Sustainable Energy Scenarios in Sweden

Sweden can cut greenhouse gas emissions by well over 50 per cent by the year 2020, if results of recent studies for 2050 are "telescoped" into the shorter timeframe, and if the consequences of exported electricity and biomass are accounted for. This could take place without CCS and while much of the nuclear capacity is decommissioned.

Several energy scenarios have been published in recent years, though with different methodology, scope, assumptions and time frames. Here is a short summary with respect to GHG/CO_2 results, nuclear power, main methods, and the inclusion/non-inclusion of CCS.

The Swedish Academy of Engineering IVA[1] 2009 states that Sweden can reduce its GHG emissions by 62 per cent by the year 2030 and to zero by 2043, but definitions of emissions are different from those of the Kyoto protocol. The study includes land use, land use change and international transport. Much of the reduction is achieved by afforestation (which already takes place now), and CCS. Nuclear power is not phased out, and some of the 1030/2043 nuclear power is converted to combined heat and power. The carbon footprint of imported goods is assumed to decrease radically, and all cars are either electric or bio-fuelled.

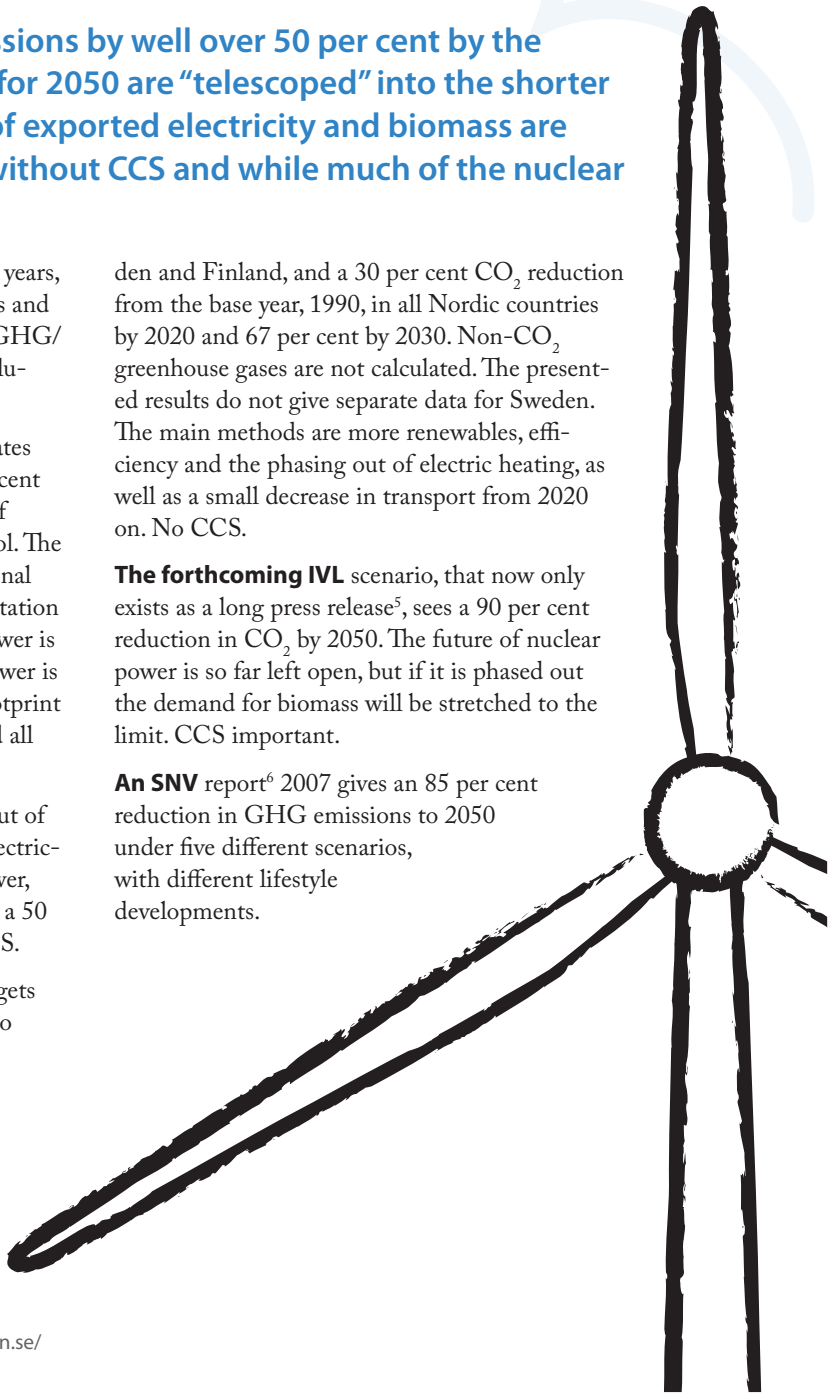
An SNF study[2] from 2005 aims at a complete phase-out of fossils and nuclear power by 2020 but only from the electricity and heating sectors, mainly through more wind power, more bioenergy and increased efficiency. This results in a 50 per cent reduction in CO_2 from the 2003 level. No CCS.

A 2009 SNF and LRF scenario[3] for 2020 sets high targets for renewables and eficiency, and describes the means to achieve them, but does not specify emission reductions and assumes a 60 year life for nuclear power, i.e. no phase-out. No CCS.

A Greenpeace Nordic 2006 scenario[4] for 2030 postulates a total phase-out for nuclear power in Sweden and Finland, and a 30 per cent CO_2 reduction from the base year, 1990, in all Nordic countries by 2020 and 67 per cent by 2030. Non-CO_2 greenhouse gases are not calculated. The presented results do not give separate data for Sweden. The main methods are more renewables, efficiency and the phasing out of electric heating, as well as a small decrease in transport from 2020 on. No CCS.

The forthcoming IVL scenario, that now only exists as a long press release[5], sees a 90 per cent reduction in CO_2 by 2050. The future of nuclear power is so far left open, but if it is phased out the demand for biomass will be stretched to the limit. CCS important.

An SNV report[6] 2007 gives an 85 per cent reduction in GHG emissions to 2050 under five different scenarios, with different lifestyle developments.



1 http://www.iva.se/PageFiles/8349/200901-IVA-v%C3%A4gval%20energi-nollvision-K.pdf

2 SNF Energipusslet 2020 http://www.naturskyddsforeningen.se/upload/rapport_klimat_energipusslet2020.pdf

3 Förnybar energi och energieffektivisering - Potential för 2020.pdf report June 2009, download from http://www.förnybart.nu/

4 Ett nordiskt energiscenario Greenpeace 2006 http://www.greenpeace.org/sweden/rapporter-och-dokument/ett-nordiskt-energiscenario

5 Sverige kan minska koldioxidutsläppen med 90 procent till år 2050 www.ivl.se 2009-05-19

6 Tvågradersmålet i sikte? Scenarier för det svenska energi- och transportsystemet till år 2050 Rapport 5754, Oktober 2007 by Jonas Åkerman, Karolina Isaksson, Jessica Johansson, Leif Hedberg.

Nuclear power is phased out. Limited CCS (20 TWh fuel burned with CCS.).

The latter, a study for the Swedish Environmental Protection Agency is in some respects the most relevant and detailed study on relations between policy and resulting emissions. The authors conclude that an 85 per cent reduction in greenhouse gas emissions can be achieved through five different scenarios, grouped by world access to biomass on one hand and societal preferences on the other, meaning either high material consumption, more consumption of services, or a more leisurely life.

This article will summarize their findings, and try to assess the extent to which the results can be "telescoped" or contracted for a much shorter timescale. It should be made clear that this is by no means warranted by Åkerman et al.
The main requisites for the 85 per cent cut are (with different shares for each scenario):

- Efficiency/Technology
- Less car and air travel
- Less meat consumption
- More biomass
- Large increase in wind power
- CCS, some of it for bio (negative emissions)

The role of transport emissions is enhanced compared to the standard national inventory reports because international transport emissions are included. The 2005 emissions were about 67 million tons of CO_2 equivalents, and 78 million tons with the inclusion of international transport.

In all scenarios, Swedish energy use is projected to shrink from 460 TWh in 2005 to about half in 2050. This is a consequence of the GHG reduction and is not further discussed in the study. There is however at least one specifically Swedish aspect to this: the very high Swedish per capita use (16,000 kWh/year) of electricity is likely to drop to the continental level (about 6,000 kWh/year) as a consequence of an increasingly open market and increased transmission capacity from the Nordic countries to Germany, the Netherlands and the UK. Indeed, Swedish electricity consumption peaked in 2001 and has slowly dropped ever since. This does not mean that adaptation to higher electricity prices has already taken place, especially not in industry. Both normal efficiency improvement and structural changes – gradual or traumatic – look increasingly likely.

Higher fuel efficiency for cars is expected, but will not suffice.

Less car and air travel is to be achieved both through planning and infrastructure measures: more trains, better bicycle routes, other technology (video conferences) and through changes in lifestyle and priorities.

Åkerman et al expect Sweden to still have considerable energy-intensive industry in 2050.

Another factor behind the decreased use of energy so far is that heat pumps have replaced electricity and oil for heating. The heat pump boom cannot continue much further, since there is not much more oil to substitute and the lowest hanging fruits of electricity heating replacement have already been picked.

Sweden has huge biomass resources, so it is fairly easy to design a low emission scenario if all this biomass is used for Swedish industry, transport, heat and power. But this is not certain. If world biomass resources are severely limited, much of Swedish biomass will be exported. From 112 TWh in 2005, biomass use in 2050 is thus projected to fall within a wide range: from 88 TWh to 161 TWh.

Meat consumption, both globally and in Sweden, is an important factor, as it affects how much surplus land is available for bioenergy.

A third factor that is important in determining how much land will be available for bioenergy production is the intensity of agriculture. At least in the shorter term, high inputs of pesticides and fertilizer give much higher production per unit of area than organic methods, but with other costs in the form of health hazards to workers, loss of biodiversity, and depletion of finite resources.

Wind power. Sweden had less than 1 TWh of wind power in 2005. The scenarios predict 30–45 TWh for wind and wave power for 2050, the higher figure if less biomass is available.

CCS is assumed to store CO_2 from 20 TWh of fuel input, some of which is fossil and some biomass. Assuming all is coal and 90 per cent of the CO_2 is separated, this translates to 6 Mtons of CO_2 stored.

Could all this happen earlier than 2050 or much of it even by 2020?

In many cases the answer must be yes, a qualified yes.

Wind power could increase much faster – as it has in Germany, Spain and India over a short time.

If meat consumption can be reduced in 40 years, it can be reduced in ten years.

Air and car travel habits can also change fast, if necessary.

With much higher fuel prices, heavy goods transport by road will fall fast in recession and slowly even in good times.

CCS cannot be expected to deliver anything much by 2020 (if indeed ever). Biomass CCS is even more distant than coal power CCS. Biomass CHP plant capacities are typically less than 100 megawatts, whereas big coal power plants are 10–20 times bigger. The economy of scale works strongly against biomass CCS.

This means that even if everything else could be done by 2020 instead of by 2050, this scenario cannot deliver an 85 per cent cut. But a forthcoming study by the IVL[7] ups this to 90 per cent (of CO_2), so the full potential may not be tapped.

The Åkerman et al study scenario for 2050 estimates that energy use could be halved by 2050.

7 Sverige kan minska koldioxidutsläppen med 90 procent till år 2050 www.ivl.se 2009-05-19

Most people would argue that this cannot happen in ten years' time without major economic, social and political disruption.

On the other hand this happened in the years 1939–42 in Sweden. Sweden was spared from the war, though all its neighbors were either occupied by Nazi Germany or co-belligerents. Sweden was cut off from most supplies, cut its coal consumption by half and its oil consumption by 93 (!) per cent. This did not lead to any major disruption. CO_2 emissions dropped to less than half (44 per cent) of what they had been before the war[8]. GDP dropped nine per cent in 1940, but economic growth resumed in 1942.
This could not happen in the same way today. There are other bottlenecks and other flexibilities in the national economies of 2010 than there were in the 1940s. Much depends on what people see as necessity, or not. Popular opinion saw clearly in 1940 that the cause of hardship (if any) was the war, not the government.

But if the rules of the game are overturned, both individuals and governments are bound to act in new ways to cut their losses.

What is even more certain today than during the 1940s is that Sweden does not make the rules. It is quite possible that the next boom will lead to very much higher oil prices and that other raw materials prices will follow.

Technology can be as disruptive. If e-books and electronic newspaper finally make it, the demand for Swedish paper and pulp will plummet, though demand for wood as a construction material and for wood residue fuel may see a sharp rise.

Climate policy can also happen quite fast. EU burden sharing after Kyoto gave Sweden a target of plus four per cent for 2010 compared to 1990, which was a demanding target according to many economists and industrial lobbyists. The next burden sharing gave Sweden minus 17 per cent compared to 2005 emissions, and this figure could rise if the EU overall target is increased from 20 to 30 per cent in Copenhagen. CDM could also disappear fast as a major escape clause, meaning that what many now consider "paper commitments" will become very real.

In a globalized world, national climate policy has its limitations for a small nation like Sweden. But that does not mean that national policy is ineffective. Often it means that a good climate policy will indeed cut emissions, but that the government has little influence over where the cuts will take place.

The Swedish politicans can take decisions to ensure that 30 TWh/year of wind power will be built. But it can't decide where the extra electricity will be used.

The same goes for electricity efficiency. If less electricity is used, less electricity will be produced – inside or outside Sweden.

This also applies for biomass. The government can order more biomass to be produced, but it can't tell where it will be used.

This may not be a bad thing, but it makes accounting more difficult.

Sweden has cut its emissions by about 10 per cent between 1990 and 2007, and all data points to a further decrease in 2008 and 2009. Most of Sweden's neighbours have less favorable trends, and will have problems in reaching their Kyoto targets and great difficulties in reaching whatever is agreed in Copenhagen. Sweden has direct electricity connections to Norway, Finland, Denmark, Germany and Poland. The four latter have coal power stations that are normally considered as "marginal production" i.e. they are shut down or operated according to demand.

Sweden and Norway essentially have no fossil power production.

By and large, this means that each terrawatt hour of new renewable power or electricity savings in Sweden will mean less coal power production elsewhere.

But is this not double-accounting? It would be, under the assumption that the neighbouring nations cut their emissions in the trading sector in proportion with the EU commitment in Copenhagen, for example by 30 or 40 per cent by 2020.

Under the more realistic assumption that the EU will have great difficulties in producing such large cuts in such a short time within the community, Swedish electricity exports will help to cut emissions. The current ETS directive does allow for a very large inflow of CDM, but it is very questionable if all that CDM will be available. If a very large inflow (several billions of tons of CO_2 worth) can be produced it will inevitably compromise the quality. The mechanism will be questioned, and the credibility of the whole system will be at stake.

It seems therefore reasonable to assume that extra, exported renewable energy from Sweden will lead to real cuts in EU emissions.

The worst lignite power stations, such as Vattenfall's Jänschwalde plant, emit about 1,200 grams of CO_2/kWh, but it would be overstating the case to assume that all Swedish wind power would lead to production cuts in such power stations. Other possibilities are that it will lead to reduced nuclear power output, for example through earlier retirement or avoided investments in capacity uprates. It could also lead to less utilization of gas power plants. Somewhat arbitrarily, it will be assumed that Swedish renewable power has a net negative carbon effect of 500 grams/kWh.

Biomass is less complicated. It will mainly be used for heat and power as a substitute for coal or oil, and as a transport fuel to replace oil. On average it is assumed to replace light fuel oil, with a carbon effect of 270 grams per kWh.

Biogas mainly replaces gasoline/diesel for transport, but if produced from manure it also cuts methane and N2O in the lifecycle perspective, so every kWh of biogas is worth

8 Boden, Marland, and Andres, Carbon Dioxide Information Analysis Center, Oak Ridge http://cdiac.ornl.gov/ftp/trends/emissions/swe.dat

almost 500 grams/kWh. As some of the biogas will "only" replace oil at 270 gram/kWh, the average is assumed to be 350 grams/kWh.

According to a recent study from the Swedish Society for Nature Conservation (SNF) and the Farmers organization LRF[9], the final energy use can be cut to 323 TWh by 2020 from 396 TWh in 2005, a reduction of 73 TWh. They assume no new hydro and unchanged nuclear. This would mean that the 73 TWh come mainly from oil, but also some oil and some gas. If it replaces biomass, that biomass will be used to replace oil somewhere, often in Sweden but also abroad.

Efficiency savings would then be worth 270 grams/kWh. But this may not be a conservative assumption, as some of Sweden's large fleet of nuclear reactors may be (or should be) retired by 2020, so here we assume that 69.5 TWh of nuclear power in 2005 will become 50 TWh in 2020, which incidentally is line with the falling trend over the years since 2004. The remainder of the reduction in energy use is assumed to come from oil savings. A saved kWh is thus valued at 200 grams/kWh.

In 2005, emissions of greenhouse gases excluding land use change totalled 67.2 Mton. In 1990, emissions were 71.9 Mton.

The SNF/LRF study thus sets goals of 30 TWh for wind power by 2020, an increase of 29 TWh, a biomass increase of 48.5 TWh of which 10 TWh is from biogas, an increase of 4 TWh in solar and wave power (from near zero in 2005), and a 73 TWh reduction in energy. Solar and wave energy is mainly solar heat and is here assumed to replace oil.

	TWh	gram/kWh	Mton GHG cut
biomass excl. biogas	38.5	270	10.4
biogas	10	350	3.5
windpower	29	500	14.5
wave and solar	4	270	1.1
reduce energy use	73	200	14.6
sum			**44.1**

This is only 39 per cent of the 1990 emissions, i.e. a reduction of more than 60 per cent. This should leave provisions for other ways of calculating avoided emissions, for more nuclear phase-out and for possible inclusion of international transport in the national targets.
It should also be noted that the 30 TWh of wind power is less than Germany has now (40 TWh), though Sweden is a larger and windier and less populated country. Sweden has also the added advantage of hydro, which means that much energy can be stored at very low cost, in Sweden and Norway.

The SNF/LRF back up their goals with several policy recommendations, for example:

- Increased energy renewable obligation. There is already a system in place.
- Special support for offshore wind power, solar energy and wave power.
- Planning targets of 30 TWh wind power (which already exists), 10 TWh for biogas, 8 TWh for solar energy.
- A 20 per cent renewable target for transport energy, including electricity for trams and railways.
- An increased climate investment programme along the lines of presently or previously existing systems.
- No new fossil gas infrastructure.
- Subsidies for energy efficiency investments in houses and commercial buildings.
- White certificates for reduced electricity use.
- Energy efficiency support to industry other than electricity-intensive industry (for which a program already exists).
- National efficiency target for new cars.

It certainly can be done. Whether it will be done will depend both on Swedish policy decisions, as well as on external pressure, such as oil price hikes, more demanding climate targets and ensuing demand for Swedish electricity and biomass.

In the context of a greater European effort, Sweden can do its part.

9 Förnybar energi och energieffektivisering - Potential för 2020.pdf report June 2009, download from http://www.förnybart.nu/

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