TWENTY STATEMENTS ON THE ELECTRICITY DEMAND IN SWEDEN

Electricity demand in Sweden

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NEPP is a coherent multi-disciplinary research project focusing on the development of the electricity systems and the electricity market in Sweden, the Nordic countries and Europe with the time perspective 2020, 2030 and 2050. The research is performed by around ten well-merited researchers and analysts. The current phase of NEPP will run up to March 2016.

NEPP's goal is to deepen the insight about how the Nordic countries and the actors on the Swedish and Nordic energy markets can act to be able to - in a cost effective way and with the focus on the growth perspective – meet the expectations from the energy and climate politics in EU and the Member States, and the challenges from a changing world.

The research is charged with the task of showing how *a balanced and effective development* of the Nordic countries' and the EU's energy systems can be achieved, and how the political goals can be realised for the benefit of the society and its actors. The research should strive to identify the *success factors* for this balanced development. This can relate to the choices made in the development of the operations of electricity and energy systems, market rules, the choice of and the design of policy instruments, etc. A deeper understanding should also be gained about *the expectations* on the energy actors, politicians and the society at large, to realise various goals and development paths
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NEPP is funded by the electricity companies, Svenska Kraftnät, The Swedish Energy Agency, and The Confederation of Swedish Enterprise. Nordic Energy Research, Swedish Smartgrid and The Royal Swedish Academy of Engineering Sciences (IVA) have contributed to the financing of some of the sub-projects. The work is supervised by a steering team which is chaired by the Director-General of The Swedish Energy Agency. Energiforsk acts as a project host.

The research and synthesis efforts in NEPP are carried out by five research teams at Chalmers University of Technology, KTH Royal Institute of Technology, Profu, Sweco and IVL Swedish Environmental Research Institute. Profu is the project leader for NEPP and Sweco is assistant project leader.

This publication presents results and conclusions from NEPP's analyses of the electricity demand in Sweden, which are mainly done be Bo Rydén, Håkan Sköldberg and Thomas Unger at Profu, Johan Bruce at Sweco and Stefan Montin at Energiforsk. The work has been done in close cooperation with The Royal Swedish Academy of Engineering Sciences (IVA).

If you have questions regarding the content, please do not hesitate to contact any of the responsible researchers at Profu and Sweco.

More information about the NEPP project can be found at www.nepp.se.

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February, 2016

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Content

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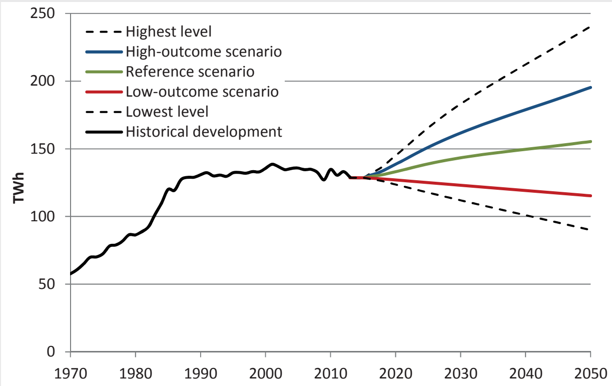
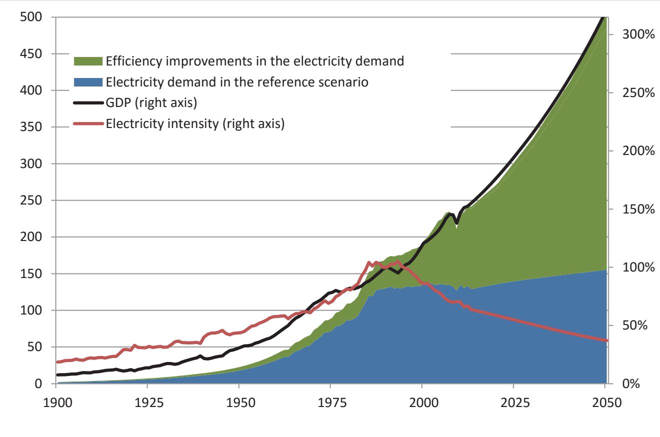
The development of the electricity demand to 2030 and 2050

1 **We present three different scenarios, within a relatively broad outcome range, with an increase as well as a reduction of the electricity demand.** The scenarios are mainly based on official prognoses and assumptions regarding some *ten factors that have an influence on the development of the electricity demand*, upwards as well as downwards. The scenarios are *not* characterised by simplistic extrapolations of the historical electricity demand, although we have incorporated important knowledge from the history, as well as the development of the different influential factors up to today. Our reference scenario is based on the official reference prognoses and basic assumptions that are available for the different factors. The resulting development in the reference scenario shows an increasing electricity demand up to 2030 and 2050, whereas the low-outcome scenario shows a reduction in demand and the high-outcome scenario shows an even larger increase. We also present (as seen in the figure below) a lowest and a highest development level, based on the lowest and highest assumptions for the development rate of the influential factors respectively.



Electricity demand in Sweden. The historic development since 1970, and three scenarios for the future development up to 2030 and 2050. The scenarios are based on official prognoses and assumptions regarding the developments of approximately 10 factors that influence the development of the electricity demand.

2 The energy efficiency improvement is the single most influential factor on electricity demand, and its rate is predicted, in all scenarios, to gradually increase compared with current level
The average annual improvement rate has, during recent decades, been 2-3%, but in the future scenarios, we apply an increased rate of 3-4% per year for the period up to 2050. The figure illustrates how the sum of the electricity demand and efficiency improvement correlates well with the GDP development. The electricity intensity shows a continued "decoupling", i.e. a separation between the development of the GDP and the development of the electricity demand, increasingly less electricity is used for every unit of GDP.



The historical and the future (according to the reference scenario) electricity demand and electricity efficiency improvement (TWh – Left axis), and GDP and electricity intensity (i.e. electricity demand per GDP unit) relative the levels 1970 (100 % 1970, Right axis).

3 Another four factors, besides efficiency improvement, have high impact on the electricity demand development: population growth, the economic development (GDP), structural changes and technology break-throughs. Generally, these factors are driving the electricity demand upwards.

The annual electricity demand in Sweden has, more or less, remained at the same level of 130-140 TWh since late 1980s. Prior to that, the electricity demand increased by 4-5 percent per year. Four simultaneous processes, targeting different end-use sectors, explain the observed slowdown in electricity demand growth. Without these processes, the electricity demand would instead show a rather even yearly growth from the 1980s up to the financial crisis of 2008. The processes that together led to the stabilisation in demand for 25-30 years are:

1a) During the 1980s and 1990s, electric heating in buildings (direct-acting electricity and electric boilers) increased significantly, and at a pace exceeding prior years. This pushed the growth of electricity demand upwards.

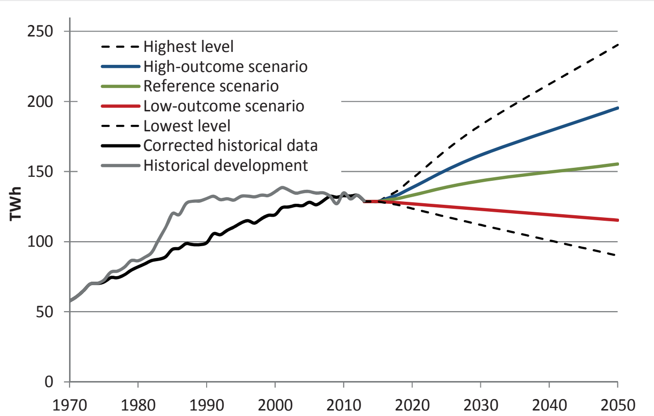
1b) Since the turn of the century, heat pumps have been installed, at a large scale, for heating purposes in buildings, and this has, in turn, had a declining effect on electricity demand.

2a) During the 1980s, the electricity demand also increased rapidly in the district heating sector; but

2b) in the late 1990s this demand decreased once again.

3a) During the 1980s up to the mid-1990s ,the electricity demand in the industry sector increased, both in total number as well as in specific use (electricity per value of output), as a consequence of the significant conversion from oil to electricity.

3b) Thereafter, a "decoupling" between electricity demand and production has been established



Electricity demand in Sweden. The historical development is illustrated by two curves: the actual electricity demand (grey line); and an "alternative" or corrected demand curve (black line) where the four processes during the last 25-30 years (described in the text above) are substituted with a more even development. For the future development up to 2030 and 2050, the figure shows the different scenarios of the NEPP project.

in the industry sector, which has substantially reduced the electricity demand growth.

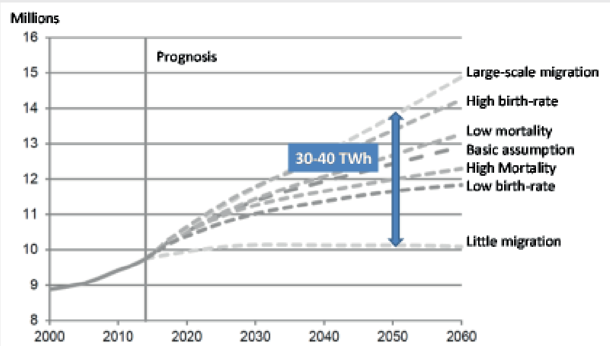
4a) Within the forest industry sector, the electricity-intensive mechanical pulp production increased rapidly during the 1980s.

4b) This production growth declined during the 1990s, and after the turn of the century, mechanical pulp production has levelled off and during the last years even declined. Since the financial crisis of 2008, the global economy has slowed down with a significant impact on the demand for electricity. We have seen a declining electricity demand, particularly in the industry sector. Our reference scenario includes – at least to a certain extent – a (global) recovery of the economy in the decade ahead, which will act as a driving force for a (partial) "recovery" of the last 5-7 years of decline in electricity demand.

5 **Former prognoses/scenarios for the development of the electricity demand have shown a fair precision up to 10-15 years,** but a limited precision in the more long-term perspective of 30-35 years. This is probably true also for our prognoses. The uncertainties in the development as seen in the scenarios, especially beyond 2030, must therefore be regarded as large.

Factors that influence the electricity demand

6 **SCB (Statistics Sweden) has during 2015 revised their population growth projection upwards by 0.5 million inhabitants for 2030 and by 1 million for 2050**, since their previous projection (2012). *This adjustment alone* increases the electricity demand by up to 5 TWh by 2030, and by 5-10 TWh by 2050. In the main projection from 2015, SCB predicts a future population in Sweden of 11.4 million persons by 2030 and 12.4 million by 2050. This can be compared with the current population of 9.8 million. **If we look at the total impact from the population growth on the future electricity demand, it will account for an increase of, at least, 15-20 TWh by 2030 and of 30-40 TWh by 2050** (in our reference scenario).



SCB's most recent population projection (published in May 2015) regarding the development up to 2060, for a "main scenario" (basic assumptions) and for six alternative scenarios/assumptions.

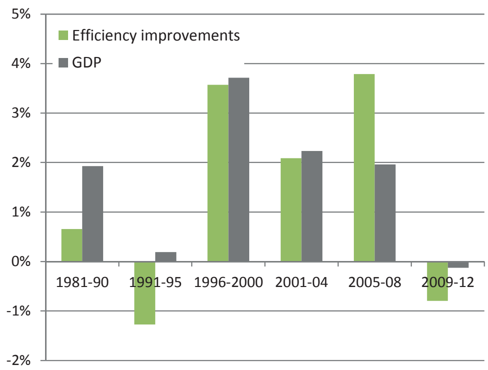
7 **The development of the electricity demand follows the economic development, in spite of a continued "decoupling".** Therefore, the economic development has a significant influence on the development of the electricity demand, and the difference between a slow growth (less than 1.5 % increase of the GDP per year), and a fast growth (up to 2.5 % per year) might be as big as 15-20 TWh by 2030 and 25-35 TWh by 2050.

8 Structural changes and technology shifts have been influencing the development if we look at the history, but they are difficult to predict. In point four above, we have presented the most important breaks in the trends in the housing and service sectors, the industry, and the district heating production. Several of these are caused by structural changes (e.g. increased share of mechanical pulp in the forest industry) and technology shifts (e.g. the "heat pump boom" for heating of single-family houses), that together have had a large impact on the development of the electricity demand. We will likely see structural changes and technology shifts also in the future, but which, and when and how they will influence the electricity demand is hard to tell. Therefore we have been restrictive with assumptions about new structural changes and technology shifts, even if we, of course, have taken the future development of are ongoing changes and shifts into account.

9 Energy efficiency improvement is taking place in all sectors, and it is to a large extent "autonomous", i.e. not driven by a pronounced efficiency improvement policy (not *directly* policy driven). The driving forces behind most of the efficiency improvements are rather economic, technological and structural (even if these three driving forces to a certain extent are influenced by political decision, e.g. taxes, norms and support to technology development and research). Our scenarios are based on the assumption that economic, technological and structural driving forces will continue to be strong or, even stronger over time, in industry as well as in the housing, service and transport sectors.

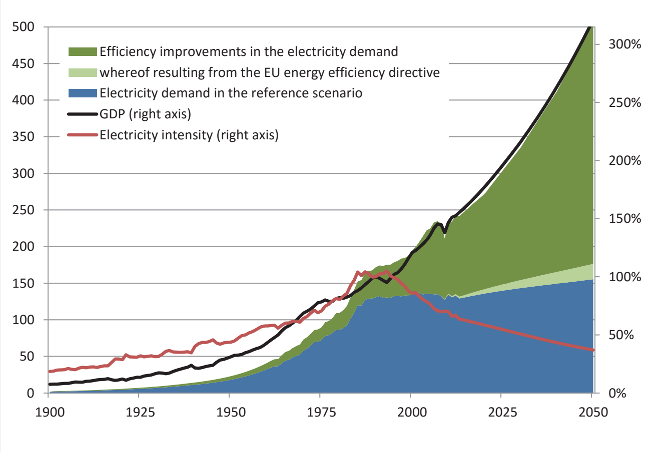
10 Efficiency improvement is (much) more pronounced in periods of economic growth than in periods of recession. The correlation is distinct and in periods of slow economic growth, efficiency improvement is very moderate (close to zero).

Yearly change of GDP, and yearly efficiency improvement of the household electricity. (Source: NEPP's analyses). If the efficiency improvement is compared with the economic term "Household Expenditure" a similar result is attained. Source: NEPP's analyses



11 **The political power in influencing the development of the electricity demand use is limited**, and it is probably easier to increase demand than to reduce it (through political decisions). For instance, a massive introduction of electric vehicles would increase the electricity demand. The use of electric vehicles can be stimulated through political support programs. An increased use of electric boilers for district heating production during periods with very low prices of electricity (even negative prices), would not be attractive unless the taxes for such a use are reduced or entirely eliminated. Such a tax reduction is an uncomplicated political action, which we saw in the low price period during the 1980s and 1990s. These are two examples of political measures that would contribute to an increased electricity demand, maybe as much as 5-10 TWh each. A general stimulation of the economy and the competitiveness, would also result in an increased electricity demand, even if it might at the same time stimulate efficiency improvements. But, it is more uncertain if targeted policy triggered measures, programs and directives for electricity efficiency improvements would have a real impact on the development of the electricity demand, beyond the very large "autonomous" efficiency improvement taken place anyhow.

12 **The EU energy efficiency directive will have a relatively small impact on the development of the electricity demand.** Less than a tenth of the efficiency improvement of the electricity demand in the reference scenario is a result of measures related to the directive. The efficiency directive is aiming at a reduction of the primary energy use in the European Commission's, relative a reference development (in which the primary energy use increases). The most cost-effective approach is not to reduce (or improve) the use of the different energy carriers equally. Electricity use should, for example, not be reduced to the same extent as fuel use.



Electricity demand and electricity efficiency improvement (TWh – Left axis), and GDP and electricity intensity (i.e. electricity demand per GDP unit) relative the levels 1970 (100 % 1970, Right axis).

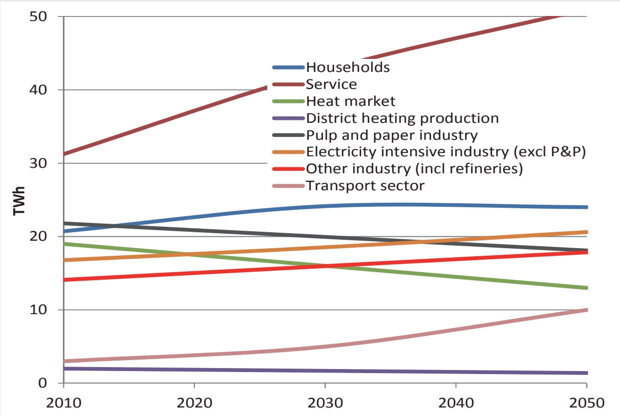
The European Commission's analyses even show a continued slow *growth* of the electricity demand in the EU with an implementation of the energy efficiency directive (but a reduction compared to the reference development). Moreover, the European Commission's analyses show that the electricity demand will be reduced less in Sweden than in EU as a whole, as compared to the reference development.

The electricity demand in different sectors

13

The electricity demand in the service sector continues to grow but not as fast. The increase of household electricity stagnates completely. The electricity use in the service sector (i.e. business electricity in premises and property electricity in premises and dwellings) has increased by 3-4 %/year since 1970, as a result of the population growth, GDP development and the increased standard of living. At the same time there has been a "decoupling" as a consequence of even larger efficiency improvements, and in all our scenarios we assume continued significant efficiency improvements.

Accounting for these developments of the electricity demand projection of the service sector shows only an average growth of 1-2 %/year during the period 2015-2030, and less than 1 %/year during the period 2030-2050. The household electricity demand has, in average, increased by 2 %/year from 1970 up to today. Concerning household electricity demand, in similarity to the service sector demand, the efficiency improvement rate is assumed to increase. Our reference scenario shows an annual average demand increase of only 0.5-1% during the time period of 2015-2030, and 0-0.5% during the period of 2030-2050.



The development of the electricity demand in the reference scenario, sector by sector.

14 **The industry's electricity demand is expected to start growing again in parallel with the presumed economic recovery internationally and nationally, but it is assumed to grow slowly. Electricity demand in the pulp and paper industry will not increase at all.** But, the future development for the industry is still difficult to predict. We have, together with subject matter experts/branch representatives, looked at the factors influencing the electricity demand in the different branches, and we found a relatively large outcome range for the future electricity demand in the industry. The projections in a reference scenario is based on an assumed recovery of the economy the next coming years, and thereafter a somewhat slower rate of growth. At the same time, the industrial electricity efficiency improvement will be strong, which partly reduces the demand of electricity. (A continued "decoupling" between electricity demand and production will thus hold back the increase in electricity demand, despite a significant increase of the production value/value of refinement.) For the electricity intensive industry, the reference scenario shows an increased demand in branches like iron and steel, and chemistry and mining, while the electricity demand will decrease in the forest industry (mainly as a result of a decreased demand for newsprint, and thereby a reduced production of mechanical pulp). In the engineering industry and other less electricity intensive branches electricity demand increases in the reference scenario.

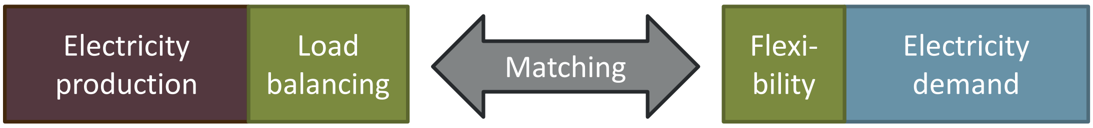
15 **The electricity demand for heating will decline significantly in all scenarios.** The housing and service sector´s energy demand for heating and hot tap water is dominated by district heating, heat pumps, electric heating and biofuels. Taxes and policy instruments have so far greatly influenced when choosing means of heating, and so have the relative investment costs for new heating systems. Also the technical development is of high significance when it comes to choice of heating system and the associated energy carrier, with the increase in heat pumps in the 21th century as a illustrative example. Energy efficiency improvements have a restraining effect on the heating demand which is partly balanced by, for instance, an increased demand for comfort heating. The energy demand for heating is also impacted by new construction and the population development. In the running project *Värmemarknad Sverige (Heating market Sweden)*, the future Swedish heating market has been analysed in four different heating market scenarios. Significant for all of them is a reduced electricity demand, in spite of a growing market share for electricity-based heating in several of scenarios. The reasons behind this are continued heat pump expansion, a continued efficiency improvements in existent buildings, and new buildings with lower heating demands. In the scenarios, the annual electricity demand for heating and hot tap water spans from the current level of 19 TWh to 12-17 TWh by 2010, depending on scenario, to an even lower demand of 9-14 TWh by 2050.

16 Examples of future ”jokers”: the transport, district heating and the IT sector.

If electric vehicles are introduced on a large scale, the electricity demand in the transport sector will increase considerably. Our reference scenario includes an increased electricity demand of about 2 TWh/year by 2030 (which corresponds to 0.5-1 million vehicles that can be run on electricity), and of about 7 TWh/year by 2050. Today there are discussions about using electricity during low price periods for district heating production, but the currently high electricity tax rates are restricting the profitability significantly. If these taxes are reduced or removed entirely, it might promote an increased electric demand of several TWh in the district heating production. In the reference scenario we have not included an increased electricity demand in the district heating production. In the IT sector, server centres are being prospected planned, and also built at several locations. These server centres are energy craving, and a large scale development would increase the electricity demand by several TWh. In our reference scenario we assume only a modest development in Sweden.

The capacity demand

17 **The capacity challenge is all about matching production to demand. The development of the production, rather than the demand will represent a growing challenge!** When the balance between production and demand is stretched, we see high prices of electricity. Hitherto, high prices have been associated with a large electricity demand. In a future with an increasing amount of variable power, the high prices will be related to a large demand as well as to a small production. If, for instance, the production is large in a situation with a large demand, the price of electricity might remain low. And the other way around, the price might be high in a situation with a low demand and a small production. Therefore, in the future it will be the production, more than all, that will be the factor challenging the electricity balance. For the capacity demand, no dramatic changes are expected.



18 **Demand flexibility will increase in importance and will include "new features and applications".** Adaption of the electricity demand is mainly driven by high electricity prices. The role of these demand adaptions, or demand flexibility, will partly change in the future as high prices are predicted to appear more frequently over the year and will also be induced by additional causes compared to today. This will give demand flexibility new functions in the system. We have identified a technical potential of capacity demand reduction corresponding to at least 4000 MW, assuming that demand reduction is limited to a few hours. Half of this potential is a result of load shifting while the other half is due to load shedding

19 **Electricity load will mainly change proportionally to the energy demand.** Electric heating and electric vehicles will define the peaks. The capacity demand from the electricity use will mainly change in parallel with the development of the energy demand. For heating of buildings, the electricity energy demand will most likely decline. The maximum capacity demand will then also decline, even though a bit slower. This will give a somewhat more pointed electric heating load, but at a lower level. In the transport sector a massive introduction of electric vehicles might increase the capacity demand at certain points in time. Here there are no seasonal variation, but a quite distinct diurnal variation. Intelligent loading strategies might reduce the diurnal variation significantly though.

Table: The development of the capacity demand in the electricity use

	Households	Service	Heat market	District heating prod.	Industry	Transport
The development of the capacity demand in the electricity use	Like energy demand	Like energy demand	Reduced maximum effect but somewhat more pointed load	Like energy demand	Like energy demand	Larger diurnal variations

20 **Matching between electricity demand and electricity generation is complicated by some of the policy instruments.** One example is the electricity tax, which even with a zero-price is preventing electricity from being utilised. Conversely, it is illogical that electricity certificates powerfully stimulates electricity generation even when no demand exists.

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