AIR POLLUTION AND CLIMATE SERIES

8

Better together?

Discussion paper on common Nordic-Baltic energy infrastructure and policy issues from an environmentalist's view

By Fredrik Lundberg

STOP ACID RAIN

The Swedish
NGO Secretariat
on Acid Rain

Published in collaboration with the Baltic-Nordic NGO Network for Sustainable Energy

Previous reports in the series:
No. 1 The Eastern Atmosphere (1993)
No. 2 The "Black" Triangle – a General Reader (1993)
No. 3 Sulphur emissions from large point sources in Europe (1995)
No. 4 To clear the air over Europe (1995)
No. 5 Large combustion plants. Revision of the 1988 EC directive (1995)
No. 6 Doing more than required. Plants that are showing the way (1996)
No. 7 Attacking air pollution. Critical loads, airborne nitrogen, ozone precursors (1996)

AIR POLLUTION AND CLIMATE SERIES

Better together? Discussion paper on common Nordic-Baltic energy infrastructure and policy issues from an environmentalist's view.

By Fredrik Lundberg

Cover illustration: © Per Elvingson.

ISBN: 91-558-3626-7

ISSN: 1400-4909

Printed by Nykopia, Stockholm, Sweden, 1996.

Published by The Swedish NGO Secretariat on Acid Rain, Box 7005, S-402 31 Göteborg, Sweden. Phone: +46-31-10 55 90. Fax: +46-31-711 46 20. in collaboration with the Baltic-Nordic NGO Network for Sustainable Energy.

Contents

Introduction

There are two large scale energy infrastructures in the Nordic-Baltic region: electricity and natural gas.

Power companies and sometimes politicians have from time to time proposed grand schemes such as a Baltic Ring for electricity and a natural gas connection between Finland and Norway through Sweden, possibly adding a supplier to the Baltic republics.

The prime object of this paper is to give a background for the environmental assessment of such joint projects of rigid structures (pipes and pylons). The second object is to discuss other cooperation and interdependence around soft issues such as the so-called de-regulation of the electricity market and harmonization of taxes on energy and pollutants.

The paper is limited to the Nordic countries Denmark, Finland, Norway and Sweden which have a long history of cooperation and many common features, and the three Baltic republics Estonia, Latvia and Lithuania, which are close neighbours and, like the others, small nations. As the Baltic republics obviously have much in common, the "Nordic-Baltic region" seems to be a manageable unit – at least more manageable than if Russia, Poland or Germany were also to be included. More to the point, perhaps, is that Finland and the Baltic republics import all their natural gas from Russia, which is perceived as a constraint to increase its use. The nearest alternative supplier is Norway, and Sweden (which now gets all its gas from Denmark) is in between. This defines the region.

The reader is strongly recommended to take a good look on the figures, with some comments, in the following chapter.

As for electricity, the "Nordic-Baltic" region is no natural entity. The Nordic countries are, however, almost a closed system: a considerable amount of power is traded between the four countries but not much to the outside world (Russia and Germany). The Baltic republics have most of their trade with each other and with Russia and Belarus. The Nordic influence is however strong, through development assistance, and through the "Energy Master Plans" where the Swedish and Finnish giant power companies have outlined their agenda.

Power and heat (fuels) are to some extent interchangeable, especially in Sweden, Norway, and Finland where electric heating is very common. Where there is district heating or industrial process heat, there is also a base for combined heat and power. From a thermodynamic point of view, power is energy of a superior quality; this is so because while electricity always can be transformed into heat with almost no loss, the transformation of heat to electricity always involves large losses; typically 2/3 of the energy content of the fuel fed into a power station is lost as lukewarm water heat into the sea or a river or a lake.

For this reason, it is generally more important to save electricity than to save heat. The utility Göteborg Energi in Gothenburg, Sweden, considers one unit of electricity equal to 2.6 units of heat in its efficiency program. This is good rule-of-thumb, also applicable in the Baltic republics.

The environmental impact of power (and heat) production is obviously huge. Fossil fuel power plants are major emitters of CO_2, sulphur and nitrogen dioxides. Hydro power often involves a large scale habitat destruction, as does shale and peat exploitation. Nuclear power can cause catastrophes, and have also negative impacts or risks associated with the life cycle from uranium mine to radioactive waste.

The environmental impact from different sources of power differ very much from each other. In some cases they are directly comparable. A modern natural gas power plant emits much less CO_2, and very much less NO_x, SO_2, N_2O etc. than an old coal or shale power plant. A modern Swedish nuclear reactor (those commissioned in the 1980s) is much safer than the Ignalina reactors or an older Swedish reactor.

For any one nation, it costs a lot to close down all the worst plants and build new and better ones. Technical coordination could result in less use of the bad plants and maximum utilization of the best ones. (This is what the Nordel, a voluntary coordination between power producers and grid companies in the Nordic countries claim to have achieved already.) Optimized use of the existing infrastructure and shared investments could produce environmental benefits. This is the traditional technical planning approach, moved a step up from the national level.

This is however not the only approach to the problem. Centralized technical planning has been a strong feature in the power industry not only in the Soviet union but also in the supposedly market economies of the Nordic countries, whose power sector is largely government-owned, and subject to strong political intervention. There are historical reasons for this. But their validity for the future is contested by a new school of liberal thinkers, with increasing support from environmentalists and younger Leftists.

According to this school, all environmental targets that could be achieved by strategic investments and political control-and-command could, largely, be achieved faster and cheaper by "market instruments". Eco-taxes is the most well known such instrument; they are supposed to "internalize the environmental costs" and make the market work for less emitting methods of production. Just as important is to stop all subsidies of energy infrastructure and for energy consumption (for example subsidized energy prices to energy intensive industry).

Both those will lead to more expensive energy, which will enhance efforts to save energy. Eco-taxes at a reasonable level will make the worst plants lose money, and thus put them in a situation where they will have to choose between closing down and cleaning up their act. Whether they do this by switching to a cleaner fuel, by retrofitting existing plants with flue gas desulphurization etc. or by just running their plants less time and buying the rest of the power they need, this is left to them to decide.

Other relevant economic instruments are liability and compulsory insurance levels. If a nuclear power is legally obliged to be insured to cover potential damage at a level of, say, 25 billion dollars, the insurance company will demand a much higher policy from a plant deemed risky than one considered relatively safe. If it is a *very* bad plant, no insurance company will be found. The present policy for nuclear power accidents in most countries is that the reactor owner is legally immune to the costs. The victims will have to carry the costs themselves – with some assistance from the taxpayers in the victim countries.

The finer details of the environmental problems in the Nordic-Baltic region cannot be elaborated here. It is indeed questionable if it would be worthwhile to point out a worst-500-list or so, because the target is moving. There is no fixed or predictable demand for energy to plan for. Consumption patterns differ by a large factor between whole nations, so that for example Norway uses six times as much electricity per capita as Italy which has a similar level of industrial development. There are even bigger differences for more specific applications such as lighting, refrigeration, industrial processes etc. This is even more striking if the whole chain from raw material input to final energy service is taken into account. One million kWh of electricity from the shale-fired Estonian Thermal Power Plant, serving ordinary incandescent lamps produces 1400 tons of CO_2, 13 tons of SO_2 and 800 kilograms of NO_x.

This awful situation could be remedied in steps:

a) bulbs are replaced with compact fluorescent lamps giving the same light with 80 per cent less energy consumption and thus cutting CO_2 emissions to 280 ton, SO_2 emissions to 2,6 ton and NO_x emissions to 160 kg.

b) a modern efficient natural gas combined cycle plant demanding still 50 per cent less energy input *and* CFL lamps. Now the emission of CO_2 is down to 66 ton, SO_2 is nil and NO_x emissions less than 90 kilograms.

c) Take a good look at the lamps and find out whether and how they are needed. Take maximal use of daylight (perhaps with new technology to reflect and diffuse more daylight into a shop or an office) which electronic gadgets which dim and turn on/off the light as needed. The energy demand is halved once again. The energy input is now 90 per cent less than it was in the first place, CO_2 emissions 95 per cent less, other pollution reduced to insignificant levels – and the lighting just as good.

Still more dramatic energy savings and pollution cuts can be achieved by changing the economical structure – such as when a loss-making polluting heavy industry is closed and replaced with light manufacturing (no pun intended, but CFL factories are booming in Poland) or service industry.

In a rapidly changing world it can be a very expensive mistake to try to forecast the future and invest capital to meet the forecast energy requirement.

The "Baltic ring" kind of solutions should therefore be rejected out of hand. The electricity supply and transport system has a huge over-capacity all over the region, and any new projects should be subject to a critical review. With a view to long term sustainability, and to the potential for electricity saving, this overcapacity is even more striking.

The notion, sometimes vented in Sweden, that a cable to Lithuania should replace Ignalina with Swedish safe nuclear power, is absolute nonsense or rather a political smoke-screen. It takes many years to negotiate and build a trans-Baltic cable, and it costs hundreds of millions of dollars. It will also never happen. Who would pay for it? An increase in cross-border trade of electricity within the existing grid is however both likely, and under some conditions economically and ecologically good for all parties.

As for the natural gas project, the situation is less clear-cut. There are some advantages with such an undertaking as well as some drawbacks.

The most important question-mark, however, is not whether it is desirable or not, but whether it is realistic or not. If all the NGOs campaigned for it, it is still far from sure that it would be realized. If it would actually take place, the question is when. After all, the issue has been on the table for twenty years, and even if all political and economic issues were resolved immediately, it would still take some years before the benefits would be tangible. Even with the pipeline in place, the branches to the places where it would replace coal, peat, shale and oil would take still more years.

It would also cost a lot of money, In the "order of magnitude" 10-15 billion Finnish Marks, according the 1994 study by the Nordic Council of Ministers – and the estimate is made by the rather vested interests of Statoil and Neste. It does clearly not include the costs from the Norwegian gas well to the mainland, nor any branches, nor any of the gas-using equipment. The grand total could be 4-5 billion dollars or more.

Is there any way to get the same benefits but quicker and cheaper? That depends of course on the definition of the benefits. For the environmental NGOs, a rough definition would be: a substantial cut in CO_2, SO_2, NO_x, VOC, CO, heavy metals and particulate emissions, as well as substantially decreased risks of nuclear accidents.

The Nordic environmentalist NGOs demand a 20 per cent cut of CO_2 emissions from base year 1990 by 2005 and for a phaseout of nuclear power by at latest 2010. To present a more detailed set of targets and time tables does not seem meaningful. The "substantial cuts" of the above emissions gives the rough idea of where we are heading. The issue here is not "how much? and "by when?" but "how?".

The non-environmental benefits of a Finnish-Swedish-Norwegian gas connection is that it would add to the security of supply for Finland, and to the Baltic states and give them better negotiating terms with Russia. The security of supply issue is not so simple as that (as discussed in the chapter about natural gas) but it would be politically naive to dismiss it.

Could the objects (pollution, cuts, nuclear phaseout and a reasonable security of supply) be achieved faster, cheaper and on a durable basis? Yes, they could. If the environmental costs of energy are internalised, and demand side management is vigorously pursued, there are splendid expectations for reducing both the energy input and its environmental consequences.

With a CO_2/energy tax like the one proposed by the EU Commission, with sulphur taxes already in place in some of our countries, with NO_x taxes introduced, the worst polluting and least efficient power and heat producing plants would be least used, and some of them could soon be closed down. The worst polluters would have to choose between switching fuels, retrofitting flue gas desulphurization and NO_x reduction systems or to close down. Whichever the choice, the environment will win.

The transport sector is almost completely separated from the power and heat sector, but is also a very large emitter of CO_2, NO_x, VOC and some SO_2. No substantial improvement of the environmental situation can be achieved without a transport policy. The simplest way to cut emissions is that every nation increase taxes on petrol and diesel up to the highest level in the region. Secondly, leaded petrol should be out-lawed, and diesel oil qualities subject to strict legal standards. Third, car taxes, and tax exemptions (if any), should be designed so as to minimize road transport and emissions. Fourthly, road tolls should be examined, especially as an alternative to new road schemes. There are other, more sophisticated, ways to deal with transport emissions, but these can be done now, with immediate effects. The tax money could be used to cut other taxes – or to increase old age pensions, unemployment benefits etc.

Economic instruments is not the only way to move towards sustainability. Legal standards for emissions is necessary for attacking local environmental and health problems, and represent a second best solution for long range pollution. Even if the Polluter Pays Principle is implemented through a number of eco-taxes, etc., the market will not by itself do all the job.

Often there is a chicken-egg problem of introduction of new, efficient and clean technology. Before there is a market, there is no product. Before there is a product, there is no market. This can be helped by coordinated procurement. The Swedish government authority Nutek's Energy Efficiency unit has set some examples. A few years ago they arranged a competition for an energy efficient refrigerator, where the first prize was an order of 500 refrigerators to new flats to Community Council flats in Malmö – and the commercial credit for the winner, which was the Electrolux company. The specification for energy consumption was not only fulfilled, but surpassed. A new product entered the market, and the cost for the tax-payer was small: for the work with specification and to find a group of purchasers and a limited subsidy for the first order. Similar success stories could be told about competitions for efficient (and aestethically pleasing) windows and superefficient heat pumps.

Mandatory standards for efficiency and eco-labelling (for example as declaration of energy consumption for refrigerators, as required in the European Union) are related issues. Eco-labelling helps the customer to choose a better product without spending much time and work. It also influences the manufacturer, importer, retailer and shop. A low rating in the Eco-label gives a shabby image, a high rating is associated with cleanliness and modernity – quite apart from the actual economic value of energy saving. It should also be born in mind that the customer is not always an individual. It can also be a hotel chain or the local school board, which decides as a matter of policy to buy eco-labelled or low energy-rated products whenever possible.

Demand Side Management, as an alternative to supply side planning was invented by energy utilities in the United States. The first idea was, and is, that new power plants cost a lot of money. If the customer can be persuaded to save electricity (or gas, or heat), the new plant will not have to be built, or could be built later. The second idea was that the customer usually does not want energy as such, but energy services such as lighting, heating, cooling, fresh air, electrical motive power etc. Often the customer, such as factory, a shop, and office, a landlord or an ordinary house owner, has no expertise in these fields. If the customer can get better quality for the same money, they do not worry too much about the price per kWh. The utility then sells energy services rather than as many kWhs as possible.

In a competitive situation, this can be a strong selling point – to keep customers and to win new customers. It is also a way to provide the staff with new jobs, as old jobs are being rationalised. But it does not necessarily happen by itself, because companies that have sold kWhs, the more the better, for hundred years do not change easily. The legislative and political environment is very important.

The intellectually easiest way to formulate energy policy is to give a table of what we have on the supply side (coal, peat, nuclear, oil) which we do not want, and to list a number of alternatives (wind, solar or natural gas) which could make up for the losses.

The Norway-Sweden-Finland-Russia natural gas connection is easy to grasp. So are some proposed new powerlines. But supply side investments are probably not the cheapest, nor the quickest, nor the most durable way to achieve large cuts of pollution and risks.

Increased energy efficiency does not only displace polluting power plants. It would also help the transformation of our economies to become more modern, flexible and competitive.

This paper argues that we should do first things first. First we should see how far we can go with eco-taxes and a concerted effort to save energy, especially electricity. If that fails, we should look for large scale supply side alternatives.

Basic figures

Warning: as no uniform database has been found, there are inconsistencies!

Table 1. Population, million people 1990.

Denmark	5.1
Estonia	1.6
Finland	5.0
Latvia	2.7
Lithuania	3.7
Norway	4.3
Sweden	8.4

Table 2. Electricity production 1989/90, TWh (=billion kWh).

Denmark	22.8
Estonia	14.4 (1991)
Finland	54.4
Latvia	6.6 (1992: 3.8)
Lithuania	28.4 (1993: 11.0, 1994: 7.6)
Norway	119.6 (1993)
Sweden	143.9

Source: general (1) Norway (2), for Lithuania 1993-94 (3), later Latvian figure (4)
Comments: The above figures give a rough idea about the capacity

Table 3. Electricity production per capita 1989/90.

Denmark	6300
Estonia	9300
Finland	10900
Latvia	2500
Lithuania	7600
Norway	27800
Sweden	17300

Source: (1), Norway own calculation from (2).

Comment: Electricity was traded between the countries and to third countries, which explains most of the difference between the Baltic republics: Estonia and Lithuania were exporters and Latvia importer. The other nations are roughly self-sufficient (within a margin of 10 per cent). The link between a large electricity supply and economic prosperity seems weak, to say the least. Sweden and Norway had roughly the same economic level as Denmark in 1990, in spite of having 3-4 times as much electric supply. And Lithuania was certainly not richer than Denmark.

Since 1990 most of the electricity exports in the Baltic republics and also internal consumption have fallen drastically. There is now a very large overcapacity.

Table 4. Electricity consumption, TWh, and forecast growth 1990-2010

	1990	1992	el. growth	GDP growth
Denmark	30.7	32.5	0.6%	2.5%
Estonia	7.2	4.8	3.7%	1.7%
Finland	60.0	63.0	1.9%	3.0%
Latvia	8.6	6.3	2.4%	0.3%
Lithuania	13.0	9.8	2.4%	0.0%
Norway	103.3	107.0	0.7%	2.5%
Sweden	138.9	138.4	0.9%	1.7%

Source: (8), table 1.17.

Comments: The forecasts are not to be believed, but are still telling as they are derived from official sources, and reflect the "conventional wisdom". This is very different in different countries. Denmark, with a relatively low electricity consumption forecasts low growth of it, while Finland with a relatively high electricity consumption forecasts a very fast growth. An annual 1.9% growth amounts to a 48% growth over the 20 years, from 60 to 89 TWh. In the same fashion, Sweden's and Norway's enormous consumption is predicted to grow by another 40 TWh.

Table 5. Electricity final consumption 1992 per capita, kWh.

Denmark	6400
Estonia	3000
Finland	12600
Latvia	2300
Lithuania	2600
Norway	24900
Sweden	16000

Sources: own calculation from tables 1 and 4.

Comments: The figures for Latvia and Lithuania reflect the miserable situation, which is actually even worse than they show, because some of the heavy industry still consumes a lot of electricity (though it does not always pay for it), leaving even less room for private, small-business and commercial consumption. The very large discrepancies between the four rich countries suggest that above a certain level (that of Denmark, approximately), there is no link between high electricity consumption and economic wealth.

Table 6. CO_2 emissions 1990.

	Mtons	kg/capita
Denmark	56	11
Estonia	36	23
Finland	55	11
Latvia	36	23
Lithuania	39	10
Norway	31	8
Sweden	63	8

Source (1), Norway (9).

Comments: The emissions from the Baltic republics have decreased drastically since 1990, much of it due to irreversible structural change and abandonment of some of the subsidies for fuel. By 1995 the predominant emissions of CO_2 do not come from the Baltic republics. If CO_2 emissions are to be cut substantially for the whole region it cannot exclude any countries.

The difference between the rich four are easy to explain: Norway and Sweden hardly use fossil fuels for electricity, but rely on hydro and nuclear. Finland has also hydro and nuclear, though not as much as Sweden/Norway (and large biomass resources) but is still as carbon-intensive as Denmark, which has neither nuclear, hydro nor much forests.

Table 7. Coal consumption.

Denmark	6.85 MToe 1992
Norway	0.8 MToe 1992
Finland	3.8 MToe 1992
Sweden	2.4 MToe source (9)
Estonia	2.4 TWh 1991 = circa 0.2 Mtoe coal and ca 5 MToe oil shale
Latvia	648 kton 1992 = circa 0.4 MToe
Lithuania	12 TWh 1992 = circa 1 MToe

Sources: 4,5,6 and own calculations.

Comments: Coal combustion produces very large amounts of CO_2, and it is easier to substitute for than natural gas and oil. If a fuel switch is needed it should be targeted for the rich countries, especially Denmark and Finland, rather than the poor ones.

Table 8. Natural gas consumption, Mtoe 1992.

Denmark	2.2
Finland	3.0
Norway	-
Sweden	0.73
Estonia	1.2 Gm^3 = circa 1,1 Mtoe
Latvia	2.2 Gm^3 = circa 2 Mtoe
Lithuania	3.2 Gm^3 = circa 3 Mtoe

Source: (8).

Comments: Natural gas is a substantial source of energy except in Norway, where it is produced but not used, and Sweden.

Table 9. SO_2 and NO_x emissions, kg per capita 1990.

	1990 SO_2	1990 NO_x	1993/94 SO_2	1993/94 NO_x
Denmark	35	55	35	55
Estonia	146	13		
Finland	52	58	28	53
Latvia	47	4		
Lithuania	47	10		
Norway	9	51	8	53
Sweden	15	48	12	44

Sources for 1990: (1) and for Norway calculations after (7).

Comments: The Estonian oil shale is a very big SO_2 problem, though the figures have gone down since 1990. Finland cut its SO_2 emissions to 28 kg/capita in 1993, source (2) which leaves Danish coal the chief remaining culprit of the rich countries.

NO_x is clearly a problem caused by the rich countries, due to the much higher use of cars, lorries, ships, air-planes and agricultural machinery.

Table 10, Energy intensity 1973 and 1993 in total final consumption per Gross Domestic Product (GDP) in tonnes of oil equivalent (toe) per 1000 dollars

	1973	1993
Denmark	0.17	0.11
Finland	0.23	0.20
Norway	0.23	0.16
Sweden	0.21	0.16
Japan	0.17	0.10

Source (9).

Comments: the energy intensity has not been calculated for the Baltic republics. It would not be meaningful as GDP is not a good measure of the state of their economies. Japan is included for comparison. It has half the energy intensity of Finland.

Sources

1 Statistiska centralbyrån: The Baltic region. Statistics on resources, environment and economy. Stockholm 1993.

2 OECD in figures. Statistics on the member countries. 1995 Edition (Brochure).

3 Commisariat a l'énergie atomique: Les Centrales Nucleaire dans le monde 1995.

4 Energy Master Plan for Estonia. Pre-feasibility study. March 1993 by Vattenfall AB, Imatran Voima OY, RE Eesti Energia.

5 Energy Master Plan for Latvia Pre-feasibility study. January 1994 by Vattenfall AB, Imatran Voima OY, Latvenergo.

6 Energy Master Plan for Lithuanian State Power System. Pre-feasibility study. Main Report December 1993 by Vattenfall AB, Imatran Voima OY and Lithuania Ministry of Energy and Lithuania State Power System.

7 Yearbook of Nordic Statistics 1995.

8 Naturgasens roll i Norden och Baltikum fram till år 2010. Study by the Nordic Council of Ministers. Tema Nord 1994:68.

9 International Energy Agency: Energy Policies of IEA Countries 1993 review. OECD 1994.

Natural gas – the pros and cons

Natural gas is a misnomer since it is a fossil fuel. The "natural" about it is that, unlike city gas, which is a derived, processed product from coal or oil, it is found in nature. Even this is not exactly true. Natural gas is also processed, so that for example all sulphur is removed before it is sent out through a pipeline or by ship.

Natural gas *as a fuel* has several economical and environmental advantages compared to coal, peat, oil and shale. But it cannot be seen just as a fuel. The infrastructure goes with it. Coal or oil can be bought by the wagon-load, but natural gas has to come through a large, expensive pipe system. This system is suitable for one single fuel, i.e. fossil natural gas. As discussed further down in this chapter, it is theoretically possible to run renewable gas through a natural gas pipe system, but in practical economical and technical terms it does not work.

A large investment in natural gas infrastructure is a commitment to a very large and very long term use of a fossil fuel, which translates to emissions of many millions of tons of CO_2. The problem is thus how to make best use of natural gas to replace worse fuels – without diverting the resources necessary for investment in efficiency and renewables.

Natural gas – advantages

Natural gas contains no sulphur, so it emits no SO_2. There are no heavy metals. No ash is produced. Because of its homogenous and gaseous character the combustion conditions can be well controlled over a wide range of outputs. This makes it possible to minimise NO_x emissions (which are the result of atmospheric nitrogen and oxygen combining in the hot flame). As natural gas mainly consists of methane (CH_4) about half of its energy content comes from hydrogen and only one half from carbon. This means roughly half as much CO_2 emissions per unit of heat produced as from coal, peat or shale. The other "waste product" is just water vapour.

If natural gas is in place (which however is a big "if") it needs no storage, no complicated feeding mechanism, no ash treatment, no flue gas desulphurization and often no special equipment to treat NO_x. Therefore it can be used in small, medium or large scale. The ovens or boilers can be built without much advance planning and capital outlay and be expected to have a long life, high reliability and low maintenance costs.

The natural gas transport and distribution is also an *energy carrier* which in some respects compares favourably to electricity.

A pipeline can transport more energy, with less losses, than a 400 kV power line over a long distance. Unlike electricity, natural gas can also be transported over the oceans in special ships. In these ships the gas is cooled to liquid natural gas (LNG) at -161 °C. Some 15 per cent of the energy is lost from cooling and transport, and there are huge capital costs for liquification terminals, LNG tankers etc. Still it is a flourishing business. About 1/4 of the trade with natural gas goes with LNG.

Natural gas can be used for direct heating as an alternative to electricity in many industrial processes – for example for melting glass and metals and for drying paper pulp to paper. It can be used for direct space heating (and hot water production) of homes and buildings, which since many years is common practice in the Netherlands and in parts of the United States. It can also be used for cooking, for clothes driers etc. where electricity is the normal alternative. When natural gas is used directly, as an alternative to electricity from coal, there are very substantial environmental gains. A traditional coal power plants has an efficiency of some 35 per cent, whereas direct natural gas use is 80-95 per cent efficient.

Even if natural gas is used for power-only, it is environmentally vastly superior to other fossil fuels. With "combined cycle" (gas turbine plus steam turbine) a 60 per cent efficiency is now within reach: all the big international manufacturers have advertised this near target. If heat is demanded, still higher total efficiencies (more than 90 per cent) can be reached in combined heat and power output.

A 60-per-cent-efficient natural gas power plant replacing the worst solid fuel plants in the region can cut the CO_2 emissions by a factor 4, NO_x emissions by at least as much, and eliminate SO_2 emissions.

Natural gas can also be used as an alternative to other fossil fuels for transport, and is used that way in for example busses in Malmö and Gothenburg in Sweden. Russia is experimenting with gas-driven aeroplanes, and a project for natural gas-driven heavy trucks is under way in Sweden. This promises very big improvements compared to the 15 year old trucks they replace, but compared to other new trucks with new high quality diesel fuel the edge is much slighter.

It is not sure that natural gas will be, or should be, the vehicle fuel for the future. Perhaps traffic planning and engine development are the key issues rather than fuel type.

Leaving a question mark for transport, natural gas is versatile. It can be used for power plants, for high-temperature industrial processes with sensitive control, for industrial and home heating, as feedstock for polymer and methanol production, as a reduction agent in the steel industry etc. etc.

Developing technologies such as catalytic combustion (for small scale direct heating) and fuel cells for small scale combined heat and power, might still increase the popularity of natural gas.

Natural gas is a finite resource. This is no great problem in itself, since the resources are adequate for any viable investment to be written off.

Natural gas proponents claim that on top of the vast fossil gas resources, there are theoretical possibilities to feed non-fossil hydrogen and biogas into the pipelines.

This is not quite true. Gas from landfills with membrane separation of water vapour, CO_2 etc. has been fed into natural gas grids since 1980 or so, though only insignificant amounts. This may change. Biogas, i.e. methane, is produced in all anaerobic processes, which are used for waste and waste water treatment of over a wide spectrum of operations ranging from manure to sugar refineries over (toilet) waste water, fermentation of separated household waste, and paper pulp plants.

Hydrogen can be fed into the natural gas system with modest needs for modifications. This would of course be very nice, since the exhausts from hydrogen combustion is only water vapour and small amounts of NO_x.

But, but, but... The solar hydrogen option exists only in a technological sense, i.e. there is enough solar energy, enough space on earth and known methods to produce hydrogen with a reasonable efficiency. The natural gas industry emphatically claims that some 15 per cent hydrogen could be fed into the natural gas system with no changes, and 100 per cent with stronger compressors and if the customers change burners.

But it would cost at least ten times as much as natural gas. Under very optimistic assumptions solar hydrogen could be on the market in the region earliest by 2015[1] and more likely some decades later, if ever.

---

[1] If solar cells could be produced at prices competitive to other electricity sources by 2000, the first several gigawatts would be for direct electricity, not for hydrogen. If large scale hydrogen production from photovoltaics were to start by 2010, it would obviously first be introduced in sunny countries. The hydrogen could then be fed into natural gas pipelines from north Africa to south Europe, but it would still not reach the Nordic region. When (if) solar hydrogen is a profitable operation in the Sahara, the costs still have to go down by a factor of 3 for this technology to make profits up here. This follows from the fact that south Scandinavia has an insolation of 1000 kWh/m2 each year compared to 3000 in the Sahara. The complete mismatch between demand (peaking February) and supply (peaking June) pushes the economic viability still further away.

As for the biogas option, there are likewise severe limitations. There are two kinds of biogas. The most efficient way to produce gas from wood is high temperature processes, and this gas consists of carbon monoxide and hydrogen. This is a very promising technology of interest for large scale combined heat and power production, and also for the paper and pulp industry. This gas has, however, a much lower heat content than methane and if fed into the gas grid it would cause unacceptable variations of quality for most users. The costs for cleaning and pressurizing the gas would also be prohibitive.

The microbial biogas mentioned above (from landfills, water treatment plants etc.) means a less efficient use of the biomass energy content, and will not be available in really significant volumes. And while there are no technical problems for feeding fermentation gas into the natural gas power system, it makes little economic sense. The best and cheapest way to use both kinds of biogas is to combust it locally, which saves the costs for some cleaning stages, pressurization, and extra pipelines.

Thus, the pipelines and grids for natural gas will be used by natural gas and nothing else (other than insignificant quantities) for a very long time.

There are three major disadvantages associated with an expanded natural gas:

1) It competes not only with coal, oil, peat, oil shale and nuclear power but also with wood, wind, solar and energy efficiency. Once it is in place, it tends to devour the whole energy market. This is a very problematic aspect of the proposed trans-Baltic pipeline, because to pay its way this pipeline would pass from about Gothenburg to Stockholm along a path where it would compete not only with nuclear and fossil fuels with local wood fuel, which are otherwise the first option for district heating and CHP and which could develop into more of an option for industry. A massive introduction of natural gas would therefore be a massive obstacle for the transition to sustainable energy sources in Sweden.

2) Natural gas emits less CO_2 per unit of useful energy than other fossil fuels, but the emissions are still very large if its use is expanded. If, for example half of the Swedish nuclear power were replaced with most modern natural gas power plants (60 per cent thermal efficiency), the CO_2 emissions would increase with almost 11 Mtons, which is clearly incompatible with any CO_2 reduction or even stabilisation targets. (Sweden s 1990 emissions were about 60 Mtons.)

3) Its security of supply is vulnerable in some aspects. This is indeed a tricky, and emotional issue, and needs some elaboration. The security of supply is the Achilles heel of natural gas, but not in a global strategic sense. The worrying aspect is not that we will run out of gas in a generation or two, but rather the disruptions that could take place next week or next year. In Finland and the Baltic republics there is justifiable worries of becoming too dependent on Russian gas. The Norway-Sweden-Finland connection is one way to deal with this. It also has the added advantage of creating a more competitive market, i.e. cheaper gas.

This latter aspect has nothing to do with the environment, and is anyway rather speculative. Is there any evidence that Russia is using its supply monopoly to over-charge? If that did happen, there are several countermeasures on option, such as forming a cartel with other importers, *threats* to connect to Norway, and action plans to switch from gas to other fuels or to imported LNG.

The fears that Russia could cut off the gas supply for political reasons also seem unfounded. Such a measure would damage Russia's credibility as a supplier to all Western Europe and would inflict large and long term economic damage to Russia itself. This would not be in the interest of any conceivable future government, be it liberal, socialist, communist, fascist, or Moslem fundamentalist. A very different matter is that Russia could cut off supply because the receiver country has not paid its bills, but so far Russia has been extremely patient.

The notion that Russia first would soften the neighbour states by a gas cut-off and then subdue them militarily looks away from the fact that

Russia is capable of subduing them militarily anyway. This is not the place to discuss why Russia occupied the Baltic republics in 1940 and why she left 1918 and 1991. But natural gas had nothing to do with it.

A more justified concern is the scenario of a Russia in disintegration, civil war, terrorism and infrastructural decay, including insufficient maintenance of the gas transport system.

In the worst case, a total chaos, natural gas deliveries is probably not the only, or worst, thing to worry about.

If supplies become less reliable, i.e. that contracted deliveries can not be met, this should be compensated for by money. This means a) that Russia has a very strong incentive to mend ruptured pipes, failed compressors etc. as fast as possible and b) that the receiving nation will be reimbursed so that economic damage is slight there.

If the delivery capacity is strained to near maximum output, it could however be in the interest of both Russia and the importers to divide the deliveries into two categories: a bottom level of "safe" supplies with very heavy penalties for non-deliveries, and a top level of less safe deliveries without guarantee but at a lower price.

In any case there are several possible back-up options. There are natural gas storages in Denmark (300 million m^3, expandable to some 5 billion m^3) and Latvia (2.1 billion m^3 active volume, expandable to 3 billion m^3).

Liquid Petroleum Gas (LPG, in Swedish known as "gasol") can easily be stored, and can immediately replace natural gas for most industrial users. If gas is used for electricity, this can be replaced within seconds (by hydro) or hours (solid or oil power) with other power plants in stand-by. (As this does not happen very often, it is acceptable to use rather dirty fuel in plants with rather low efficiency).

Many natural gas user also have dual fuel capacity, so that for example diesel oil can be used alternatively. For district heating purposes there are often several such options.

This means that if the pressure in the pipe line starts to fall, this is normally not a calamity other than during winter peak hours, as there is normally a large surplus capacity, and the grid is a storage in itself, dampening minor mismatches between supply and demand. A falling pressure can first be met from storages, then by switching fuel in many places and moving electricity production to other plants, and finally by temporary stops where it hurts least. A few days of halved supplies would not mean that people would have to starve and freeze, and during those days most ruptures or compressor failures should be possible to repair.

The dangers of dependence on Russian gas should thus not be overstated. Some risks are hypothetical, others are manageable. It should also be kept in mind that in a strategic sense, Finland and the Baltic republics are not alone. All Western Europe is to some degree dependent on Russia, because most of the natural gas is there – ten times more than in all West Europe and more than the Middle East together.

In effect, we are all becoming more dependent on each other. That goes for Russia as well. Even the United States would experience enormous hardships if cut off from outside supply. The notion that energy is "strategic" is dated. There are thousands of strategic items, ranging from computer memories to pollution control devices, which are produced by only a handful companies in the whole world. In a crisis situation any nation could start producing some of these goods, but no one has capital and know-how to produce all. Neither is it feasible to stockpile most strategic goods, because they either rapidly become obsolete or will need spare parts, up-date of software and other technical support. Self-sufficiency was, more or less, possible before the age of mass consumerism. Now it is only a recipe for losing money.

In conclusion: gas gives an important option to reduce CO_2 emissions if it replaces shale, coal, peat, oil. Much more gas can, and should, be used in most of the region without a trans-Baltic pipeline. Sweden could expand its natural gas use from the present 10 TWh to 30 TWh (roughly from 1 to 3 MToe) without any additional supply route. For Finland, the situation is similar, and there is room for a considerable expanded use of natural gas also in Baltic republics, and obviously in Norway.

It is interesting to note that Sydgas (the main Swedish gas company) aims at building a pipeline to Stockholm irrespective of if there is a trans-Baltic cable.

If the enormous investment in a pipeline from Norway to Finland is deferred, most of the advantages (fuel switch from other fossils and nuclear to gas) can be realized quickly and gradually, by exploiting the existing transport capacity. That could also narrow the gap between the existing grids/production point and somewhat cut the size, costs and timescale of the superproject. If nothing else, each year of postponement is a year for which interest rates will not have to be paid. Some of the advantages of a connection between Russian and Norwegian gas are non-environmental. There may be commercial benefits for both the suppliers and importers. If so, it is none of our business.

One alternative would be import of gas by LNG tankers. A re-gasification terminal for 5 billion cubic meters costs some $500 million. A ship transporting that amount by 35-40 voyages costs some $250 million[2], though this could probably could be cut somewhat by chartered voyages to other destinations.

This is much less than the rather inscrutable costs for the whole Norway-Finland connection, estimated at 10-15 billion Finnish marks excluding Norwegian offshore costs given by the Nordic Council report; translate that to $4 billion plus.

The costs are not directly comparable, though. Clearly the costs for liquification of the gas has to be carried either as capital costs or as a higher price for the gas delivered to cover the same capital costs. The latter is preferable, as it precludes the danger of overcapacity and price dumping. If there is no buyer for the more expensive LNG, the delivery will not take place. If at least some of the demand is for a spot market (dependent on prices of alternative fuels, demand side measures, business cycle, weather etc.) rather than by long contracts a real market situation could be established. All experience shows that this leads to a more efficient use of resources than the strategic planning approach.

If on the other hand a pipeline or a complete LNG chain is built, there is a danger that the prices will be kept low to expand the market and so recover some capital costs though at a very low rate. Later on, with a captured market, the gas exploiters and transporters can charge more. The overcapacity leads to over-use.

If the technology is improved, LNG could provide a cheaper and faster means of transporting Norwegian gas to Finland or the Baltic republics. According to the above report, Norway has no plans for LNG production. This could change, and if not there are other suppliers.

For an NGO position on the Norway-Finland connection, the time aspect is vital. More natural gas now (or for the next few years), to replace worse fossil fuels and nuclear power is good. Very much natural gas over a long future is not so good. Nor is it a good idea to spend very large sums on infrastructure for a fossil fuel. If the $4 billions plus were spent on natural gas storage, energy efficiency and renewables we would get better, quicker and more durable results.

The key player in the power game is Sweden. The Russia-Norway connection is not much of an option unless Sweden pays a large part for it. The Swedish seems to be vaguely in favour of natural gas expansion but in comments to the parliamentary Energy Commission s report of December 1995, several important agencies and organisations have voiced their opposition to such a scheme, such as the Environmental Protection Agency (Naturvårdsverket), the Energy and Technology Development Agency (Nutek) and the Power Producers' Union (Kraftverksföreningen). The environmental NGOs are also against, as of course the Swedish Biomass

[2] Natural gas transportation. Organisation and regulation. IEA and OECD, Paris 1994.

Association (Svenska Biobränsleföreningen). This is essentially the same forces that stopped the natural gas plans the last time, in 1990.

The governing Social Democrat party has no clear position, though some ministers and high ranking party officials have expressed support for the gas project, as have some people from their de facto coalition partner, the Center Party. The biggest opposition party, the conservative Moderata Samlingspartiet, and its 1991-94 government liberal coalition partner Folkpartiet oppose the gas expansion. So do the opposition parties to the left. If the cabinet decides in favour of the gas scheme, there is a risk for a parliamentary defeat.

On balance it looks unlikely that Sweden will take the vigorous initiative needed. Norway will obviously not just wait for Sweden but will work hard to sell its gas to other customers.

Future energy patterns: Less, not more

The conventional method for forecasting energy demand goes as follows. First you take energy (or electricity or oil) consumption for one year. Then you make assumptions on future economic growth, i.e. how much the gross domestic product will grow. Then you assume that energy will grow as much.

Example: If a nation 1994 has an electricity consumption of 100 TWh, the economic growth is assumed at 4 per cent per year, the electricity consumption by 2014 will be 1.04x20=2.19 times the 1994 value, i.e. 219 TWh.

A somewhat more sophisticated approach includes energy (or electricity) intensity, so as not to arrive at clearly absurd figures. Some environmentalists have accepted this way of reasoning, and have drawn the conclusion that economic growth is undesirable.

This is (in my opinion) unwarranted. Clearly there is a limit to growth in the mining, waste, transport etc., i.e. physical processes, which will have to be arrested and reversed. But economic growth is also a measure of for example education, health care, research, reafforestation, decontamination, investments in energy efficiency etc., growth which can have neutral or negative impacts on the physical material flow.

Energy use is strongly correlated to environmental destruction and exhaustion of resource base, though there is obviously a difference between for example coal on one hand and solar heating on the other.

The link between energy intensity and degradation of environment is indeed very strong. The chain coal mining (encroachment of habitat, methane emissions, ground water pollution), transport, and combustion (CO_2, SO_2, NO_x, N_2O, heavy metals in the large ash volumes) is clear enough. Hydropower, which for ever disrupts the river ecosystem, but later does not cause much additional harm by its use, has severe secondary effects. Hydro power is cheap, and cheap energy means cheap production of copper, aluminium, mechanical paper pulp, chlorine by electrolysis, heavy water, nitrogen fertilizer, ferro-alloys etc. etc. Low prices for these products results in larger volumes and less use of alternative materials or processes and lower rates of recycling than if the prices were higher.

From the fact that the earth is round, and thus has a finite extension, it follows that we are 1) using resources on an unsustainable scale, and 2) that more pollutants are produced that nature can neutralize.

It is theoretically conceivable that one day mankind will arrive at not only a completely harmless energy system but also a transport and manufacturing which only use renewable resources on a sustainable scale.

This is however sure not to happen before 2010. Energy and electricity use will therefore have to be limited. But limited to what? The limits are given by:

1) Nuclear phaseout in Sweden, Finland and Lithuania.

2) No new hydro.

3) A substantial reduction of CO_2. Suggested level: 25 per cent reduction to 2010 from base year 1990. Over the 20 years, this amounts to a decrease of less than 2 per cent annually.

4) Several other environmental targets for VOC, CO, NO_x, SO_2 etc.

The energy and electricity consumption will, in effect, be a function of the environmental requirements, which can only be achieved through substantial energy saving efforts.

This is fair – since all the Nordic-Baltic nations have a higher per capita energy use than the unsustainable average for the Earth. It is also realistic, since there is an enormously wasteful use of energy in all forms. The future should, in short, not be predicted at all. It should be shaped!

Obviously we do not have a complete freedom to create a perfect world, at least not over the period concerned. Many of the buildings, industries, power stations, cars, roads etc. now in place or just being built cannot just be deleted and replaced with something else. On the other hand, many of the buildings, cars, industrial plants, refrigerators, lamps etc. etc. will be obsolete and scrapped and can be replaced with something cleaner and more efficient over the period. Even the whole industrial structure and infrastructure change over decades.

There are some arguments for why our countries should be allowed a higher energy intensity than others.

"Hydropower is there, and should be used". (Norway, Sweden, Finland). This is a classic comparative advantage argument, and would be valid if this asset was used for competitive electricity-intensive industry. But the truth is that it isn't. Norway and Sweden use very relatively little power for modern, competitive, power-consuming industry. Instead, most of the electricity is used for heating buildings and for wasteful lighting, ventilation etc. and to some extent for non-competitive industry. The hydropower is indeed there and should be used. If used efficiently it could minimise investments in new power stations while nuclear power is phased out. We could survive on hydro alone. The about 200 TWh hydro in Sweden, Norway and Finland would be enough to give them plus Denmark some 8500 kWh/capita without any other source of electricity; this is considerably more than France or Germany has now.

"Our countries are cold" (Sweden, Norway, Finland). Where most of the people live in Scandinavia, at least in Sweden and Norway winters are not much worse than in the US, or in large parts of Europe. The relatively few people living under severe arctic conditions cannot justify the energy use in south Sweden or along the Norwegian coast. It may also be noted that we have conversely less need for air conditioning than many other countries. The US summer peak for electricity has no equivalent here.

The coldness of our countries is also absolutely no excuse for the widespread use of electric heating in Norway, Sweden, and Finland

"Our countries are sparsely populated" (Sweden, Norway, Finland). This calls for some more transport, but is clearly not a justification of the enormous transport apparatus in the Nordic countries. Theoretically, the long distances could cause excessive grid losses for electricity, but this is actually not the case.

Also, theoretically, a thinly spread population would make it harder to use district heating and combined heat and power. But in the real world Sweden and Finland are among the world leaders in district heating. Denmark is not sparsely populated, and actually most of the population in our countries live in densely populated regions.

"We have an energy-intensive industrial structure" (Sweden, Norway, Finland). This is to some extent true. But the by far most important industry in Sweden, Norway and Finland together is the paper and pulp industry, which could and should be at least self sufficient with energy. This industry swims in renewable energy. As for production of chlorine, ammonia, aluminium, ferro-alloys etc., these are not of central importance for the economy and employment in any country. Chlorine should hardly be produced at all, as it is harmful for the environment, and mainly unnecessary. Chlorine bleaching of paper is not needed, and there are usually good alternatives to PVC plastics. Ammonia for nitrogen fertilizers is a very harmful product: there is too much fixed nitrogen rather than too little, and the nitrogen needed for agriculture should be taken from manure, urine etc., for which we now pay good money to get rid of. Aluminium, other metals, plastics and glass are used on an unsustainable scale, and should be recycled more effectively.

Though the preceding paragraph was written with Norway, Finland and Sweden in mind, it is certainly also true for Lithuania.

In the 2010 perspective much of the raw-materials using energy intensive industry will shrink, transform (to recycling), and specialize – at least if we are supposed to move towards sustainability.

The alternative to sustainable development is unsustainable development. This is not only unethical, unwanted etc. but impossible. It might, just, be possible that the Nordic countries can stick to a very unsustainable economy for another 14 years, but it is not very likely. Nature does not negotiate, so as long as eutrophication, acidification and climate change are taking place in the real world, they will force their way up the political agenda. If we do not adapt voluntarily, we will be coerced to do so.

The romanticism about heavy industry, a common feature for Sweden, Finland, Norway and the former Soviet Union, will also have to give way for another reason. The costs for creating jobs in heavy industry are absolutely absurd. An investment of 2.1 billion Swedish crowns in a Norrköping (east Sweden) paper pulp factory in 1995 resulted in 150 jobs, close to two million dollars per job – not counting the enormous infrastructure investments paid by the tax-payer. If we do not accept a permanent unemployment of 10 per cent and rising we cannot use our resources in this way. The new millions of jobs needed will have to be supplied in services, marketing, food, education, health care, environment, security, specialized light industry, information and so on, in both the public and private sectors. In an increasingly competitive world (one of the few things we can safely predict), niche markets will grow more than bulk markets. The market is willing to pay more for good food rather than just food, for high quality steels rather than pig iron, for custom-made plastics rather than just bulk PVC, for machines with guarantees and service contracts rather than just machines. And so on. All our countries have a competitive advantage in that we have a high educational level, many international contacts and that very many people can communicate in a foreign language. In international comparison we also have a strong social fabric, which is a prerequisite for stability. The social fabric is now threatened by the transition in the Baltic republics and by unemployment in the Nordic countries, but it still compares favourably to most other countries.

Stability is the most important factor for an investor. Competent workforce and access to major markets come second. Cheap energy and even cheap labour and low taxes are of much less importance, which is why Germany attracts more investment than most other countries, despite high-cost labour, high-cost energy.

According to IEA, world primary energy demand in 1992 was 8319 million tons of oil equivalent plus a rough estimate of 450 MToe biomass outside OECD. This gives an average per capita consumption of some 1.7 Toe.

This is clearly too high. Around 90 per cent of world energy supply was fossil fuels and uranium. In order just to limit global warming to 0.1 degrees/decade, the CO_2 emissions will have to be reduced by some 60 per cent. As population grows from 5 to 7 billion, this leaves us some 0,7 Toe/capita. We now use several times as much in all Nordic-Baltic countries, in Sweden and Finland about 6 Toe, Finland 5.

If sustainability, in the narrow sense of a 60 per cent CO_2 reduction, is to be achieved by 2040, energy use will have to be rolled back continually from its 1990 level in all the Nordic-Baltic nations.

It is meaningless to make long term plans to that effect. What we can do is to gear the development in the right direction, by shifting taxes from labour to natural resources and by an increasing number of ever-stricter mandatory energy efficiency standards. Macroeconomic models can give a rough idea about how high the eco-taxes must be in order to achieve a certain reduction of pollutants, but the only way to really know is by doing.

In 1992 the Swedish government decided the level of CO_2 taxes for industry to be a little bit higher than the one proposed by the EU Commission. There were actual omissions and flaws in the Swedish tax construction, but the line of reasoning was sound: we can not impose arbitrarily high taxes on our industry, but we can be a little bit better than anyone else.

This line of reasoning should be used by every government, and it works just as well for efficiency standards as it does for eco-taxes. If Denmark can have a CO_2 tax on electricity, why couldn't we have one, slightly higher? If the Norwegians accept a so and so high tax on petrol, why don't we have it, with a little topping. If Sweden has the so and so norms for maximum energy losses through windows, walls and roofs for new buildings, why don't we just surpass them a tiny bit?

The extent to which this will actually happen should not be predicted. We know essentially what we have to do, and it just cannot be done too fast.

Much of present energy supply capacity will have to be phased out (nuclear power and large part of the fossil power) before 2010. There is not time and money to replace every kW with renewable, so the best bet is to plan for a shrinking, rather than expanding energy supply and consumption, especially for electricity.

The de-regulation of the electricity market

De-regulation of the electricity market is a world-wide trend, and has been in effect some years in Norway. In Sweden and Finland, the reform took place in January 1996.

There is a strong, perhaps irreversible, tendency to treat power more as normal commodity than as something linked to national security, industrial strategy and social policy. But deregulation is not a straightforward issue.

A totally free market would obviously be absurd. Two competing power-lines or two competing distribution grids would clearly not be in the interest of anybody but the electric equipment manufacturers. Also, somebody has to take responsibility for meeting the supply in quantity and quality. For these reasons alone, the amount of regulation is not likely to decrease, in terms of quantity of legislative text and government staff.

Given the monopolistic or oligopolistic traditions in the power sector there are also other obstacles for a free market. The main difference is that after the so called deregulation, the customer has a free choice of suppliers. Electricity can be purchased and sold from anyone to anyone else. This is primarily of interest for big consumers. This means of course big electricity intensive companies, but effectively also the collectives of household consumers, such as a town, or a big landlord.

In Sweden it is yet difficult to change supplier for individual customers. Distributors demand individual metering hour-for-hour which is expensive. It could easily be replaced by a standard assessment, which is done in Norway.

After less than a year of experience with deregulation of Sweden and the operation of the common Norwegian-Swedish spot market/futures market, it is still difficult to judge the results. One reason is that due to unusually low precipitation, hydropower production has been very low during the year, both in Sweden and Norway. The market prices for electricity are for this reason higher, not lower, than last year. Many people believe that Vattenfall and other big producers also cornered the market. It is a fact that deliveries to interruptible electric boilers were very large in both Sweden and Norway in the months preceding the Swedish deregulation, which helped keeping the prices high.

Many found it hard to believe that fair competition would be the name of the game, with so few companies dominating the market. This scepticism has been reinforced by the very lively trade in power stock shares in the Nordic countries over the last year. Most purchases have been made by government-owned companies, such as Vattenfall, Electricité de France, Statkraft, Imatran Voima etc. The effect is that the government owned share of the power sector has increased, though the government in question is often a foreign one. Many distributing companies, previously owned by municipalities have been purchased by the big power companies. How does deregulation influence the environment? In itself, not a lot. The two important factors for the environmental impacts from electricity is:

a) the mix of power supply (nuclear, coal, biomass, wind), where some sources of power have more adverse environmental impact than others, and

b) the amount of electrical energy produced, where a higher level means more impact.

There is no way to tell in general terms what effect, if any, a more competitive market might have on these factors. The best way to decrease the environmental damage done by the power system is in any case a combination of economical and regulatory instruments, such as CO_2/energy taxes and a legal ban on new hydro construction.

However, in a competitive market, the eco-taxes are likely to have a quicker and more pervasive impact. With no captive customers, and no option to pass the costs to the customer, the dirty, heavily eco-taxed power plant will immediately be used less than its cleaner competitor. The market becomes more responsive to eco-taxes.

According to neo-classic theory, more competition should also bring prices down. This is however by no means so sure. Greater efficiency in operation and maintenance of the power system will press the prices downwards. But in a planned "market", demand can be fitted to supply. Building new power plants is thus not a big financial risk. The return of capital outlays is slow but sure. In a competitive market the risk is bigger, so an investment has to pay for itself in a shorter time. The power companies will have to compete with other investments for bank loans or on the stock market.

The prices will therefore have to reflect higher profits. Also, the whole marketing apparatus, in-house of the power companies and power purchasers, and the retailers in between is bound to grow. These costs have to be passed on to the final customer. So any fears from environmentalists that lower prices will boost demand, and thus emissions, seem to be unwarranted.

With a competitive market in place, there may be less room for direct political intervention, such as closing down a specific plant, for example a Swedish nuclear power plant. But then, under the old system we have not exactly seen a lot of that kind of intervention.

The "market" can provide a new pretext for a government inaction. But the state has strong instruments at its disposal – if it wants to act for the environment. One important such instrument is the "concessionary procedures" (the Swedish word is koncessionsprövning), in which environmentally hazardous activities are given a number of conditions for the permit to operate over a defined period of time. In 1996, for example the municipal district heat producer Uppsala Energi in Sweden had its permit renewed on the condition that fossil fuels (including peat) are phased out by 2005, which the Concessions Court motivated by Sweden's national CO_2 stabilisation/reduction commitment.

Another worry is that deregulation will be technologically conservative. The argument goes that as new investments are risky, nobody will invest in wind, solar energy or any unproven technology. This is generally true, but then neither did the old system produce a lot of these. Also, inherent conservatism of a competitive market works two ways with regard to nuclear power.

First: nuclear power plants are usually described as having high capital costs and low running costs. If this indeed is true, the owner's rational decision will be to run it rather than to shut or close it, especially if the alternative is to invest in a new power plant. This is however only true for some of the nuclear power plants some of the time.

Second: the conservatism will also include reinvestment in old plants, especially in old nuclear power plants. Within a planned economy, which is a fair description of the Swedish power system till now, a decision to make a $100-200 million reinvestment in nuclear power plants was easy and not subject to a hard-nosed scrutiny of alternative options such as closing down the plant. This will, hopefully, no longer be the case.

Swedish nuclear power will now have to compete with Norwegian power (which was not a problem earlier, as the Norwegian government imposed export quotas, and not a problem in 1996 because of drought). If the avoidable costs (fuel, operation, maintenance, reinvestment) exceed the price of Norwegian electricity, the power company will lose money. For some time, the stockholders might be persuaded to accept this, but not indefinitely.

Oskarshamn-1 is Sweden's oldest reactor. It was down for renovation from August 1992 to early 1996, and has since operated erratically. The full bill for the reinvestment is not yet disclosed, but it amounts to at least $150 million so far and a similar amount decided upon for the next five years. Given the competition, these costs cannot be recovered by price hikes. Even if the reactor performs perfectly and no unforeseen costs occur, it is bad business – with a potential to become disastrous business. Even if the stockholders of OKG and its majority owner Sydkraft are inclined to "strategic" thinking (losing money now in the hope of winning more later), it will be extremely difficult to pull another one.

Before the deregulation, the huge energy companies did their best to tie up large customers with long-term contracts, deferring competition by a few years.

Big companies are trying to buy many of the smaller distributor companies and the associated many more or less captive customers.

This is not to say that things will remain the same. Some companies, notably Göteborg Energi, are much more customer-oriented, and if a few follow, the rest will be forced to do the same. If a customer can choose between a supplier that just supply kWhs at a low price and one that can supply expertise in how to use energy, the latter is bound to win in the long run.

For some kinds of industry it can be acceptable to have a slightly increased risk of power cut, if the power comes cheaper. For others it is worth to pay very much more for a very safe supply, so that the supplier perhaps will operate a battery and a DC/AC converter. For some customers the quality (frequency variability, allowed level of phase shift) is worth extra money.

The "marketization" of the utilities will bring the supplier closer to the needs of the customer. A package of energy services tailored to those needs can be expected to compete better than just cheap kWhs, if it means that motors run longer etc. As the supplier often can provide more expertise than the customer has, he can also offer lighting, ventilation rather than just power. It can pay to help the customer save electricity by using better equipment – either because the supplier offers those as well, or because he can keep and win customers by providing better service.

Green choice of electricity

The most spectacular new "product" on the power market is "green power", which was launched under the label "good environmental choice" by the Swedish Society for Nature Conservation in November 1995, just before the deregulation.

Green power is defined as power of renewable origin, including existing hydro but excluding new hydro.

The Swedish Society for Nature Conservation was immediately flooded by applicants for this green label. It also created considerable tensions within the organisation, as many members had spent much of the 1960's and 1970's fighting against hydro construction. They could not stomach that the idea that the dams they had fought against lost would now be labelled good environmental choice.

At the annual meeting of the society summer 1996, however it was agreed to go on labelling, and to launch a campaign against new hydro. After all, nobody calls for blowing up the existing hydropower stations. The destruction is essentially irreversible, so it is better to use the resource than not to use it.

The beauty of the operation concerns nuclear power. Unlike hydro it cannot go on forever. If nothing else, it will one day cost more in operation and upkeep than what the electricity sales cover. The economics of ageing nuclear power plants is a tricky business, because nobody knows can tell what it will cost nor what it will give to operate a reactor over the next few years.

But with lower sales (in Kwhs and money), the end should come sooner. The effect of green power is slightly lower sales. That is bound to hurt, as the avoidable cost (operation, maintenance, reinvestments, taxes) is sometimes above the electricity price. Even the short term running cost (fuel and taxes) are sometimes too high to operate the reactor.

It appears that many companies are enough concerned about their environmental reputation to be willing to pay a little extra for the green power. Some of the prospective customers are big (the State Railways, for example). With new criteria for "good environmental choice" labelling of paper, some of the paper producers will have to buy eco-labelled electricity or lose their label. The environmentally conscious market in Germany can now demand nuclear-free paper.

The Danish Companies Elkraft and Elsam now have the choice of not buying electricity from Barsebäck.

The power companies initially tried to muddle the issue by suggesting alternative eco-labelling criteria, so as to include either new hydro or nuclear. They could not get their act together, and the above-mentioned criteria is now firmly established. By October 1996 some 14 per cent of the power supply on the Swedish market is now eco-labelled.

Electric trade and cables

In a competitive market with few restrictions on export and import, it appears obvious that Norwegian and Swedish power companies would prefer to sell power to a high price to Germany rather than for a low price at home.

If this were a realistic scenario, it is supposed have two important consequences. First the prices would go up, which is good. Secondly, it would add profits to nuclear power production, and thus block a phase-out.

But this is rather hypothetical. To transport electricity to Germany costs a lot of money. The 600 MW "Baltic Cable" from south Sweden to north Germany will be in full operation 6-7 years from when the project started, at a cost of at least 250 million dollars. To make it profitable, Swedish companies will have to sell their kWhs at 1-2 cents more over the whole year than what the Swedish market will pay. It is possible that this could be done, on average. But this first cable skims the cream of the market in both countries, and a second cable would have to transport electricity which costs more to produce in Sweden to a German market with less willingness to pay. The surplus capacity in Sweden is almost exclusively nuclear. Its long term marginal costs (for the most expensive nuclear power station) is more than 2 cents, and at it costs about 1.5 cents to transport it to Germany. That makes 3.5 cents without any profit. A new combined cycle gas power plant or a combined heat and power gas-fired plant can produce power at less than that. Why should the Germans pay more for imported capacity than for a plant of their own?

This calculation also excludes several risk factors: the risk that the Swedish reactors are down, or even retired, when most needed, the risk of German political intervention, the risk that German demand does not go up fast enough, the risk that new taxes will hit nuclear power, the risk that the next cable will be delayed even more than the first.

This applies equally to other cables from Sweden, be it to Poland, Russia or any of the Baltic republics. Nevertheless Vattenfall is aiming for another $450 million cable project of 600 or 800 MW to Poland. It is unpopular at both ends of the proposed cable, and the economic rationale is questionable to say the very least. It seems far-fetched that the Poles, with a substantial surplus of power capacity, would be willing to pay the market price of Swedish power (about 3 cents) plus the 1.5 cents for covering the costs of the cable. This is of course far above the cost of producing it in existing Polish plants. It is even above the price for electricity from new combined cycle natural gas power plants. The other possibility, Polish exports of power to Sweden is even more absurd. Either it means more coal power, with well known ecological effects, or that natural gas power plants are built for exporting electricity. If, however, Sweden should get its electricity from natural gas, it is much cheaper to build the power stations in Sweden than to build them in Poland and add the cost of the cable.

There is no likely buyer of electricity on either side of the Baltic, and there is also no reliable seller. Poland will have to close down some of its power plants and retrofit others, either because its own citizens care for their health and nature or because it is a prerequisite for EU membership (or both). Wouldn't the Swedish connection be handy then?

No it would not. Swedish energy policy is absolutely inscrutinable, and thus unpredictable. So is the future of several nuclear power plants, irrespective of political decisions. The load factor for Oskarshamn-1 over the five years 1992-96 will be about 15 per cent, which gives an idea about the reliability of 20+ year old reactors. The year 2005, during the first years of operation for the cable, all Swedish reactors are 20 years or older.

If it is built, it would provide a route for export of another 6 per cent of the Swedish nuclear power capacity, and about 2 per cent of the total Swedish power capacity. This cannot induce a price hike all over the Swedish or Scandinavian market, and it cannot save nuclear power from a slow death.

The audacity of the cable project clearly shows that a liberalization of the electricity market is incompatible with such companies as Vattenfall, whose size, financial muscle, lobbying power and market share precludes control of any kind. They cannot be controlled by democratic political means and not by the marketplace. Vattenfall defends their size by maintaining that they compete all over Europe with even bigger companies, such as Electricité de France. Vattenfall itself provides a justification for all other oligopolists.

A privatization of Vattenfall in its entirety would be even worse, as it would then be transformed into a private monopoly.

As environmentalists, we can hardly be expected to form a common opinion on privatization or nationalization. But we should be able to unite against the formation of too big companies. There is no advantage to the public of such a big producer company, and if there was it is still no advantage in allowing the same company a large part of the distribution and a "de facto monopoly control of natural gas imports", as the International Energy Agency puts it in its Sweden 1996 review.

The big power companies are survivors. They adapt to liberal and dirigiste environments with the same ease.

The environmentalists should do the same. The present trend is economistic, liberal, market-led. This means that every energy project is presented in these colours.

The odd dollar per kW here and the 0.5 cents per kWh there and the proper workings of the market mechanisms may not be what is closest to the heart of an environmentalist.

But that is how the advocates of nuclear and coal argue, and that is where their bluffs will have to be called.

Nuclear Problems: Ignalina and Barsebäck

The US department of Energy has classified Ignalina as one of the most dangerous nuclear power plants in the world in a report from February 1995.

The Ignalina nuclear power plant consists of two reactors, originally rated 1500 MWe each, the largest reactors in the world. Construction of two more reactor started in 1986-87, but have since been cancelled. The reactors are all of the same kind, so called RMBK reactors, as the defunct Chernobyl 4 reactor that exploded in April 1986. These reactors are dangerous.

The reactor safety hazards can roughly be divided in two categories: hardware and "safety culture". Deficiencies in both respects contributed to the Chernobyl accident. Examples of hardware deficiencies were: large reactivity coefficient instability (loss of cooling water causes reactivity increase to an explosive level), slow and badly designed control rod system (the brake of the reactor), no full secondary containment. Examples of safety culture deficiencies were: disregard of legislation and regulation, confused chain of command, cover-ups instead of information etc.

In the wake of the Chernobyl disaster, some improvements were made. The instability has been reduced, the control rods have been re-designed, the control rod system is faster. But the instability is still there, and the secondary containment still isn't. (It can withstand some, but not all pipe ruptures.)

If the situation in Ignalina today is compared to as it was in Chernobyl before the accident, some things may be worse. Ignalina 1 started production late 1983, same time as Chernobyl, so now it is nine years older. It is hard to believe that the maintenance programme keeps pace with the ageing process.

Though the Ignalina reactor capacities are downrated from 1500 to 1250 MWe, they are still run at 25 per cent higher power than the 1000 MWe Chernobyl, which has consequences for how fast the transients develop, how much water is needed to cool the core etc.

Experience from Sweden shows that many safety incidents were initiated during the construction, and that early design flaws can go undetected for decades. The quality of construction during the two last decades of the Soviet union did not inspire much confidence, and it is a safe bet to assume that there are undetected flaws in welds and tubings, air pockets in concrete etc. in Ignalina.

It is not clear which of the two reactors is in better shape. Ignalina 2 is newer, i.e. less aged and marginally better designed. But it probably has more welds, as its tubing was partly from pipes left-over from Ignalina-1. Ignalina-1 was a more military project than Ignalina 2, which probably means better discipline.

Regarding "safety culture", there are mixed news. The atmosphere of secrecy is gone. Incident reporting (for example to the IAEA international nuclear incident scale INES) appears to be at least as honest as the average OECD reactor operator. The management takes safety and health at work seriously. Discipline is however not good. Many workers do not even care to wear their dosimeters visible.

The size of the staff (some 5000, several times that of a Swedish nuclear power station) is an asset in case of an accident, but it is also very difficult to fit as many people into a strict organization and for the management to know where everybody is and what they are supposed to do.

A worrisome aspect is that Vesaginas is a ethnic Russian island in Lithuania. It is a very demanding task for the tiny Lithuanian nuclear inspectorate and radiation protection authority to keep check of the huge Ignalina organization, and nationality tensions aggravates the problem.

The closure of Ignalina is technically an easy task. As electricity production went down to less than half its 1989 level in 1993 and even lower in 1994, there is no risk for black-outs. There is also no need for investments in new power plants for several years, according to the world bank study of 1993.

The extra cost for a phaseout is difficult to calculate. The real costs for keeping Ignalina are not known, other than that the uranium fuel is supplied by Russia for hard currency, at a cost of less than a US cent per kWh. A "worst case" can be thought of where it is replaced with a *new* combined cycle natural gas power plant, which costs 3.1 US cents. (7 per cent real interest rate, 6000 hours of operation per year.) The difference, some 2.3 cents, is narrowed by the fact that there are a) other costs than fuel if Ignalina is kept running, such as maintenance and wages for the staff, waste handling and the risk costs and b) that all existing plants should be run at a lower cost than 2.3 cents.

The disaster cost can however not be monetized. A severe accident may not only cost thousands of billions of dollars, but spell the end of the nation state of Lithuania (or Latvia or Belarus) and cause incredible economic disruption even in Poland, Ukraine or Sweden. The whole global insurance business could not swallow that kind of loss, so Ignalina could not sign an insurance remotely adequate.

The costs for keeping Ignalina, disasters thus disregarded, will however include some reinvestments which will have to be paid in hard currency. Even in the short run the fiction that costs in indigenous currency is not really a cost can not be upheld. (Estonia has clearly profited from the stability of convertibility.) Somewhat arbitrarily the costs for keeping Ignalina can be estimated at 2 cents/kWh (if upkeep and staffing of reserve plants is at least partly debited on Ignalina, and if realistic load factors are assumed). The fuel costs for oil and gas are some 2-3 cents, and coal less than that.

In round figures, closing Ignalina would add a cent to the electricity bill, which is a small importance for the households, shops and to most business, as the major part of the electricity costs is for transport and distribution, not for production of power.

For the heavy industry a cent per kilowatt hour is a considerable cost, but then much of this industry is in any case not competitive, and should be closed or restructured as soon as possible, if the nation is ever to prosper. Lithuania simply does not have any competitive edge in this field. Lithuania can compete with a well educated work-force, with low wages, with some up-market agricultural produce, with trade (due to a large, though inadvertent, knowledge of the former Soviet union). To pour money into moribund industry is not an act of social responsibility. It is perpetuating misery.

It follows from what has been said that there is no need for common infrastructural projects to put an end to Ignalina. No new power lines or gas pipelines are needed.

But as Lithuania is the poorest nation in the Nordic-Baltic area, it is fair to ask from the wealthier Scandinavian countries that they increase their contributions to a wealthier and cleaner Lithuania, as well as exerting maximum political pressure against the Lithuanian government to close Ignalina.

The second most feared nuclear power station in the Nordic-Baltic region is Barsebäck. This 2x600 MW boiling water reactor station is within viewing distance from Copenhagen and also close to Malmö and also within 50 kilometres from the Swedish cities Malmö and Helsingborg.

The reactors were commissioned about 20 years ago, and are of an obsolete design. There are 600 millimetre pipes under the water line of the reactor vessel. This means that if a pipe ruptures, the high-pressure water will rush out of the vessel, leaving the hot uranium fuel dry within about 10 seconds. This puts extraordinary demand on the emergency cooling systems: the core cooling system, the containment cooling system and the vessel lid cooling system. If any of them fails or if the isolation valves do not close properly, disaster is to be expected.

Up to 1992 the cooling systems did not live up to the specification. A minor valve failure in July that year caused a steam beam to rip off mineral wool wrapping to clog up a sieve for the water supply. Subsequent investigations showed that this would have probably also have happened after a more serious loss-of-coolant accident. In fact there was no functioning cooling system in the Barsebäck and three other reactors of the same design from when Oskarshamn 1 went critical in December 1970 till September 1992, when the Swedish Nuclear Inspectorate ordered those five reactors down.

The sieve problem has since been solved, but the fact that it was ignored for so many years does not inspire trust for the Barsebäck plant – nor for the Swedish Nuclear Inspectorate. The mineral wool was replaced with another less rippable insulation material in the four younger Swedish boiler reactors (Forsmark 1-3 and Oskarshamn 3) and the three pressurized water reactors (Ringhals 2-4) about 1980, in the latter case for the specific reason that the wool could clog up the emergency cooling system.

The Asea company built all the nine boiling water reactors in Sweden (and the two Olkiluoto reactors in Finland). They changed the design for the four younger reactors, probably not just for fun, so that the large pipes are *above* the water level; this means that *steam*, not water rushes out in case of a pipe rupture. To boil off the water takes much longer time, so the demands on the emergency cooling systems are much more modest – at least in terms of time.

Denmark has demanded the closure of Barsebäck at several occasions, as have the Swedish NGOs.

Sweden has unused other nuclear capacity, other unused CHP, and unnecessary use of electricity such as electrically heated water in the district heating, altogether some 15-20 TWh annually, compared to the about 8 TWh that Barsebäck produces. The other older boiling water reactors, Oskarshamn 1-2 and Ringhals 1 might be just as dangerous and unnecessary, but at least they are on less dangerous locations. A Barsebäck accident could necessitate an evacuation of the Danish capital.

Nuclear power is generally an unsustainable source of energy with a large number of problems from mining to disposal of the irradiated fuels rods as well as other radioactive waste. This is common to all 18 reactors in Sweden, Finland and Lithuania. But the worst problem is nuclear reactor accidents, the probability of which is low, but the consequences of which are horrendous. This risk differs considerably between the reactors, and though it is a hard task to compare different designs and safety cultures, the Ignalina and Barsebäck plants can be singled out as the ones that first should be retired.

The proposed trans-Baltic natural gas pipe line is irrelevant for this issue. In both places, combined cycle natural gas power plants are possible, but not needed successors (Barsebäck is located near the existing pipeline).

The way to get rid of nuclear power plants is to close them, and let demand pay the price for new power plants – or cut excess use of electricity so they won't have to be built. Sweden has tried the other way for more than 15 years: to first find the alternatives and then close down the nuclear power plants. This has been a complete failure. The large surplus of electricity has killed all new market for electricity and killed interest for improving efficiency.

There is no need for a repeat.

The European Union CO_2/energy tax

The European Union has been discussing a CO_2/energy tax since 1991. Though it has not been adopted, it is still the most important initiative of its kind, against which all other economic instruments for environmental purposes are measured.

If, or rather when, it is adopted, it is likely to be copied also outside the EU, especially in countries dependant on the EU (such as Norway and Switzerland) and applicants for EU membership.

The background: on the summit meeting in Dublin 1990 the EU decided to stabilize its CO_2 emissions on the 1990 level by the year 2000. The same target was later set in the climate convention.

The commission developed a number of instruments to achieve the target. The SAVE program was created to promote energy efficiency by minimum efficiency standards for appliances. The ALTENER aims at market measures to speed up the introduction of renewable energy. The THERMIE and JOULE programmes for development and research on energy technologies have been redirected to have more stringent CO_2 reduction targets. Much can be said, good and bad, about these programs. But the crown jewel in the package was the directive on CO_2/energy tax, which was published after much discussion in 1992, failed to be adopted by the Council, was re-drafted and published in a new version in May 1995.

Will it fail once again? Will it then be dead and buried?

There are several reasons to believe that it will pass sooner or later. As it is of a more voluntary character in its new version, no country will actually block it. As it is presently the only really important environmental initiative from the EU, it would be politically risky to actually kill it without killing all credibility for the EU as a tool for environmental action. As it is an advance towards central decision-making (on taxation) it is strongly favoured by the European Parliament and the Commission. As it is the only coordinated effort for a CO_2 tax, it is clearly a better alternative for a number of countries than going it alone with home-made tax designs. As the tax can achieve the stabilization target (which is an international commitment) and it won't be achieved without the tax, there is pretty little time to think of something else and implement it. It will become a severe embarrassment for the EU to miss its target. And finally, the original motives for that target, the fear of uncontrolled climate change, have grown ever stronger since 1990. It will be impossible to lift climate change off the agenda, and it will be impossible to lift the issue of CO_2/energy tax off the agenda.

The opposition against the tax is also growing weaker every year.

The main opposition comes from the coal lobby, and from a few heavy energy-intensive industries. The coal industry in the European union is rapidly disappearing, and the number of employees are shrinking even faster. The coal miners' unions, the coal-mining constituencies etc. are no longer much of a political factor.

Some of the energy-intensive industries are moribund, such as chlorine production. Much of the steel, aluminium, cement, ferrochrome and fertilizer production is obsolete and lives on state subsidies. Some of the energy-intensive industry (for example cement) could live with higher costs, as the competition from non-EU countries is only marginal. Some energy-intensive industry has looked again and found that it is not necessarily so. The "paper-and-pulp" industry is using a lot of electricity if seen as a block, but mainly in *mechanical* paper pulp production. The recycled and chemical processes are not in the least dependent on low energy prices; in the latter case it might even be the other way, because a modern chemical paper pulp plant is a net producer of electricity from biofuel. Other industries, such as the glass industry, can see new opportunities: they produce window glass with thin films that reflect the warmth back, thus saving energy. They also produce insulation material. On balance they might win more than they lose by jumping on the sustainability bandwagon.

Other industry have either realized that their energy bills are insignificant or that there are ways to reduce them when the tax becomes effective. The reflex to oppose any tax gives way for a more open attitude – especially for industries with a strategic perspective. In the long run it is an untenable to be anti-environmentalist. A company must have a working relationship with society in order to get support from local and central government, to get the best students to work for them etc.

As the CO_2/energy tax should make energy more expensive and decrease the labour costs, more and more unions and politicians see it as a way to decrease unemployment. In fact there are not many other ideas around to that end. In short: the EU commission and parliament will continue to press for the tax, the opposition is growing weaker and the support is growing stronger.

This proposed directive is the only one on the table, after five years of struggle. It won't be easy to change, replace or disregard. If introduced in the Nordic Baltic region, it would have profound and generally beneficial consequences. Its main elements:

The tax is voluntary in the sense that there are recommended taxation targets for 1999, but they can be set lower, including 0. This is mainly intended to placate the British opposition against a *mandatory European tax* rather than the tax itself. In spite of that the tax could be in force in a large part of Europe.

At least Austria, Sweden, Finland, Denmark, Germany and the Netherlands have strong commitments to a CO_2 target. If a few of these takes an initiative, the others will have little choice but to join. If this group is formed, others would follow (for example Italy, Luxembourg and Belgium). I could also spread outside the EU, to Norway, Switzerland, Hungary, the Czech Republic and others.

The taxes will influence the electricity markets considerably. The base tax is 9.37 ecu (about US$12) per tonne of carbon dioxide and 0.7 ecu (about US$0.9) per gigajoule of energy input. For electricity, energy is taxed according to output, instead of on input. For nuclear power it is 7 ecu per MWh (about 0.9 US cents per kWh). For large scale hydro it is 2.53 ecu per MWh (0.3 US cents). For wind, solar, tidal, biomass produced electricity, and small scale hydro there is no tax at all.

For fossil electricity the tax depends on *carbon content of fuel* (coal contains mainly carbon, natural gas more hydrogen and oil is in between) and *efficiency of process* (how much of the fuel energy which ends up as electricity). This is added to the tax on electric output.

For a typical, fairly modern, coal power station, 40 per cent efficiency, hard coal, this will give a CO_2 tax of 7.85 ecu per MWh or about 10 dollars.

This should be added to the energy tax of 7 ecu, i.e. 14.85 ecu/MWh. For peat and shale it will be slightly higher. An older lignite plant with 30 per cent efficiency would be taxed 19.5 ecu/MWh. There are even worse plants, such as the Estonia Power plant in Narva with a 29 per cent efficiency and a shale with still higher CO_2 emissions (along with SO_2, NO_x etc. emissions). For natural gas, efficiency 58.5 per cent, the combined tax will be 10.17 ecu/MWh.

A tax of about 15 ecu/MWh will put coal to a considerable disadvantage compared to biofuels electricity. It has no dramatic effect on household prices, which are about 80 ecus per kWh in the Nordic countries. But a large part of this price is transport (high voltage power lines) and distribution grid cost. The power producers sell their power at prices like 15-30 ecu per MWh. In the case of coal power-only, this means a 50-60 per cent increase. Another way of putting it is that in Sweden biofuel costs about 10 ecu per MWh, coal 4 ecu (before taxes, but there is no tax on coal for electricity). This presently means that it is good business to burn both coal and biofuels in a CHP stations.

The consequences for *new power plants* are that new coal power-only plants will not be built, as the high capital and operation and maintenance costs will no longer be compensated by low fuel costs.

The natural gas power costs will also increase, but much less, and as combined cycle or CHP plants have the lowest capital costs of all new power sources, they will remain an attractive alternative. Hydro will not be much affected since hydro construction is mainly a political choice. New nuclear power, as previously argued, is out of the question anyway and will be still more out of the question with the tax in place.

Wind power would be more attractive. With small maintenance cost and typical total costs of 18 ecu/MWh (at 4 per cent real interest rate) or 36 ecu/MWh (at 8 per cent real interest rate), it could survive on its own, with no further subsidies. But this is a very average estimate, while actual investments has to take into account the expected prices at a specific site, and how they and the production is distributed over the year.

For *existing power plants* it can be concluded that some Swedish nuclear reactors would be shut down. As this concerns the hot issue of Barsebäck (which many Swedes and all Danes want to see closed), some elaboration is called for.

The marginal value of power in Sweden is about 11-12 ecu per MWh (which is what Vattenfall gets for its "temporary deliveries", without guarantees). This covers about three reactors' production, but is concentrated to the months April through November. As much or all of the winter needs can be stored in hydro magazines at virtually no cost, it can be claimed that some 10-15 TWhs are worth no more than those 11-12 ecu/MWh. On top of that there is an unused surplus capacity of nuclear power which is priced even lower.

On the cost side, an expert report to the Swedish Energy Commission, has come to the conclusion that the running costs (excluding capital costs) are on average 12 ecu/MWh, i.e. costs for fuel, waste handling, staff and operation and maintenance. These costs vary, however, considerably from reactor to reactor and from year to year, with a clear tendency that the bigger and newer reactors produce much cheaper electricity, typically at 10 ecus/MWh, while the older and smaller reactors have much higher and much more varying. For the Oskarshamn 1 plant the costs have not been estimated by the expert report, but some 1400 MSEK have been spent during three years of shut-down, which over the four years 1992-1995 will give a cost of close to 100 ecu/MWh.

This is a view with the benefit of hindsight, and a myopic one at that. But huge reinvestments to keep old reactors going are not all that unlikely, not the risk of a long stand-still. But the bottom line is that reactors which perform well and do not demand large reinvestments can stand a tax burden of 7 ecu/MWh. The others can not bear that burden when facing a large reinvestment.

The obvious candidates for closure are one or two of the following: the two Barsebäck reactors (especially Barsebäck 2), Oskarshamn 1 (in spite of all money just spent on it), Oskarshamn 2, and Ringhals 1.

The retired reactor would, according to economic logic, be replaced by first more production from the remaining reactors, second by less use of electric boilers district heating (replaced by still un-taxed biomass), and third, more use of utility and industrial CHP. The present CHP uses fossil fuels and some biomass, but there would be a strong incentive to replace coal with biomass.

For heating-only purposes the present Swedish CO_2 tax gives stronger incentives than the new tax would, and should be kept. Peat, which has the same tax treatment as biomass, would however disappear.

It should also be noted that while transport is a major cause of CO_2 emissions, the CO_2/energy tax does not influence vehicle fuel taxes very much. The reason for this is that relatively high taxes already are in place, and that the costs for refining and distribution are higher than the costs for crude oil input. So though the energy/CO_2 tax means a 50 per cent increase of crude oil, the gasoline price will increase no more than perhaps 7 per cent.

It is therefore not possible to define one single CO_2/energy tax aiming at both heat/electricity and transport. This is not much of a problem. Increased vehicle fuel taxes can be motivated by a large number of reasons apart from that of climate change.

New supply technologies

In the given time-frame (4-14 years) the practical importance of new technology on the supply side will be limited. In most of the region there is ample supply of power and heat, so there is little need for new investments. In the case of Norway there is hardly a case for ever building another power station. Sweden also has more hydro and CHP than should be needed in a reasonably energy efficient economy.

The time from identification of a promising emergent technology till the production of billions of kWhs is usually longer than 14 years.

Whereas, for example, it can confidently be predicted that *photovoltaic solar cells* will be a very big world-wide industry by 2010, this technology is irrelevant for the energy balance of any nation concerned here: if low price solar cells will become available (which is likely), the first several gigawatts will go to sunnier countries, which both have a more favourable match between demand and supply and get more kWhs from each cell; also, they have excellent features in the absence of a grid.

In the long run solar cells are probably still of importance, since they are expected to produce cheap kWhs as our countries collectively have vast hydro resources, storage from summer to winter is no big problem.

Solar heating is a well-developed technology for producing hot water to district heating, swimming pools, hospitals etc., but it is still too expensive to compete with oil and electricity. The difference (in a Nordic climate) is too big to be offset with subsidies, but efficiency and production technology can still improve considerably with more development efforts, which can be expected to bring down the costs. The climate, even in the far north of Scandinavia, poses no qualitative problems. In the long run, it is very hard to imagine a sustainable energy system without a very substantial contribution from solar thermal collectors. The reason is that solar collectors even now typically can catch about a third of the sunlight, whereas photosynthesis only catches 1 per cent. It takes up 1/33 as much area to produce a given amount of heat as it takes to grow dedicated energy plants, such as salix or energy grass!

This comparison is not quite just. First, bioenergy is often a *by-product* from agriculture or forestry. Second, it is cheaper and easier to store biomass from summer to winter than to store hot water from solar collectors. Third, space is not much of a problem in our countries.

A realistic assessment of thermal solar collectors is that in the 2000 and even 2005 perspective, they are irrelevant. They can play no important part for achieving phase-out of nuclear, nor for CO_2 or SO_2 and NO_x reduction up to then. In the 2010 perspective, they could produce several TWhs, and be a small but increasing part of the effort to further cuts of CO_2 emissions.

Wave power is a promising technology which however has no relevance for the time considered, though it seems worthwhile to continue research and development.

Wind power can be expanded to a significant source of power, which it is already becoming in Denmark. It is exceedingly likely to become a low price option even without any further political action, but its contribution depends largely on the development of a level playing field. Though technical development will undoubtedly take place, wind power would, with present performance and prices, be a competitive source of energy at favourable sites if the proposed EU CO_2/energy tax were in place.

With the large hydro capacity and the enormous capacity of the high-voltage grids, the intermittency of wind poses no problem. If the wind blows, less water is let through the water turbines. The next day, when there is no wind, the hydro is turned on full. This control system is already in place, and costs next to nothing to use. Other power stations could also act as back-up at a reasonable cost.

The technical potential for wind power in the region could be in the order of 50-100 TWh, but all such figures are hypothetical and should not be banked upon. However, if nuclear and fossil power sources are to be phased out, there are indeed alternatives. Denmark has targeted a 10 per cent share of wind of its electricity by 2000 (some 3.5 TWh). If the rest of the region were as ambitious, wind could replace the five oldest Swedish nuclear plants, Ignalina and a number of fossil power plants.

According to Shell[3], wind power and new nuclear power have the same costs – but that was calculated for 1993, and wind power is becoming cheaper whereas nuclear is not. Contracts have been signed in the US at 4 cents per kWh the first year.

Natural gas is treated elsewhere in this paper, so it should just be mentioned that natural gas combined cycle is generally the most competitive source of new electricity everywhere where natural gas is available. Efficiency and environmental performance is still advancing in strides. The development of high-temperature, low-NO_x gas turbines has allowed efficiency for plants to increase from less than 50 per cents in the late 1980's to promises of 60 per cent in the next few years. This is important also for plants using wood etc. (see below).

The astonishing development of gas turbines have probably left *fuel cell* technology behind. Fuel cells "burn" the gas (preferably hydrogen) and converts chemical energy directly into electricity, like a reversed battery. The advantage of fuel cells is that they can be built in small sizes, that they are silent, that they emit extremely small amounts of NOx, and that they promise high conversion efficiencies compared to conventional power stations. Now the combined cycle of gas turbine plus steam turbine show all these characteristics, and they work, and are on the market. Fuel cells could still have a place in very small scale generation (less than 10 MW electricity), or for vehicle propulsion (with electric motors). Fuels cells have been promising for a long time, and will probably remain promising for a long time.

Coal technology has developed considerably over the last decade. But there is no way coal can be burnt without emissions of CO_2. "Clean coal technology", therefore is a contradiction in terms. And though coal is incredibly cheap, the capital costs for a coal power plant is huge. It is also very expensive to build as the pollution control equipment makes it more like a chemical process plant than the old boiler-and-chimney kind of plants. Of the relatively new coal technologies, pressurized fluidized bed combustion (PFBC) has so far fulfilled little of their promises, technically and economically. Coal gasification combined cycle is in an earlier phase and might be a sounder technological concept; higher efficiency and better control of pollutants. With an energy/CO_2 tax in place it is unlikely that any new coal power plants can find a market – unless they are subsidized. (There are many examples of such uncoordinated policy.)

The coal lobby is relatively weak in the region as coal is not mined other than in Norway. But coal incredibly cheap (if environmental costs are not taken into account), and is used on a large scale all over the region, especially in Denmark and Finland. There is also a relatively strong lobby for peat in Finland and Sweden, potentially also in Estonia, and obviously for oil shale in Estonia. The hopes pinned on "clean coal technology" could cause calls for investments in those technologies adapted to other solid fuels.

This is environmentally and economically dangerous if it concerns peat (or oil shale). Peat is a fossil fuel (as its CO_2 content is not emitted if not extracted). This is also how it is interpreted in the OECD statistics, so there is not really much to discuss. New technology applied to *solid biofuels* is, on the other hand, very interesting.

---

[3] The Economist October 7, 1995 The future of Energy. The battle for world power. p. 23f.

Combined heat and power (CHP) from fossil, wood or waste is already widely used throughout the region (except Norway). It can either be used together with district heat production or to give steam for industrial purposes (for drying etc.). Compared to conventional power stations, it uses the fuel much more efficiently: typically 90 per cent of the fuel is put to use compared with 29 per cent for the oil shale power-only plant or 35-42 per cent in more modern coal power plants. Less fuel burnt, of course, means less emissions. The limitation for CHP up to now has been that the ratio between power and heat produced ("the alpha factor") is relatively low. There is not enough demand for all the hot water, especially not during the summer.

With two new technologies, this can change dramatically. The development of ever better gas turbines, initially for air plane engines, then applied for natural gas makes it possible to get more electricity for each unit of heat. In other words: a district heating system can form the base for much more power production. A conventional CHP can supply 0.5 MW power for each MW district heating. A new CHP with gas turbine combined with steam turbine can produce 1.1 MW power for each MW heat, i.e. more than twice the present situation.

This demands, obviously, that the fuel is a gas. There is now demonstrated technology for gasification of wood and some waste. The technology is not yet commercially mature, but is rapidly closing in. Swedish, Finnish and Norwegian companies are among the world technology leaders.

Biofuel gas combined cycle could produce 27 TWh per year in Sweden alone, according to a recent study by Termiska Processer AB, a R&D company which won an order to design a plant in Brazil in international competition in September 1995. These 27 TWh can not be realized overnight, but rather over a couple of decades, as the existing CHP, or heat-only plants become obsolete. But the figure – which could translate to the order of 100 TWh in the whole Nordic-Baltic region – is very significant.

Gasification and power/heat production has another potential outside district heating. Low pressure steam – which can be produced in combination with power – is needed for many purposes in industry.

The paper pulp industry is very important in the region, especially in Sweden and Finland. There are principally three ways to make paper:

1) mechanical paper pulp, which uses the wood efficiently but needs a lot of electricity input,

2) chemical paper pulp, which does not need any external supply of energy and has a potential to produce a large surplus of electricity (and heat) from by-products, and

3) recycled paper, which needs little external energy input.

This is not the place for detailed analysis of the different markets, but the conclusion that the paper and paper pulp can survive and thrive even with much higher electricity prices – if the emphasis is shifted from mechanical pulp production. The paper and pulp industry could become a significant net producer of renewable energy instead of a large net consumer of electricity and fossil fuels. The reason for this is simply that the fibres, wanted in the paper are only about half of the tree. The rest, the glue between the fibres called lignin, the smaller branches etc. contain more than half of the energy.

Much of the lignin in the chemical paper pulp industry is now contained in "black liquor", a very alkaline and corrosive stuff which can be burnt only in special boilers. With new technology, the organic content of the black liquor can be reformed and purified to a gas that can be used much the same as natural gas or gasified wood.

The potential for black liquor gasification power has been estimated to 15 TWh in Sweden alone.[4]

---

[4] Energimagasinet 5/95 Svartlut: skogsindustrins gröna bränsle.

Some non-options

New nuclear power

Nuclear power does not emit CO_2 nor any of the other major pollutants, if it works. But new conventional nuclear power plants are out of question in Sweden, Denmark, Norway, and Finland for the next several years for political reasons. Even if that were not the case, the costs are prohibitive; whereas a combine cycle natural gas power plant costs $500 per kilowatt capacity, a nuclear power station costs 2000. And while natural gas power stations has a lead of two years or less, a nuclear power station has at least six years. Even more important is the fact that nuclear power stations come in sizes of 1000 megawatts or more, whereas gas power plants can be built in sizes 125 megawatts or less. Lastly, whereas there is a risk that a nuclear power reactor does not start on schedule, or is a bad performer, this risk hardly exists for the gas power station.

It is true that now and then some Finnish or Swedish politician or industrialist call for more nuclear power, as also happens in other countries (Poland and Belarus, for example). But the statistics are unequivocal. During the first five years of the 1990s there were 11 reactor orders, against 39 cancellations of reactor projects, according to the *Nuclear News* biannual lists of nuclear power in the world. The few remaining reactor constructions are mainly either soon finished or extremely long overdue, or both.

In a more competitive market (as is the likely trend), a nuclear revival is out of question.

With a new kind of reactor, such as the accelerator-driven subcritical reactor concept proposed by professor Carlo Rubbia, all the economical arguments stated above are strongly reinforced. The costs and economic risks will be even higher. The costs and times for research, development and demonstration of new technology are in the order of tens of billions of dollars and decades; still no guarantees can given. It may or may not be true that reactors of new technological concepts could have much better safety than conventional reactors, but a comparison between dream (new concepts) and reality (reactors as operated) is meaningless.

The fast breeder reactor development has swallowed tens of billions of tax-payers' money since though the concept is much less radical than Rubbia's. (The first fast-breeder prototype produced electricity in 1951!) It is still by no means a proven technology. The French Super-Phénix, the first "commercial-sized" fast breeder reactor, started in 1985 and has so far only produced electricity equivalent to five months of full capacity. This should give some idea about the costs and time involved for a totally new concept.

The "ultimate" solution, the thermonuclear reactor is in this respect in a class of its own. If everything works perfectly, this will become a commercial source of energy by 2050. Other people believe that will never happen, or even should.

Reduce other greenhouse gases instead

All other greenhouse gases emissions than CO_2 are open to technical fixes, such as catalysts or optimized combustion chambers, or (in the case of CFCs) substitution of chemicals. In order to avoid action against CO_2, some nations have tried to credit themselves for cutting other emissions.

This cannot work. As CFCs are being phased out anyway, CO_2 is the absolutely dominant greenhouse gas. CO_2 cuts, on the other hand, have extra benefits, as energy conservation, introduction of renewables and fuel shift also tends to cut emissions of methane (from less coal mining), nitrous oxide (from less combustion) and ozone (less production of its precursors NO_x and VOCs through less combustion).

Emission discount from growing forests
In some countries, for example Sweden and Finland, the forests are growing faster than they are logged. This situation may last for decades, but in the cycle of a forest it is still temporary. The present net growth could also be a result of previous periods of overlogging. To include carbon sequestration in CO_2 balances creates several problems for international negotiations, due to poor data quality, divergent opinions on relevant time scales and justifiable exemptions. And then it might not be such a good idea to have climate policy determining when it is time for logging.

Other CO_2 sequestration
It may be possible for Norway and Denmark to reinject CO_2 from combustion into oil or gas wells. For other nations this is not feasible, and the scope for this method is indeed very limited. The perspective of large pipelines leading back CO_2 (chemically separated from nitrogen, oxygen, all oxides, trace hydrocarbons etc.) is far-fetched, to say the least. CO_2 injection in gas or oil wells is also a method to squeeze more hydrocarbons out of the well, which may be good economics, but hardly a way to reduce CO_2 emissions.

Biofuels for vehicles
Though biomass has an important part to play in the heat-and-power sector, the use of (agricultural) *vehicle* biofuel is a dead end, however much it is promoted by the farmers' interest groups, for example in the European Union.

The distinction is perhaps not familiar, but it is vital. Biofuels for heat and power are mainly of wood origin, usually parts of the trees that are not be used for sawn timber or paper production. This is a cheap resource because the forests grow without much human intervention. It is a plentiful resource, as the forest are vast. It can often be burned without much further processing and almost 100 per cent of the energy content is transformed into hot water.

Vehicle fuels of *agricultural* origin have very different characteristics. The farmed land occupies a much smaller area than the wood, so the resource base is much smaller. The intensive agriculture means high costs for work, machinery, chemicals and energy, so it is not cheap. The farm produce is not ready for use but has to be processed extensive for use as a vehicle fuel. This costs money, and energy losses. There is an economy of scale, which means a lot of transport to one big processing plant and more transport out to the customers.

Ethanol from cereals or rapeseed oil (RME) from agriculture could substitute some diesel or gasoline. This is however very marginal. Biofuels cannot support the present transport sector. A Swedish 1994 joint study by the farmers organization LRF and the oil company OK found that maximum Swedish rape seed production would occupy 220,000 hectares, almost 10 per cent of all cultivated land. This would still only achieve a substitution of 3 per cent of the diesel oil used in Sweden. It would lead to an increase of N_2O and NO_x emissions, to increase acidification, eutrophication and decrease biodiversity. And due to fossil energy input for fertilizer production, agricultural and processing machinery and various emissions during the life cycle of rapeseed oil production, the greenhouse gas emission reduction is at best 50 per cent compared to keeping diesel oil.

After an all-out effort to replace diesel oil with rapeseed oil, the result would be that 98.5 per cent of the diesel-induced greenhouse emissions would still be there, as would accidents and noise. The costs for this substitution were no calculated in the study, but rapeseed oil is substantially more expensive than diesel oil, a difference that would have to be born by the taxpayer.

If diesel fuel prices were increased by 2-5 per cents by higher fuel tax, the same 1.5 per cent reduction of greenhouse emissions would take place, along with a proportional cut of other pollutants, noise, accidents etc. This would not burden the taxpayer, instead it would bring money in – and reduce the costs for roads upkeep.

The exact figures can be questioned and they might be slightly different for ethanol from cereals. But the conclusion is inevitable: vehicle biofuels is not a relevant nor a cost-effective route to sustainable transport.

Even if agricultural by-products or waste (such as straw) is available in huge quantities, it is usually better to use them directly for heating fuel than to process them to vehicle fuel, though this could change in a distant future.

By the year 2010, however, no substantial switch from oil to biofuels for vehicles will take place, though a radical policy for transport can reduce the need for oil, and the emissions of CO_2 by large amounts.

The neighbours

The immediate neighbours to the Nordic-Baltic region are Russia, Belarus, Poland and Germany. Ukraine is also near enough to influence the region. The developments in the European Union also has considerable influence.

Energy policy in the Nordic-Baltic region depends heavily and in many ways on the surrounding countries, if nothing else because they are so much bigger. This is not true only of Germany and Russia. Poland has more people (38 million) than the seven Nordic-Baltic countries together. Ukraine with almost 52 million people is still bigger.

The vicinity of populous countries and/or big markets will of course influence the flow of electricity and natural gas. Though it is very difficult to find any good up-to-date statistics from the ex-Communist countries, the qualitative picture is not so hard to outline.

Common for all ex-Communist countries is that the energy intensity is high, i.e. the efficiency is low. The power sector is universally under-financed. The sales do not cover operating costs, and the prices are not only too low, they are also unpaid. In Russia for example the electricity customers owed the national grid company more than 5 trillion rubles by September 1, 1996. (About 1 billion dollars). This is an untenable situation, as the utilities cannot pay for fuel, spare parts or wages to their own employees.

With better payment enforcement, and higher prices (to cover costs for improved maintenance and some environmental upgrades of plants, and some investments in transport and distribution of electricity), the financial black holes will move out to manufacturing industry, landlords etc.

They will face the choice of either rationalizing their energy use or die. In either case the energy consumption will go down. This can go faster or slower and be different in different countries, but it must happen.

Meanwhile, if the economy grows, new industry will need more gas and electricity. It is however hard to believe that much of this will be energy-intensive industry. Modern smelting plants, refineries, mechanical paper pulp etc. require huge amounts of capital, which is unlikely to appear.

If the economy grows, more households will buy more lamps, fridges, dishwashers etc. to put in bigger houses and apartments. This will create more demand for electricity. But hardly enough to compensate for the falling industrial demand. If a steel mill with 5000 people employed is closed down, and some of the employees go into light industry, and services industry and some are unemployed, it is hard to believe that the growing prosperity could boost energy consumption anywhere near that of the previous steel mill. (Of course the electricity consumption can grow in the next town which has no steel mill to close down, but still the electricity consumption from obsolete industry will dwarf the modest growth of energy services to households, light industry and services industries.)

For this reason it is a reasonable prediction that no ex-communist nation will create much market for electricity exports (from for example Lithuania or Sweden) for a long time.

The chances for export from East to West is more complicated. The present situation of surplus capacity everywhere will create little rationale for new power stations anywhere, for cross-border trade of electricity, and especially for new high voltage connections – though it might be built anyway for political reasons or as a result of oligopolistic aspirations to conquer still more market. (The European Union is a black horse here.)

This situation is however bound to change. The most important factor is the environment. Most power plants in the ex-communist countries are either very dirty/dangerous or inefficient/unreliable or both. The pressure to conform to European Union standards for SO_2, NO_x, VOC, dust etc. will grow, especially in Poland which wants to join the EU soon.

If Poland is to conform to EU coming standards, many coal plants will have to be closed down. The same development can be expected in all ex-Communist countries, give or take a few years. Health and environment are important political factors, and the external pressure (from the EU, the World Bank etc.) will work the same way.

The surplus capacity will be cut, and eventually an equilibrium will be established. But, meanwhile in the West...

If the 1997 Climate Convention Conference of the Parties achieves a protocol for reduction of CO_2 emissions Germany, Finland and Denmark will be in much the same situation. The protocol is expected to contain fairly stringent commitments for OECD countries (like 2 per cent CO_2 decrease from base year 1990 to 2005, 10 per cent till 2015 or something like that). The non-OECD countries will either be allowed a limited growth of CO_2 emissions up to some time or will effectively be left out of the protocol.

Even if the 1997 COP fails, the issue is bound to reappear in the Climate Convention context, in the EU context and elsewhere. A year before the COP, it is impossible to guess if there will be a protocol or not. It is still harder to predict the fine print of it, though this is extremely important.

The technicalities of the protocol itself are very complicated. On top of there are numerous ways of implementing it, each with different consequences in our region. Will there be a uniform CO_2 tax, tradable CO_2 permits, joint implementation, border point tax adjustment etc.?

If Sweden, Finland, Denmark, Germany, and Norway will have to actually cut their CO_2 emissions, and the ex-Communist countries have no such obligations, there is an obvious risk that the former will import much more electricity from the latter. This would be very bad for the environment.

Such a situation would not be accepted for long, but it could reappear, for example if Poland joins the EU and will have to close much of its power capacity over a relatively short time. The transition to a sustainable energy system will take place in fits and starts, which will create temporary booms for electricity trade and not much doing in between.

Meanwhile, Sweden will have to make up its mind about nuclear power. If phaseout starts, whatever the reason, Sweden will hardly have any electricity to export. The possible phaseout of nuclear power in Germany could increase the pull for East-West trade.

If very short term trade advantages are dismissed, the truth is that there are no strong comparative advantages for electricity production, with the exception of hydro in Norway and Sweden.

- Natural gas combined cycle is now the preferred alternative for new power everywhere in the greater region, because of low capital costs, short lead times, wide choice of sizes, reliability, good emission values. It costs about the same everywhere to build and operate. The fuel is a little cheaper close to the gas fields, but the difference to the total cost is slight. It takes very high CO_2 tax or expensive tradable permits of CO_2 emission to cancel out these advantages.
- Coal-power plants are expensive to build today, though coal is dirt cheap. With any kind of CO_2 restrictions, even mild, they are not much of an option. The political pressure from labour unions, mining constituents etc. is growing weaker all the time, so though still a few new coal power plants will be built despite their economics, for political reasons only, it will be on an insignificant scale. It is unfeasible to first subsidize loss-making mines and then subsidize the output once again by build coal power stations. "Cheap coal" far from being a comparative advantage, is a heavy liability to Germany, Poland, Ukraine and Russia.
- Wind power is close to competitive production costs. There are obviously competitive advantages for some nations, but the availability of good windy sites is only part of such an advantage. Planning instruments, access to other power sources, popular attitudes etc. are more important. This explains why there is a lot of wind power in Denmark and Germany, but

not in Sweden and Norway. But the marginal cost for new wind power (at the best site) is not so different in different countries.

☐ If (when) thermal or photovoltaic solar energy becomes an option, the difference between countries is small. It is at least not great enough to motivate long distance transport of power.

☐ The best "negawatt" option is usually cheaper than any supply option, but it takes sophisticated administrative methods to exploit even a fraction of its potential. The crude saving method of closing down obsolete energy intensive industry, which has most potential in the East, but also in most Western countries, notably Norway. As for technology substitution like bulb-to-fluorescent, old-to-new fridges, motor drive technology for pumps and fans, etc. have all large economic potentials in all nations. In spite of all differences in absolute energy use, average age of equipment, availability of capital and persistence of market barriers, these differences often cancel each other out, so we cannot say for sure if negawatts are cheaper or more plentiful in Germany or Russia.

☐ Energy from waste and biomass should cost about the same everywhere, though the amounts of biomass per capita are much greater in for example Sweden

☐ Industrial combined heat and power costs about the same in every country.

☐ Combined heat and power where the heat is used for district heating is an option only where district heating exists or is planned. The existence of *untapped* potential for power production from district heating is a genuine comparative advantage.

☐ In a medium term perspective possession of aged nuclear power plants is a clear comparative disadvantage, as they will be phased out, often preceded by falling load-factors.

The conclusion is that the only *predictable* long term trade is that from Norway to other countries. In a very long perspective Sweden should also be an exporter of electricity, due to its enormous existing hydro capacity, untapped CHP potential, biomass potential, wind potential and energy efficiency potential. But with about 65 TWh nuclear power to phaseout no stable export capacity can be predicted until about 2015.

Sweden has, however, sufficient connections to export large amounts of power right now, so there is no case for new connections. Norway could and should export more power and invest in those connections, for exporting hydro, that is. The notion that Norway should export natural gas-based power runs against its CO_2 stabilization target. Generally speaking it is also more expensive to transport electricity than natural gas over long distances, so what is the point anyway?

The lack of predictable patterns for export-import of electricity should inspire caution. All investments in new power capacity and transport are high risk, and should be calculated with a correspondingly short pay-back time.

Given the long term restrictions on CO_2 (see next chapter), it should also be clear that electrical power is not an expanding business, at least not during the coming decades of nuclear phaseout and fossil fuel phaseout.

Sustainability 2030?

The target for the energy sector (especially electricity and heating and cooling) is, of course, sustainability.

Sustainability should always be defined in negative terms, i.e. in terms of quantified maximum deviations from sustainability. It is a relatively straightforward task to define criteria for unsustainable NO_x and SO_2 loads, because the a certain oil has a certain capacity to buffer acid loads. If that is exceeded continuously, the pH will fall continuously. It is obvious that no ecosystem can be undamaged in an ever more acid soil. Smaller loads may have adverse effects on a microscopic level of an inhomogenous soil, or directly on organisms; if that is found the acceptable load should be stricter.

In this way "sustainability" is a list ever more items of what is not accepted.

For some of the chemical loads science has made very good progress. In terms of biodiversity we have still a long way to go. To stop species extinction is clearly not enough, though it is very hard to even achieve that minimum.

The climate issue is still more complex. Minimal criteria for acceptable change is for example that:

a) greenhouse gas concentrations in the atmosphere cannot be allowed to grow forever, because then it will become as hot as on Venus,

b) that the stabilized level will not make the Earth much hotter than it has ever been since life began, or so that key eco systems will be endangered (tropical rain forests and coral reefs are examples),

c) the rate of global warming should not be faster than nature can cope with. Fishes and birds might follow the shifting climate zones, but forests cannot. As mountains, seas, cities etc. are in the way when ecosystems try to migrate towards the poles, many species will be left behind to die if the change is too rapid.

In climate negotiations, based on IPCC scenarios and presumptions, this has often been quantified as:

a) a stabilization target for CO_2 to year 2050,

b) a maximum greenhouse gas concentration equivalent to a doubling of the pre-industrial CO_2 concentration, and

c) a maximum increase of 0.1°C per decade.

These criteria are not conservative. First, there are several conceivable positive feedbacks of the climate system such as:

- ☐ warmer – higher evaporation – more clouds night-time – less radiative cooling – accelerated warming,
- ☐ warmer – drier – more forest fires – more CO_2 and methane – accelerated warming,
- ☐ warmer – less permafrost on tundra – more methane released to atmosphere – accelerated warming,
- ☐ shrinking ice and snow cover – more solar absorption – accelerated warming,
- ☐ warmer – faster decomposition of dead material – more CO_2 and methane released – accelerated warming.

Second, even if such worries could be dealt with within the climate models, the focus is still on *average* figures. But nobody lives at the average place on the average time. The mean surface temperature on our planet is about 15°C. But any given moment this varies from perhaps at least -50 to +50. Even at a certain latitude (say 60 degrees north) at a certain time of the year and day (say October 12, noon), the temperature varies from perhaps -20 to +15 from year to year or from one place to another. Even if the average temperature changes only slowly, due to unpredicted negative feed-backs, the distribution of temperatures, winds, precipitation etc. could change the local climate very dramatically.

Third, even rather small changes of climate can have huge ecological consequence in many ecosystems. The losing species are usually the slow-growing, slow-moving, specialists. The winners are opportunists or species that reproduce very fast. Under optimal conditions a population of elephants can double in perhaps 30 years. A population of bacteria can do it in 20 minutes. In changing conditions the parasites (from bacteria to fungi and insects) will multiply at the expense of their hosts. Of course the plants and animals will fight back both in an evolutionary sense and by reinvading temporarily lost territories. But many never come back, and the eventually restored ecosystem will be less diverse, perhaps also less productive and less resilient.

Fourth, nature is a result of a million disasters over billions of years. Nature has learned to cope, in its cruel way. Modern human civilization is less robust. Flooding and drought are very relative phenomena. Our hydro power stations, or riverside thermal and nuclear power stations are built for operation in between a minimum and maximum water level. Outside that the plant is first useless and then dangerous. Our buildings, tunnels, sewers, roads, railways, natural gas pipelines, etc. are optimized for a climate, especially ground water levels. If local climate changes, settlements and land-slides will occur more frequently. Human adaptability in agriculture is limited. The farmers can switch from one crop to another, but it is neither easy, quick nor cheap. If the farmer grows rye, and the harvest is bad due to hot and dry weather, it is of little comfort to know that the conditions for wine or avocados would have been perfect. In a period of climate change, the weather is more unpredictable than usual. Even a clair-voyant farmer needs new machinery (which means an understanding banker) and new knowledge to be able to grow the right crop.

The transition costs could be very high in economic and human terms.

Even if CO_2 concentration stabilization by 2050 is something of a Russian roulette, it is still quite exacting in political terms.

There is not, to my knowledge, any work done on the long term energy sustainability requirements for the Nordic-Baltic region. There is one for Scandinavia, though.

In a paper called *Sustainable Energy Scenarios for the Scandinavian Countries* from Niels I. Meyer, Olov Benestad, Lennart Elmborg and Eivind Selvigt in *Renewable Energy* (Vol 3 No 2/3 1993, the authors outline a possible Scandinavia (Sweden, Norway and Denmark) by year 2030.

The usefulness of such a long view is that over about 40 years time it is clear that science has pre-eminence over politics. If critical loads and limits are exceeded, it will not be possible to dismiss the effects as coincidence, local anomalies, unknown interaction with other factors, data inconsistencies, within limits of natural variability.

You might say that you can fool some of the natural laws some of the time but not all the natural laws all of the time.

The criteria for sustainability investigated by Meyer et al are SO_2, NO_x and CO_2. They see little problems in achieving the SO_2 target, but that requires structural change to achieve NO_x and CO_2 target. However, if the CO_2 target is achieved, the rest is relatively easy.

The CO_2 target aims at limiting its maximum air concentration level to 5-20 per cent above the 1990 level by 2030 and an equal per capita emission quota for all regions of the world.

The total global reduction needed to achieve this is 80 per cent, and 95 per cent for the Scandinavian countries. That gives food for thoughts.

Though published in 1993, the paper takes its starting point in 1990 and uses much of the input from 1987 for technology assessment. This does not make a lot of difference. CO_2 emissions are still growing in most OECD nations. Globally the growth has been very weak 1990-94, but that depends mainly on the depression of the ex-communist economies, which cannot go on compensating for growth in the rest of the world.

Essentially the 95 per cent emission reduction still applies, but it would have to be achieved in even shorter time. 95 per cent cut to 1997-2030 translates to about 9 per cent cut each of the 33 years.

It is hard to believe that this will happen in an orderly process, by smooth transition, though it is eminently achievable without too much suffering. Still, you cannot run away from natural laws, so there is a terrible price to pay for doing nothing, and climate change will again and again force its way up to the top of the agenda. It will move in fits and starts.

This is sad, of course. The drastic energy supply cuts in the early 1990's in the ex-Communist countries meant a lot of suffering.

But crises are not always of the worst kind. In 1973/74, oil prices increased about 200 per cent in a few months time and stayed there. The 1979 hike was almost as drastic. The oil-importing countries, many of them with a 50-70 per cent oil based economy were completely unprepared for this. Still, we managed somehow. The OECD nations all went through some structural changes which strengthened them, most radically in the case of Japan. The Soviet bloc with access to cheap oil, and industry protected from competition did not adapt. The message is clear.

Drastic cuts in energy use is however not necessarily not equal to social misery. Some examples from Sweden. The use of heavy fuel oil was 14 million tonnes in 1973 and 2.5 million tonnes in 1990, a decrease of 82 per cent. The use of coal for district heating was reduced from 12.9 TWh 1987 to 4.4 TWh 1995, a 66 per cent decrease in eight years.

Indeed, the CO_2 emissions in Sweden decreased 28 per cent from 1980-92, most of it despite both lack of policy (which had effect only the last two years, and only for some sectors) and falling prices for fossil fuels. What could we have achieved if we had really tried? Or rather: what can we achieve if we really try from now on?

Meyer et al assume that 1987 energy service level could be kept constant with the CO_2 restrictions. This is still a reasonable assumption. Energy efficiency is making fast progress in terms of both best available technology on the market and emerging technology. The renewables have also made steady progress, though most of it is less visible: the gap to commercial competitivity has narrowed.

It would be very interesting to re-run the computers with new data to see if we have closed in on the 2030 sustainability target or not. But a few things are obvious, without new data.

- The electricity sector in Scandinavia could manage without any CO_2 emissions, through hydro and biomass CHP and a slow decrease of electricity intensity.
- The heating and industrial sectors could radically cut their emissions by fuel switch and efficiency without much problems on such a time-scale, given the right incentives.
- The transport sector is the really big problem.

The transport sector is not the focus of this paper. Let it be enough to say that there are solutions. The "hypercar" outlined by the energy visionary Amory B. Lovins of the Rocky Mountain Institute[5] is an ultra light weight vehicle with a small fuel engine and an electric motor. Lovins calculates the fuel consumption of such a car to about 1/10 of the average car today.

This is however still not enough, as he has no answers how to reduce specific fuel consumption for lorries, ships, aeroplanes anyway near as much. The universal trend for growth in transport has to be reversed at least for the richer 10-20 per cent of the world's population. Part of this can be achieved by higher fuel taxes and part by road pricing. If this is still not enough, vehicles will have to run on more expensive renewable fuels.

It should also be noted that electricity is the "easy part" only in the Scandinavian context (with an integrated market, though not for Denmark

---

[5] Reinventicng the Wheels. Atlantic Monthly, January 1995. This 12 page article can be down-loade from the internet at
http://solstice.crest.org/efficiency/rmi/hypercars/Reinventing_the_Wheels.html

alone.) In Germany it is hard indeed. In a CO_2 restriction regime with open borders, there will be a very strong export demand for CO_2-free electricity. In the Meyer et al paper, this results in an export of 113 TWh from Scandinavia 2030! As an alternative to physical export, they discuss the option of using this capacity to establish more electricity intensive industry in Scandinavia.

An up-dated "bottom-up" approach to new and emerging technology is of great interest, as one then can see how far its is technically possible to achieve to reduce energy use and CO_2 emissions.

This is however hardly meaningful in a 30+ years perspective, as technology cannot be predicted. At this moment, developing the instruments for radical change and formulating shorter term goals must have priority.

The Swedish NGO Secretariat on Acid Rain

The Swedish NGO Secretariat on Acid Rain was formed in 1982 with a board now comprising one representative from each of the following organizations: Friends of the Earth Sweden, the Swedish Anglers' National Association, the Swedish Society for Nature Conservation, the Swedish Youth Association for Environmental Studies and Conservation, and the World Wide Fund for Nature Sweden.

The essential aim of the secretariat is to promote awareness of the problems associated with air pollution, and thus, in part as a result of public pressure, to bring about the necessary reduction of the emissions of air pollutants. The eventual aim is to have those emissions brought down to levels – the so-called critical loads – that the environment can tolerate without suffering damage.

In furtherance of these aims, the secretariat operates as follows, by

☐ Keeping under observation political trends and scientific developments.

☐ Acting as an information centre, primarily for European environmentalist organizations, but also for the media, authorities, and researchers.

☐ Publishing a magazine, Acid News, which is issued five times a year and is distributed free of charge to some 5000 selected recipients.

☐ Producing and distributing other information material.

☐ Supporting environmentalist bodies in other countries by various means, both financial and other, in their work towards common ends.

☐ Acting as coordinator of the international activities, including lobbying, of European environmentalist organizations, as for instance in connection with the meetings of the bodies responsible for international conventions, such as the Convention on Long Range Transboundary Air Pollution.

☐ Acting as an observer at the proceedings involving international agreements for reducing the emissions of greenhouse gases.

The work of the secretariat is largely directed on the one hand towards eastern Europe, especially Poland, the Baltic States, Russia, and the Czech Republic, and on the other towards members of the European Union. By emitting large amounts of sulphur and nitrogen oxides, all the countries here in question add significantly to the depositions of acid over Sweden.

As regards the eastern European countries, activity mostly takes the form of supporting and cooperating with the local environmentalist movements. Since 1988, for instance, financial support has been given towards maintaining information centres on energy, transport, and air pollution. All are run by local environmentalist organizations.

The Baltic-Nordic NGO Network for Sustainable Energy

The Baltic-Nordic NGO Network for Sustainable Energy is a channel for communication, exchange of ideas and common statements. Participants are environmentalist NGOs in the Baltic States, Russia, Poland, Germany and the Nordic countries.

For more information, please contact:

The Swedish NGO Secretariat on Acid Rain
Box 7005, S-402 31 Göteborg, Sweden.
Phone: +46-31-10 55 90. Fax: +46-31-711 46 20.

Naturvernforbundet (FoE Norway)
P.O. Box 2113 - Grünerløkka
N-0505 Oslo, Norway.
Phone: +47-2271552. Fax. +47-22715640
E-mail: naturvern@sn.no

AIR POLLUTION AND CLIMATE SERIES

STOP ACID RAIN

THE SWEDISH NGO SECRETARIAT ON ACID RAIN