The Swedish Kyoto target and reductions in greenhouse gas emissions 1990 to 2012

The EU burden sharing agreement in 1997–98 allowed Sweden a plus four per cent GHG target for 1990–2010.

This was motivated by Sweden's supposed plans to phase out nuclear power by 2010, plans that were already abandoned.

Two of 12 reactors were however phased out, while CO_2 emissions fell considerably.

In April 1997 the Swedish government adopted its second national communication to the climate convention. The date is significant. The Kyoto protocol was to be adopted the following December. The EU was well prepared and had adopted an "indicative" burden sharing agreement of climate emission caps for each of the 15 member states the previous month. With minor adjustments this agreement was confirmed a year later.

The national communication (NC2) includes an energy forecast for 2010, and provides insight into how the government then thought; "government" meaning not just the ministers but also executive bureaucracy and associated academia, industrial lobbies etc. The NC2 contains an energy forecast up to 2010, i.e. the average of 2008–2012.

Most energy forecasts are wrong and this was no exception.

Electricity consumption – of strategic importance for emissions – was predicted to grow from 142 TWh in 1995 to 153 TWh in 2010. In fact[1] it peaked in 2001 after which it decreased slightly.

For other sectors the statistics are inconsistent (though the difference is not very large). But final energy use in industry was predicted to increase from about 147 TWh in 1995 to 158 in 2005 and 166 in 2010. This was, so far, almost spot on. But the production index was forecast to increase about 18 per cent from 1995 to 2006. In fact it grew 85 per cent. Even though industrial production grew very much faster than predicted, energy use grew only modestly.

Energy use in the residential, commercial and institutional sectors was predicted to increase very slightly. In fact it has decreased from about 157 TWh in 1995 to 145 in 2006.

Much of this is due to heating. The total heated area was forecast to increase some 7 per cent in 1995–2005.

Forecast April 1997 in Mton emissions[1]					
	1990	**1995**	**2000**	**2005**	**2010**
CO_2	55.4	58.1	60.1	62.1	64.3
CH4		6.3	6	5.7	5.5
N_2O		2.9	3.3	3.6	3.9
HFC		0.2	0.8	0.9	0.9
CF4		0.4	0.5	0.5	0.6
SF6		1.2	1.2	1.2	1.2
Total	**66.52[2]**	**69.5**	**71.9**	**74**	**76.4**
Index	100	105	108	111	115
Actual[3]			**2000**	**2005**	Extrapolated **2010[4]**
CO_2	56.3	58	53.4	52.6	50.4
Total	72	73.4	68.3	66.9	64.3
Total index	**100**	**102**	**95**	**93**	**89**

Table 1. Note: Emission accounting methods have changed over the years, so the inconsistencies in absolute numbers are substantial. especially for gases other than CO_2.

1) p16 and 100-101 in swenc2

2) The stated figure is 68.7 but that includes a "normal year correction" of 2.2 Mton extra CO_2

3) Sweden's National Inventory Report 2008

4) Trend from 1990–2006 extended to 2010

In fact it grew 14 per cent[2]. More buildings, but less energy.

Finally the transport sector's energy use grew even faster than predicted. Gasoline use decreased somewhat, against expectations of a small rise. But diesel oil use almost doubled from 1995 to 2006, against a rather small predicted increase.

To sum it up, the forecast underestimated economic growth and overestimated energy use, so the resulting emission forecast was much too high. The forecast for CO_2 for 2005 was an 11 per cent increase. In fact emissions decreased 7 per cent. The forecast for 2010 (all Kyoto gases) was 76.4 Mton CO_2-equivalents or +15 per cent on 1990. An educated guess (extrapolation with some data for 2007–2008) is that it is more likely to be about 64 Mton or -11 per cent.

The discrepancy cannot be explained by pessimistic assumptions on economic growth, which so far has been much higher (about 3 per cent in 1997–2007) than the forecast (about 2 per cent).

In fact there seems to be no relation to GDP at all. The input of all energy into the economy has been more or less

1 Energy in Sweden. Facts and figures. 2007. Swedish Energy Administration www.swedishenergyagency.se/web/biblshop.nsf/FilAtkomst/ET2007_50.pdf/$FILE/ET2007_50.pdf?OpenElement

2 Boverket www.boverket.se/upload/publicerat/bifogade%20filer/2007/energianvandning_i_byggnader.pdf p 34

constant since 1970, excluding waste heat from nuclear power.
The decoupling between GDP and electricity took place in 2001. There seems now to be no reason to expect a further increase in electricity use.

Year	Electricity consumption,TWh
1990	139.9
1995	142.4
1997	142.6
1998	144.0
1999	143.5
2000	146.6
2001	150.4
2002	148.6
2003	145.1
2004	146.8
2005	147.1
2006	146.2
2007	145.9
2008	144
2009*	138*

*Short-term forecast by the Energy Authority 2009-07-08

The reason why electricity use has stagnated, in the midst of a tremendous boom, is pretty obvious. Sweden and Finland have the highest per capita use of electricity in the EU, way above the other rich EU countries. (Most of the 2009 drop is of course due to the economic downturn, which hit Swedish heavy industry severely.)

It may not be as simple as saying that at about 14,000 kWh/capita the need for electricity is saturated. With stronger economic, political and technological pressure this figure might be reduced. But even with moderate pressure, as in Sweden in the years following 2001, there seems to be a limit to electricity consumption. Even for the very wealthy and with very cheap electricity it is hard in the long run to avoid heat pumps, CFLs, and more efficient ventilation and cooling.

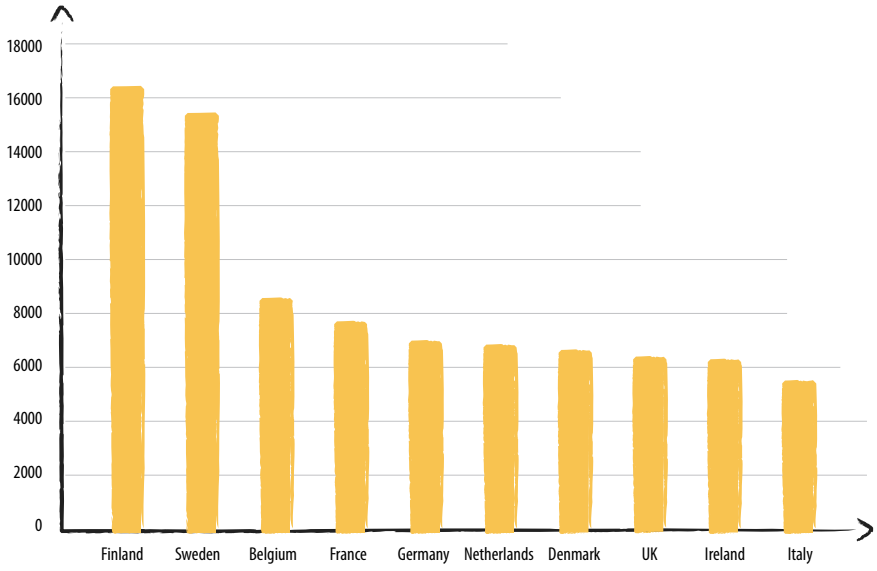

Figure 1. Per capita use of electricity 2003 in selected EU countries. Source World Resources Institute http://earthtrends.wri.org/text/energy-resources/variable-574.html

The fall in CO_2 emissions, or lower fossil input, has taken place mainly in two sectors.

Coal use in district heating decreased by 60 per cent or 5 TWh. The coal cut equals 1.7 Mton CO_2. The other fossil fuels also decreased slightly. This was made possible by the rising use of biomass: from 10 TWh in 1990 to 36 TWh in 2006.

While getting greener, district heating was also getting bigger. It grew 30 per cent during that time, mainly substituting oil heating. At the same time many oil boilers were replaced with heat pumps. Together these two factors produced dramatic results. Oil use in the residential and service sectors (and in all probability in much industry as well) fell from 41 TWh in 1990 to 15 in 2006, equivalent to some 7 Mton CO_2.

These two factors together explain why Sweden's emissions dropped. In fact the 9 Mton they account for is more than the whole drop. Other sectors increased their emissions, notably inland transports and some industries such as refineries and steel.

The root cause for falling CO_2 emissions existed well before 1997: the CO_2 tax introduced in 1991. That tax has changed several times, but has been fairly consistent for households and district heating. Oil was heavily taxed in these sectors even before 1991 as a result of the 1990s oil crisis.

Despite some large loopholes, the CO_2 tax worked, but it did not always work fast. Some district heating companies kept using coal and oil for another ten years in the hope that they would be able to get rid of the tax through more lobbying. Many people were initially unwilling to throw out their oil boilers because they did not trust the alternatives (especially heat pumps) or thought they would involve too much hassle (wood pellets).

Other policy instruments have contributed as well as the oil price increases from 2003, but with the CO_2 tax alone, a decrease rather than an increase in emissions could have been predicted.

The +15 per cent increase was what Sweden expected would happen under its business as usual scenario, not very different from other similar EU member states.

The decisive EU burden-sharing agreement was reached by the environment ministers in March 1997. The Dutch presidency was well prepared and used a complicated model,

Triptych, for the indicative distribution of commitments. At the time the model input data was collected, the Swedish parliamentary decision to phase out all nuclear by 2010 was still in force, though nobody in Sweden believed it valid. By March 1997 it was absolutely obsolete.
Sweden did not actually lie about its nuclear phase-out, but according to Sweden's then chief negotiator Bo Kjellén, there was little discussion at the March 1997 meeting. He readily admits to not having studied the Triptych model results very closely, and believed then that Sweden was being rewarded for its past (pre-1990) emission reductions. Sweden had reduced its CO_2 emissions between the 1970s and 1990 partly due to the fact that new nuclear power had replaced oil for heating.

But a 1998 paper[3] from the Triptych modellers shows that they assumed a complete nuclear phase-out by 2010. The base case emissions were calculated to increase from 4 million tons in the power sector in 1990 to almost 20 Mton by 2010.

This projection may have been reasonable (or not) under the assumption of a phase-out. But the assumption was mistaken.

In February 1997, the Social Democrat government along with the much smaller Left and Center parties declared a new energy agreement, which in effect said that two of the 12 reactors were to be phased out by 2001, with nothing more said about the rest.

The reason why Sweden was allowed +4 per cent in the burden-sharing agreement was that the Dutch presidency in early 1997 engaged a complex scientific model called Triptych to calculate the differentiated burdens of the then 15 EU member states. The model aimed at convergence of CO_2 emissions per capita and GDP but treated three separate sectors: power production, industry and domestic, and weighed in a number of national factors such as GDP, climate, and industrial structure.

The model results were favourable for Sweden, which had relatively low emissions per capita, and was supposed to phase out its nuclear power according to the understanding of the modelers.
The indicative burden-sharing table handed down by the Dutch presidency, based on the Triptych model, was accepted, without too many questions.

The final burden-sharing decision was even easier, since it was now eight per cent, all six Kyoto gases, instead of 10 per cent (actually only CO_2), which meant a lighter burden for everybody but with the same distribution.

Whatever reason there was for Sweden to get away with +4 percent, the fact remains that there is a huge surplus, worth at least a billion euros, at €30/ton. It might be worth more, as it can be banked past 2012, when prices are expected to be higher, at least if Copenhagen 2009 results in an agreement which will force global emissions down.

What Sweden actually will do with the surplus "has not even been discussed on the political level" during the present Right-Center government, according to chief negotiator Anders Turesson.

Under the previous Social Democratic government, the minister for the Environment, Anna Lindh (later Foreign minister, murdered in 2003) declared that Sweden would not "use" the surplus, but then she was probably referring to the difference between +4 per cent and stabilization at the 1990 level, which was Sweden's national target.

There are three options for the surplus: sell, save or burn.

Sell. To sell it would be illogical, as parts of the GHG reductions in Sweden have cost more per tonne than the going price. One such example is vehicle ethanol, which has cost a lot in lost taxes and in investment subsidies, mainly presented as climate policy. If the reduction has cost €50 per ton it makes no sense to sell it for €30. Sweden has done more for the climate than required. But this good deed is totally lost if all the good effort is sold. If openly declared it would undermine Sweden's standing in the preparations for Copenhagen 2009, when Sweden has the presidency of the European Union.

Save. To save it is actually the same thing as selling it, though it is less obvious.

Burn. If Sweden declares that it intends to cancel or surrender the surplus, this would send a clear signal of goodwill on top of an exemplary capacity to cut emissions. It would force the hand of others with a greater need to up their ante. This would hardly work if it was left until the day of reckoning in 2013. It has to be done well before Copenhagen.

Nuclear vs climate

In the late 1990s, Sweden had the most nuclear power per capita in the world, a little ahead of France. But by 1999 the first Barsebäck reactor was closed down, and by 2005, the second followed suit, to the relief of the Danish government and people. The reactors can be seen from the Danish capital Copenhagen across the Öresund strait.

Barsebäck was a special case, rather than a first step in the phase-out of nuclear power. The previous Social Democrat government remains committed to a general nuclear phase-out, but with no specifics as to when and how this would take place. The second biggest party, the (conservative/liberal) Moderate party has no policy at all. Of the smaller parties, the Left, the Greens and the Center party are more or less anti-nuclear, whereas the Folkpartiet (liberal) wants to build new nuclear power.

The Energy policy proposition[4] of March 2009 from the four center-right parties of government phased out the phase-out. The former anti-nuclear Center party now accepts even new nuclear power plants.

3 Phylipsen et al: A Triptych sectoral approach to burden differentiation; GHG in the European bubble. Energy Policy Voll 26 No 12, 1998

4 En sammanhållen klimat- och energipolitik – Energi Prop.2008/09:163

For the foreseeable future, it does not look likely that the future of Swedish nuclear power will be decided by politics, even if the present government is re-elected in 2010. (If the opposition wins, the three parties have said that the phase-out will continue, though with little specifics.)[5] The decisive factors will instead be safety and economics.
Most reactors are planning uprates in capacity, and could thus more than recover the capacity lost in Barsebäck. In 1999, before the closure of the Barsebäck reactors, capacity was 10,055 MWe.

Reactor	Present capacity, MWe (2008)	Planned
Forsmark 1	1,014	1,134
Forsmark 2	1,014	1,134
Forsmark 3	1,190	1,360
Oskarshamn 1	490	490
Oskarshamn 2	630	805
Oskarshamn 3	1,200	1,450
Ringhals 1	880	880
Ringhals 2	910	910
Ringhals 3	1,010	1,110
Ringhals 4	915	1,160
Sum	9,253	10,433

Table 3. Current capacities and uprates of Swedish reactors
Source: N Garis, Swedish Nuclear Inspectorate 2008-02-08, own calculations

To judge from table 3, Sweden will have more nuclear power than ever in 2012 or so. But this is not so sure. The actual nuclear production has decreased each of the five last years and will continue to do so in 2009

	TWh net
2004	75.0
2005	69.5
2006	65.0
2007	64.3
2008	61.3
2009	<60

Table 4. Nuclear power production in Sweden Source: Energimyndigheten, for 2009 own calculation as of the situation in late August 2009

The fact that there are applications for power uprates at most reactors does not mean that implementation is a foregone conclusion. They have to pass several stages of licensing by the radiation safety authority and by the government, and at every stage there are conditions, which can be very costly even at first glance. Several projects are years behind schedule (Forsmark 1–3), or far over budget (Oskarshamn 3).

Uprates, life-extensions and mandatory safety upgrades all mean long shutdowns. When one thing is fixed, other problems appear. The Oskarshamn 1 reactor lost five years of production during its modernization in 1992–2003, and even after that it has had a most unsatisfactory performance.

The Swedish reactors are not running well. Sweden's "unplanned capability loss" for the latest three-year period was way above the world average. In the 33 nuclear nations league Sweden came in 26th place with a 7.3 per cent unplanned loss, compared with 0.5 per cent in Finland and 1.5 per cent in the USA[6].

The economic outlook for nuclear power has improved greatly as a result of the huge increase in electricity prices since the late 1990s. But this does not mean that every investment will make economic sense. The uprates can be postponed, if judged too expensive. But the mandatory safety upgrades are not negotiable, and life-extension measures cannot be postponed very long. Projects in the billion dollar range for each reactor, and with large uncertainties, cannot always be justified. Then there will be a fast and unexpected decision to shut down the reactor for good, or possibly to "mothball" it as was done for seven Canadian reactors in 1997. Most of them never started again, though.

It is possible, even likely, that some of the uprates will take place, but that 1–3 reactors will be closed by 2015.

In the longer term a complete phase-out of nuclear power seems unavoidable, as no new nuclear power is envisaged. Politics is not the main obstacle, though most politicians do not want to hear about new nuclear, let alone pay for it. The nearby Olkiluoto-3 project in Finland is at least three years behind schedule and has turned out to be a first-class disaster for the Areva-Siemens vendor consortium, and they are unlikely to sign another turnkey fixed price contract. Even if the power company TVO can stay clear of the 1 billion plus in extra costs for construction (which is legally contested by Areva), they have lost a lot of money for at least three years of electricity production from the biggest nuclear power reactor in the world.

The eventual fate of Swedish nuclear power will probably not influence Swedish greenhouse gas emissions. New power in Sweden will mainly be wind power, not fossil power. The planning target for the Swedish energy authority is 30 TWh of wind power by 2020 (from just 1 TWh in 2007). Even if several reactors are closed down, this will only decrease electricity exports. As electricity consumption falls slowly, there will be even less need for new fossil power.

5 www.socialdemokraterna.se/Mona/Artiklar/Vi-ar-overens-om-energi--och-klimatpolitiken/ Article in Dagens Nyheter

6 Data retrieved 2008-09-17 from IAEA PRIS at http://www.iaea.org/programmes/a2/

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