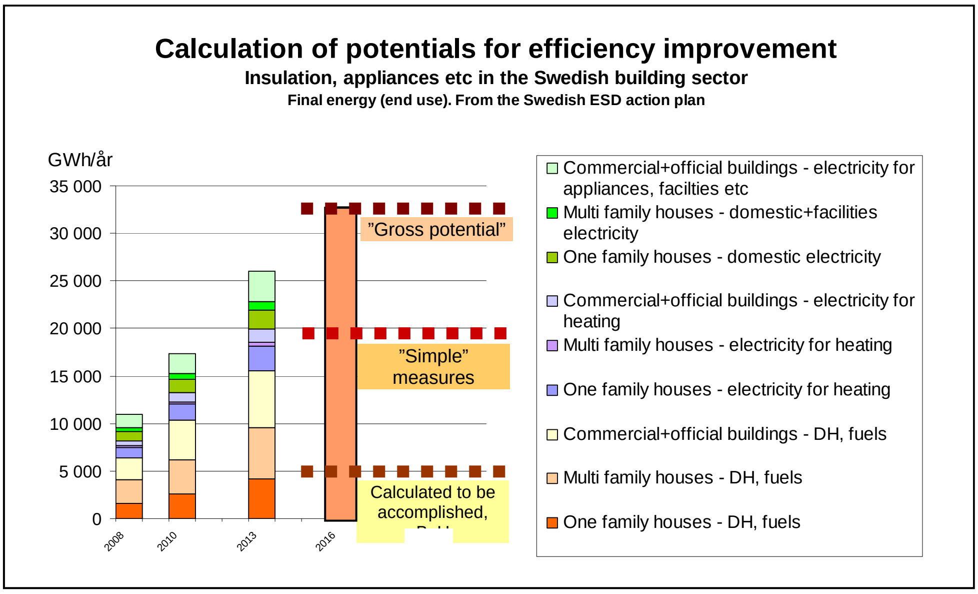


How much of the "gross potential" should be easy to realize?

All of the measures in the "gross potential" are profitable in calculation terms, but naturally their profitability differs. A very large part of the measures are actually quite simple to implement, and many of them cost nothing in investment. We have separated out such “simple measures”, such as:

- Adapting air flows, and operation times for ventilation and illumination, to the times when premises are used. This often requires only the right adjustments of existing clocks or the like.
- Electricity efficiency in households, buildings and businesses, in the form of change to the best on the market when changes are to be made anyway. Change to low-energy lamps.
- Insulation of attics.

These simple and cheap measures constitute more than half of the entire gross potential; see the figure below! The “easily accessible potential” is thus much greater than what is implemented in reality. (And what is implemented may not be the most profitable – experience from elsewhere indicates that real implementation is widely spread between the more and the less profitable).



Our conclusion is that there are certainly obstacles (e.g. transaction costs) which lead to a great deal not being done, but that the house owner has many very profitable possibilities within reach when the obstacles have been passed. Policy instruments that help the decision-maker over the obstacles seem to be well justified!

The transaction costs

In the following we try to quantify the transaction costs. They can reflect what is needed in terms of e.g. information efforts or grants, as well as related administration that would be needed in order for profitable measures to be implemented to a certain extent. One can build upon evaluations of already introduced policy instruments, but it has often proved difficult to establish the connection between policy-instrument costs and energy efficiency. We assume that the transaction cost is lower for conversions than for climate-screen measures and the like. In Section 5, a preliminary assessment of transaction costs is used.

2b. Results from the initial model analyses – runs with MARKAL Nordic

The MARKAL analyses show that the energy efficiency acquires a key role in the energy changeover when the EU's three 20% goals are implemented:

- 20% energy efficiency – efficiency measures throughout the energy system may be exploited
- 20% decrease of emissions of greenhouse gases – mainly carbon dioxide
- 20% renewable share in the EU energy mix – increase by about 10% in the Nordic countries

MARKAL results for the Nordic energy system for 2020 show that the energy efficiency gives both resource conservation and CO2 reduction, at the same time as the improved energy efficiency contributes to increasing the renewable share in the energy system. But our judgement is that relatively great (political) "incentives" are needed in order to realize the efficiency potential.

MARKAL runs

We have analyzed the following scenarios with MARKAL Nordic:

1. Reference case ("business as usual")
- Energy use according to STEM's reference case
- Today's policy instruments and other political decisions
- Not the EU's three 20% goals (nor e.g. 9% efficiency goal)

2. EU 20-20-20 until 2020
- Energy use according to STEM's reference case
- Today's policy instruments and other political decisions
- All the EU's three 20% goals (and e.g. 9% efficiency goal)
- Primary energy weighting on nuclear energy of 1 (instead of 3)

3. As in 2 above, but with an alternative definition of the efficiency goal, where renewable energy has been given the primary energy weighting of zero.

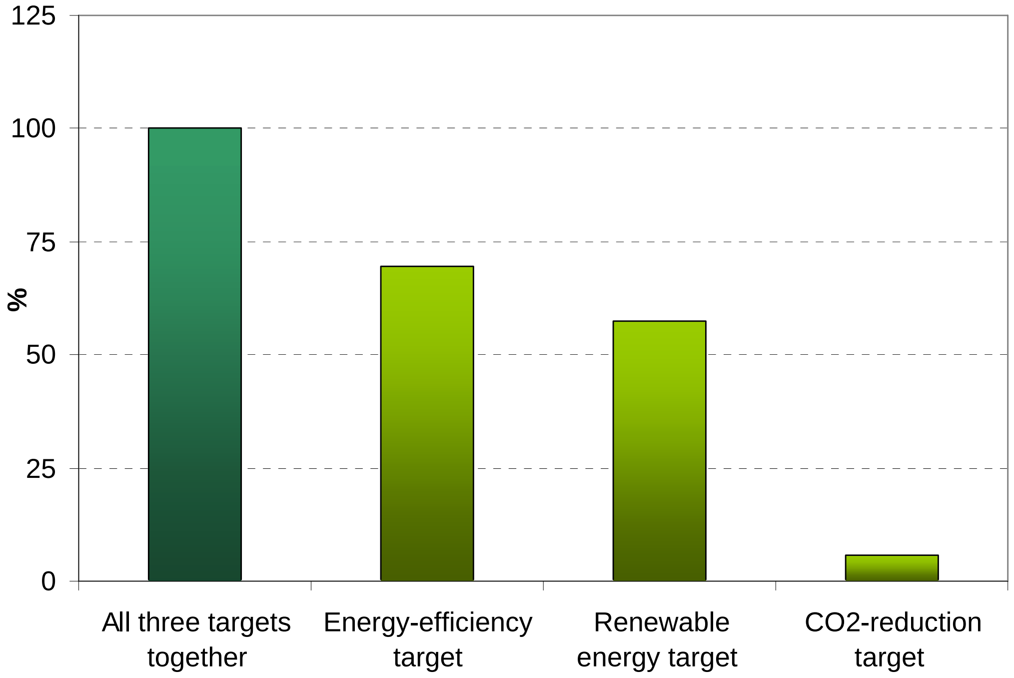
Costliness for the Nordic countries to reach all EU goals

The socio-economic cost for reaching the EU's three 20% goals in the stationary sector (excluding the transport sector) in the Nordic countries has also been calculated with the NEP's energy models. The climate goal is the "cheapest", while the efficiency goal is the most expensive. We have calculated the costs for reaching the goals as a "cost increase compared with the development in a reference case". Already in this reference cases, which among other things includes EU ETS (with a CO_2 price of 20 Euro/ton), the Nordic countries will come a good way along the path toward the EU's goal of 20% carbon dioxide reduction. Therefore, the increased cost for reaching 20% is relatively small. Also the share of renewable energy increases in the reference case – as a consequence of the supports that are already acting in the Nordic countries – although here a greater effort is needed in order to reach the EU goal.

Transaction cost of 100 Euro per MWh – as a one-time cost

The energy efficiency goal also demands a large socio-economic effort, even though many of the measures are profitable. The "transaction costs" (e.g. state support) which are needed to implement the measures are substantial.

We have made the judgement that an average "transaction cost" is required that corresponds to 1 SEK per year-kWh, as a one-time contribution, in order to implement the measures. This corresponds to about 100 Euro per MWh.

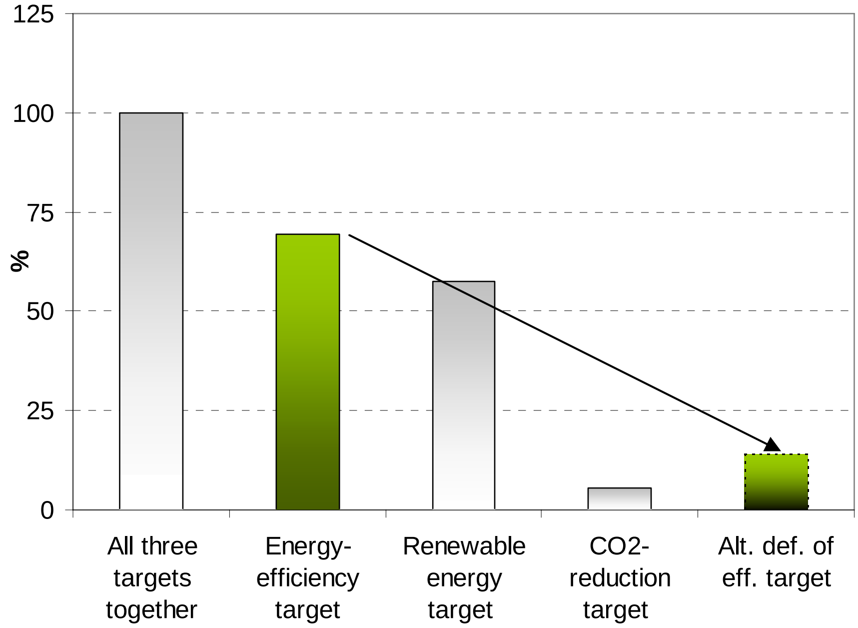


The ranking in cost of the three EU policy goals*, compared to the cost in a reference case. The cost for fulfilling all three targets within the Nordic energy system is set to 100%*

The decisive importance of primary energy weighting

The choice of primary energy weighting for the different kinds of energy is decisive for obtaining synergies between the efficiency goal and the other two goals. With a "strict" primary energy weighting "according to the directive", the phasing out of nuclear power is the "best" efficiency measure, yet a measure that increases the CO2 emissions instead of reducing them. In our analyses with MARKAL in NEP, we have therefore given a primary energy weight to nuclear power of 1 instead of 3. Then MARKAL no longer exploits nuclear power phase-out as the best efficiency measure.

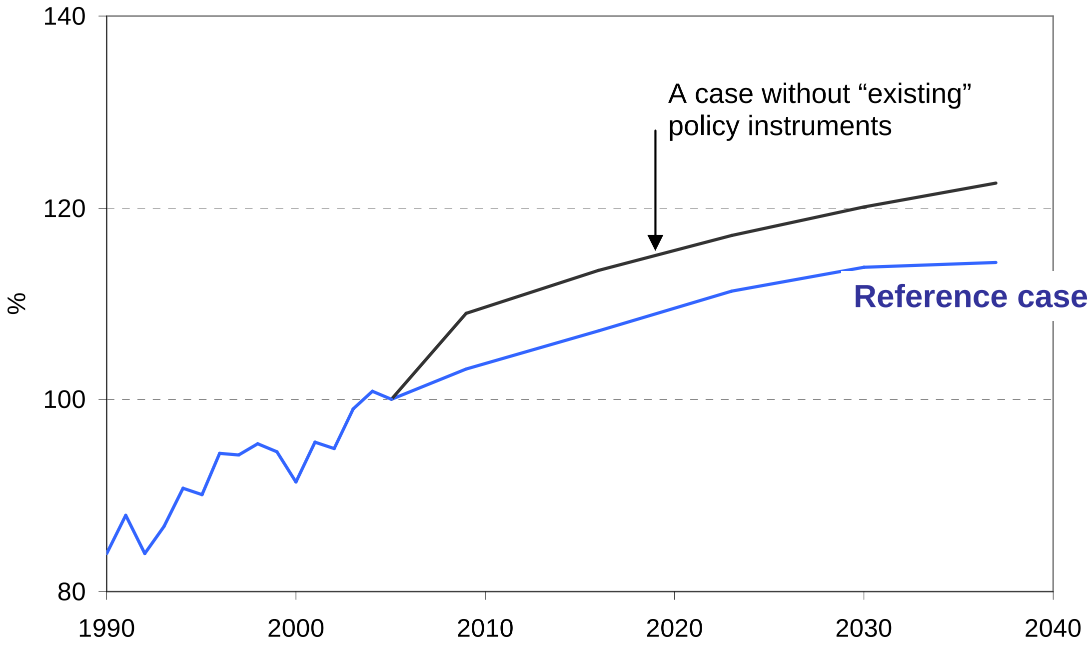
With the EU goals as they are now formulated, there is thus an imbalance in the menus of measures between the efficiency goal and the climate and renewable goals. However, there are several ways to increase the synergies between the efficiency goal and the other two goals. For example, if one concentrates the energy efficiency on the fossil fuels, the synergies increase dramatically, and the costs for reaching the efficiency goal decrease very substantially. The figure below shows the cost reduction with such an alternative definition of the efficiency goal.



The ranking in cost of the three EU policy goals*, vid en alternative definition av effektivseringsmålet, där förnybar energi primärenergiviktats med noll.*

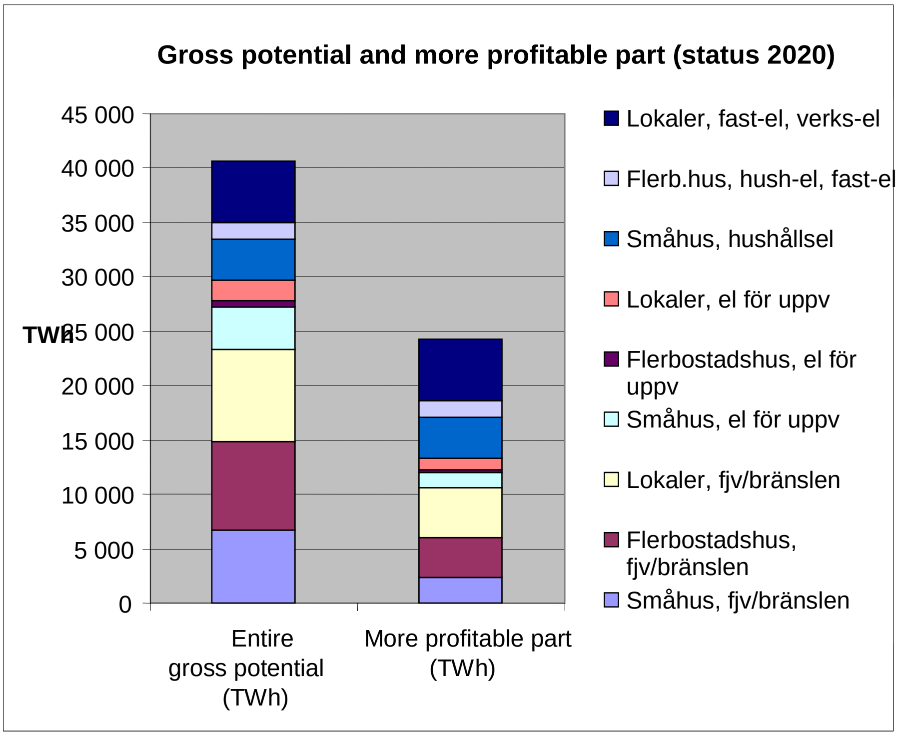
Handling of 20% improved energy efficiency in MARKAL

The definition of the energy efficiency directive that prescribes 9% more efficient use of energy until 2016 allows that the member countries credit themselves with the improved energy efficiency which is brought about by already implemented policy instruments. In the same way we – with MARKAL Nordic – have calculated what primary energy weighting is achieved by today's policy instruments in the Nordic countries until 2020, by comparing the primary energy use in the reference case to a case entirely without policy instruments. The comparison shows that today's policy instruments decrease primary energy by about 5%.



The remaining 15% energy efficiency must therefore be achieved through “new” policy instruments. An important experience from the MARKAL analyses with the two other 20% goals is that neither the CO2 goal nor the renewability goal reduces the primary energy use very much. In contrast, today’s policy instruments do so (by 5%).

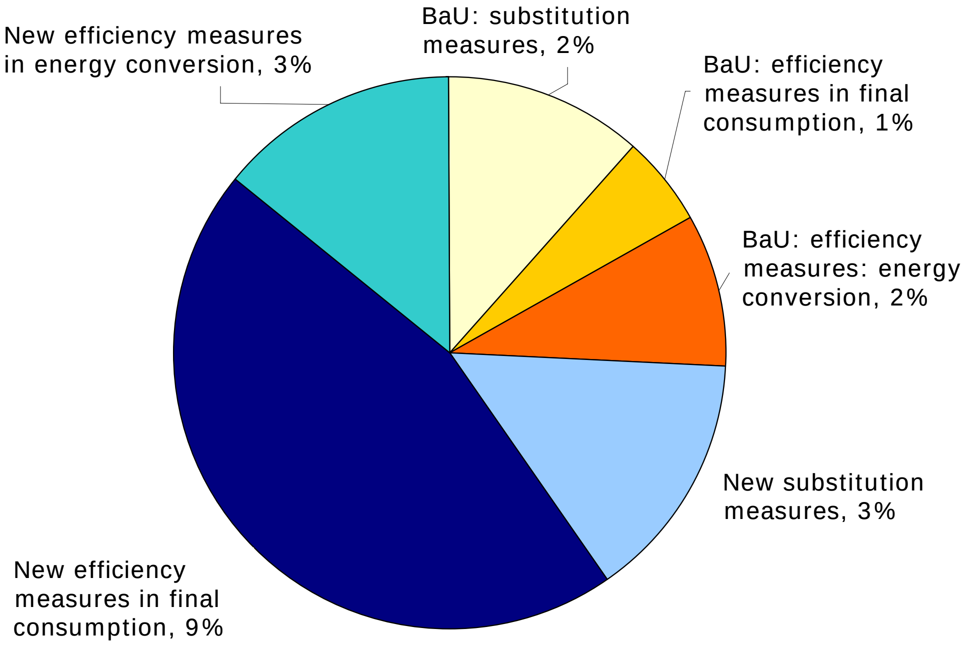
How, then, do we reach 15% improved energy efficiency in the Nordic countries? In Section 2a above, it is discussed how large a part of the efficiency potential in the sector “residences and service premises in Sweden” may turn out to be implemented. In the figure below, the measures that may be actualized are reported. They are both electrical and heating measures, divided into small houses, multi-residential buildings and premises.



On this basis, together with corresponding ones (but less detailed) for other sectors and countries, we have (relatively roughly) made the assessment that about 9% (of the 15%) can be implemented by 2020 with end-user measures of this kind. In MARKAL we have "inserted" these end-user measures by reducing the energy demand in the different demand sectors. The costs for the measures (including the transaction costs) have been calculated alongside the model. We have, however, employed MARKAL to calculate the "revenues" for the reduced energy use.

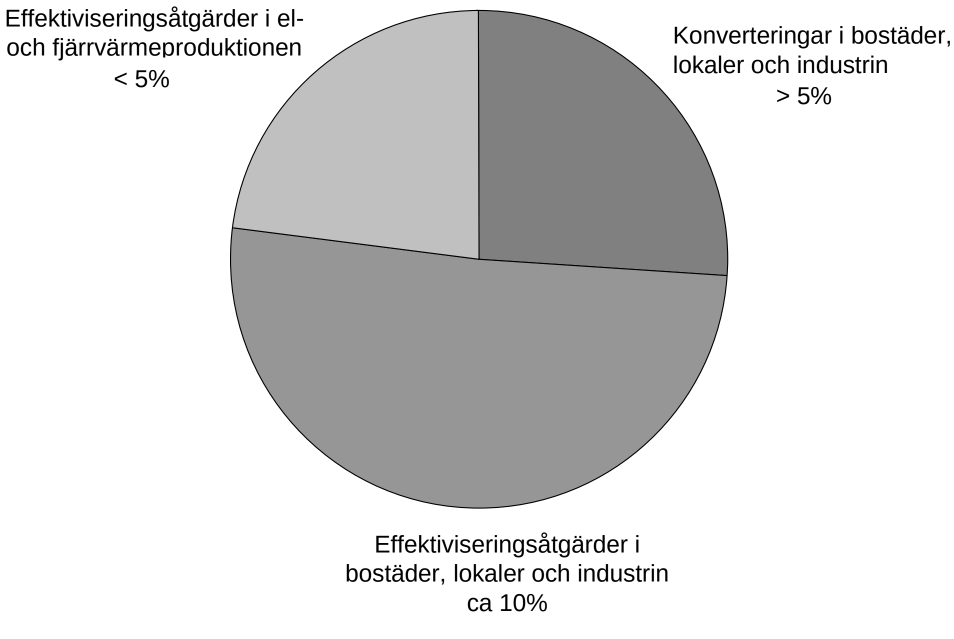
The remaining efficiency measures (6%) is identified by MARKAL in the optimization. The result of the run shows that MARKAL chooses 3% as "conversion measures" (e.g. change from electrical heating to heat pumps in small houses) and 3% as efficiency measures in the "energy-changeover path" (e.g. more electricity produced by heating plants instead of by condenser).

If we include the 5% measures that today's policy instruments achieve, the entire "menu" of efficiency measures to reach the 20% goals is seen to be as in the figure below.



The menu of measures to reach 20% energy efficiency improvement in the Nordic countries. The yellow fields are measures achieved already by today's policy instruments (BaU = Business-as-Usual). The blue fields show "new" measures until 2020.

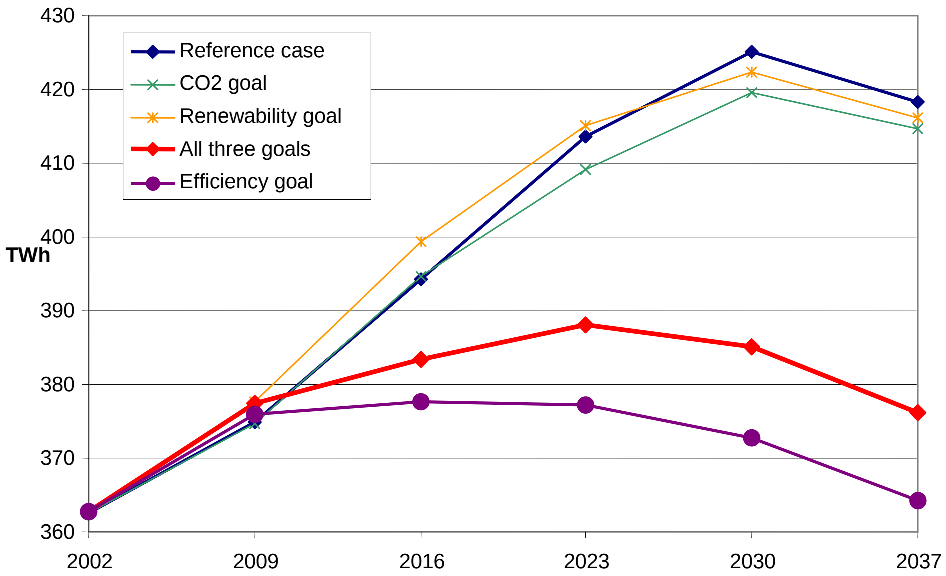
If we add the "yellow and blue" fields/measures in the above figure, we obtain the following menu:



The menu of measures to achieve 20% improved energy efficiency in the Nordic countries

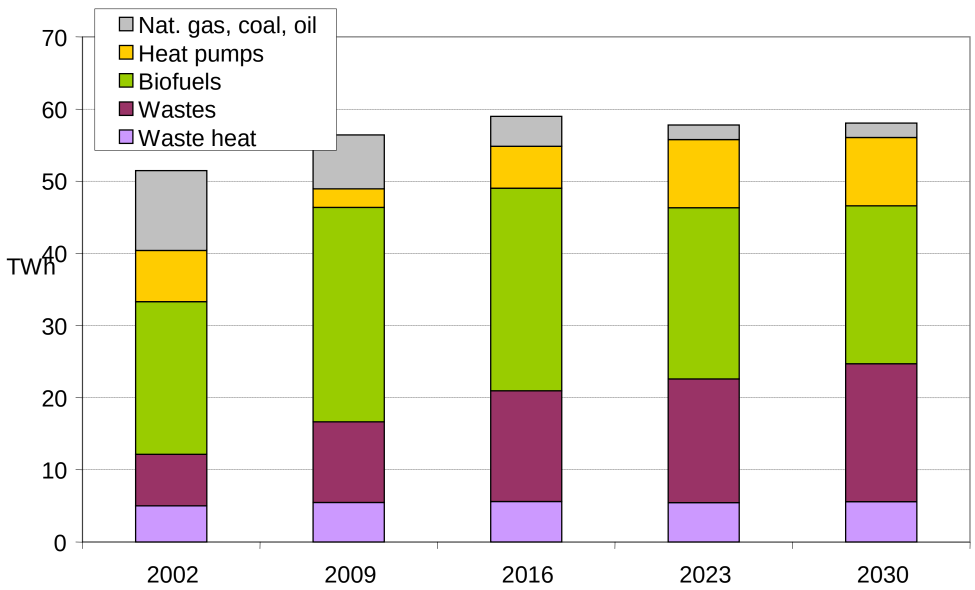
Decrease in use of electricity and district heating in the Nordic countries

The efficiency goal has a clear impact on electricity use in the Nordic countries. From the figure below, we can see that neither the CO2 goal nor the renewability goal influences the electricity use (in comparison with the electricity-use level in the reference case). In contrast, it decreases by 35-40 TWh as a consequence of the efficiency goal by the model year 2023. In the scenario with all three goals, the decrease is 25-30 TWh for the model year



The trend of electricity use in the Nordic countries for different scenarios

A 20% efficiency improvement also has a clear effect on the heating market. The figure below shows the trend for Swedish district heating. In the reference case, district heating increases by 5-10 TWh between the model years 2009 and 2023, but in the scenario with all three goals it does not increase at all.



District heat production in Sweden in the scenario with all three goals.