



IEA BIOENERGY PROGRAMME

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1. INTRODUCTION

The energy sector of Sweden is in a stage of transformation as a response to several new conditions. This seems to be true also for the sub-sector bio-energy. Thus, a prolongation of trends for the historical data and information in the presented statistical tables and charts in this report would not necessarily be the most appropriate method to predict future development. However, the historical data can be used to determine the starting points for new development trends.

Examples of these new or changed conditions are: an established (?) high price level for crude oil; signs of an emerging shortage of biomass raw material in northern Europe which has led to sharp price increases for raw material especially in neighbouring countries; and strong political commitments for future independence of fossil fuels.

In the field of bioenergy, the focus of technical R&D has shifted from issues related to utilization of inferior surplus biomass, to planning for rational and integrated use of available biomass resources. This includes, not only CHP (combined heat and power), but bio-refineries for combined production/generation of e.g. pulp, propellant fuels, pellets, heat and electricity.

Three major aspects are supporting the transformation of the energy sector: long term sustained security of supply, environmental sustainability, and energy cost efficiency. At present, all three aspects are included with more or less equal weight in the policy decisions for future development.

Table 1. Sweden in brief

| | |
|------------------|-----------------------|
| Population | 9.2 million |
| Land area | 41.3 million hectares |
| of which | |
| forest | 23 |
| bogs and swamps | 4.5 |
| barren mountains | 4.4 |
| agriculture land | 3.4 |
| others | 6 |



Supply and use of energy in Sweden 2005, TWh and PJ

Supply

| Total energy supplied | TWh | PJ |
|------------------------------|------------|-------------|
| Crude oil and oil products | 197 | 711 |
| Natural gas, gasworks gas | 10 | 36 |
| Coal and coke | 28 | 101 |
| Biofuels, peat, waste, etc | 112 | 403 |
| Heat pumps.(net) | 6 | 22 |
| Hydro power | 73 | 262 |
| Nuclear (incl. waste heat) | 210 | 755 |
| Wind Power | 1 | 3 |
| Import-export electricity 4 | -8 | -27 |
| Total | 630 | 2267 |

Source: Energimyndigheten

Use of Energy

| Losses and use for non-energy purposes | | |
|---|------------|------------|
| International marine bunkers and use for non-energy purposes | 44 | 160 |
| Conversion and distribution losses (excl. nuclear power generation) | 47 | 171 |
| Conversion losses in nuclear power generation | 137 | 492 |
| Subtotal | 228 | 823 |

The use of energy as it emanates from different energy carrier was as follows:

| Total final use per energy carrier | | |
|--|------------|-------------|
| Oil products | 133 | 479 |
| Natural gas, gasworks gas | 7 | 27 |
| Coal, coke | 17 | 61 |
| Biofuels, peat, waste etc (direct use, not including use for electricity and district heating) | 66 | 237 |
| Electricity | 131 | 472 |
| District Heating | 47 | 170 |
| Subtotal | 402 | 1446 |
| Total final use, losses and non-energy purposes | 630 | 2268 |



The use of energy for various sectors was as follows:

Total final use per sector

Industry

| | | |
|---------------------------|------------|------------|
| Electricity | 57 | 205 |
| District heating | 5 | 19 |
| Oil products | 21 | 76 |
| Natural gas, gasworks gas | 5 | 17 |
| Coal, coke | 17 | 61 |
| Biofuels, peat, etc. | 51 | 183 |
| Subtotal | 156 | 560 |

Transport

| | | |
|-----------------|------------|------------|
| Electricity | 3 | 10 |
| Oil products | 96 | 347 |
| Natural gas | 0 | 1 |
| Ethanol | 2 | 6 |
| Subtotal | 101 | 364 |

Residential, services, etc.

| | | |
|---------------------------|------------|------------|
| Electricity | 72 | 258 |
| District heating | 42 | 150 |
| Oil | 16 | 57 |
| Natural gas, gasworks gas | 2 | 9 |
| Biofuels | 13 | 48 |
| Subtotal | 145 | 522 |

| | | |
|-----------------------------------|------------|-------------|
| Total final use in sectors | 402 | 1446 |
|-----------------------------------|------------|-------------|



2. POLICY

For a very long time, the Swedish energy policy issues have focused primarily on the pros and cons of nuclear energy. The opinions have been split from mid 1950's and onwards, more or less in two equally strong sides, one for "high tech" (nuclear), the other for organic growth (CHP, district heating, local energy) Ref. Kaiser, A., Kåberger, T. Still to-day, when a general consensus is expressed regarding the long term goals – renewable energy – these different views are embedded in the energy policy issues.

The current energy and climate policy.

Sweden's new government, a coalition of four parties, "Alliance for Sweden", took office on 6th October 2006. In the government's Statement of Policy, the Prime Minister sets out the government's intentions for the coming mandate period. In its Budget Bill for 2007 (presented to Parliament on 16th October, 2006), the new government sets out its proposals on its policy regarding Area 21, Energy:

- The government intends to invite all parliamentary parties to agree on a wide-ranging and long-term energy policy accord.
- The government's objective is to break the historical connection between economic growth and greater use of energy and raw materials, by means of improving the efficiency of energy use.
- Sweden's environmental activities will be determined by ambitious environment and climate targets, accompanied by clear plans of action. Strong actions will be taken in the transport, residential and industry sectors.
- Environmental and energy taxation will be designed in form of incentives for individuals and companies to act responsibly in energy and environmental matters. Taxes and regulations will promote more efficient use of energy aiming at energy conservation measures in industry and in the residential sector.
- The specific green taxation will be suspended, aviation tax will be discontinued, and harmonization with the EU Energy Taxation Directive will take place. A reduction of the energy tax on electricity in northern Sweden will be proposed.
- No political decisions on a phase-out of the country's nuclear reactors will be taken during the 2006-2010 mandate period. The nuclear plant at Barsebäck will not be allowed to restart. The ban on constructing new reactors will remain in force, and the government intends to consider the applications for increases in nuclear power output in accordance with existing legislation.
- The government will appoint a commission to review the specific problem that many Swedish nuclear power plants are jointly owned by leading energy corporations.
- An incentive will be introduced to encourage the use of environmentally friendly vehicles.
- Expansion of combined heat and power generation will be encouraged.
- Small-scale hydro power will be entitled to green electricity certificates also after 2012.



- The government will introduce special funding for development and acceleration of the planning process for new wind power installations.
- Sweden will press for clear targets within the EU for reduction in the use of fossil energy.
- The EU Emissions Trading Scheme should be expanded in terms of parties covered and of substances, and efforts should be made to bring more countries into the system. The Kyoto Protocol should be extended (i.e. continued) as soon as possible.
- Sweden will press for the establishment of a strategic energy agreement between the EU, China and India. Swedish aid to developing countries will remain at a high level with greater importance attached to environmental and energy considerations.
- Support for climate investments will be increased, particularly for biomass based motor fuels.
- The budget allocations for research will be increased. SEK 1000 million (€110 million) will be invested in climate research.
- Targets in terms of converting research results into commercial products and services should be raised.
- Energy matters will be transferred from the Ministry of Sustained Development to the Ministry of Industry and Commerce.

Excerpts from Government Policy and Budget Bill (bill no. 2006/2007:1)

Policy measures and incentives

A number of policy measures and incentives have been introduced in order to achieve the objectives set out in the energy and climate policy. The overall objectives are: to ensure the supply of electricity and other energy to create favourable conditions for efficient use of energy and a cost-efficient supply of energy having a low negative impact on health, the environment or climate, and to promote the transformation to an ecologically sustained society.

For several of these overall objectives, it will be important to increase the proportion of renewable energy, to improve energy efficiency, to reduce the use of energy in absolute terms and to reduce emissions. One general means of achieving energy policy objectives, and which is intended to help to meet several of the objectives, is energy taxation, in the form of an energy tax as such, carbon dioxide tax and sulphur tax. Other important policy measures and incentives are the electricity certificate trading scheme, the energy efficiency improvement program, policy measures for infrastructure and transport, technology procurement, the climate investment program, and information activities. Emissions trading (ETS), and Research, Development and Demonstration (RD&D) constitute important elements of a long term development strategy.



Table 1: Main groups of policy measures

| <u>Administrative</u> | <u>Economic</u> | <u>Information</u> | <u>R&D</u> |
|---|----------------------------|--------------------|-------------------|
| Controls | Taxes | Information | Research |
| Limit values for Emissions | Support, grants, subsidies | Advisory services | Development |
| Target values for fuels and energy efficiency | Lodging of securities | Training | Demonstration |
| Long-term agreements | Emission trading | Opinion formation | Commercialization |
| Environmental classification | Certificate trading | | Procurement |

Taxes

Energy taxation

The original objective of energy taxes was to finance the State's public spending requirements, but in later years the emphasis has increasingly been on the need to control the production and use of energy in order to achieve various energy and environmental policy objectives. The present energy taxation policy aims at improving the efficiency of energy use, encouraging the use of renewable energy, creating incentives for companies to reduce their environmental impact and creating favourable conditions for generation of electricity. During the oil crises of the 1970s, the aim was to reduce the use of oil. The environmental element of energy taxation was given greater importance at the beginning of the 1990s, and ever since Sweden joined the EU, there has been a progressive alignment of Swedish taxation with EU regulations. The earlier Mineral Oils Directive and the associated Tax Rate Directive have been complemented by new minimum taxation levels as part of the process of harmonization of taxation of fuels and electricity throughout the EU. Therefore, a new Swedish taxation model is being developed at present, aiming at a coordinated and consistent taxation structure. The present energy taxation system is complicated. There are different taxes on electricity and fuels, on CO₂ and sulphur emissions, and a levy system on NO_x emissions. The taxes can then vary, depending on whether the fuel is being used for heating or as a motor fuel, whether it is being used by industry, domestic consumers or the energy conversion sector and, in the case of electricity, what it is being used for and whether it is being used in northern Sweden or in other parts of the country.



Types of taxes and tax rates

'Energy tax' is an umbrella name for spot taxes on fuels and electricity. They can be roughly subdivided into fiscal taxes and environmental incentives. This latter group of taxes includes carbon dioxide and sulphur taxes. However, there is no distinct boundary between the types, as both groups have incentive effects as well as a fiscal function. The general energy tax, which has existed for several decades, and with varying purposes, is levied on most fuels, based on various factors such as their energy contents. The carbon dioxide tax, which was introduced in 1991, is levied on the emitted carbon dioxide.

The electricity certificate system

Since the beginning of the 1990s, several different systems intended to support the production of electricity from renewable energy sources have come and sometimes gone. They have included investment grants for the production of electricity from biomass, wind power and small-scale hydro power, as well as an operational subsidy for electricity generated from wind power, known as the environmental bonus.

In 2003 a new support system started for renewable electricity production, based on trading in electricity certificates for renewable electricity. The certificate trading system is complemented for wind power production by environmental bonus which, in 2005, amounted to 9 öre/kWh (about 0.01€kWh) for onshore production and 16 öre/kWh (about 0.018 €kWh) for offshore production. It is intended that a progressive reduction of this subsidy would take place.

The electricity certificate system is intended to reduce the production costs and support the development of new production in the long-term by creating competition between different types of renewable electricity production. Producers receive one certificate unit for each MWh of renewable electricity that they produce. Qualifying renewables are electricity from wind power, solar energy, geothermal energy, certain biofuels, wave energy and certain hydro power.

With effect from 1st April 2004, electricity produced from peat in cogeneration plants has also qualified for certificates. All electricity users, with the exception of energy intensive industries, are required to buy certificates corresponding to a certain percentage of their electricity use. In 2005, users had to buy certificates corresponding to 10.4 % of their electricity use. The proportion of certificates that users are required to buy (their quota obligation) varies from year to year:

During 2005, the average price of one unit of electricity certificate was SEK 216 (€23). The system covers only electricity produced in Sweden.

The aim of the certificate trading system is to produce a greater proportion of the country's electricity from renewable sources, an increase by 10 TWh between 2002 and 2010 is the indicative target. In June 2006, Parliament decided on changes in the electricity certificate system. The target for renewable electricity Production was raised by 17 TWh for the target year 2016 (as compared with production in 2002), and extending the life of the scheme itself to 2030. Quota obligations have been set for this entire period, and the number of allocated certificates was adjusted for the period 007-2010.



Energy efficiency in energy-intensive industries.

An energy tax, 0.5 öre/kWh (0.05 eurocent), on electricity used in manufacturing industry was introduced on 1st July 2004. It is possible to receive full tax rebate for companies which commit themselves to participation in an energy efficiency improvement program. More than 100 companies participate in the program, operating about 270 separate plants. In total, they use about 30 TWh/year of electricity in their manufacturing processes, which means that they receive a total tax reduction of about SEK 150 million (about €16 million) per year. Most of the companies are in the pulp&paper industry, the wood products industry, the chemical industry.

Energy in buildings

Building regulations

A wide range of policy measures are used in order to reduce energy consumption in buildings. The target for the measures is that buildings must be designed and constructed to reduce overall heat losses and for efficient use of electricity.

Energy declarations

Owners of buildings are required to provide information on the use of energy together with certain parameters of the indoor environment, in form of an energy declaration.

Investment grants for solar heating

The purpose of the solar heating grant is to encourage solar heating technology for detached houses, apartment buildings and certain types of commercial premises. The grant is in the form of a subsidy for installation of solar heating systems for space heating and/or domestic hot water production.

Support to conversion of heating systems

Owners of detached houses, apartment buildings or other premises associated with residential premises having direct electric heating can receive a grant for the cost of partial or complete replacement of such heating systems by district heating, heat pumps, or by bio-energy boilers. The grant is also available for replacing oil fired heating systems. The grants are available for the period 1st January 2006 to 31st December 2010:

Tax relief

For new detached houses the owner can apply for tax relief for the installation of a biofuel fired facility, such as a pellets-fired boiler, as the primary heating source. The boiler must be able to provide both space heating and domestic hot water, and must also be the main source of heating in the house.

Transport

There are several different types of policy measures affecting the transport sector. Energy tax and carbon dioxide taxes on motor fuels are indexed annually following cost



developments. The energy tax is mostly fiscal in its purpose, while the carbon dioxide tax is intended to reduce net carbon dioxide emissions from fossil fuels.

Biomass-based motor fuels are exempted from energy taxation. The intention is to encourage the introduction of new motor fuels, as well as to improve their security of supply in the longer term. Support to domestic production and increase of the security of supply are the purposes of the customs import duties on ethanol, which were introduced on 1st January 2006. (the present government is not in favor of such import duties, but wants to harmonize duties within the EU) The Act also states that larger petrol stations must provide renewable motor fuel.

Technology procurement

Technology procurement is a policy measure intended to encourage the development of new energy-efficient technology. Various technologies are tested and evaluated by an independent party and one more winners are announced. The winners are given assistance with market introduction, and are guaranteed an initial order. Technology procurement is intended to encourage the spread of new, efficient technology in the form of new products, systems or processes. Its main application areas are in the fields of heating and control systems, domestic hot water and sanitary systems, ventilation, white goods, lighting and industry. Since 1990, 56 different technology procurement projects have been initiated and financed.

Energy RD&D activities, and commercialization

The Government Bill on Research and New Technology for a Future Energy System presents a long-term program for RD&D with the aim of developing technologies and processes for the transition to a sustainable energy system. The budget for RD&D in the energy sector for 2006 was considerably increased over that for 2005, when it had been severely cut. In the Bill, the Government states that an annual budget on the same level as that for 2006 would be required in order to reach the targets regarding the restructuring of the energy system.

Current guidelines call for an overall objective to develop cost effective energy systems based on renewable energy sources, and to develop systems for more efficient use of energy. A holistic approach is important, and special efforts are made to cover the relationships between man, society, technology, economics and the environment.

Activities are structured in six theme areas:

Energy System Studies

Energy Use in urban Environment

Transport

The Energy-intensive industry

The Power System

Fuel based Energy Systems.

Research in the field of **energy system studies** aims at improving knowledge and competence in energy systems and international climate policy issues. The research



focus on energy and climate related policy measures, the function of the energy markets, energy-related climate issues, behavioural science, as well as innovation and implementation factors etc.

The research field **energy use in urban environment** includes the supply and distribution of heating, electricity for domestic and services systems. The work include several different technology areas, such as small scale combustion of biomass fuels, district heating and district cooling, heat pumps, solar heating and energy systems.

The **transport** theme area includes RD&D of biofuels, combustion engines and electrical drive systems. In the longer term, improvements in combustion engines and electrical drive systems should result in substantial reductions in the fuel consumption of cars and of heavy vehicles. Research into electrical drive systems is concentrated on electrical and hybrid vehicles, and on fuel cells.

The **energy-intensive industry research** area gives priority to improvements in the efficiency of energy use, particularly for energy intensive processes in the pulp and paper industry and in the steel industry. Gasification of black liquor can provide the forest products industry with a fuel for additional electricity production capacity, and may also provide a means of motor fuels production.

The **power system research** area includes hydro power, wind power, solar cells, wave power, power transmission and energy storage in the power system. Research in wind power aims at improving conditions for an increase in the country's power supply from wind, and for reducing costs. The RD&D in the field of solar cells are concentrated on thin-film solar cells and nanostructure cells, as well as on their integration, installation and use in buildings. Research in power transmission systems and energy storage in power systems is deals with the support to new technologies and means of production.

The **fuel based energy systems** research area includes RD&D on sustainable biomass fuel production and energy conversion. Research in the area is intended to reduce costs and to utilize a greater proportion of the overall production potential. Sweden is leading country in terms of production and use of solid forest based fuels, such as pellets. Heating and combined heat and power production technologies are studied in order to acquire knowledge that can be used to improve efficiency.

Particular importance is attached to the development of **three larger bioenergy-related pilot plants**, covering the entire chain from research to demonstration. A pilot plant for ethanol production is in operation in Örnsköldsvik, and a demonstration plant for the second generation biofuels in Värnamo for gasification of biomass is re-commissioned after a major conversion. Public funding is also supporting a pilot plant for black liquor gasification in Piteå. Black liquor gasification in the pulp industry would improve the efficiency of chemicals recovery and the efficiency of energy processes. A potential of about 10 TWh/year of electricity production is estimated for Sweden through this process. Alternatively, this process could be used to produce motor fuels for about 30 % of the present demand for propellant fuels in the transport sector.



The climate investment program (Klimp)

The Klimp, (climate investment program) supports local authorities in form of grants for measures intended to reduce emissions of greenhouse gases in Sweden preferably by application of interesting new technology. Klimp has been running since 2003. However, to some extent it can be regarded as a continuation of previous local investment programs with similar purposes. Klimp provided grants in 2006 to an amount of SEK 317 million for 25 climate investment projects, in total worth SEK 1200 million. In total, the measures are intended to reduce annual emissions of greenhouse gases by about 203 000 ton, and to accomplish energy saving by 215 GWh.

Information activities

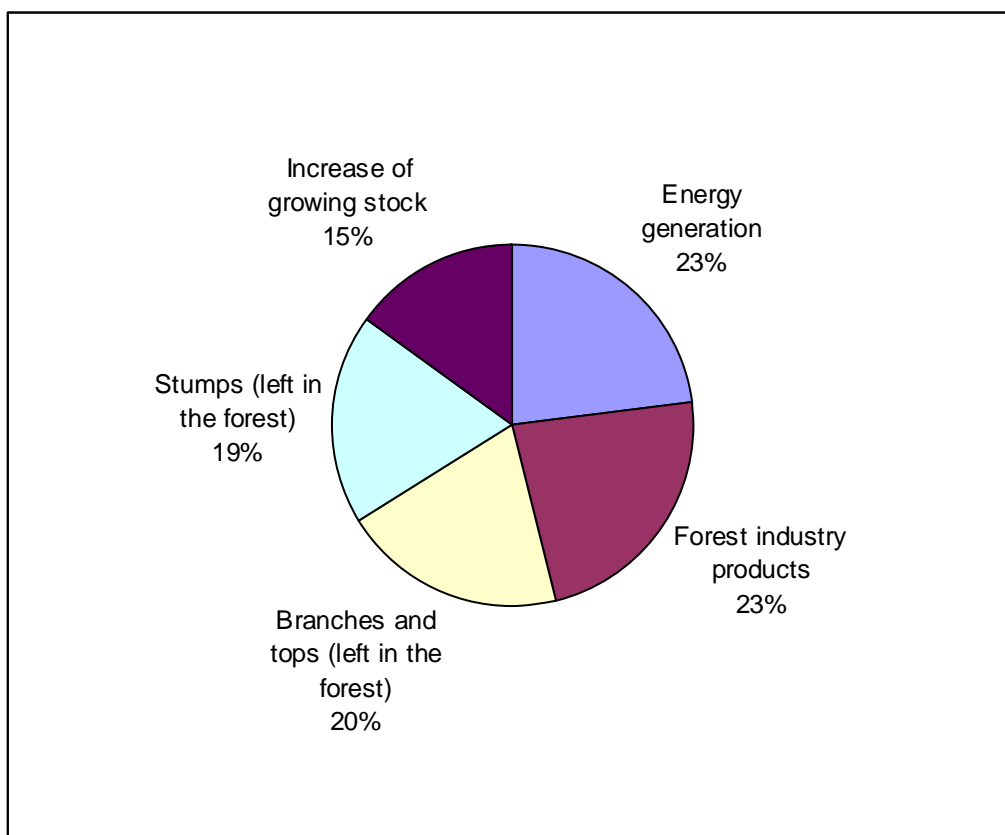
The fact that increase in knowledge and understanding will influence human behavior in given situations means that information activities occupy an important and central part among the policy measures available to get acceptance for the transformation of the energy system. Here, the local energy advisors constitute a unique network available in local districts throughout the country. They provide the general public, small companies and organizations with impartial advice, tailored where appropriate to local conditions. These advisors are, in turn, backed up by regional energy offices that provide training and coordinate information activities.



3. BIOMASS RESOURCES

Biomass from forestry in Sweden.

The total annual biomass production in the Swedish forests is estimated to be about 76 Modt (Megaton oven dry substance). It corresponds to about 1.36 EJ. More than half of that quantity is left in the forest site, due to market restrictions and restrictions of technical, environmental, economic, etc. reasons.



Source: Swedish Board of Forestry, 2006



One example of the predictions of a “realistic potential”, e.g. after considering future restrictions, is listed below.

| | TWh | PJ |
|---|------------|------------|
| Branches and tops | 57 | 205 |
| Trees from early thinning, etc. | 13 | 47 |
| Split fuel wood | 9 | 32 |
| Wood from non-forest land | 3 | 11 |
| Cull logs and breakage | 6 | 22 |
| SUBTOTAL | 88 | 317 |
| Stumps (est.) | 20 | 72 |
| SUBTOTAL, Forest Fuels | 108 | 389 |
| Woody by-products (bark, saw dust, chips) | 27 | 97 |
| Recycled wood from Swedish sources | 4 | 14 |
| Black liquor from the pulp industry | 40 | 144 |
| TOTAL | 179 | 644 |

Source SLU, P. Hagström. 2006, except the value for stumps, which is estimated by SCA. 2007.

Biomass from agriculture

The total annual bio-energy production potential of Swedish agriculture is estimated by the Commission on Bioenergy from Agriculture (SOU 2007:36) to be as follows:

| | TWh | PJ |
|---|----------------|-----------------|
| Set-aside land | 5 -10 | 18 -36 |
| Land presently used for exported grain | 4.5-7.5 | 16 – 27 |
| Land used for surplus fodder production | 5-7.5 | 18 – 27 |
| Increased production efficiency | 4 -14 | 14 – 50 |
| Total | 19 – 39 | 66 – 140 |

It should be noted, that the total potential estimate is based on generic policies regarding the Swedish self-sufficiency for basic food.



Current energy use of biomass for energy in Sweden

Consumption of biomass fuels in Sweden 2006, including peat. (*Note! Some double accounting occurs.*)

| | MWh | GJ |
|--|-------------|------------|
| Industry | | |
| . pulp industry, black liquor | 38.7 | 139 |
| . pulp&paper industry, other by-products | 8.3 | 30 |
| . saw mills, by-products | 5.1 | 18 |
| . other industries | 3.5 | 13 |
| . for electricity generation, all industries | 4.8 | 17 |
| Total industry | 60.4 | 217 |
| District heating | | |
| . recovered biomass fuels | 8.3 | 30 |
| . wood fuels | 19.9 | 72 |
| . tall oil | 0.7 | 3 |
| . peat | 2.0 | 7 |
| . others | 3.6 | 13 |
| . for electricity generation | 6.1 | 22 |
| Total, district heating | 40.5 | 147 |
| Pellets | | |
| . small scale users | 2.9 | 10 |
| . large scale users | 5.1 | 18 |
| Total pellets | 8.0 | 28 |
| Split firewood | 9.0 | 32 |
| Other | 1.0 | 3 |



| Propellant fuels | Cubic meters |
|------------------|--------------|
| . ethanol | |
| - low mixture | 250 000 |
| - E 85 | 110 000 |
| - Busses, etc | 16 000 |
| . FAME | |
| - low mixture | 56 000 |
| - other | 5 000 |
| | TWh |
| . biogas | 0.25 |

Sources: STEM, SVEBIO



4. LARGE SCALE USERS OF BIOMASS FUELS

Current users of biomass fuels

CHP (Combined heat and power)

| | |
|---------------------------------|-------------|
| In district heating utilities | 44 units |
| Industry sector (back-pressure) | ca 30 units |

| | |
|---|-----------|
| <u>District heating distribution networks</u> | 264 units |
|---|-----------|

Planned investments for CHP and back-pressure power generation in the period 2008-2012 in utilities and industry.

Total investment amount SEK 44 billion (€ billion)

Number of new projects

| | |
|--------------|--------------------|
| - industry | 19 projects |
| - utilities | 47 projects |
| Total | 66 projects |

New planned electricity generation from biomass (2012)

| | |
|--------------|-------------------------|
| - industry | 1.5 TWh per year |
| - utilities | 5 TWh per year |
| Total | 6.5 TWh per year |

Source: SVEBIO



5. FUEL PRICES

Published statistics on fuel prices exist for wood fuels. It is based on information from about 200 district heating utilities and about 20 industries. The statistics reflects the costs at the mill site for the various wood fuels per three month periods. The validity of the statistical data is often criticised by the users as it registers the cost irrespective of spot deals or long term contracts.

Wood fuels, SEK/MWh, excluding VAT, at plant site. (1 SEK/MWh appr. €0.03/GJ)

| | <u>2003</u> | <u>2004</u> | <u>2005</u> | <u>2006</u> | <u>2007:1</u> |
|-----------------------|-------------|-------------|-------------|-------------|---------------|
| Forest chips (“grot”) | | | | | |
| - to industry | 131 | 125 | 121 | 119 | 129 |
| - to utilities | 126 | 138 | 137 | 146 | 153 |
| Bark, saw dust, etc. | | | | | |
| - to industry | 90 | 112 | 95 | 112 | 148 |
| - to utilities | 109 | 114 | 121 | 128 | 123 |
| Recovered wood (“RT”) | | | | | |
| - to utilities | 71 | 74 | 80 | 78 | 69 |
| Pellets, etc. | | | | | |
| - to utilities | 196 | 206 | 204 | 211 | 233 |

Official price data for other biofuels are not available.



6. INTERNATIONAL TRADE IN BIOENERGY

1. Background and brief history

International trade within the bio-energy sector started early in Sweden. Several factors coincided to develop strong drivers for that development of international trade, i.e. public policies, the structural pattern of the end users, and the traditions and contact patterns of the Swedish industry with regard to international trade.

Most cities in Sweden had district heating systems originally based primarily on combustion of imported oil. When the policy measures led to change to solid renewable fuels that structure was also suitable for import of these fuels.

Major companies in Sweden related to the bio-energy sector were and are working in international markets. That is true for enterprises e.g. in the forest industry and in the combustion technology. Therefore, sourcing of raw material, shipping and international trade were already parts of their established businesses, and consequently it was relatively easy in the emerging bio-energy trade to mobilize competence to carry out economic analyses and to go on with practical handling.

In a comparably small scale the import of bio-energy took place in the period 1975-1990. It was mainly cheap fuels in form of waste from the food industries, e.g. olive kernels and other similar fuels which could compete with coal in a direct price comparison.

After 1990 the import grew due to introduction of stronger incentive measures and to the development of new sources: (1) the opening of direct access to cheap biomass in the Baltic states, and (2) the stricter rules for wood waste handling and combustion in Germany and Holland which led to a flow of very cheap fuel from recovered wood (“RT-chips”) to those existing plants in Sweden which already had feasible combustion technology for those fuels. However, after some years, the construction of similar plants in e.g. Germany has led to a decrease and almost to a stop in that flow.

2. Biomass flows at present

The user pattern differs with the various biomass products. Imported fuel such as chips, bark, saw dust, and fuel chips from imported round-wood are utilized primarily in large and medium sized district heating utilities. The typical importing utility plants are located at or near suitable ports. The same pattern is true for industrial users. The map below shows the general city pattern, which corresponds to locations of utility plants and industry plants. Thus most plants are located at sites with suitable logistics for import of biomass fuels.



With the introduction of electricity certificates and tradable emission rights, the process industries, in particular the forest industries increased their use of biomass fuels and consequently also increased their use of imported wood fuels.

In free and open competition with domestic biomass fuels, imported wood, pellets and briquettes are also used in district heating utilities. In an increasing rate these types of imported fuels, in particular wood pellets, are also used in small and medium scale burners in individual households, small energy heating units, schools etc.. In these cases fuels are imported by middle men or distributors.

Propellant fuels, e.g. ethanol are used by the main oil companies either as low mix (5%) in petrol or as 85% ethanol fuel (E 85).



2.1 Quantities and types of biomass

The official statistics is a poor source of information for biomass import. Biomass is imported under different definitions and it is often mixed with other categories of products. This is especially true for wood in unrefined forms.

Round wood in form of pulp wood and saw logs is normally imported in debarked form, and as the bark is used for energy purposes it could be classified as “imported biomass”. The same could be the case for saw dust and other residues from imported logs.

Moreover, a portion of the round wood import consists of energy wood for direct use (after comminution) for energy generation. However, the import statistics does not separate round wood directly used for fuel.

A rough estimate of the bio-energy portion of that import can be carried out based on the total import of wood.

Total import of wood (Board of Forestry)

| | <u>2005</u> | <u>2006</u> |
|--|-------------|--------------|
| Round wood million m3 solid under bark | 8.7 | 6.7 |
| of which coniferous | 46 % | 47 % |
| broad leaved | 54 % | 53 % |
| and | | |
| saw logs | 12 % | 12 % |
| pulp wood | 88 % | 88 % |
| Chips, million m3 solid, | 2.1 | 1.6 |
| of which coniferous | 83 % | 82 % |
| broad leaved | 17 % | 18 % |
| Wood residues m3 solid | 805 000 m3 | 1 018 000 m3 |



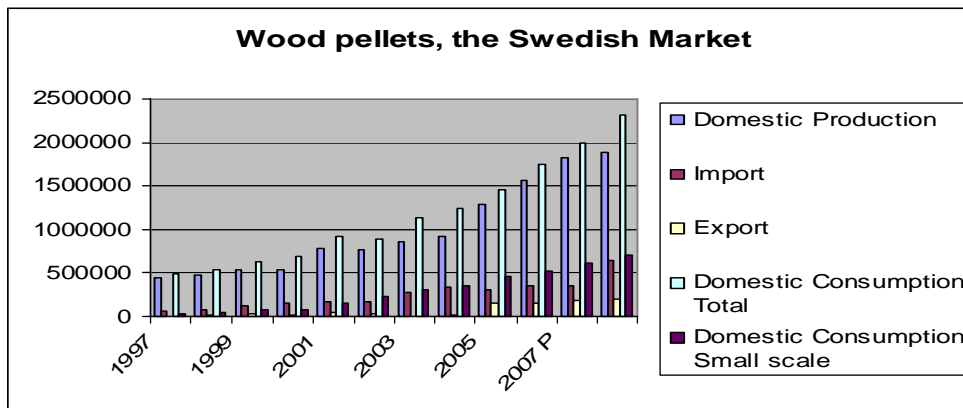
The bioenergy portion of the wood import can roughly be assumed as follows: “Direct” refers to the portion that directly is used for fuel, “indirect” to secondary fuels like bark, saw dust, black liquor, etc. from the portion that is used in industrial processes. (2006)

| | Direct | Indirect |
|---------------|--------------|--------------|
| Round wood | 7 PJ | 22 PJ |
| Chips | 1 PJ (est.) | 2 PJ |
| Wood residues | 7.7 PJ | - |
| Total | 26 PJ | 59 PJ |

The production and trade of pellets are recorded by the Swedish Pellet Association (PIR) and the published values for 2005 and 2006 are.

| | 2005 | | 2006 | |
|--------|-------|-----|-------|-----|
| | K ton | PJ | K ton | PJ |
| Import | 311 | 5.3 | 445 | 7.7 |
| Export | 144 | 2.5 | 129 | 2.2 |

The trends and prognoses are shown in the diagram below. (ton)





The import of propellant biofuel, mainly ethanol for 2006 was about 376 000 m³.

Other biofuels, such as tall-oil and residues from the food industry were imported in 2006 to an amount of about 7 PJ.

2.2 Origin

The main part of the imported round wood and the chips in 2006 had its origin in the Baltic states and in Russia. To a large extent it was integrated in the harvesting and in the flow of wood to the Swedish forest industries.

A few years ago, wood residues, especially recovered wood fuels (RT) came from Germany and Holland. In later years, the major part of the flow of residues to Sweden emanates from the Baltic states.

Pellets are imported mainly from neighbouring countries in the east, Finland, Estonia and Latvia, and the main single supplying country is Canada.

| Origin | Kton (2006) |
|---------------|--------------------|
| Canada | 130 |
| Latvia | 99 |
| Finland | 92 |
| Russia | 47 |
| Estonia | 46 |
| Poland | 14 |
| Others | 16 |
| Total | 445 |

Source: PIR

Propellant biofuels, mainly ethanol have their origins in southern Europe and in Brazil. The ethanol from southern Europe is based on the wine industry while the Brazilian supply emanates from the sugar industry.

| Origin | Km³ (2006) | |
|----------------------------------|------------------------------|------------------------|
| Wine-ethanol, Mediterranean, etc | 100 | (dehydrated in Sweden) |
| Brazil | 290 | |
| Total | 390 | |

Source: SVEBIO



The import can be compared to the production in Sweden

| | |
|------------------------|----|
| From pulping liquor | 15 |
| Grain based production | 60 |

2.3 Trade structure

The trade is organized and carried out in a variety of forms and patterns. There are several examples of long term contracts. Seasonal contracts are also common and so are spot contracts.

As mentioned above, some of the trade in round wood, chips and wood residues is captive, meaning that the entire chain is controlled by the end user or the national distributor. But other portions are performed in form of fob or CIF contracts, etc. either directly between producer and end user or involving one or several agents or other middle men.

Two different trends of emerging patterns could be noticed, namely (1) that the major users of imported biomass fuels tend to prefer buying biomass fuels in the same manner as they buy other types of fuel i.e. from established trade channels and based on well defined quality norms and classifications and (2) major producers and large end users sign contracts for biomass fuels that are suitable for the specific requirements of that particular end user. When the resource base for raw material widens due to increased general demand of biomass fuels, this trend would be further explored.

3. Drivers and barriers for and against trade

A number of drivers have created favourable conditions for trade of biomass for energy i.e.

- Differences in policy incentives between countries
- Cost structures
- Drivers from a procurement perspective
-

Policy incentives have until recently been more favourable in Sweden than in the exporting countries (in the Swedish case, trade has up until now been dominated by import) making it attractive to move biomass from none or low bioenergy incentive countries to Sweden with high incentives. These positive policy incentives have been paired with a favourable **cost level** in the Baltic countries as well as in Russia. This and changed regulation in Holland and Germany has turned the focus of biomass sourcing toward east.



However, in the last year several of these conditions have changed. Supply of biomass raw material has tightened in the Baltic states, Finland and Poland, and the prices have increased to levels over and above the prices in the Swedish domestic market. The Russian export levies on round wood have been implemented. These factors have obviously reduced the biomass fuel import to Sweden, but there are still no public statistical data available to illustrate the quantity and structure of that change.

From a **procurement** perspective there are a number of factors that are positive with import:

- Competitive fuel costs
- Risk distribution
- Negotiation power

The third point has been an important (but not transparent) factor for biomass import. Both forest industry companies and the major utilities are interested in keeping the prices of biomass as low as possible in the Swedish market. The forest industries want to safeguard their supply of cheap pulp-wood; the utilities want cheap biomass for fuel. Thus, import from other independent market has been a rational choice, even in cases when prices are higher for imported biomass.

Barriers and obstacles.

In the Swedish perspective three main types of barriers related to bioenergy trade are identified

- Technical barriers
- Transport, mainly shipping barriers
- Quotas

Technical barriers have their roots in difficulties to describe and measure quality and energy content in adequate and efficient ways. As uses and applications for biomass fuels has widened and become more diversified more technical issues have been included, e.g. regarding contamination, durability, storability, and health risks.

There are a number of cost driving aspects of **shipping** biomass for energy. The harbour facilities are often not equipped in fashion that enables cost efficient handling of the products. In addition to that, there are only few units of the shipping fleet, which are specially designed for efficient shipping of biomass for energy.



Bio-energy trade is generally carried out within unrestricted and free trade principles. One exception from that policy is the import of fuel ethanol to Sweden which is regulated in form of quotas. which of course limit the possible import volumes. Recently, the rules regarding import duties on fuel ethanol import have been changed to be more protective. The difference in approach could be explained by the assumption that ethanol is regarded primarily to be an agricultural product.

However, the Swedish long term policy is to establish free trade within the entire energy sector, including propellant fuels. At several occasions representatives of the new government have taken initiatives e.g. within the EU to get support for that policy.

4. Trends and development

Three major trends are identified, namely:

- From local to regional and now more international
- From demand in Sweden to demand in other parts of Europe
- Increasing quality concern

From local to regional and now more international

The bioenergy sector in Sweden started as local demand/supply in the late 1970-ies and 1980-ies. In the 1990-ies energy utilities started a regional markets for biomass e.g. by shipping biomass from surplus areas in northern Sweden to plants in the major cities. That trade developed soon to import of cheap recycled demolished wood from Holland and Germany and thereafter to import of wood chips from the Baltic states. Now steps are taken to an international market in which prices of biomass for energy are set in competition with products from sources far away, e.g. from south of Europe as well as from North and South America.

From demand in Sweden to demand in other parts of Europe.

Some years ago Sweden was pretty much alone when it came to demand for imported biomass for energy. This created a favourable situation with low prices and reliable sourcing. Now, as the demand in other parts of Europe are emerging and the cost structure in the east Baltic region is rising the cost argument for imports are diminishing. The imported biomass is often a more expensive material compared with domestic biomass.

Increase in quality concern.

The process of increased application of bioenergy in various applications and a simultaneous process of widening the resource base to other types of biomass have led to an intensification of the quality issues. This is generally appearing in all applications of biomass fuels but varying with different combustion technologies, size, requirements for accessibility, etc.. For example, the number of user of wood pellets for small scale domestic heat generation is increasing rather fast. In the early stages of that application most users were enthusiasts and hence prepared to handle minor disturbances



themselves and to identify adequate pellet quality to suit their equipment. However, now new users are expecting to get similar technical performance from their pellet burning equipment than from oil or electricity heaters. They also want cheap fuels, which sometimes mean that the chosen pellets are unsuitable for their application.

5. General policy towards biomass trade

In Sweden, the policy towards import of biomass for energy is trade liberal. There are very little of quotas and other limitations to imports. In addition to a trade liberal policy the general energy policy is very much pro-bioenergy. This has enhanced the competitiveness of biomass for energy compared to competing energy sources and other energy generation technologies. Especially the CO₂ taxation has had a decisive impact.

Pro-trade and pro-bioenergy policies have created the needed framework for trade of fuel from biomass. So far the flows have predominantly been inwards but with increasing demand in the rest of Europe and higher costs emerging in the eastern Baltic region and Russia, drivers might be on the edge to shift the direction of the trade.

6. Key issues for further development

Four key elements are identified that need to be in place in order to facilitate an increasing international trade of biomass for energy, namely:

- Increased demand for bioenergy
- Trade liberal policy
- Efficient total logistic systems
- Prevent powerful actors, potential losers, to block or disturb a viable development.



REFERENCES AND SOURCES

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Kåberger. T. History of nuclear power in Sweden. ESTUDOS AVANÇADOS 21 (59), 2007

For further and more detailed data on Swedish Bio-energy see the following home pages:

www.energimyndigheten.se

The Energy Administration

www.svo.se

The Forestry Administration

www.svenskfjarrvarme.se

The Swedish District Heating Association

www.svebio.se

The Swedish Bioenergy Association