

# **Towards a Sustainable Energy Policy in Sweden**

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## **1. SYNOPSIS**

Sweden is facing a great challenge. It has decided to shut all its nuclear power stations in 2010. This means that there are only 15 years left and still no major steps have been taken to achieve this goal. Nuclear power is now responsible for half the production of electricity and 1/6 of the total energy supply. Who are the alternative energy carriers? What can be accomplished by better energy efficiency and by a more sustainable energy strategy?

## **2. ABSTRACT**

By a referendum Sweden has decided to close all its nuclear power stations already in 2010. At present half the Swedish electricity production and 1/6 of Sweden's total energy use come out of nuclear power. Very little has hitherto been done in order to replace nuclear power. This article discusses and shows, which the obstacles are and how it is possible to replace half of the electricity by Combined Heat and Power Production (CHP). Other solutions in order to get a better sustainability and to reduce energy use are also discussed. Sweden's energy policy development is compared especially with that of Germany, Austria and Denmark.

This paper is based on a historical-humanistic and social scientific perspective. This means that it concentrates on socio-cultural and organisational aspects and to some degree economical, too. Technological elements are not considered that much, since the energy technology for CHP has been well-known for a long time.

## **3. INTRODUCTION**

Sweden is now facing a very difficult energy problem. To a very big extent Sweden's energy use is based on electricity. Out of a total energy demand of 440 TWh in 1993, nearly 1/3 or about 140 TWh was electricity. Almost half of this came from nuclear and nearly half from hydro power. Very little electricity, only about 5 TWh, was produced in other ways. Based on a referendum in 1980 Sweden has decided to close down all its nuclear power plants in 2010, but up till now very little has been done to replace the nuclear power or to reduce the use of electricity. The Swedish water resources are already much regulated and used, and the Swedish parliament has decided not to exploit four remaining, big and unutilized, rivers in Northern Sweden in the future. Thus, the road against more hydro power is closed.

Sweden has big energy resources, big forests and many big water falls. On the other hand, Sweden is sparsely populated and the climate is cold -- thus its heating demand is large. After the Second World War there has been a marked change-over from wood and coal to oil -- as in all Western countries. When the first oil crisis appeared in the autumn of 1973, imported oil amounted to 3/4 of Sweden's total energy demand. After this event - and still more after the new oil crisis 1979 - 80 - the government got more aware of Sweden's exposed position, and an energy policy was formed, aiming at a better energy efficiency, a larger part of domestic instead of imported energy carriers - especially oil. A rather big national energy research programme was started, concerning energy-saving technology.

## **4. METHODOLOGY**

This study focuses on organisational, socio-cultural and economic aspects of energy use and energy policy in Sweden and not on technological ones. Parts of its analyses are based on Thomas P. Hughes' theories of large technological systems (Hughes 1983) and on theories of organisation culture (Alvesson and Berg 1988; Dierkes 1988). It stresses the development of the energy use and policy in Sweden in the last twenty years, but it is also looking into the future. The research is mainly based on official statistics and secondary sources. It is also based on interviews of managers in the energy sector to some extent.

## **5. CHANGES OF ENERGY USE SINCE 1973**

In some respects clear changes have been achieved in the last twenty years. First, in the period 1950-1973 Sweden's total energy use increased very rapidly, but not for the time afterwards (Figure 1). In 1993 the consumption level was still the same as twenty years earlier. Second, in the period 1973-1993 the share of oil diminished from 77% to 43% of total Swedish energy use (Figure 2). Third, the demand for electricity expanded tremendously -- electricity is now mainly used for heating purposes and for industrial processes; but there is a lot of new electrical equipments everywhere in modern society, too. This additional demand has to a small extent been met by more electricity produced by hydro power but the lion's share has come from nuclear power plants. Twelve reactors were built in Sweden in the 1970ies and in the beginning of the 1980ies, but after that none has been built or is planned to be built. In Sweden the first reactors began to produce electricity at the end of the 1970ies. Fourth, district heating (DH) has substantially expanded during the last two decades. In 1993 1.6 million apartments and about 110 000 small buildings were connected to district heating, and about 36 TWh were delivered as DH. This means that DH is very well established in Sweden, which is actually one of the best DH-supplied countries in the world together with Denmark and Finland. And fifth, since the middle of the 1980ies the environmental aspects have been more pronounced. As most Western countries Sweden endeavours to use energy carriers which are as clean as possible, and shows a will to use renewable materials.

The most obvious national, long-term, energy policy has been the big investments in nuclear power, which has doubled the access of electricity, resulting in low prices on electricity and thus making Sweden a pronounced "electrical society".

Thus, even if there are a few signs of a more alert national energy policy in the 90ies, there hasn't been any consistent policy except for short periods since World War II. There has been a harsh time for sustainable energy carriers such as bio-mass and wind power. The economic subsidies have been meager and established energy actors, which are a few big ones in Sweden, have been able to dominate the market. Most of them belongs to the electricity production side (above all Vattenfall and Sydkraft) and their influence on the total energy sector has been enormous, as the prices of electricity has been kept very low and favorable to the consumer. Thus there has been a marked trend to change over from oil to electricity for heating for instance. Low prices on electricity have largely stopped a change-over to other energy carriers or stopped development of other solutions.

Up til now Sweden has done very little to replace the electricity produced by nuclear power, although it's only 15 years left to the closure of the plants in 2010 as decided. The investments in the existing energy systems are so big, that there is a strong reluctance towards new competing energy carriers. One examples of this is the difficulties to expand a natural gas system across Sweden. The Swedish governments have not given -- independently of being social democratic, liberal or conservative -- the gas promoters a fair chance to accomplish their goal: an integrated Swedish (and Nordic) gas net, because of the governmental reluctance to support the construction of a national gas grid. Still, there is a gas net only in the south and west of Sweden, where gas corresponds to about 10-15% of total energy use, but for all Sweden its share is less than 5% (Biel, Lorentzon and Olsson 1994). It has also be established, that when introducing natural gas in energy systems for heating or industry processing or generation of electricity, a major energy saving is made due to the inspection of the energy system, the change from old to modern energy equipment and trimming of the systems (Olsson 1992). A new (future) possibility to expand the natural gas net in Sweden might be to use gas as input fuel in CHP-processes as is now the case in Denmark.

Another is Finland's new interest to get gas link to Sweden in addition to the only one which it has to Russia. For security and competitive reasons it would be favourable for Finland to have a second gas link through Sweden to Denmark and Norway, especially as deregulation and open acces are under way in the EU. The same arguments could of cause be used for Sweden. And the new social democratic government has shown a growing interest for a gas expansion and an integrated Nordic gas grid, but has made few or none steps in that direction yet.

## **6. PROSPECTS FOR MORE CHP IN SWEDEN**

In cold countries like Sweden heating is very important. Thus district heating (DH) is suitable in densely populated areas as cities and municipals, being both flexible and economical. It is for example possible to use industrial waste heat together with bio-mass, oil or gas as input fuel. Combined heat and power production (CHP) has lately been acknowledged as an appropriate way of using energy efficiently and thus of cutting down the environmental impact (Koch 1994). CHP for instance is substantially used in Denmark, but not in Sweden, although Sweden has a well established DH-system. By input of natural gas in stead of oil and coal CHP is now becoming more common in all Europe -- and with much less air pollution than before.

In our research my colleague, Prof. Mikael Hård, and I have studied the growth of DH and CHP after 1945 (Hård and Olsson 1994; Hård and Olsson 1995). We have found, that there are favourable conditions for CHP in Sweden. Modern CHP-plants are very energy efficient since energy transformation can be done in a so-called combi-cycle -- which gives half electricity and half heat and where the energy losses are only 10-15%. It is possible to use coal, oil, gas, bio-mass; waste heat from industrial processes or refuse burning, which makes the system very flexible. The technology is well-known. But we have also noticed that although the prospects are advantageous for CHP in Sweden, very little electricity, only 2-5 TWh a year, is produced in CHP. We state (out of figures and calculations made by the Nutek and the Swedish DH Association), that it is possible to replace about half the electricity of nuclear origin by investments in rebuilding DH- into CHP-plants and in building new ones. This could be a part-solution, for a period ahead. Another part-solution could be a better energy conservation and energy saving, especially in industries and housing.

Based on figures from analyses of the development of CHP in Denmark, Germany, Austria, Sweden, Great Britain and The Netherlands we have noticed, that if there are a few strong energy actors in a country, as Electricité de France in France, British Gas in UK, Vattenfall and Sydkraft in Sweden, they will oppose every newcomer that will threaten their position on the energy market. People and organisations as well as the power producing industries themselves develop a system culture, a common view on the future development of the energy sector. In small countries like Sweden this system culture is especially homogeneous, as the managers often have got their education in the same institute of technology, KTH, (Kaijser 1994, Hughes 1983).

Energy systems have long lead times and are typical economies of scale. Small, flexible units, based on renewable energy, can push their way into the market, only if they are economically supported in an initial phase and if there are strong local or regional promoters or "Fahnenräger" (Knie 1992). In addition, there must be a stable long-term energy policy, because investments are valid for such a long time in the energy sector. Taxation must be not be a disadvantage for a newcomer as for gas and CHP at present in Sweden. For instance, Denmark has much higher electricity prices than Sweden, which stimulates both to electricity saving and to searching alternative energy solutions. The local governments are strong promoters, both as electricity and DH producers and distributors. The expansion of the natural gas system has been carried out all over Denmark and the investments costs for it has been taken by the state and the local governments. Gas has also had a tax advantage in comparison with coal and oil (Olsson 1992).

## 7. CONCLUDING REMARKS

Global threats on our environment can be faced only by a common international policy considering sustainable development (Our Common Future . . . 1987; Jaqueline Cramer 1992). A step towards better energy efficiency and thus better environmental considerations in Europe could be taken by an expansion of CHP, which is a flexible energy system making it possible to use not only different energy carriers as oil, coal, natural gas and bio-mass or electricity from hydro, nuclear and wind power but also waste heat from industrial processes and refuse burning. The Nordic countries, especially Denmark, Finland and Sweden, have expert knowledge on DH and CHP and industries working in this field. Yet we can see, that CHP is not much used except for Denmark, Finland and the Netherlands. Sweden has enormously expanded DH during the last two decades but has still very little electricity production in CHP. Why?

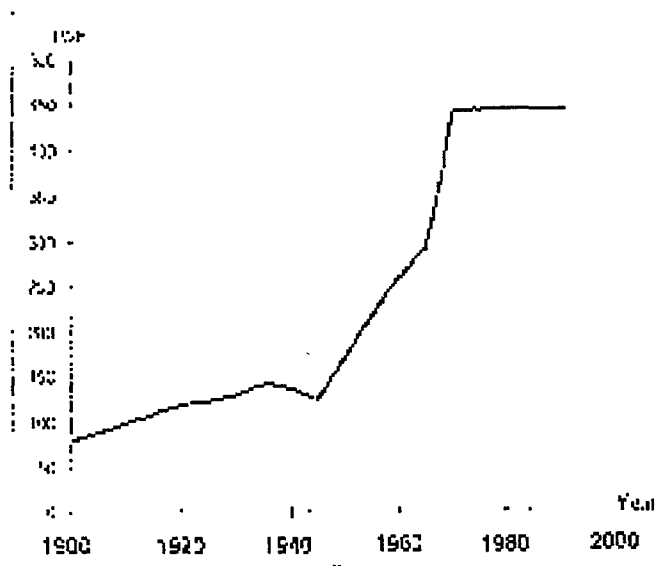
The energy policy will be conservative and new energy carriers will be kept out of the market if there are just a few very strong actors dominating the energy scene of a country. New solutions are blocked -- both by the big companies and the government. Leaders, industrial or governmental dealing with energy matters, are characterized by the same corps spirit, as they often are educated at the same institute and all of them therefore belonging to the same energy elite. This is particularly true in small countries. This inertia can be clearly seen when introducing new, not yet established energy technologies in Sweden. Where there are many energy actors competing and where there are strong local authorities there will be more room for small-scale energy plants and flexible energy solutions. It will be easier to carry through a consistent long-term policy to reach an energy goal. This can be seen in Denmark which has a flexible energy system allowing many types of energy carriers and which has accomplished a natural gas grid all over the country. Denmark is one out of very few industrialised countries that have managed to lower their total energy demand over the last two decades. A more sustainable energy policy in Sweden can be accomplished only if there is a long-term energy policy aiming at energy efficiency and giving room for alternative sustainable energy carriers as bio-mass and wind-power. An expansion of CHP might be a step away from nuclear power, but it has to be combined with other solutions, making both the energy producers and consumers more aware of energy saving and the use of renewable energy carriers.

In a global context it is very important that leading industrialised countries show responsibility to the environment and let other countries benefit from their advanced technology. The Nordic countries which are among the best qualified according to energy technology can contribute a lot here, first in Europe and EU, where Denmark, Finland and Sweden now are members -- and secondly globally.

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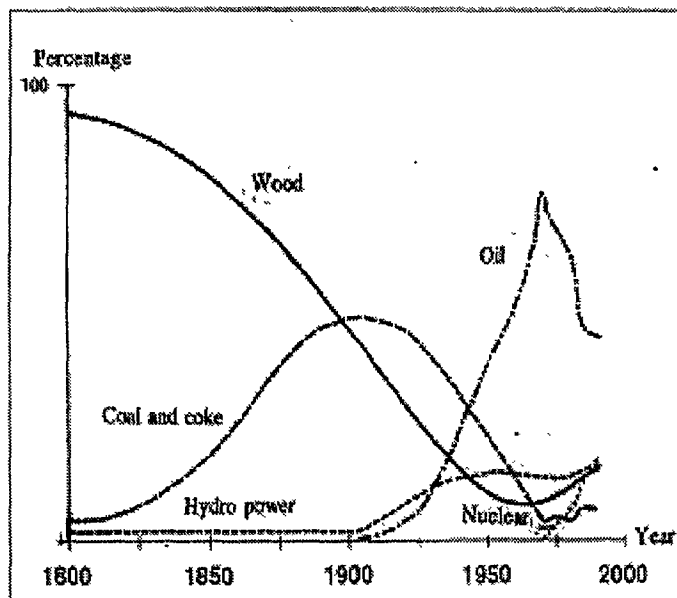
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Figure 1. Sweden's total energy use since 1990 in Twh.



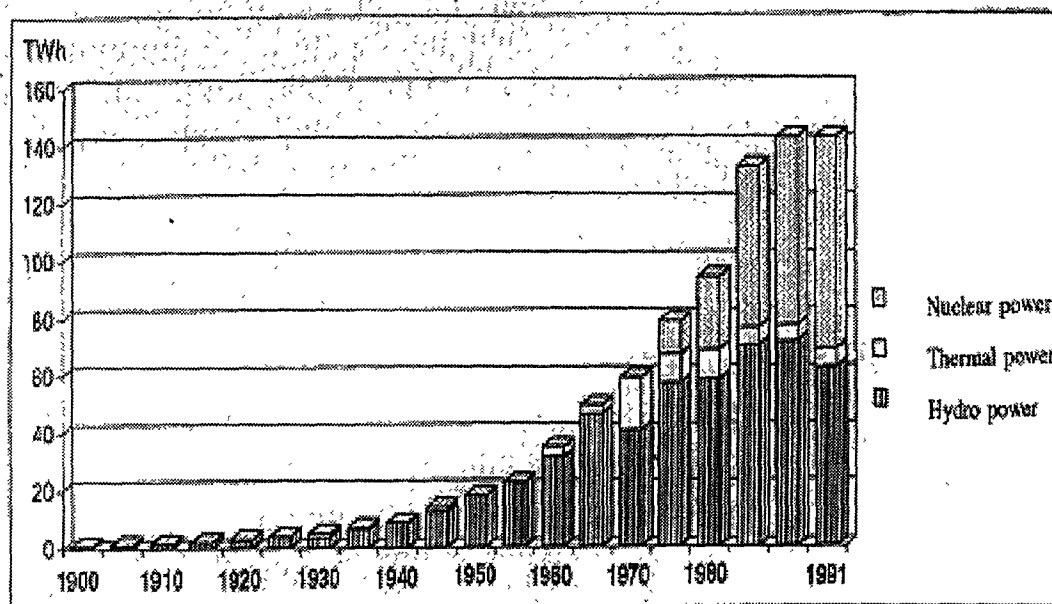
Source: Olsson, Sven-Olof. 1993. *Energihistoria med miljökonsekvenser*. In: Furuhausen Birgitta (ed), *Äventyret Sverige*, p. 229. Utbildningsradion, Stockholm.

Figure 2 Sweden's Energy Use 1800-1990. Energy Carriers In Percentage.



Source: Olsson Sven-Olof. 1993. *Energihistoria med miljökonsekvenser*. In: Furuhausen Birgitta (ed), *Äventyret Sverige*, p. 229. Utbildningsradio.

**Figure 3.** Sweden's electricity production 1990-1991. In Twh and divided in hydro, thermal and nuclear power.



Source: Olsson, Sven-Olof. 1993. *Energihistoria med miljökonsekvenser*. In: Furuhausen Birgitta (ed.), *Äventyret Sverige*, p. 229. Utbildningsradion, Stockholm.