Future Forests | Working Report

Energy as a driver of change

Gustaf Egnell[1], Ola Rosvall[2] & Hjalmar Laudon[1]

1 SLU Umeå

2 Skogforsk, Sävar

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External drivers affecting Swedish forests and forestry

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Contact Gustaf Egnell: gustaf.egnell@seksko.slu.se

This working report is one in a series of ten reports which focus on external drivers that have a potential of affecting the Swedish social-ecological forest systems in the future. The drivers were chosen after discussions in Future Forests' Core Team of researchers and in Future Forests' Panel of Practitioners. The reports are essential inputs to the research program's scenario analysis of possible futures for the Swedish social-ecological forest systems. Other reports on *External drivers affecting Swedish forests and forestry* are:

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Future Forests analyzes conflicting demands on forests systems
to enable sustainable strategies under uncertainty and risk

Content

1. Introduction

Man and society has increased in number and global impact over the past 10 000 years by successively extended the use of new technologies and energy sources to exploit natural recourses for food, materials and fuels. Human population is almost 7 billion people and is according to UN expected to reach 9 in 40 years (http://esa.un.org/unpp/). The greatest expansion has taken place in an accelerated rate during the last 100 years and is considered to result from the large supply of low cost fossil fuels, resulting from millions of years of accumulated solar energy captured by photosynthesis.

For industrialized countries like Sweden there are signs that the relation between increased use of energy and welfare is broken but globally a great increase in the energy use is prognosticated (IEA, 2008; EIA, 2007). At the same time global oil reserves are found not to be endless (Höök and Aleklett, 2008). With expected use of oil the supply rate is believed to peak during the coming decades and then decrease.

Therefore, there is a global awareness about the need to go from finite energy sources like fossil fuels towards more renewable energy sources. The total dominance of fossil fuels in the global, still growing, energy consumption together with the potential in the currently commercial alternatives implies that there is need for several new alternatives. Among these alternatives biomass is one of the more promising and important alternatives in the coming decades.

There are two major reasons why energy supply and demand may become a major driver of change for Sweden's forests and forest sector during the coming decades. The first is the growing concern about climate change and the potential impact of global warming on ecosystems, society, and economy (IPCC, 2007). To mitigate this, forests, forest management, and forest industry play a major role through carbon uptake by forests, forest management effects on the Green-House-Gas (GHG) balance, and probably most important in the long term, through substitution with wood substituting energy sources and materials with poor GHG/energy balance such as fossil fuels, concrete and steel (Eriksson et al., 2007). The second reason is the security of energy supply, with a finite resource of fossil fuels as the by far dominating energy source, and the annual consumption increases (figure 1.1). Furthermore, a large proportion of the fossil fuel supply is to be found in politically instable regions making geopolitics another issue to consider.

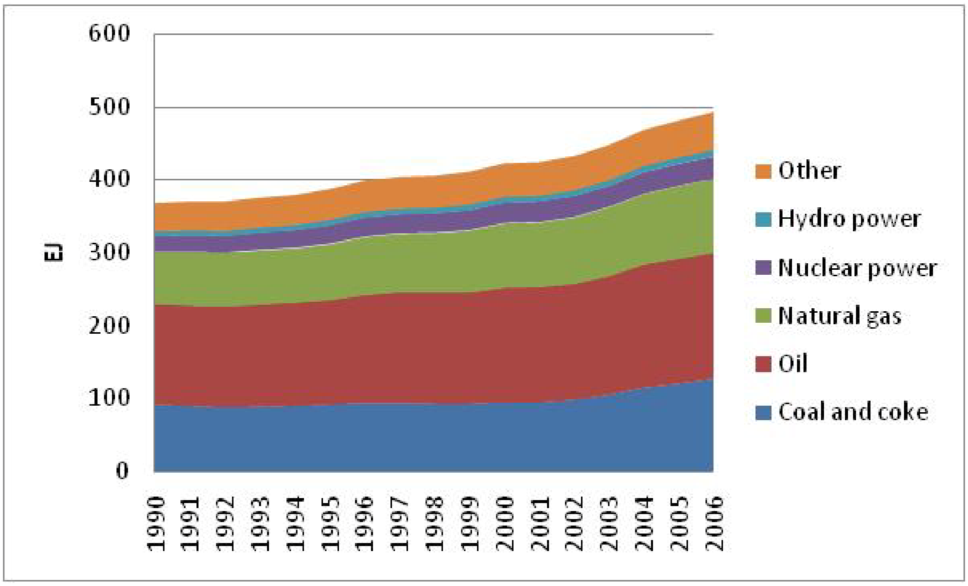

Figure 1.1. Total world primary energy supply by source, 1990-2006 (EJ) (IEA, 2008a).

Both of the above reasons, to increase the proportion of renewable energy sources, and to decrease the dependence of imported energy within the union, are drivers behind the current European energy policy and commitments to reduce GHG emission (EC, 2008).

This paper will focus on how global, European, national, and local concerns about climate change and security of energy supply may affect Sweden's forests and forest sector within the next 50 years. A lot of the background information comes from four publications (Silveira, 2001; IPCC, 2007; IEA 2008a; SEA, 2008). This information has been complemented with mainly peer reviewed scientific publication on certain topics and our own thoughts and conclusions based on that information.

2. Energy in the context of Sweden's forests and forest sector

From figure 1.1 it is clear that the global energy consumption is increasing and that the energy mix is by far dominated by a finite source of fossil fuels with potential impact on global warming. The increased energy consumption is a result of an increased population and an increased energy use per capita in both the developed and the developing world (figure 2.1), particularly in Non-OECD countries with China as a major contributor. Other estimates show similar results, i.e. IEAs (2008b) "reference scenario" estimate of 712 EJ primary energy demand by 2030.

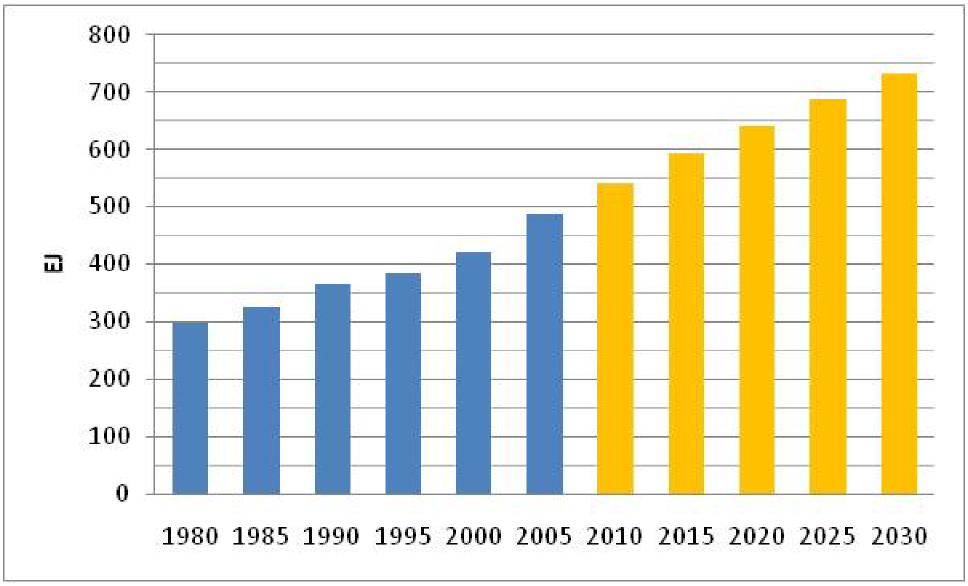

Figure 2.1. World marketed energy consumption 1980-2005 and the forecasted consumption 2010-2030 (EIA, 2007; 2008).

If biomass will make up a noticeable part of the global energy supply there will be an apparent increased demand for biomass from both agriculture and forestry, and a global market for more or less refined biomass for energy purposes will develop. For Sweden, a country dominated by forests, focus will be on forest biomass. This will pose a challenge for the Swedish pulp and paper industry that is both a big consumer and a potential supplier of renewable bioenergy. The profitability of the industry depends to a large extent on energy and pulp-wood costs. A growing bioenergy market may push the price for pulp-wood upwards at the same time as the growing energy market offers business opportunities beyond pulp and paper. These business opportunities will be exploited in competition or cooperation with the growing energy industry based on biomass.

A comparison between the Swedish energy use and the energy potential in our forests gives an idea about the impact the use of our forests for energy purposes may have on forests and forest management without even including the potential European and global market. Despite discussions and ambitions towards energy efficiency, Sweden like other OECD-countries has increased its energy use since 1970 up until today (figure 2.2). But the dependence on fossil fuels has decreased at the same time as nuclear power and the use of biomass, peat and refuse have increased.

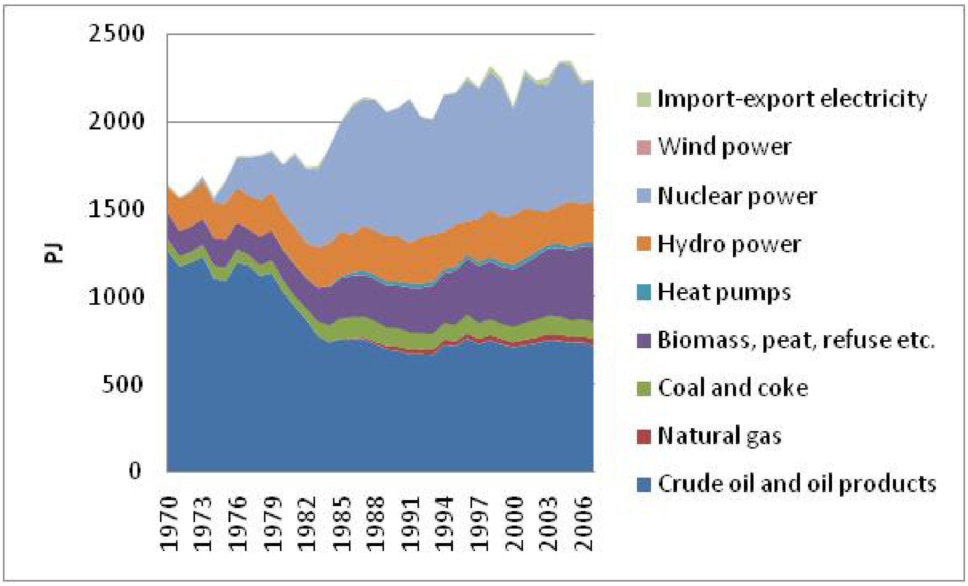

Figure 2.2. Total energy supply in Sweden 1970-2007 (PJ). Production and distribution losses included. Source: Statistics Sweden and the Swedish Energy Agency.

Assume an energy content of 7.2 PJ (cf. Hakkila and Parikka, 2002) in one million cubic meter of wood and a biomass expansion factor of 1.7 (cf. Teobaldelli et al., 2009) to ad potentially available logging residue and stump biomass to the annual round-wood cut in Swedish forests. Then the energy potential in the physically available biomass in the annual cut in Swedish forests can be estimated. In figure 2.3 the energy potential in the historical annual cut is compared with the total energy supply and use in Sweden. It clearly shows that even if we used the whole tree biomass potential for energy purposes, reaching approximately 1 000 PJ, it would not be sufficient even in a sparsely populated country like Sweden, with a large forest resource. As a comparison the estimated energy potential in the whole cultivated biomass from agriculture in Sweden ends up around 280 PJ per year, with 100 PJ in residues like straw (SOU 2007:36).

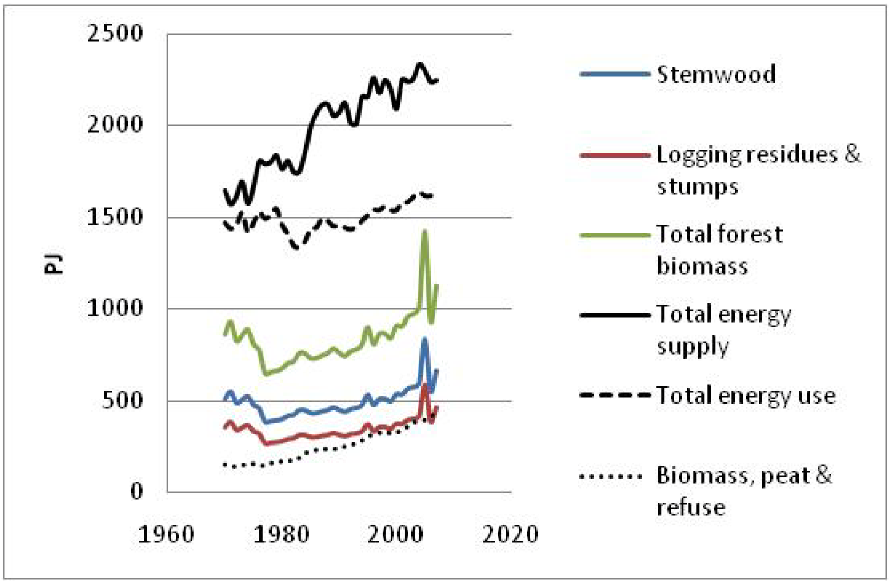

Figure 2.3. Bioenergy potential in Sweden's annual forest harvest compared with total energy supply and use (excluding conversion and distribution losses and losses in nuclear power stations) and biomass, peat, and refuse already used in Sweden 1970-2007 (PJ). Source: The Swedish Forest Agency and the Swedish Energy Agency.

This shows that if forest biomass or other biomass is to carry a more dominant burden in the future energy supply in Sweden, there will be an increased pressure on the forest resource and a competition for biomass between the forest and energy industry. On top of that the markets outside Sweden may become stronger – especially in densely populated countries in Europe with limited forest/biomass resources per capita when they are striving to meet their 2020 targets for renewable energy (figure 2.4) and reductions in CO_2-emissions.

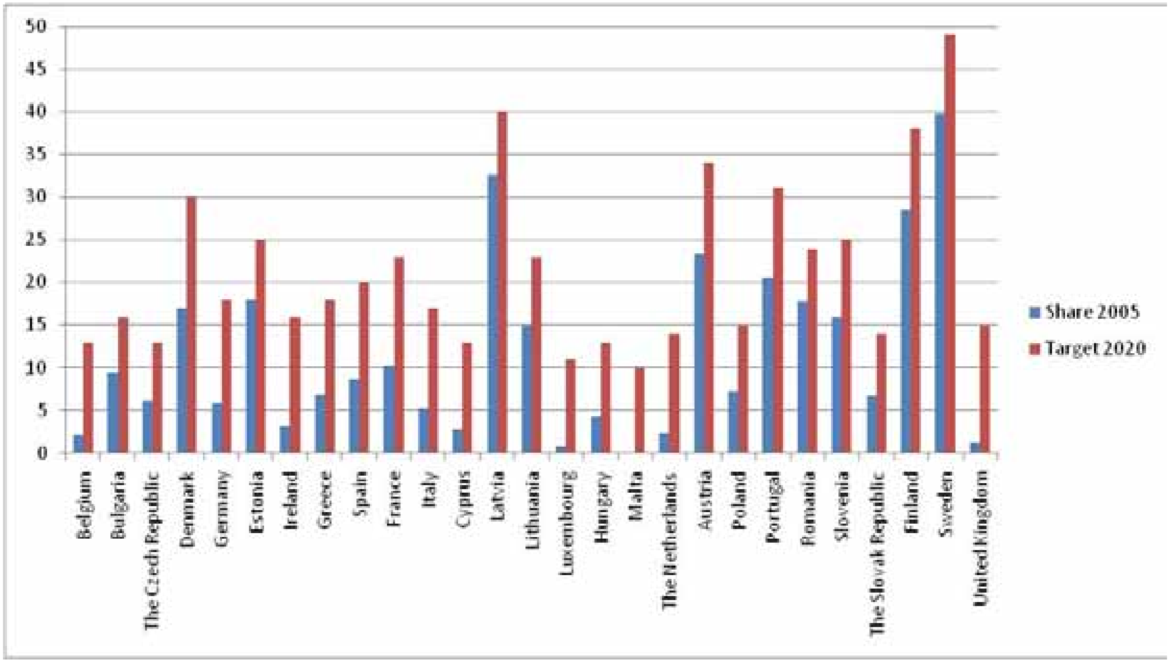

Figure 2.4. National overall targets for the share (%) of energy from renewable sources in gross final consumption of energy in 2020 (EC, 2008).

Germany, as an example, with 6 % renewable energy sources in 2005 and a total consumption of 13 850 PJ has an 18 % target for 2020. Assuming the same energy consumption in 2020 as in 2005, another 1620 PJ renewable energy is needed to reach the target. This is slightly more than the total energy consumption in Sweden (figure 2.3). Another perspective on the German example is to compare it with the energy potential in the total biomass bound in all Swedish forest stands today. Since the National Forest Inventory (NFI) started in the 1920s the standing stock in Swedish forests has increased by 80 % (figure 2.5) and it is still increasing due to improved silviculture and an annual cut that usually is lower than the annual growth.

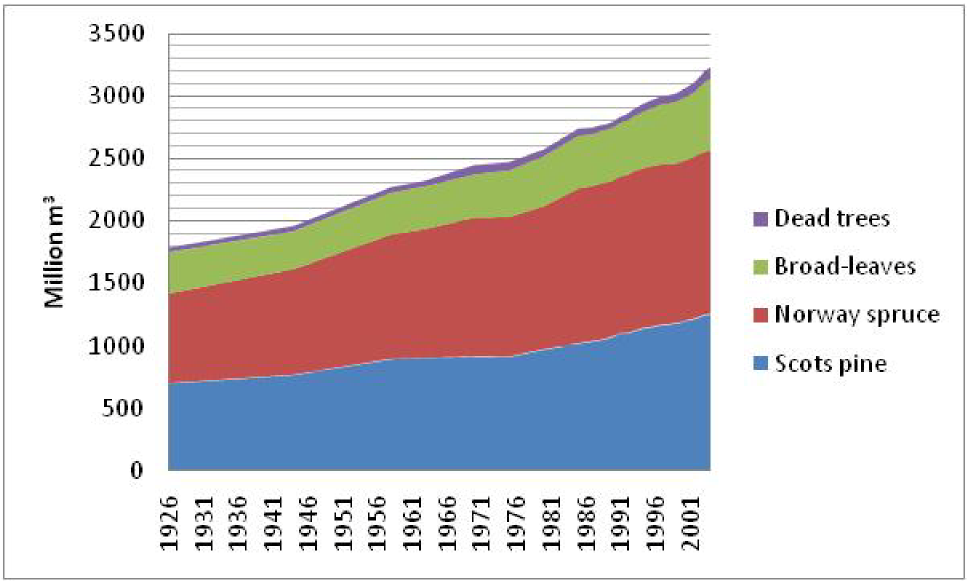

Figure 2.5. Standing stem-volume in Sweden 1926 – 2004. Source: National Forest Inventory, Swedish University of Agricultural Sciences.

With the same assumptions about energy content in woody biomass and a biomass expansion factor of 1,7 the standing volume in Swedish forests has a potential energy content of 3200 x 1,7 x 7,2 = 39 168 PJ. Thus, with a mining strategy on the Swedish forest resource Sweden and Germany alone would consume it all within approximately 20 years if this was the only renewable alternative used to meet the set targets for 2020.

Another important lesson learned from figure 2.4 is that it takes time to build up biomass volumes in Swedish forests. This is due to the long rotation periods in cold climates. This means that in short term (0-20 yrs), we have to harvest more intensively in the forests we already have. That is also what presently is happening with more biomass being harvested to meet the growing bioenergy market. Primarily more of the logging residues i.e. branches and tops are harvested to feed the energy market and there is a growing interest for harvesting stumps and low diameter stems from "pre-commercial" thinnings. The amounts of harvest residues on the market have not been sufficient to meet the need of the energy industry, resulting in an increased competition for pulp wood between the pulp and paper industry and the energy industry. There is therefore also a growing interest to further increase the production in our forests. In a longer perspective (20-70 yrs) there is a potential in more intensive silviculture practices using fertilizing, ditching, improved stand establishment, improved seedling material, fast growing tree species, afforestation of marginal land, shorter rotation periods etc (Rosvall, 2007).

Thus, if the energy market pressure for forest biomass will continue to grow it is likely that harvest intensity, forest biomass production intensity, and competition between traditional forest industry and energy industry will increase. As forest biomass often is a bulky, low value commodity that is expensive to procure and transport the highest pressure will be close to major end users or refiners like large heat and power plants wood pelletizing industries and close to roads, railroads, and harbours.

3. Looking back

Wood has been used as an energy source ever since man discovered fire, with higher and lower intensity levels depending on price and quality of the alternatives. For instance, charcoal was intensively used in Swedish mining and the metal industry from the very start to the mid 19th century when coal became a competitive alternative (Kaijser, 2001). Since fossil fuels entered the market, they successively took over. But the idea of using indigenous wood instead of imported fossil fuels has been an issue now and then. Under the title "We have to use the wood fuel in our forests more rational", Professor Gustaf Lundberg (1918) writes: *"For the less initiated it may appear strange that a forest rich country like Sweden shall depend on foreign fuel. That is however, unfortunately the case."* The use of wood fuel had an upswing during and after the First and Second World War and during the oil crises in the 1973 and 1979, but fell back as the availability of cheap fossil fuels came back to normal again.
The oil crises during the 1970s, however, changed the energy policy in many countries and the Swedish government decided to go for nuclear power as one alternative to decrease the oil dependence. At the same time the forest industry responded to the high oil prices by starting t make more use of their residues – primarily by using it as process energy, to generate electricity, and for heating. Concurrently biomass for energy came up as a competitive option in district heating. Currently this is the fastest growing bioenergy sector in Sweden, where heat in most cases is generated together with electricity in combined heat and power plants (figure 3.1). On top of the bioenergy used in the forest industry and in district heating some is used for heating of individual houses (firewood or wood pellets) and a small but growing fraction as biofuels (predominantly ethanol).

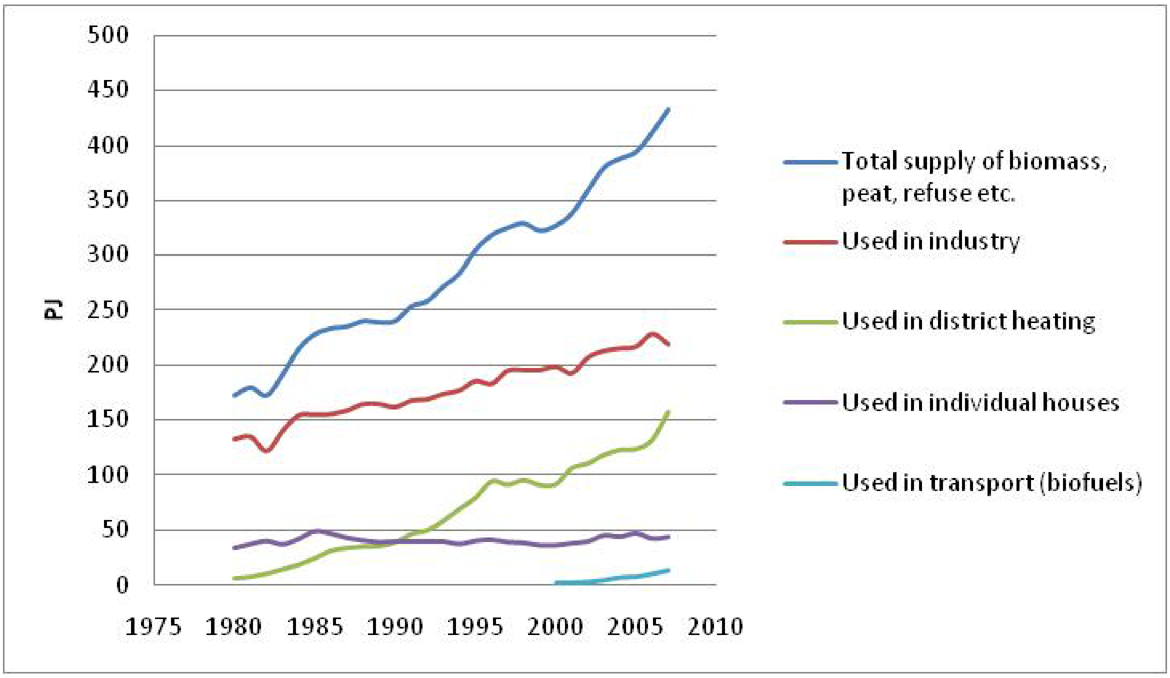

Figure 3.1. Total bioenergy supply in Sweden (including peat and refuse) and the proportion of the total used in industry, district heating, individual houses and in transport (biofuels) 1980-2007, PJ.

While the industry predominantly is using biomass from forests, also refuse and peat is used in district heating. However, biomass from forests dominate also in district heating (figure 3.2)

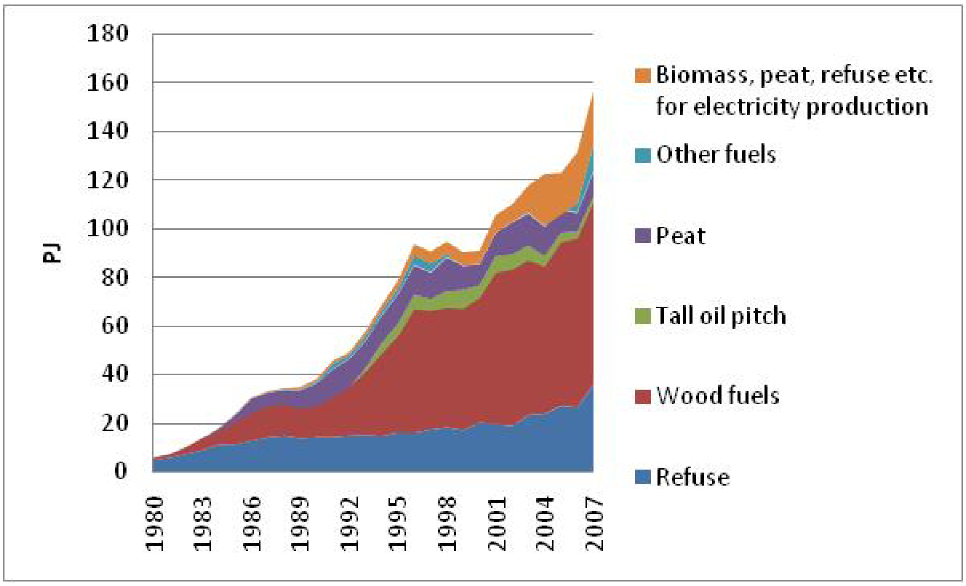

Figure 3.2. Use of biomass, peat, refuse etc, in district heating in Sweden, 1980–2007, PJ

The use of renewable bioenergy was also promoted by the concern about global warming, politically manifested in the Climate Convention from 1994 that came into action after the Earth Summit in Rio de Janeiro in 1992, and the Kyoto Protocol, negotiated in Kyoto, Japan in 1997 and ratified in 2005, with Sweden as one of signing countries, thereby agreeing to reduce its average GHG emissions during the period 2008-2012 by 8 % compared to the emissions in 1990.

Björheden (2006) identified a number of drivers behind the development of forest energy in Sweden during the last three decades with an initial development driven by the political aim to reduce the dependence of fossil fuels together with a “green lobby” that impeded the development of nuclear power and further exploitation of our hydro power potential. Vedung (2001) states that the Swedish nuclear power path became less passable after the Three Mile Island accident in 1979 and the Swedish electorate voted for a long-term phase-out of nuclear energy in a referendum in 1980. The Swedish Parliament then decided to phase-out nuclear power until 2010 without any set starting date. After a push from the Chernobyl accident in 1988, it was decided to start the phase-out in 1995. Even though only one plant has been closed up until today this has been important for the development of a forest fuel market. During the last 10-15 years the global concern for climate change due to emissions of green house gases has gained a higher importance underpinned by the work of the Intergovernmental Panel on Climate Change (IPCC, 2007), the Stern report (Stern, 2006) and media. Björheden (2006) claims however that these two drivers have not been enough to explain the fast growing forest energy market in Sweden. Equally important has been governmental support for research and development and economic incentives, i.e. energy taxation, to create a market for biomass for energy from forests.

4. Looking forward

An indicating step policy vice will be the outcome of the United Nations Climate Change Conference in Copenhagen in December 2009. The conference is the first step towards a new treaty replacing the Koyoto Protocol. It is unlikely that all details in the new treaty will be in place at the conference but hopefully in due time after the conference. The UN climate Chief Yvo de Boer has pointed out four political essentials that he hopes to achieve during the conference. That is set reductions in greenhouse gas emissions for the industrialized countries, growth limits in GHG emissions for major developing countries like China and India, and how to finance and manage the money needed to help developing countries to engage in reducing their emissions and adapting to the impacts of climate change (http://en.cop15.dk/).

The future market for forest biomass for energy looks promising in a 50 year perspective as global energy consumption is expected to increase substantially (cf. figure 2.1) and the current total dominance of a finite energy source with potential negative impact on the global climate (cf. figure 1.1). As fossil energy sources so totally dominate the energy use today, biomass cannot be the single solution on the carbon and climate problem for the next 50 years. But it is one of the options that already today has passed beyond the laboratory and demonstration project stage and in many cases reached a full industrial scale ready to be implemented throughout the world (Pacala and Socolow, 2004). But fossil fuels cannot be substituted by biomass only. Other alternatives including energy efficiency means has to be implemented as well. A fast implementation on the European market, driven by the new targets within EU (EC, 2008), could be co-firing in existing coal based power plants (Berndes et al., 2009; Hansson et al., 2009).

More oil price spikes like the one in July 2008 or oil crises like the once in the 1970's , irrespective of its major cause is supply and demand imbalance, geopolitical uncertainty, or pure speculation (Sornette et al., 2009), will definitely act as a driver for the alternatives. Another boost for forest biomass could be biofuels. This, however, requires a breakthrough for the second generation biofuels based on lignocellulosic feedstock on one or several paths that currently are under development (Regalbuto, 2009). Even a technological path towards the more energy efficient electrical engine would require biomass and other means to produce electricity for battery-driven vehicles (Ohlrogge et al. 2009). Other tempting fuel options at high oil prices include tar sands, gas-to-liquid and coal-to-liquid technologies but they have their obvious GHG emission problems (Brandt and Farrell, 2007).

Another argument for a growing future market for forest biomass for energy is that residues and forest biomass often falls out as the best feedstocks when both GHG balance and other environmental impacts are considered as compared to other biomass alternatives like agricultural crops and palm oil (Scharlemann and Laurance, 2008; Fargione, et al., 2008; Searchinger, et al., 2008). But forest biomass still has to compete with other energy sources with favourable GHG balance like wind, wave, nuclear, thermal and solar power.

Carbon capture and storage (CCS) technology in fossil energy driven heat and power generation could offer a competitive alternative to biomass, but current technology is still to energy-intensive and expensive (IEA, 2008). And as fossil fuels resources are limited there will be a need for renewable sources in the long run.

Current and future presumably more advanced use of wood for bio-materials and bio-chemicals will add a new opportunity for forest biomass. Bio-refinery is a concept that is getting more attention where biomass is converted to materials, chemicals and energy (Kamm and Kamm, 2004). A trend in the Swedish pulp and paper and saw mill industry is that energy to a larger extent becomes a market commodity through connections from the industry to district heating and power grids. This could be seen as the first step towards a bio-refinery that eventually can make use of the whole tree biomass. Such a development will have an impact on the whole chain from primary production to the industry where total biomass production will get more attention rather than stem-wood production only and technology and logistics in harvest operations and transport to the industry will be altered. Together with an assumed strong market for forest biomass this will also lead to a higher intensity in forest production and harvest – a trend that is obvious already today.

One uncertainty for the future lies in the consensus on GHG-effects on the climate and potential severity of damages caused by a changed climate. Even though there is a scientific consensus today that human activity is the major explanation for the global warming we are now facing (Oreskes, 2005), there are some disagreements about the severity of the damages caused by a changed climate (Pfeffer et al., 2008). And if, despite current scientific consensus, it turns out that the scientific community and the models were wrong, either in the GHG effect on the climate or the severity in damages caused by that, or if politicians and decision makers becomes less convinced in the future, this will open the door for utilizing more fossil fuels and close the door for further strong development for forest biomass and other alternatives globally during the next decades, unless it is competitive with fossil fuels without policies and economic incentives favouring renewables like forest biomass. However, for countries like Sweden and Finland, without any fossil fuel resources, security of supply will continue to be a strong sub-driver.

Policies and political action based on that will also be critical for the future development of renewable energy sources throughout the world. In a European perspective it is important that forest biomass gets the attention it deserves considering its superior features when it comes to GHG balance and other environmental impacts as compared to most if not all agricultural crops (Searchinger, et al., 2008; Londo, et al., 2009). To get that there it is a strong agricultural lobby together with the complex agricultural politics within the Union that has to be met. The present biofuels policy within the European Union supports to a large extent the 1st generation biofuels based on conventional food crops. Berndes et al. (2009) identifies that problem and suggests two possible paths and suggests policies that eventually would favour the 2nd generation biofuels based on lignocellulosic feedstock like forest biomass. The outcome of that struggle will have a major impact on the future development of the importance of forests and forestry as a major energy supplier to the society.

Even though it is likely that all alternatives to fossil fuels and energy efficiency means will develop during the next 50 years, it is not likely that any of them on its own could carry the burden that fossil fuels have carried up until today. Considering the total dominance of fossil fuels today it is more likely that there will be a need for a lot of all available alternatives and even if the European or global market for forest biomass will be weak in competition with other biomass the Swedish market will continue to be strong as many investments close to the Swedish forest already have been made.

Considering the uncertainties above, the long investment horizon in boreal forestry, and the conservancy that characterize Swedish forestry and forest owners it will take decades before the future market opportunities will have a major impact on the intensity in silvicultural practices to improve forest production i.e. fertilizing, improved seedlings, fast growing tree species etc. But it will have an immediate impact on harvest intensity, where more of the tree biomass will be harvested (small diameter trees, branches, tops and stumps), rotation period may become shorter, and the volume of annual harvest will most likely get closer to annual growth. This also requires new research and development favouring technical and logistic development of logging operations, storing and transport to the industry. A lot of that forecast depends, however, on how much the market is willing to pay for forest biomass.

During the 2009 economic crisis the energy industry keeps the price for pulpwood up. This is nothing that the pulp and paper industry is happy about as pulpwood is the major cost for them. If the competition for raw material between the energy industry and the pulp and paper industry together with the tough global competition in the forest industry leads to closure of a large part of the forest industry in Sweden and Europe, forest biomass prices will most probably drop and more of the expensive biomass to procure like small diameter trees, logging residues and stumps will remain in the forest.

More intensive primary production and harvest practices will also have an impact on the whole forest ecosystem. This may have a negative effect on other ecosystem services. The magnitude of those effects and the attendance it gets will have an impact how much more intensive production and harvest regimes society will accept. Eventually, the demand for forest biomass may challenge “the Swedish model” with comparatively small protected forest areas set aside and a number of measures on the major part, managed primarily for production, such as retention trees on harvested sites, to promote biodiversity, sustainability, and other forest services (Eriksson, et al., 2007).

The discussion about uncertainties for energy as a driver of change for Sweden’s forests and forest sector is summarized in figure 4.1. Any uncertainty linked to any sub-driver axis is relevant for the strength of energy as a driver. However, the Swedish bioenergy market is likely to remain strong as a lot of investments are already done or decided on. The threat here lies in a global market of relatively cheap biomass alternatives from areas in the world with a high potential in terms of land resources for biomass production (cf. Hoogwijk, 2004; Berndes et al. 2003) or, climate induced or not, large scale forest dieback, like the one caused by the mountain pine beetle in Canada that could release large quantities on the market during some time.

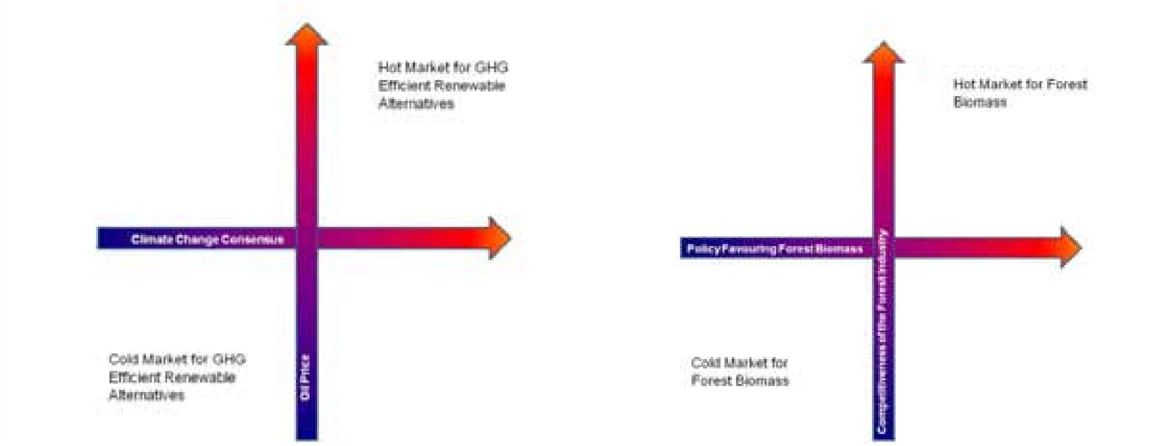

Figure 4.1. Figure illustrating important sub-drivers for energy as a driver of change for Sweden’s forests and forest sector and their effect on the Swedish market for renewable energy and biomass from forests.

5. Conclusions/take home messages

To sum up, energy will probably be a strong driver of change for Sweden's forests and forest sector during the next 50 years but it depends to a large extent on:

1. Energy supply and demand and future energy prices (oil price)
2. Future consensus about climate change, i.e. its causes and severity of future consequences, in the scientific community as well as among policy and decision makers
3. If forest biomass gets the attention policy vice that it deserves considering its climatic and overall environmental advantages compared with other biomass
4. If the Swedish and European forest industry will continue to be competitive on the global market
5. If increased harvest and production intensity will be considered sustainable considering impact on the forest ecosystem and surrounding ecosystems

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Appendix 1. How energy affects other drivers

Climate change and climate politics	One plausible explanation for climate change is the use of fossil fuels and thereby increasing the concentration of GHG in the atmosphere. Renewable bioenergy as biomass from forests offers one solution to that problem.
Governance	Secure supply of cheap energy is one of the most important factors for the future development of the global and local economy and by that a highly relevant governance area.
Land use claims (in Sweden)	If biomass is to take a substantial burden in future energy supply a lot of arable land is required in competition with other land use. Furthermore, intensity in primary production and harvest intensity may increase and thereby potentially challenge “the Swedish model”.
Markets for forest products	Bioenergy from forests will open new markets and business opportunities for forests owners and forest industry. A development towards bio-refineries will be favoured by having energy as one important product line.
Ecological disasters	Unsustainable biomass harvest and production may cause ecological disasters in the future.
Geopolitics and conflicts	Energy (read oil) has always been one of the major causes for conflicts and is likely to continue to do so.
Demography	Biomass production for bioenergy requires arable land that requires labour in rural areas.
Technological developments	A high demand and price for bioenergy will have a positive effect on development of logistics and technology to procure and transport biomass from our forests and to refine the biomass to more convenient energy carriers like heat, electricity, pellets, and biofuels.
Norms, values and attitudes	All energy alternatives are surrounded by norms, values, and attitudes. This is due to the fact that we all are so dependent on energy in our daily life at the same time as all alternatives have their advantages and disadvantages in terms of convenience, price, and environmental impact.

Appendix 2. How other drivers affects energy

Climate change and climate politics	Highly relevant as consensus about climate change and potential future damages and costs has a direct impact on energy politics
Governance	The choice of future energy sources is highly dependent on political decisions and agreements where renewable energy sources like biomass for the moment are favoured.
Land use claims (in Sweden)	Other land use claims such as rain deer herding, hunting, fishing, conservation or recreation will be in conflict with increased biomass production because: Even if woody biomass only should substitute a proportion of global fossil fuel use there has to be a higher pressure on forest land in terms of intensity in harvest and in silvicultural means to promote higher biomass production.
Markets for forest products	Indirectly - as the use fossil fuels is assumed to cause climate change the forest industry has a selling point in marketing wood as green, renewable substitute to concrete and steel from a climate point of view.
Ecological disasters	Ecological disasters killing a lot of trees may result in large quantities of biomass on the world market interrupting the domestic market for some time
Geopolitics and conflicts	Conflicts in major oil-producing areas tend to push the oil price up. This and concerns about security of supply will promote the development for alternatives in countries like Sweden and in Europe.
Demography	If urbanisation continues there may be a shortage of labour in rural forested areas that will hamper procurement of the forest biomass resource.
Technological developments	Technical development in the supply chain will be critical for the amount of biomass procured from our forests and a breakthrough in making lingocellulosic biofuels and/or the bio-refinery concept will have a major impact on the demand from the biomass market.
Norms, values and attitudes	Critical for renewable energy sources like biomass from forests as they may seem bulky and unhandy at the first glance. Furthermore, intense harvest and production practices may get some attention from media and the public due to aesthetics or negative impact on the forest or surrounding ecosystems (other ecosystem services).