INTERNATIONAL ENERGY AGENCY

Energy Policies of IEA Countries

SWEDEN

2004 Review

OECD

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INTERNATIONAL ENERGY AGENCY
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The International Energy Agency (IEA) is an autonomous body which was established in November 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme.

It carries out a comprehensive programme of energy co-operation among twenty-six* of the OECD's thirty member countries. The basic aims of the IEA are:

- to maintain and improve systems for coping with oil supply disruptions;
- to promote rational energy policies in a global context through co-operative relations with non-member countries, industry and international organisations;
- to operate a permanent information system on the international oil market;
- to improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use;
- to assist in the integration of environmental and energy policies.

** IEA member countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, the Republic of Korea, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States. The European Commission also takes part in the work of the IEA.*

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996), the Republic of Korea (12th December 1996) and Slovakia (28th September 2000). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

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SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

Swedish energy policy employs a mix of government involvement and lightly-regulated market forces to achieve its objectives. On the one hand, Sweden has high and complicated energy taxation, the largest electricity company is 100% owned by the State and the government intends to shape the supply mix through a possible phase-out of nuclear power and the encouragement of renewable energy technologies. On the other hand, as part of the Nordic Power Market (Nord Pool), Sweden is one of the true pioneers in liberalised electricity sectors and generally employs a very light-handed approach to regulating energy companies. In general, this mix of government influence and free market forces has been judiciously applied and consequently, Sweden has a successful history of providing its citizens with low-cost, reliable, secure and environment-friendly energy.

Swedish energy policy is currently facing many important issues, which will test whether its success will continue. The issue currently receiving the most attention is the proposed phase-out of nuclear power. Concerns about nuclear safety were expressed politically as long ago as 1976 in the general election and in 1980 the people voted in a public referendum for a delayed phase-out of nuclear power plants. In the 1990s and early in this decade, a number of government decisions called for the closure of nuclear power plants and in 1999 one reactor was shut (Barsebäck 1). To date no further nuclear power capacity has been closed since conditions for plant closure have not been met. A government negotiator is now discussing with the industry and other stakeholders the conditions of a gradual phase-out, which will take place during the first half of 2004. The national energy policy implications of phasing out nuclear power, which currently provides 46% of electricity generation and 35% of TPES, are significant. The review team encourages any such plan for government-mandated plant closures to take into account the costs associated with replacing nuclear power and the implications for Sweden's energy security, greenhouse gas (GHG) emissions and economic growth. Such information should be widely disseminated to the general public. Concrete plans for replacing the phased out capacity should be developed and deployed as soon as decisions on this issue are final.

Sweden uses energy taxation as an important tool for promoting certain energy sources while discouraging others. In connection with the 1990/1991 tax reforms, Sweden began its green tax shift whereby taxes on energy were raised while other taxes, such as payroll taxes, were decreased by an equivalent amount. This process continues with the carbon tax on fuels being increased by 18% to SKr 910[1] per tonne of CO_2 on 1 January 2004. Biomass is one beneficiary of the green tax shift. From 1990 to 2002, Swedish biomass use increased by nearly 50%, rising from 12% to 16% of the country's TPES. While effective in this sense, continued increases in energy taxation may yield increasingly diminishing returns. If the tax already makes a less-emitting fuel more attractive than a more-emitting fuel, added taxation will not serve to change supply-side behaviour any further, although resulting higher energy prices would probably curb demand. By way of comparison, the current SKr 910 per tonne of CO_2 is equivalent to approximately €100 per tonne, well above the expected prices for allowances under the European Union (EU) emissions trading scheme.

Simultaneously, energy tax exemptions given to industry mitigate the effectiveness of the taxes in changing overall national energy behaviour. While the exemptions are understandable on international competitiveness grounds, Swedish industry still faces energy-related taxes on a par with industrial companies in other EU countries. Nevertheless, the exemptions do leave industrial emissions largely uncovered by one of Sweden's main climate change mitigation policy tools. The EU emissions trading scheme can play a key role in tackling industrial emissions although the effectiveness of this programme will depend on the price of carbon allowances and the initial allocations to industry. As the emissions trading scheme is put in place and, assuming it becomes effective at curbing emissions, other purely domestic policies may be streamlined to ensure their compatibility with the trading scheme.

The lingering uncertainty surrounding the possible nuclear power phase-out and continued energy tax increases can undermine investor confidence and thus deter investment in both energy supply infrastructure and energy consumption infrastructure such as factories. The government is encouraged to provide as much certainty as possible to the market, particularly regarding the nuclear question, so that companies can make plans and proceed with investments.

Sweden is to be commended both for the pioneering and far-sighted spirit in which it liberalised its electricity market and for its continued efforts to improve the system as it evolves and as more experience is gained. Many countries beginning the liberalisation process look to Sweden as a successful model to be emulated. However, Sweden faces several challenges, including a tightening supply-demand balance throughout the Nordic market; growing concentration of ownership, particularly among generators; and the emergence of significant constraints on the Nordic transmission network, particularly on interconnections. These factors could erode the sustainability and effectiveness of the Nordic electricity markets. Svenska Kraftnät, the transmission system operator (TSO), now administers a transitional capacity mechanism contracting 2 000 MW of peak capacity until 2008 to ensure

1. In 2003, 1 Swedish krona (SKr) = US$ 0.123.

sufficient capacity is available during times of potential capacity shortage. Noting that this could potentially crowd out an efficient private response to peak demand, clearly identified trigger conditions for intervention are essential. As increasingly international electricity trading takes place both inside and outside Nord Pool, the above-mentioned challenges for Sweden will need to be addressed internationally in co-ordination with other countries both at political and regulatory levels. In particular, there is no clear responsibility among stakeholders for translating the planning process of Nordel, the Nordic TSO co-operative body, into timely and efficient investment. Effective regulatory arrangements to improve price signals for new interconnector investments should be explored. It is worth noting that Sweden can best address these and other issues in an international context through enhanced co-operation with governments and regulators from other countries.

Sweden has ambitious targets for increasing electricity generation from renewable energy technologies. It intends to raise annual generation from renewable plants by 10 TWh from 2002 to 2010. The primary means of meeting this goal is the newly introduced electricity certificate scheme in which electricity suppliers are obliged to acquire electricity certificates from renewable plants equal to a certain percentage of the electricity they supply. This percentage level began at 7.3% in 2003 – approximately equivalent to Sweden's existing level of renewable generation at that time – and will rise in steps to 16.9% by 2010. This scheme has a strong market component that will promote generation from the lowest-cost renewable energy technology and also foster competition and thus increase production efficiencies. However, the costs of such a system must be monitored closely as the ambitious targets may lead to excessive prices for the certificates, which will ultimately lead to very high bills for consumers. If certificate prices reach "politically unacceptable" levels, the target level should be reconsidered and alternative means of achieving the same emissions reductions should be explored.

Sweden's high energy intensity as measured by national TPES per unit of GDP is primarily the result of its cold climate and energy-intensive industries rather than the inherent inefficiency of energy producers or consumers. Nevertheless, further improvements in energy efficiency offer a very attractive way to meet national goals, especially in light of the proposed nuclear phase-out and the potential high costs of meeting the renewables target. Such goals may be more easily achieved through introducing quantitative efficiency improvement targets that could involve national energy efficiency improvement or efficiency improvements for companies that sign long-term agreements with the government. A programme for energy efficiency for energy-intensive businesses is under preparation within the Swedish government. Sweden's goal of keeping transport sector emissions at 1990 levels by 2010 is very ambitious judging from the recent trends. The government will have to undertake more aggressive energy efficiency activity in this sector to meet this target.

District heating is used extensively in Sweden and contributes to the country's energy efficiency. While largely regarded as successful, the sector could benefit from greater regulation in those regions where it enjoys a *de facto* monopoly. This would encourage greater operational efficiency of the systems and decreasing prices for consumers.

While natural gas currently provides only 1.5% of Sweden's TPES, it is seen as a fuel whose use could expand substantially in the medium to long term. In areas where the gas pipeline already extends, natural gas has captured between 20% to 25% of the relevant market. Natural gas could expand Sweden's fuel diversity, lower GHG emissions if displacing other fossil fuels and provide economic advantages if it proves to be the lowest-cost option. Gas use would become a particularly attractive option if nuclear plants are phased out. The government has taken a commendably hands-off approach to natural gas, allowing the suppliers and consumers to decide their level of involvement. However, the government could make dealing with gas easier for all parties by simplifying the regulatory structure governing transport. In addition, resolution of uncertainties over nuclear power and future energy taxation would, as mentioned above, allow investors to make the investments to expand gas use if they so desired.

Swedish government expenditures on energy R&D rose by 100% from 1996 to 2002, and represented the highest spending levels as a percentage of national GDP of all but four IEA countries. The government-appointed Commission on Energy Research, Development and Demonstration (ERDD) released its conclusions in 2003. The commission rightly commends the Swedish government for its activity in this sector but adds, nevertheless, a number of suggestions for improvement, two of which may be particularly helpful. The first is to define energy areas where Sweden requires only a minimum level of competence and areas in which it can excel. Priorities and funding should be allocated accordingly. The second recommendation is to improve the system's ability to bring more products through to commercialisation. While this need not be done through a reallocation of government resources, which are still best spent on more basic research with industry concentrating on commercial aspects, the commission proposes a number of changes to help the commercialisation yield that are worth serious consideration.

RECOMMENDATIONS

The government of Sweden should:

Energy Market and Energy Policy

- *Continue to develop a long-term vision of a sustainable energy future, based on sound modelling of the economic costs of various options.*

- *Place greater overall emphasis and attention on energy efficiency and demand-side response as a way of meeting the country's environmental and security of supply targets.*

- *Strive to create a more stable policy environment in which energy stakeholders can plan effectively by resolving the future of nuclear power (including clear ideas on alternative supply sources and consequences for GHG emission commitments) and by providing a more stable and simplified energy tax regime.*

- *Undertake more quantitative assessments of the costs and benefits of various energy policy options, including the decision on nuclear power, and disseminate this information as widely as possible to energy actors and the general public.*

- *Continue to monitor progress towards established goals and evaluate effectiveness of policy measures.*

- *Consider increasing the scope, transparency and independence of the energy regulator.*

Energy and the Environment

- *Increase the level of analysis and quantification of policies to better assess the cost-effectiveness of different measures and show how both individual policy measures and the climate strategy as a whole are consistent with achieving national objectives.*

- *Improve the environmental effectiveness of the energy and CO_2 taxation regime by addressing the tax structure (including exemptions and reductions) rather than focusing on the top rate of tax.*

- *Address the need for emissions reductions from industry, either through changes in tax structure or effective use of emissions trading.*

- *Streamline, when appropriate, climate mitigation policies, including CO_2 taxes, to ensure they are complementary to the trading scheme, and ensure expenditure on climate policies is justified on the basis of cost-effectiveness of the expected CO_2 savings.*

- *Identify ways to manage Sweden's substantial forestry assets in a way that best meets environmental goals, recognising their major potential both as sinks for GHG and as a renewable fuel source.*

Energy Efficiency

- *Make use of additional measures to encourage more efficient and rational energy use in the transport sector.*

- *Negotiate quantitative targets for companies participating in the long-term agreements, keeping in mind the forthcoming EU emissions trading scheme.*
- *Consider the benefits of extending regulation over the district heating sector.*
- *Examine the possibilities for developing heat metering in individual apartments.*

Renewable Energy

- *Share information and experiences with other countries introducing electricity certificate systems to support renewables.*
- *Monitor the cost-effectiveness of the electricity certificate system in achieving environmental and security of supply goals in comparison with measures to improve the efficiency in electricity consumption.*
- *Explore ways to move towards competitive renewable motor fuels.*
- *Assess progress towards a sustainably competitive renewable energy sector.*

Fossil Fuels

- *Establish a stable, appropriate tax regime for fossil fuels.*
- *Consider establishing a single gas transmission system operator.*
- *Consider the effects of current ownership of major gas utilities on the efficient functioning of a liberalised gas market.*
- *Establish a clear and stable policy framework to facilitate access to the system network and to allow for the development of network infrastructures by interested parties.*

Electricity

- *Explore opportunities for greater harmonisation within the Nordic market in relation to economic regulation, system operation and competition surveillance in the electricity sector, possibly in the context of the electricity group of the Nordic Council of Ministers and through Nordel.*
- *Monitor the evolution of production capacities in case of nuclear phase-out.*
- *Review closely all arrangements and responsibilities in relation to system operation and network planning to ensure that efficient and transparent development of the transmission network can proceed without undue delay. In this context, take steps to improve price signals for new investment and for expediting investment to strengthen interconnections where clear economic cases exist.*

- *Monitor the peaking power contracting by Svenska Kraftnät to ensure it does not undermine the development of efficient, market-based demand response or peak generation investment. Consider clearly identifying the trigger conditions for intervention and strengthening the link between the trigger conditions and movements in physical reliability balances.*

- *Examine options for further structural reform to strengthen competition and reduce the potential for undue exercise of market power, including options to manage concentration of ownership among generators and retailers. Examine whether strengthening the separation of transmission and distribution networks from generation and retail businesses is warranted.*

Nuclear Power

- *Pursue the negotiations with the industry to reach an agreement on phasing out nuclear power with a credible and commonly agreed implementing plan.*

- *Ensure that the nuclear power plants in service continue to be operated safely.*

- *Pursue the implementation of a final repository for high-level radioactive waste.*

Energy Research and Development

- *Renew the RD&D programme funding at a comparable level.*

- *Implement the recommendations of the Commission on Energy Research, Development and Demonstration (ERDD), including increasing the proportion of projects that will lead to the commercialisation of new energy efficiency and renewable energy technologies.*

ORGANISATION OF THE REVIEW

REVIEW TEAM

The 2003 IEA in-depth review of the energy policies of Sweden was undertaken by a team of energy specialists drawn from the Member countries of the IEA. The team visited Sweden from 5 to 10 October 2003 to meet with government officials, energy suppliers and energy consumers. This report was drafted on the basis of those meetings and the government's official response to the IEA's policy questionnaire. The team greatly appreciates the openness and co-operation shown by everyone it met.

The members of the team were:

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Jonathan Coony managed the review and drafted the report with the exception of the Energy and Environment chapter, which was written by William Blyth and the Electricity chapter which was written by Doug Cooke. Monica Petit and Bertrand Sadin prepared the figures.

ORGANISATIONS VISITED

The team held discussions with the following groups:

- Ministry of Industry, Employment and Communications
- Ministry of Environment
- Ministry of Finance
- Swedish National Energy Administration
- Parliamentary Standing Committee on Industry and Trade
- Environmental Protection Agency
- Vattenfall AB
- Sydkraft AB
- Svenska Kraftnät
- Svensk Energi
- Swedish Gas Association
- Federation of Swedish Industry (SKGS)
- Elforsk AB
- Swedish Nuclear Power Inspectorate (SKI)
- Bil Sweden
- Swedish National Road Administration
- Swedish Petroleum Institute
- Swedish District Heating Association

The assistance and co-operation of all participants in the review are greatly appreciated.

REVIEW CRITERIA

The *Shared Goals* of the IEA, which were adopted by the IEA ministers at their 4 June 1993 meeting, held in Paris, provide the evaluation criteria for the in-depth reviews conducted by the Agency. The *Shared Goals* are set out in Annex B.

ENERGY MARKET AND ENERGY POLICY

COUNTRY BACKGROUND

Sweden is the fourth-largest country in Europe and, along with its neighbours Finland and Norway, it is one of the most northerly. It has a territory of 450 000 square kilometres extending from the Baltic Sea in the south-east to the Arctic Circle in the north. It shares land boundaries with Norway to the west and Finland to the east. Approximately 90% of the land area is forest or other woodlands, bogs, fens and lakes. About 7% of the land is considered arable. Most of the 8.9 million inhabitants live in the southern part of the country with approximately one-third in the main metropolitan areas of Stockholm, Göteborg and Malmö. The average annual temperature in the capital, Stockholm, is about 6°C. The country has approximately 4 000 population-weighted heating degree days, second in the European Union (EU) only to Finland, which has 5 000.

Timber, hydropower, iron and other ores constitute the resource base of an economy heavily oriented towards foreign trade. Agriculture accounts for only 2% of GDP and 2% of national employment. Although Sweden suffered through a recession in the early 1990s, with GDP dropping by almost 5% from 1990 to 1993, the economy rebounded and has stayed strong for the remainder of the decade. From 1997 through 2002, annual Swedish GDP growth averaged 2.8%, compared to 2.4% for the EU as a whole. The economy is estimated to have grown by 1.5% in 2003 and 2.3% in 2004. In 2002, the Swedish unemployment rate was 4%.

Sweden is a constitutional monarchy with a parliament (the Riksdag) consisting of a single chamber directly elected by proportional representation. Uncertainty over the country's role in the political and economic integration of Europe delayed Sweden's entry into the EU until 1995. It waived the introduction of the euro in 1999 and, in October 2003, the people again rejected adoption of the euro in a public referendum.

SUPPLY AND DEMAND OVERVIEW

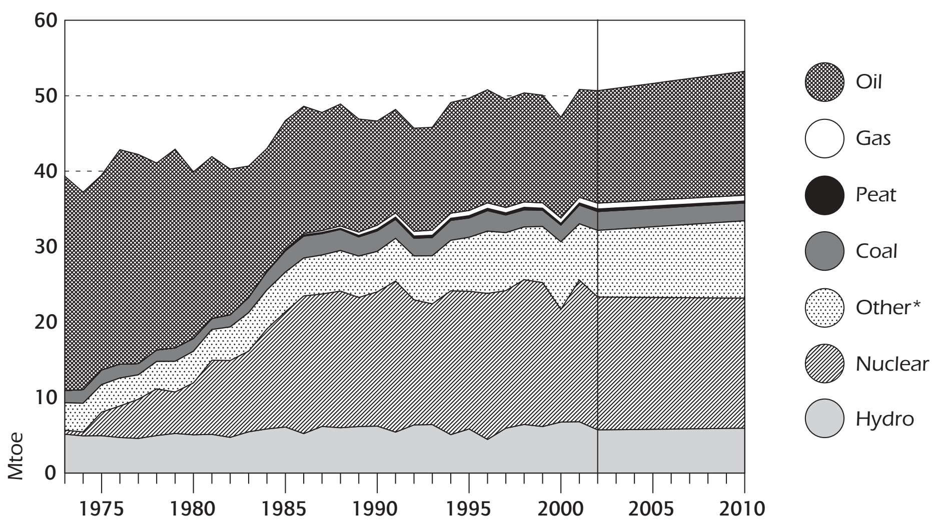
ENERGY SUPPLY

In 2002, Swedish total primary energy supply (TPES) was 51.0 million tonnes of oil equivalent (Mtoe). This represents an increase in TPES of 7.5% from 2000. This high growth rate results largely from the anomalously low TPES of 2000 when a reduction in nuclear production decreased overall energy supply by 5.8% from 1999. From 1997 to 2002, TPES growth averaged 0.6%, while from 1990 to 2002, TPES growth averaged 0.8%.

In 2002, nuclear energy accounted for 34% of Swedish TPES, followed by oil (29%), biomass (16%), hydropower (11%), coal (5%), natural gas (1.5%), peat (0.7%) and solar and wind power (0.1% combined)[2]. The percentage shares have not changed significantly over the last ten years although hydropower production fluctuates from year to year depending on weather conditions. The two most significant changes in the long-term supply over the last decade were the increase in biomass use and the decrease in nuclear power. In 1991, biomass accounted for 12% of TPES while in 2000 it reached 18% of TPES (falling slightly to 16% in 2002). Nuclear power lost the greatest percentage share of TPES over that time, falling from 42% of TPES in 1991 to

Figure 1

Total Primary Energy Supply, 1973 to 2010



* includes solar, wind, combustible renewables and wastes.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2003 and country submission.

2. Statistical treatment of nuclear and hydropower gives the impression that nuclear power generates significantly greater electricity than hydropower although this is not in reality the case. Nuclear power is assumed to operate at 33% efficiency in converting the thermal energy from the reaction into useful electricity, while hydropower is assumed to be 100% efficient in converting the potential energy of water into electricity. So, for every kilowatt-hour generated, three kWh of TPES will be credited for nuclear power, while only one kWh of TPES will be credited for hydropower. In 2002, hydropower produced 46% of the country's electricity and nuclear produced also 46%.

31% in 2000. Nuclear's 31% share in 2000 was anomalously low and while it rebounded to 37% in 2001 and 35% in 2002, its share is expected to stay below historical averages owing to the closure of a reactor at the Barsebäck nuclear plant. Increased biomass use resulted from a concerted government effort to support biomass through taxation and other means. Over the longer term, the trend has been away from oil supply, which accounted for 72% of TPES in 1973. Largely for energy security reasons, the country switched from oil-fired plants to other electricity sources, primarily nuclear power.

Apart from nuclear, the country's main domestic fuel is biomass followed by hydropower. Altogether, 70% of Swedish TPES is imported if nuclear power is considered an imported fuel, but 34% if nuclear is considered a domestic source.

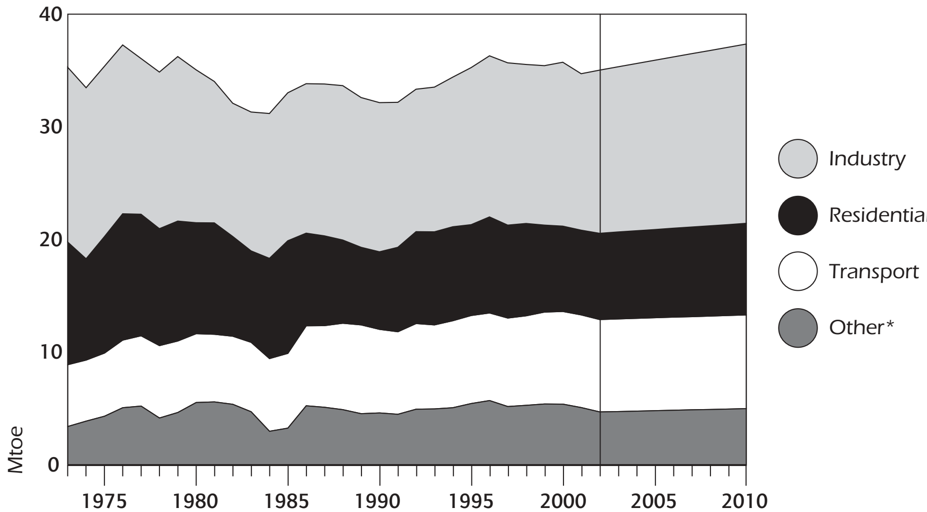
ENERGY DEMAND

In 2002, Swedish total final consumption (TFC) of energy was 35.0 Mtoe. TFC fell by an average annual rate of 0.4% from 1997 to 2002. Since 1973, TFC has shown a remarkable consistency. The 2002 TFC is only 1% less than the 1973 figure and over that time, TFC has stayed within a range of 37.2 Mtoe and 31.2 Mtoe. By way of comparison, the TFC of neighbouring Finland rose by 30% from 1973 to 2001, the TFC of all IEA European countries rose by 23% from 1973 to 2000 and the TFC of IEA countries as a whole rose by 30% from 1973 to 2000. While part of the constancy in TFC over the past 30 years is the result of improvements in energy efficiency, it also has to do with the change in the Swedish energy supply structure over that time. In general, on-site oil use was replaced with electricity. From 1973 to 2002, electricity TFC rose by 92%, while oil TFC fell by nearly 50%. Electricity when used on-site is nearly 100% efficient while oil is generally not. Given this difference in efficiencies, less electricity was needed to get the same amount of useful energy than was the case with oil. This structural change also increases TPES since energy losses in thermal plants (either oil-fired or nuclear) have to be taken into account. Another factor limiting Swedish TFC growth has been the rate of economic growth compared to other countries. From 1973 to 2001, Sweden's GDP (measured on a PPP basis) grew by 72% while neighbouring Finland's and Norway's grew by 106% and 153% respectively, and the IEA's as a whole grew by 109%.

Industry is the largest energy user in Sweden. In 2002, it accounted for 39% of Swedish TFC, followed by residential energy use (22%), transport (22%), and the commercial sector (14%). The TFC share of the industrial sector is higher than the IEA average of 31%. From 1997 to 2002, energy use in both industrial and residential sectors has fallen, while road transport energy consumption has grown.

Figure 2

Total Final Consumption by Sector, 1973 to 2010



* includes commercial, public service and agricultural sectors.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2003 and country submission.

Regarding TFC by fuel, oil still maintains the dominant position. In 2002, oil accounted for 38% of TFC, although this percentage share has fallen from a high of 70% in 1973. The second most used fuel was electricity at 32% of TFC, up from 17% in 1973, followed by biomass (14%), heat (11.4%), coal (2.2%) and natural gas (1.4%). TFC percentage shares have stayed relatively constant over the last five years. In IEA Europe, oil is the dominant end-use fuel, accounting for 50% of TFC in 2001, followed by natural gas at 22% and electricity at 19%.

GENERAL ENERGY POLICY

ENERGY POLICY OBJECTIVES

The basic line of Swedish energy policy comes from an energy policy agreement in 1997 between the Social Democrats, the Centre Party and the Left Party. Its main goals are:

- Secure access to electricity and other sources of energy on internationally competitive terms.

- Facilitate the transition to an ecologically sustainable society.
- Contribute to the creation of stable conditions for a competitive business sector and the renewal and development of Swedish industry.
- Co-operate in the Baltic region in the field of energy, environment and climate change.

Securing access to energy, including electricity, heating and fuels, at reasonable prices is an important precondition for the international competitiveness of industry and the economy of Swedish households. In the common and international market it is essential that the supply of energy take place on equal terms and with clear and unambiguous environmental objectives. A crucial component for this purpose is the harmonisation of regulations, tariffs and taxes so that producers, irrespective of country, can compete on equal terms.

To facilitate the transition to a sustainable society, the energy system needs to be based on sustainable, preferably indigenous and renewable sources of energy and efficient energy consumption. Energy technologies are to be realigned and developed hand in hand with stringent requirements regarding security, public health and environment. Sweden envisages nuclear power being replaced by other sources of electricity such as renewable energy while the use of fossil fuels will be kept low. Swedish rivers will continue to be protected by the Riksdag for environmental reasons, thus limiting the addition of substantial new hydroelectric capacity.

RECENT ENERGY POLICY BILLS

The energy policy agreement in 1997 led to the establishment of a short-term as well as a long-term energy policy programme.

The short-term, five-year programme was carried out in the period 1998 to 2002. The SKr 3.5 billion budget was allocated to the following activities:

- Measures to reduce electricity consumption: SKr 1.65 billion.
- Measures to promote renewable electricity generation: SKr 1.0 billion.
- Measures to promote energy efficiency: SKr 450 million.
- Electricity and heating production in southern Sweden: SKr 400 million.

The short-term programme ended in 2002 and was replaced with new short-term measures to promote energy efficiency and renewable energy.

The long-term, seven-year programme runs for the period 1998 to 2004. The SKr 5 billion budget is dispersed in the following activities:

- General energy research: SKr 2.5 billion.

- Energy technology: SKr 870 million.
- Introduction of innovative energy technology: SKr 1.6 billion.

In addition, a programme of climate initiatives prompted by energy policy considerations was allocated a budget of SKr 560 for the same seven-year period. The long-term programme is currently under evaluation. The government plans to submit a bill to parliament in March 2004 with its proposal for further long-term efforts.

In 2002, the Social Democrats, the Centre Party and the Left Party continued their collaboration from the 1997 agreement. The Government Bill 2001/02:143 "Co-operation for a secure, efficient and environment-friendly energy supply" was accordingly presented to parliament on 14 March and approved in June 2002.

The energy policy guidelines of the 2002 bill are consistent with those of the 1997 bill in that they continue to pledge support for renewable energy and activities to reduce electricity consumption. However, an evaluation of this programme has indicated the need for a somewhat different approach in certain areas. As a result, the energy policy bill of 2002 constitutes a shift in the direction of the policy instruments that are to influence development in the shorter term:

- It contains a new quota system with tradable certificates to promote environment-friendly and renewable electricity production (see Chapter 6).
- It contains measures designed to encourage more efficient energy consumption.
- Its proposals mean a strengthening of the competitiveness of combined heat and power in the energy system.
- It plans to examine whether an agreement similar to the one reached in Germany on a nuclear power phase-out may have certain advantages for Sweden (see Chapter 9).

The 2002 bill invites representatives of the energy sector to take part in negotiations on a controlled and responsible phasing-out of nuclear power. In Germany, an agreement was reached in June 2000 between the government and the power industry on the closure of German nuclear power plants. This agreement sets up a comprehensive framework for the production of electricity from nuclear plants, establishing a maximum amount of electricity that can be produced in the existing reactors over their remaining lifetimes. Plants must be shut down once they have reached their allotted lifetime production levels although there is considerable flexibility in allowing plants to trade their allotted production volumes among themselves. The bill also contains commitments by both parties relating to future energy supply. The Swedish government feels a similar agreement could be beneficial for Sweden.

The purpose of the negotiations between the government and industry is to come to a settlement that creates conditions for future operation that is justified from the perspective of the business economy and for ultimate closure of the Swedish nuclear power plants. Concurrent aims are to adopt other environment-friendly forms of electricity production that will secure the future electricity supply in the absence of some or all of the nuclear plants.

A further guiding objective is to increase electricity production from renewable sources by 10 TWh from 2002 to the year 2010. Such an increase would constitute approximately 6.8% of all power generation at 2002 levels. If additional prospects emerge for further increasing renewable electricity production, the government may consider a new, more ambitious target of increasing annual renewable energy production by 15 TWh from the 2002 level to 2012. Such an increase would constitute approximately 10.2% of all power generation at 2002 levels.

The existing renewables target (increasing production from renewable sources by 10 TWh by 2010) will serve as a basis when developing the quotas in the electricity certificate trading system. In January 2003 the government presented the Bill 2002/03:40 on the objective of introducing a new law on electricity certificates. The Riksdag approved the bill in April 2003. The system is based on quotas for the consumption of electricity from renewable sources of energy.

In addition, a study by the Swedish Agency for Public Management examining the independence of the energy regulator within the Swedish Energy Agency (structure explained below) was released in the autumn of 2003. The overall recommendation is to split the regulator from the Energy Agency in order to clarify and ensure the regulator's independence. The report will, together with other input, form the basis for future action on this matter.

ENERGY POLICY INSTITUTIONS

Sweden has a unitary government with active local authorities. Development of energy policy rests with the central government.

MINISTRY OF INDUSTRY, EMPLOYMENT AND COMMUNICATIONS

The Division for Energy and Primary Industries within the Ministry of Industry, Employment and Communications has an overall co-ordination and planning role for Swedish energy policy. This division has a staff of around 25 people. In addition, the ministry contains the staff of the Nuclear Negotiator. In June 2002, the government appointed a negotiator to represent the State in coming to an agreement with industry on closing the country's nuclear power facilities.

SWEDISH NATIONAL ENERGY AGENCY

The Swedish National Energy Agency is the central government body responsible for the main authority functions within the energy area. It is a separate government agency supervised by the Ministry of Industry, Employment and Communications. It is responsible for co-ordinating the Energy Policy Programme, which is partly from 1997 and partly from 2002, and implementing its components. It is also assigned a co-ordinating responsibility for the programme and monitors programme implementation. Specific responsibilities include:

- Planning and running energy and environment computer-modelling projections to develop forecasts.
- Implementing and overseeing the long-term energy policy programme for R&D.
- Administering the electricity certificate trading programme for support of renewable energy.
- Implementing Sweden's energy efficiency measures, including the voluntary long-term agreements with industry.

The Swedish National Energy Agency also has separate departments acting as the electricity and natural gas regulators. A report was released by the government at the end of 2003, which gave the general recommendation that the regulator be split from the Energy Agency to become a fully autonomous body. This report, together with other input, will form the basis of further consideration of this issue.

SVENSKA KRAFTNÄT

Svenska Kraftnät is the owner and operator of the national high-voltage electricity grid. The company is also responsible for the electricity system being in short-term balance, known as the system responsibility. It is 100% owned by the Swedish government.

Additional government agencies dealing with energy include:

Swedish Agency for Innovation Systems (VINNOVA) promotes sustainable growth by financing research and development, and developing effective innovation systems. *The Competition Authority* is responsible for promoting effective competition in the private and public sectors for the benefit of consumers. *The Electrical Safety Administration* is responsible for the security of the electricity use. All three groups are separate government agencies subject to supervision by the Ministry of Industry, Employment and Communications.

The Swedish Board of Housing, Building and Planning is responsible for promoting the efficient use of energy in buildings, notably the reduction of use of electricity for residential heating. *The Swedish Nuclear Power Inspectorate* (SKI) is responsible for regulation of nuclear activities with regard to safety, nuclear waste management and nuclear non-proliferation. SKI is also responsible for government-funded nuclear safety research. Moreover, SKI manages a special government-funded programme for co-operation and support to Eastern and Central Europe in nuclear safety and related radiation protection areas. *The Swedish Environmental Protection Agency* is responsible for the supervision of environmental issues. These three groups are all separate government agencies under the supervision of the Ministry of Environment.

The *Swedish Consumer Agency* is responsible for testing, labelling and certification of energy use in household equipment and other consumer goods. *The Swedish Research Council for Environment (FORMAS)* is responsible for energy-related building research within the programme.

The *Swedish National Road Administration*, the *Swedish Maritime Administration*, the *Swedish Civil Aviation Administration* and the *Swedish Railway Administration* are all responsible for promoting efficient use of energy within their sectors.

SECURITY OF ENERGY SUPPLY

Swedish energy security focuses on oil and electricity. Sweden imports all of its oil and has one of the biggest per capita electricity usage rates in the IEA (nearly three times the average of OECD Europe countries). Other energy sources contributing to the fuel mix are relatively secure. Biomass is domestic and supported by a thriving supply industry of multiple companies, and coal is imported from a stable, secure international market. The natural gas market is evolving and, while Sweden shares the gas security concerns of other IEA Europe importing countries, gas currently comprises only 1.5% of the country's TPES. Oil and electricity security are discussed below with more information available in their respective chapters.

OIL AND OIL PRODUCTS

Sweden has no domestic oil production, importing all oil from the international market. In 2001, 34% of imports came from neighbouring Norway, followed by imports from the former Soviet Union (20%), Denmark (15%) and the United

Kingdom (13%). Any oil supply shortfall would be met with demand restraint, fuel switching and stock draw. The Ordinance with Instruction for the Swedish Energy Agency is the legal authority for establishing and operating the Swedish National Emergency Sharing Organisation (NESO) for IEA emergency response measures. The Department for Sustainable Energy Management of the Swedish Energy Agency is the core of Sweden's NESO. In an emergency, industry experts would participate in NESO activities. Currently, the Swedish Energy Agency is reviewing the organisation and function of NESO, including treatment of oil stocks. More information on oil energy security is available in Chapter 7 on fossil fuels.

ELECTRICITY

The high rate of electricity use in Sweden makes security of electricity supply especially important. Swedish industry makes substantial use of electricity and many Swedish homes use electric heating. Although peak demand has remained relatively stable since liberalisation, generating capacity has diminished significantly, leading to a tightening supply-demand balance. Nordel's Grid Master Plan 2002 suggests that Sweden will experience an electricity deficit by 2005, requiring imports of approximately 6 TWh per annum (or around 4% of total consumption), assuming a normal year of hydroelectric production. One-in-ten dry years could require around 16 TWh of imports per annum (or 9.9% of total consumption), and extremely dry years or successive dry years could require 19 TWh of imports per annum (or 11.8% of total consumption). Nordel also estimates that by 2005, Sweden could experience a capacity shortfall of around 2 000 MW during a one-in-ten-year winter peak compared to the peak in 2001 of 27 000 MW. However, Nordel also considers that imports should be sufficient to meet Sweden's balancing requirements during the projection period to 2010.

In the early winter of 2002/03, decreased hydropower potential owing to low rainfall and increased demand owing to cold temperatures severely tightened the supply-demand balance in Sweden and across Nord Pool. Nordic spot prices rose to unprecedented levels. Between 8 and 17 December 2002 system prices averaged over 70 öre per kWh[3], sometimes spiking to over 90 öre per kWh, while prices peaked between 4 and 8 January 2003 at an average of around 100 öre per kWh. By way of comparison, the average wholesale prices in 2001 and 2002 were less than 25 öre/kWh. The market responded effectively to this situation. Imports increased, particularly from the continent, and thermal peaking plant returned to service. Demand was restrained in the face of high prices, although this occurred more so in Norway

3. One öre is one-hundredth of a krona.

than in Sweden. Supply was sufficient to meet demand throughout this period with no government intervention into the market.

Sweden experienced a substantial blackout on 23 September 2003, the most severe disturbance to the Nordic system in 20 years. The southern part of Sweden and the eastern part of Denmark were blacked out as a result of two severe faults, which occurred in quick succession. Domestic actors in the field attribute the outage to an unfortunate, coincidental series of transmission line and substation outages rather than to the tightening supply-demand balance or changes resulting from current or past market reform.

Sweden's security of supply needs to be understood in the context of the Nordic electricity market as a whole. Increasing trade and regional integration has enabled Sweden to draw on the reserves of other Nordic countries (and, increasingly, from outside Nord Pool) to enhance its security of supply, despite a continuing decline in Sweeden's excess generating capacity. Nordel estimates that the region as a whole will be able to cope with a single dry year through to 2006/07 without serious difficulties through reliance on imports. Nordel forecasts also suggest that while peak demand can be met throughout the region on normal winter days, exceptionally cold winter days will require a very high reliance on imports into the Nordic region. However, the combination of a dry year and an unusually cold winter could seriously stretch security of supply, placing substantial stresses on market mechanisms.

As a means of addressing electricity security, the Swedish government introduced legislation requiring the transmission system operator, Svenska Kraftnät, to contract for a capacity reserve of up to 2 000 MW. Svenska Kraftnät will determine the criteria for activating the capacity reserve, which is expected to be related to movements in the spot price. This measure took effect on 1 July 2003 and will remain in force until March 2008. This is regarded as a temporary measure whose ultimate objective is to encourage commercially sustainable solutions to efficiently manage Swedish peak capacity needs. Accordingly, it will seek to be a catalyst for the development of commercially-driven products, particularly those promoting greater demand-side responsiveness. More information on electricity security is available in Chapter 8.

ENERGY FORECASTS

The Swedish Energy Agency publishes long-term forecasts every three to four years. The most recent forecast is included in the country's Third National Communication on Climate Change to the United Nations Framework Convention on Climate Change (UNFCCC), which was published in 2001. The projection was made for 2010 and 2020.

The Swedish Energy Agency also makes short-term projections. In previous years the Swedish Energy Agency has made short-term projections twice a year, but it has been decided that these projections will now be made only once a year. The short-term forecasts estimate the development of energy use and energy supply three years ahead.

FORECAST ASSUMPTIONS

Assumptions used in the long-term forecast included in the Third National Communication are found in Table 1 below.

Table 1

Assumptions Used in Energy and Emissions Projections

Parameter		
	1997-2010	*2010-2020*
Annual growth rates		
GDP	1.9%	1.1%
Industrial output	2.3%	2.1%
Private consumption	2.4%	1.9%
Public consumption	1.2%	0.8%
Exports	3.5%	2.9%
	2010	*2020*
Import fuel pricing terms (1)		
Crude oil, $/BBL	17	22.5
Coal, $/tonne	42	42
Natural gas, $/MBtu	2.6	3.5
SKr/$ exchange rate	7.5	8.3
Domestic fuel pricing terms (2)		
Natural gas (industry), SKr/MWh	157	203
Natural gas (residential), SKr/MWh	464	558
Electricity, SKr/MWh	300 – 660	280 – 660
District heating, SKr/MWh	430	n/a

MBtu: million British thermal units.

(1) All figures in US dollar nominal terms.

(2) All figures in nominal Swedish kronor with all taxes included.

Sources: *Sweden's Third National Communication on Climate Change* and country submission.

All taxation and policy measures in place or currently envisaged with a fair degree of certainty are projected to be in place for the duration of the forecasts. For example, it is assumed that a certificate trading system to support renewable energy will replace the system of subsidies even though the system was not fully in place when the forecasts were made.

In addition, the forecast includes two alternative scenarios for its 2020 time frame. They are:

Scenario 1: All nuclear plants are allowed to operate until the end of their economic lifetimes. Closure does not come from government mandate. Plant owners are free to make further plant investments to increase output.

Scenario 2: The government confines the lifetimes of existing nuclear reactors to 40 years. This means reactors (apart from Barsebäck 2, which is assumed to be shut down before 2005) will begin to be shut down in 2012 with a total of six reactors placed out of service by 2020.

RESULTS

Results of the projections are shown in Table 2 below.

Table 2

Results of Energy Projections

All figures given in TWh	*2005*	*2010*	*2020 Scenario 1*	*2020 Scenario 2*
Energy use	**400**	**415**	**446**	**431**
Industry	162	172	183	178
Transport	84	86	91	91
Residential, services, etc.	154	157	161	162
Other:				
Foreign maritime transport	29	32	38	38
Non-energy purposes	20	22	27	27
Distribution and conversion losses	183	184	188	144
Supply	**632**	**653**	**688**	**641**
Oil products	207	213	232	234
Natural gas and town gas	8	9	9	24
Coal and coke	27	27	27	27
Biofuels, peat, etc.	102	114	129	132
Waste heat, heat pumps	9	9	9	7
Hydropower, gross	68	70	71	72
Nuclear power, gross	203	203	203	132
Wind power, gross	1.4	3.9	4.2	10.5
Import/export of electricity	7	4	4	4

Sources: *Sweden's Third National Communication on Climate Change* and country submission.

The major difference between the two scenarios is the supply mix. In Scenario 2 with nuclear lifetimes capped at 40 years, the nuclear generation is 35% below Scenario 1 where utilities continue with economic operation of their nuclear facilities. This difference is made up with greater supply from natural gas, wind and biomass. Prices for electricity and other energy sources are exogenous variables to the model and thus do not change with the different scenarios.

ENERGY TAXATION

Energy taxation in Sweden is used as a tool to raise revenue and reach certain policy goals such as the reduction of GHG emissions or improved energy efficiency. Sweden has three different levies on energy products: energy tax, carbon dioxide tax and sulphur tax. There is also an environmental levy on emissions of nitrogen oxides for boilers, gas turbines and stationary combustion plant producing an annual energy output of at least 25 GWh.

In connection with the tax reforms of 1990/91, Sweden began a process of green tax exchange. Under this system, energy taxes were increased while other taxes (such as income and payroll taxes) were decreased by similar amounts. Thus, the green tax exchange is intended to be revenue-neutral for the Swedish government while helping the country reach environmental goals. The government set a goal of increasing "green taxes" by SKr 30 billion between 2001 and 2010 (with corresponding reductions in other taxes). As of 2003, SKr 8 billion in taxes have already been shifted to "green taxes." The continuation of the green tax shift for 2004 included an 18% increase in the CO_2 tax for heating fuels, an increase in the electricity tax, and a 50% increase on pesticide tax. These tax hikes will be offset with a SKr 200 tax reduction for wage earners and a 0.12% reduction in the payroll tax.

This green tax shift affects domestic consumers and the service and energy sectors. The government is worried that excessive energy tax would harm the international competitiveness of Swedish industry which is, as a result, largely exempt from energy tax increases. One tool the government is considering to use to curb industrial energy consumption in place of taxation is the voluntary long-term agreement programme which is discussed in Chapter 5 on energy efficiency.

In addition to being an environmental economic instrument as part of the green tax shift, energy taxes are also an important source of government revenue. Excluding value-added tax (VAT), energy taxes raised SKr 55 billion in 2001, or about 2.5% of Swedish GNP. VAT then provides a further SKr 13 billion. Table 3 shows the revenues from various environment-related taxes between 1992 and 2002.

Table 3

Government Revenue from Energy and Environmental Taxes

(million Swedish kronor)

	1992	*1994*	*1996*	*1998*	*2000*	*2001*	*2002*
Petrol tax	14 344	22 030	(1)				
Total tax on energy products	18 930	17 399	45 636	49 811	50 739	53 080	56 243
Of which:							
Energy tax	*9 546*	*10 239*	*30 371*	*36 900*	*38 419*	*36 542*	*36 919*
Carbon dioxide tax	*9 194*	*6 943*	*15 053*	*12 796*	*12 245*	*16 457*	*19 373*
Sulphur tax	*190*	*217*	*212*	*115*	*75*	*81*	*131*
Special tax on electricity from nuclear power plants	117	137	974	1 537	1 726	1 841	1 796
Hydropower tax	1 030	817	1 423				
Special tax on acidification	63	63	64	58	..	..	..
Environmental tax on domestic air traffic	168	271	128	..	..	..	
Total energy and environmental taxes	**34 652**	**40 717**	**48 223**	**51 406**	**52 465**	**54 921**	**58 039**

(1) The petrol tax was moved under the rubric of the energy tax between 1994 and 1996.

Source. Swedish government.

TYPES OF TAXES

Table 4 provides an overview of the combined effects of all taxes on energy products.

The legislative basis of energy taxation lies in the Energy Tax Act, SFS 1994:1776. *Energy tax* is levied on petrol, fuel oil, diesel oil, paraffin, liquefied petroleum gas (LPG), natural gas, coal and petroleum coke. The general principle is that fuels are taxable if they are used for heating or as motor fuels. The actual tax rate varies from fuel to fuel, and is independent of the energy content. Tax is also payable on the use of electricity although this tax is levied at the consumer level and fuels used for the production of electricity are exempt from tax.

Since January 2004, households and the service sector pay a tax of SKr 241 per MWh on electricity. Users in the manufacturing industry, agriculture, forestry and fishing pay zero electricity tax until 1 July 2004, when an electricity tax of SKr 5 per MWh will be introduced in these businesses.

Carbon dioxide tax, which was introduced in 1991, is levied on the emitted quantities (kg) of carbon dioxide (CO_2) from all fuels except biofuels and peat.

Table 4

Combined Taxes (excluding VAT) on Energy

(2001 prices)

	1990			2001			1990-2001
	Pre-tax price €c/kWh	*Tax €c/kWh*	*% tax rate*	*Pre-tax price €c/kWh*	*Tax €c/kWh*	*% tax rate*	*% increase in tax rate*
Gas oil	3.4	1.7	51	2.9	2.5	86	43
Medium-heavy fuel oil	2.5	1.7	70	2.2	2.4	108	38
Petrol	4.0	5.8	145	4.3	5.7	134	-2
Unleaded petrol	4.0	5.4	134	4.0	5.8	145	7
Diesel	4.6	1.7	38	4.4	3.4	78	97
Coal	0.7	0.8	113	0.7	2.6	397	211
Forest fuels*	1.5	0.0	0	1.2	0.0	0	0
Sod peat	1.9	0.0	0	1.2	0.2	14	–
Natural gas, residential**	2.6	1.8	70	3.3	2.8	85	54
Natural gas, industry**	1.5	0.2	13	3.4	0.5	13	146
Electric heating, residential	5.0	2.6	52	4.8	3.7	77	45
Electricity (industrial)	3.7	0.8	21	2.5	0.0	0	-100

*Prices and taxes data available from 1993.
**Prices and taxes data available from 1996.

It does not differentiate between the uses of fuels for heating or as motor fuels. It was increased, on 1 January 2001, from SKr 370 per tonne to SKr 530 per tonne, on 1 January 2002 to SKr 630 per tonne and on 1 January 2003 to SKr 760 per tonne. Since 1 January 2004, the CO_2 tax has been SKr 910/tonne.

Since 1 July 2000, *nuclear power plants* are subject to a tax on the thermal production capacity of the reactors, at a rate of SKr 5 514 per MW per month. This is a change from the previous practice, by which nuclear power was taxed on the basis of its electricity production[4]. In addition, there is a further levy of about SKr 10 per MWh under the terms of the Act Concerning Financing of Future Charges for Disposal of Spent Nuclear Fuel (1992:1537). This levy is intended also to cover phase-out and ultimate demolition of the reactors, together with a certain monitoring and inspection. The government determines the rate annually. There is also a further tax of SKr 1.5 per MWh to cover the costs of waste management from earlier nuclear research, carried out at the Studsvik research centre.

4. Under certain normal operating conditions, the current tax is (and is intended to be) equivalent to the previous tax rate of SKr 27 per MWh.

A *sulphur tax* was introduced in 1991, and amounts to SKr 30 per kg of sulphur emissions from coal and peat, and to SKr 27 per cubic metre for each tenth of a per cent by weight of sulphur content in oil. However, if the sulphur content of liquid or gaseous fuels does not exceed 0.1% by weight, no sulphur tax is charged. This applies for fuels such as petrol, diesel oil and gas oil. In addition, no sulphur tax is charged if measures to reduce sulphur emissions are applied.

An environmental levy on emissions of *nitrogen oxides* (NO_x) was introduced in 1992 (SFS 1990:613) for boilers, gas turbines and stationary combustion plant producing an annual energy output of at least 25 GWh, at the rate of SKr 40 per kg of NO_x emissions. However, this levy is intended to be essentially fiscally neutral as far as the national economy is concerned, and is repaid in proportion to the respective plant's energy production, so that only those with the highest emissions are actually net payers.

SPECIAL TAXATION RULES

Fuels used for *electricity production* are exempt from the energy and CO_2 taxes, although they are subject to the NO_x levy and sulphur tax in certain cases. Five per cent of the fuel input used for cold condensing power production and gas turbine power production is regarded as being for internal use, and is subject to energy and CO_2 taxes.

Fuels used for *heat production* are subject to energy and CO_2 taxes and, in certain cases, to sulphur tax and the NO_x levy. In principle, biofuels, solid waste and peat are free of tax for all energy uses, although peat is subject to sulphur tax. A tax on refuse incineration is being investigated at present.

Special rules apply for combined heat and power (CHP) plants. Since 1 January 2004, no energy tax and only 21% of the CO_2 tax is paid for fuels used for heat production in these plants. This same taxation is applied in manufacturing, industry, agriculture, forestry and fishing. The reason for lowering the tax is to promote production in existing CHP plants and investments in new plants. Three per cent of the fuel input used for electricity production in CHP plants is regarded as being for internal use, and is subject to energy and CO_2 taxes.

No energy tax is applied for fuels and electricity used for manufacturing processes in the manufacturing industry, horticulture, professional agriculture, forestry or fishing and associated activities. However, an electricity tax of SKr 5 per kWh will be introduced on 1 July 2004. In addition, these businesses pay only 21% of the CO_2 tax. The CO_2 tax for industry is applied at the rate of approximately SKr 190 per tonne of CO_2. This rate has remained stable for the last three years, while carbon taxation on households and the service and energy sectors has been raised. Special taxation reduction rules enable 24% of the tax that exceeds 0.8% of the sales value of products to be offset and repaid.

All transport fuels are taxed, generally at higher rates than those used for heating. However, under the terms of the EU Directive 92/81/EEC of 19 October 1992 on the harmonisation of the structures of excise duties on mineral oils, the government can reduce or waive taxation on fuels, for instance in order to promote the development of more environmentally benign fuels, with such relief being provided for certain volumes of alternative motor fuels. Such tax reductions in Sweden have led to the introduction of biofuels like bioethanol, biodiesel (RME) and biogas.

In May 2003, the EU introduced the Directive 2003/30/EC on the promotion of the use of biofuels or other renewable fuels for transport. In June 2003, the Swedish government appointed an investigator to propose goals and strategies for the further introduction of biofuels for transport. The investigator will make an interim report in February 2004, allowing Sweden to report its national indicative target for 2005 to the European Commission before 1 July 2004 in accordance with the biofuels directive. The Budget Bill for 2004 includes the proposal of a general exemption from energy and CO_2 taxes for CO_2-neutral transport fuels.

The Taxation of Vehicles Act (SFS 1998:327) applies vehicle tax to motorcycles, private cars, buses, trucks and tractors. Sales tax on passenger cars was removed in 1996, followed in 2001 by its removal on light trucks, buses and motorcycles, with the aim of encouraging the sales of new vehicles and thus accelerating the rate of renewal of the country's vehicle stock. The average age of Sweden's vehicle stock is relatively high, and older vehicles generally have poorer exhaust cleaning and higher fuel consumption. For the same reason, the annual vehicle tax on diesel private cars of the 1993 model and older has been raised to the same level as for more modern diesel-powered vehicles.

CRITIQUE

Sweden has a successful history of providing low-cost, reliable, secure and environmentally sound energy to its people. The country is a pioneer of electricity market reform, which many other countries are now emulating. Secure access to energy, especially electricity, on internationally competitive terms is seen as essential for sound economic and social development in Sweden and energy is recognised as being a major determinant of environmental, climate and health impacts.

This is an important time for Swedish energy policy. Decisions taken now will bring significant changes in the energy sector in the near, mid and long term. Certain goals have been established which will change the energy sector, notably the 4% reduction in CO_2 emissions by 2010 and the additional 10 TWh contribution of renewable electricity to the overall supply mix. In addition, a number of important issues have been causing the future of Swedish energy to be actively debated, particularly the phase-out of nuclear energy.

This important ongoing debate about energy has produced a degree of uncertainty in areas such as the future of Swedish nuclear power, changes in the energy taxation scheme, the ultimate means of tackling climate change and the possible expansion of natural gas use. To some extent, this uncertainty has undermined the stable environment needed for all actors to make decisions on behaviour and investment. For example, this uncertainty (along with other factors) has the potential to hinder investment in new electricity capacity despite a shrinking reserve margin and periods of high prices. In addition, industrial facilities and heat and power producers may delay efficiency improvements while the GHG emission allowance allocation scheme remains undecided. The government should provide a stable energy environment as much and as soon as possible to give investors and other decision-makers the comfort to proceed with their plans. A credible solution to the question of the nuclear phase-out is imperative. Such a solution would provide clear ideas on alternative supply sources if nuclear generation is decreased and on how any such decisions would impact Sweden's obligations on cutting GHG emissions.

The nature of the current discussion may indicate the beginning of a shift in focus for Swedish energy policy. Energy discussion in Sweden has historically focused on supply-side issues, whether they be nuclear power, use of renewable energy or the structure of the electricity market in general. While this supply-side focus remains largely in place, demand-side management and energy efficiency are now receiving greater attention from both the government and the private sector. While activity in this sector still lags on the supply side, demand-side tools and measures are being more seriously considered as viable alternatives to supply-side solutions. If this trend continues, energy efficiency and demand-side response will be very helpful in allowing Sweden to meet its policy objectives. Demand-side tools can be particularly effective in Sweden, given its high electricity intensity and challenges in meeting peak electricity demand. They should be explored and utilised to a much greater degree.

Policy-makers and the public require background analysis to make informed decisions and, in this area, it seems necessary to augment analysis to give a clearer view of the different options for the Swedish energy sector. For example, no general consensus on the cost and benefits of decisions on nuclear power or the achievement of environmental objectives seems to have yet emerged or to have been disseminated throughout society. Accurately characterising each option with its benefits and costs for the whole economy will be particularly important. Information, analyses and scenarios should be as clear and explicit as possible to all, including political actors and the public. The expertise and capacity for valuable quantitative analysis exist within the Swedish government and they should be utilised with the results spread widely to all.

Sweden takes a market-based approach to reforming its energy sector and, in this context, has established a regulatory body. While established as a legally separate entity, the full independence of the regulator is not readily apparent given its position within the Swedish National Energy Agency and the Energy Agency's guidance from the government. The conclusions from the recently-released government report advocating that the regulator be split off into an autonomous body should be given serious consideration. The light-handed approach taken by the Swedish regulator has largely been a success. However, as the energy sector evolves, opportunities for a more forceful energy regulator may emerge in the fields of natural gas, electricity and district heating. In addition, possibilities for the regulator to engage in productive co-operation with international counterparts should be fully explored, particularly in the field of electricity.

Swedish energy taxation is both high and complex. With the green tax shift, taxation is used to reach environmental goals, particularly the reduction in GHG emissions. At the same time, it is a large revenue raiser for the government and is tailored to shield industry from part of the energy taxes in order to ensure international competitiveness. The government has largely met its goals regarding taxation. However, two considerations must be kept in mind. The first is the harmful effect of a complex and highly variable tax structure on private investment and behaviour. The second is the diminishing environmental returns that can be achieved with even higher taxation. If taxes already make a less-emitting fuel more attractive than a more-emitting fuel, continued tax increases will do little to promote use of the preferred fuel. Consequently, the government must do what it can to bring more stability and simplicity to the system and to constantly monitor that further tax hikes will have their intended effect.

Sweden is increasingly making use of international opportunities in the energy sector, *e.g.* the Nord Pool electricity market. In addition, much of the country's overall economy is sustained by international trade. The international aspect of the Swedish energy sector has been highly beneficial and will grow in the future as Nord Pool further integrates, the EU directives are implemented, tax harmonisation is sought and the country considers increased natural gas imports. Such developments should benefit Sweden but must be monitored by policy-makers to ensure they are properly undertaken.

RECOMMENDATIONS

The government of Sweden should:

- *Continue to develop a long-term vision of a sustainable energy future, based on sound modelling of the economic costs of various options.*
- *Place greater overall emphasis and attention on energy efficiency and demand-side response as a way of meeting the country's environmental and security of supply targets.*
- *Strive to create a more stable policy environment in which energy stakeholders can plan effectively by resolving the future of nuclear power (including clear ideas on alternative supply sources and consequences for GHG emission commitments) and by providing a more stable and simplified energy tax regime.*
- *Undertake more quantitative assessments of the costs and benefits of various energy policy options, including the decision on nuclear power, and disseminate this information as widely as possible to energy actors and the general public.*
- *Continue to monitor progress towards established goals and evaluate effectiveness of policy measures.*
- *Consider increasing the scope, transparency and independence of the energy regulator.*

CLIMATE CHANGE

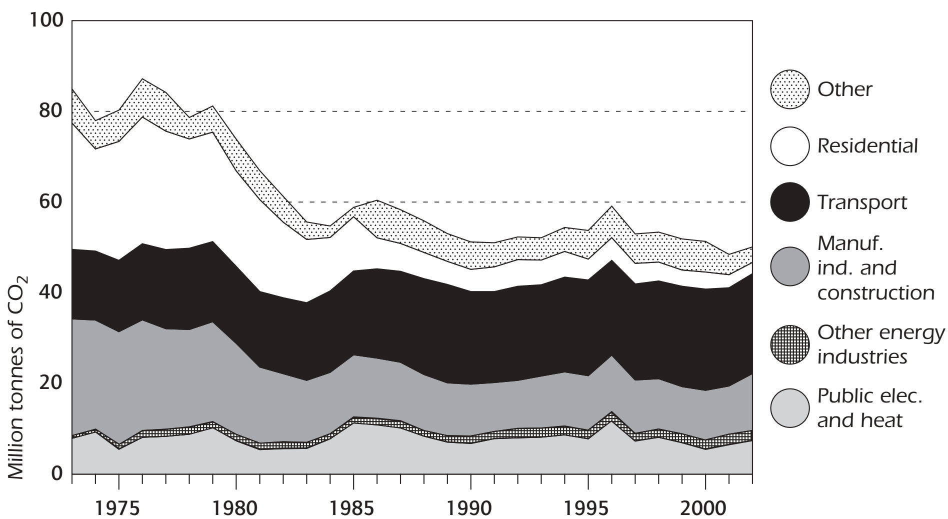
GREENHOUSE GAS EMISSIONS AND PROJECTIONS

Emissions of greenhouse gases (GHG) are currently around 70 $MtCO_2$-equivalent, of which approximately 50 $MtCO_2$ arise from energy-related activities. The largest energy-related emitting sector is transport (38%), followed by industry (24%), electricity and district heating (21%) and residential/services (15%). Emissions of CO_2 arise mainly from oil (80%), with coal (16%) and natural gas (3%) representing the remainder.

Net emissions, including land-use change and forestry activities are significantly lower than gross emissions, owing to Sweden's extensive forestry activities, which act as an emissions sink. The relative size of these sinks is much higher for Sweden (at 47% of gross emissions) than the average for the European Union (EU), where sinks represented 4.8% of gross emissions in 2001. Figures 3 and 4 show emissions by sector and by fuel.

Figure 3

CO_2 Emissions by Sector*, 1973 to 2002

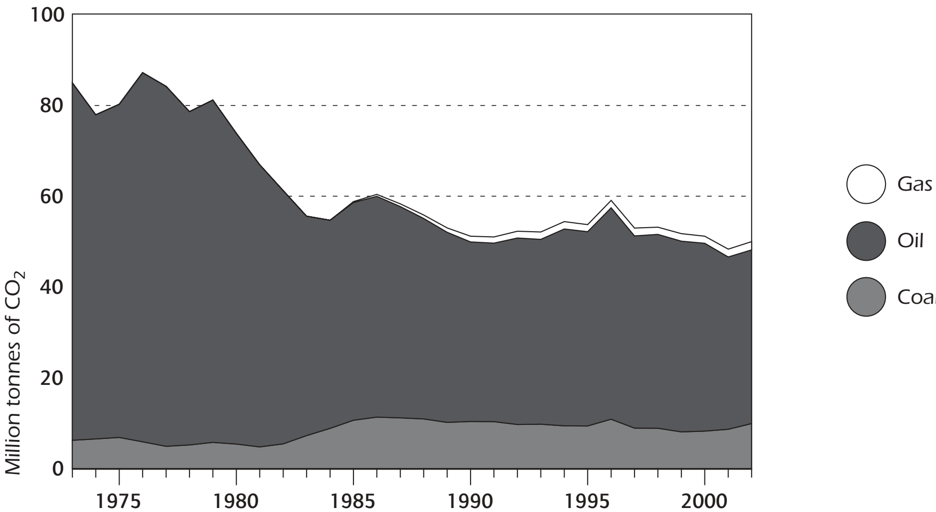


* estimated using the IPCC Sectoral Approach.

Source. *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2003.

Figure 4

CO_2 Emissions by Fuel, 1973 to 2002



* estimated using the IPCC Sectoral Approach.
Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2003.

The Swedish energy system has one of the lowest per capita emissions of CO_2 in the OECD. In 2000, Sweden emitted 5.86 tCO_2 per capita compared to an average for the OECD as a whole of 11.09 tCO_2 per capita, and an average for OECD Europe of 7.57 tCO_2 per capita. Swedish emissions per unit of GDP are also low, at 0.19 $kgCO_2$/US$ compared to an OECD average of 0.45 $kgCO_2$ per US$, and an average for OECD Europe of 0.37 $kgCO_2$ per US$ in 2000. These low emission levels are largely due to the high levels of hydro and nuclear power, which together make up 93% of electricity generation, as well as significant levels of biomass used in heat generation.

Latest published projections[5] of GHG emissions based on the expected continuation of the energy and CO_2 taxes, together with the continued use of hydro, nuclear and biomass, and implementation of planned new policies show GHG emissions remaining stable to 2010 relative to 1990. This is broken down as follows (Table 5).

5. Third National Communication to the UNFCCC. These projections do not include the increases in energy and CO_2 taxes announced in late 2003, nor the new climate investment programmes that would be expected to achieve additional reductions. The projections in the Third National Communication to the UNFCCC use slightly different emissions figures for 1990 compared to those reported in the latest official submission to the European Environment Agency.

Table 5

Gross Total GHG Emissions by Sector

	1990 emissions ($MtCO_2$ [1]eq.)[6]	*2001 emissions ($MtCO_2$ [2]eq.)*	*% change 2001 relative to 1990*	*Projected % change 2010 relative to 1990[2]*
Energy (excluding transport)	35.2	32.6	-7%	-4%
Transport	19.1	20.8	+9%	+13%
Industrial processes[3]	6.1	6.1	–1%	+25%
Agriculture	9.5	8.9	–7%	–8%
Waste management	2.7	2.1	–23%	–60%
Total	**72.8**	**70.5**	**–3%**	**+1%**

(1) Source: European Environment Agency 2003.

(2) Source: Sweden's Third National Communication on Climate Change under the United Nations Framework Convention on Climate Change.

(3) Includes emissions from solvent and other product use.

CO_2 emissions comprised more than three-quarters (55.3 $MtCO_2$) of total GHG emissions in 2001. Of these total CO_2 emissions, 19.8 $MtCO_2$ arise from transport, 30.7 $MtCO_2$ arise from other energy consumption and 4.5 $MtCO_2$ arise from industrial processes.

CLIMATE POLICIES

The Swedish government has established a strategy for tackling climate change that sets both medium- and long-term targets, as well as describing a wide range of policy measures to reduce emissions from all relevant sectors. Under the EU burden-sharing agreement for emissions of GHG, Sweden has a national target to keep GHG emissions no higher than 4% above 1990 levels by 2008 to 2012.

However, the climate strategy also sets a more ambitious domestic target of a 4% reduction relative to 1990 by 2008 to 2012. This represents an emissions level of around 5.6 $MtCO_2$-eq. lower than the EU burden-sharing agreement target, and would require an additional reduction of about 3.3 $MtCO_2$-eq. compared to the projected emissions in 2010 according to the Third National Communication to the UNFCCC.

The strategy also sets a long-term goal to reduce total (gross) GHG emissions per capita to less than 4.5 tCO_2-eq./capita by 2050 (a reduction of 43% compared to 2001 levels of 7.9 tCO_2-eq./capita). This target is set with a view to being consistent with international actions to stabilise concentrations of GHG in the atmosphere at a level below 550 parts per million (ppm).

Swedish climate policy and the national target are to be continuously followed up. If emissions do not diminish according to the target, the government may propose further measures or review the target. Account shall be taken of the competitive strength of Swedish industry. Such a study has been assigned to the Swedish Energy Agency and to the Environmental Protection Agency. The agencies are to report to the government in June 2004.

At the centre of Sweden's climate strategy is an extensive programme of energy and CO_2 taxes, which have systematically increased since 1990. The government estimates the impact of these as being a 15% to 20% reduction in CO_2 emissions between 1991 and 2003, and the taxes expected to save approximately 10 $MtCO_2$ on an annual basis by 2010.

Taxes on CO_2 emissions are a centrepiece of the environmental tax strategy. CO_2 taxes were raised on 1 January 2004 to SKr 910 per tonne. However, many sources of emissions (such as industrial) are subject to a reduced CO_2 tax rate and, in order to calculate an average CO_2 levy for the economy as a whole, the total CO_2 tax revenue is divided by the total CO_2 emissions, giving an overall average CO_2 tax rate of SKr 360 per tCO_2. The rates are planned to increase further in the latest budget proposals. By 2006, total energy and CO_2 tax revenues are expected to reach SKr 72 billion, of which CO_2 tax revenues would total SKr 32 billion. This would increase the average CO_2 tax rate for the economy to SKr 652 per tCO_2.

The EU emissions trading scheme will be another important new policy instrument for all EU member States. Allowances will be allocated to all companies with combustion plant rated at >20MW(th) as well as operations in the steel, minerals and paper sectors. In Sweden, about 300 installations, including heat and power producers and industrial sites, will be covered under the trading scheme, covering approximately 31% of total Swedish CO_2 emissions, or 49% of total non-transport CO_2 emissions. Companies that emit more than their allocated allowances will need to buy additional allowances to cover their emissions. Those that emit less may sell their spare allowances, or bank them for use in later years (although banking from the first period 2005 to 2007 into the second period 2008 to 2012 may be limited).

In June 2003, the Swedish "Commission on a system and regulatory framework for the flexible mechanisms of the Kyoto Protocol" presented its views on how initial emission allowances should be allocated for the first trading period 2005 to 2007. Two of the preliminary proposals were:

- Average emissions during the four-year period 1998-2001 should serve as the basis for allocation of the total number of emission allowances.

- CO_2 emissions in each sector are divided into two categories: first, emissions from raw materials that cannot be replaced if the product is to be manufactured, and, secondly, emissions from fossil fuels that are replaceable and are used for the primary purpose of producing power, heat or transport energy.

The government has circulated the commission's proposals, receiving over 130 comments from stakeholders, and is currently preparing for initial allocation to the trading sectors. The government submitted a bill (2003/04:31) to parliament on 4 December 2003 establishing the principles of the National Allocation Plan (NAP). In this bill, the amount of allowances to be allocated in the NAP will be equal to around 19 to 22 $MtCO_2$, and this includes approximately 1 $MtCO_2$ for peat, which was not included in the original proposal made by the commission. This allocation range is based on more accurate, bottom-up estimates than those used by the commission in its initial proposals. The final NAP is now being developed in accordance with the criteria laid out by the EU.

In addition to taxes and trading, Sweden has a number of other policy measures to tackle emissions of all the major GHGs from all the major emitting sectors. The most significant measures as regards the energy sector are project-type Kyoto flexible mechanisms, the climate investment programme and support for renewable energy.

Sweden has committed €35m in international programmes for the development of climate change mitigation projects. Of this, €4m will go towards projects funded by BASREC, a Baltic Sea regional initiative (also supported by other Baltic countries); €21m will be for direct procurement of Joint Implementation (JI) credits by the government; and €10m will go to the World Bank's Prototype Carbon Fund, which procures credits from carbon offset projects on behalf of members. This involvement is intended more as a way of building experience in the emissions trading markets, rather than as a significant contribution towards national targets. Nevertheless, this expenditure is expected to result in emissions reductions in the region of 1.4 $MtCO_2$ per year over the period 2008 to 2012 at a cost of around €5 per tCO_2.

Another significant new policy measure is the Climate Investment Programme (KLIMP). This replaces the existing Local Investment Programmes, and provides a stronger focus on climate change in the funding criteria. Expenditure is expected to be in the region of €80m over the period 2003 to 2005, supporting a range of actions on energy efficiency and renewable energy by municipalities, county councils and companies. An additional information campaign will also be funded at a level of €3m per annum.

Sweden supports a range of renewable energy technologies through grant schemes, notably for solar heating and other renewables in the residential buildings sector. The support mechanism for renewable electricity generation has recently changed from a grant scheme to a renewable electricity certificate trading scheme, as described in Chapter 6. Sweden has also enacted a number of energy efficiency policies as described in Chapter 5.

OTHER ENVIRONMENTAL ISSUES

Air quality has improved in Sweden over the past 15 years, with concentrations for the major pollutants having dropped between 1986 and 2002 by 85% for sulphur dioxide (SO_2), and by about 40% each for nitrogen oxides (NO_x) and particulates. These improvements are dependent not only on actions taken within Sweden, but are also the result of broader international action. The main programmes for international efforts to improve air quality are the ECE Convention on Long-Range Transboundary Air Pollution, and the EU's Clean Air for Europe programme.

In terms of emissions, the energy sector is the dominant contributor of these pollutants. For sulphur oxides (SO_x), energy-related sources contribute over 70% of national emissions, including 33% from combustion in manufacturing industry, 28% from combustion in energy and transformation industries, and 7% from non-industrial combustion. For NO_x, energy-related activities contribute 95% of emissions, including 46% from road transport, 31% from other mobile sources and machinery, 9% from combustion in manufacturing industry, and 7% from combustion in energy and transformation industries.

Several directives are in place or being introduced at the EU level that will affect these emissions of pollutants from installations in Sweden. These include the Emissions Ceiling Directive (2001/81/EC) which sets a cap on total national emissions of key pollutants, the Large Combustion Plant Directive (2001/80/EC) which sets emissions standards for these pollutants at the individual plant level, as well as the Integrated Pollution Prevention and Control Directive, which defines best available technology for achieving an integrated approach to environmental management.

Air quality standards are covered by an EU Framework Directive which is followed up with daughter directives covering the individual pollutants. In Sweden, the daughter directives have been implemented as environmental quality standards with respect to SO_2, NO_x, lead and particulates, adopted under the Environmental Code. A similar standard for benzene and carbon monoxide will also be established.

Sweden has a broad-based environmental strategy, which sets interim targets and action plans for the key non-climate-related indicators pertaining to energy. These include emissions of NO_x, SO_x, volatile organic compounds (VOCs), and ground-level ozone, as well as raising energy efficiency levels in the built environment and sustainable forests. Currently the strategy does not include targets for particulates, but these are to be proposed and should form the basis for future environmental quality standards.

A target to reduce local concentrations of SO_2 to below 5 $\mu g/m^3$ as an annual mean by 2005 is expected to be achieved for all municipalities, as a result of reduced emissions levels both in Sweden and many other European countries. A target to limit NO_x concentrations to 20 $\mu g/m^3$ as an annual mean, and to 100 $\mu g/m^3$ as an hourly mean has been set for 2010, and is expected to be achieved in most places. Improvements in this air quality standard has come about as a result of more stringent vehicle emission standards, although increased traffic levels have slowed the rate of overall environmental improvement. Ground-level ozone concentrations are targeted to stay below 120 $\mu g/m^3$ as an eight-hour mean by 2010. The number of episodes of exceedence of this level have reduced over the past ten years, from five to 30 days, to between zero and five days for different regions of Sweden. Exceedences and average concentrations have remained stable over the past few years. Annual emissions of non-methane VOCs are targeted to be reduced to below 241 000 tonnes by 2010. Adopted and planned measures relating both to transport and to wood burning are expected to substantially reduce VOC emissions to achieve this target.

A complex objective for sustainable forests has been set, stating that "the value of forests and forest land for biological production must be protected, at the same time as biological diversity and cultural heritage and recreational assets are safeguarded". Progress against the interim targets for this objective is more mixed, with good progress on maintaining areas of mature, mixed and old forest, and introduction of targeted measures for threatened species. Less optimism is expressed about the preservation of ancient monuments, the exclusion of conservation areas from forestry activities, and the achievement of increased biodiversity as a result of the long time-scales of biological processes involved.

CRITIQUE

The climate strategy sets out an extensive range of policies covering all major emissions sources, from EU-wide initiatives through to local investment schemes. While such a broad-based approach is helpful, the strategy does not clearly lay out the relationship and interactions between the policies, and does not estimate for all relevant policies the expected emissions reductions or implementation costs. This lack of quantification makes it difficult to compare the cost-effectiveness of different policies and thus to judge which should be chosen to reach national objectives on emissions. There is a need for improved modelling and economic analysis of policies, in order to ensure they are introduced where they are most needed, and in a way that maximises policy synergies and cost-effectiveness.

While the EU burden-sharing agreement allows Sweden to increase GHG emissions up to 4% over 1990 levels by 2008 to 2012, Sweden has set a more ambitious domestic target of 4% reduction below 1990 levels. This seems to be a challenging target. Despite government forecasts showing that emissions will be only 1% above 1990 levels under current policies, there remains some debate about cost-efficiency and whether emissions can in fact be kept near 1990 levels as projected. Transport CO_2 emissions are a particular concern, having increased by 9% between 1990 and 2001. They are forecast under business-as-usual scenarios to increase to 13% above 1990 levels by 2010, against a target in the environment strategy of stabilisation at 1990 levels.

Uncertainty about the future fuel mix for electricity generation also contributes to these doubts, and clearly the emissions will be dependent on the results of decisions about nuclear, although in practice these effects will predominantly occur after 2010. As a result of these uncertainties, a continued or even accelerated push to implement the climate change programmes is encouraged.

It is commendable that the strategy sets out long-term targets for emissions reductions, which in turn should be used to encourage the relevant players to set consistent long-term priorities. However, Sweden can only achieve its long-term per capita emissions target at acceptable costs if it takes co-operative actions with other countries, such as sharing technology development costs and gaining experience from others' experience. Sweden should therefore continue to develop the necessary links with activities at an international level to facilitate these changes.

CO_2 taxes are already at a high level in Sweden when compared to other IEA European countries. Biofuels have greatly increased their share of energy for heating over the past decade in response to previous tax changes. However, given the financial advantage that biomass already enjoys thanks to favourable taxation, Sweden is unlikely to significantly change the emission profiles of suppliers by further increasing CO_2 taxes. (The higher end-use prices resulting from this tax might, nevertheless, reduce emissions through curbing demand.) Additional shifts away from fossil fuels may be limited more by lack of available alternatives rather than insufficient price signals, and ways should be found to improve the environmental effectiveness of future tax changes.

Emissions from industry are generally taxed at much lower rates than emissions from other sectors owing to concerns about international competitiveness. Although such tax discounts and exemptions for industry are common practice in several OECD countries, this leaves industrial emissions relatively uncovered by Sweden's main climate change mitigation policy. Ways should be found to tackle industrial emissions, perhaps by finding different ways to address competitiveness concerns other than CO_2 tax breaks. While long-term agreements are one tool the government is considering to curb industrial energy use, their effectiveness is in no way guaranteed, as explained in the following chapter.

One alternative would be to focus on the EU emissions trading scheme as a key instrument for tackling industrial emissions. This provides some advantages in that it covers all EU countries, and therefore at least partly alleviates the competitiveness concern of unilateral taxation. The environmental effectiveness of the trading scheme in helping to tackle Swedish emissions will depend to a great extent on the international price of carbon allowances compared to the companies' own abatement costs. In finalising the National Allocation Plan for initial allocation of allowances to emitting sources, the government must balance concerns of underallocation of allowances (thus burdening industry with excessive costs) and over-allocation of allowances (thus reducing the motivation to cut emissions). The uncertainty over emissions projections under any business-as-usual conditions further complicates the matter. The range included in the bill submitted to parliament corresponds to an increase of between 0% and 15%[6] for the trading sector. Allocation amounts from the upper end of the proposed range could imply additional emissions reduction burdens on other sectors, including the transport sector for which emissions have been increasing rapidly, making it more difficult for Sweden to achieve its GHG emissions reduction target.

Emissions trading could play an important if not central role in climate mitigation policy. For this to be the case, it is important to ensure that other, purely domestic, policies are compatible with the emissions trading scheme. Some streamlining of policies might be required. In particular, taxes and an emission caps system might be considered a form of double regulation for sectors that fall within the trading scheme. Sweden should consider phasing out some of its regulations for those sectors once confidence in the trading scheme has been established.

Sweden's current target for GHG emissions reduction is stated in terms of domestic action, to reduce emissions by 4% by 2010 relative to 1990, without the use of emissions trading or other flexible mechanisms. However, with the onset of the EU emissions trading scheme, sectors will engage in trading with other countries in the EU, or use joint implementation (JI) or clean development mechanism (CDM) projects to help meet their targets. This means that the total emissions of GHG within Sweden's borders are no longer within control of government, and it may be necessary to re-frame this target. This could be done by modifying the commitment to achieve the target purely through domestic action, recognising the potential for trading to help meet targets in a cost-effective manner. Alternatively, if the commitment to achieving a certain level of domestic reductions is deemed important, a new

6. Range of 18 to 22 $MtCO_2$ versus baseline for the emitting sector of 17.4 $MtCO_2$ plus 1 $MtCO_2$ for peat burning.

target could be set exclusively for the non-trading sectors. Such a target would account for the estimated scale of trade within the trading, so that the overall domestic savings are approximately the same as the original target. In either case, it is important that sectoral targets can be shown to be consistent with the national target.

RECOMMENDATIONS

The government of Sweden should:

- *Increase the level of analysis and quantification of policies to better assess the cost-effectiveness of different measures and show how both individual policy measures and the climate strategy as a whole are consistent with achieving national objectives.*
- *Improve the environmental effectiveness of the energy and CO_2 taxation regime by addressing the tax structure (including exemptions and reductions) rather than focusing on the top rate of tax.*
- *Address the need for emissions reductions from industry, either through changes in tax structure or effective use of emissions trading.*
- *Streamline, when appropriate, climate mitigation policies, including CO_2 taxes, to ensure they are complementary to the trading scheme, and ensure expenditure on climate policies is justified on the basis of cost-effectiveness of the expected CO_2 savings.*
- *Identify ways to manage Sweden's substantial forestry assets in a way that best meets environmental goals, recognising their major potential both as sinks for GHG and as a renewable fuel source.*

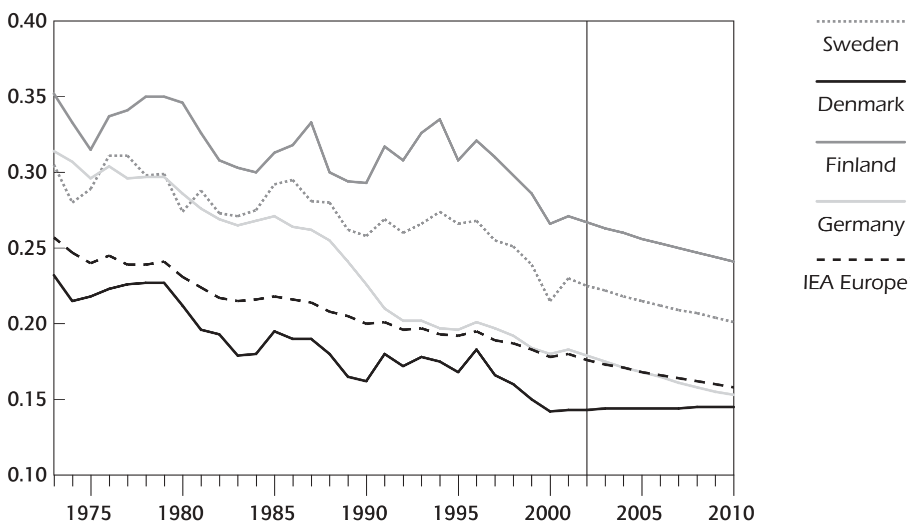
ENERGY INTENSITY AND ENERGY EFFICIENCY

In 2002, Swedish aggregate energy intensity, as measured by a ratio of the country's TPES in tonnes of oil equivalent (toe) over its national GDP (in thousands of 1995 US$ PPP), was 0.23 toe per US$ 1 000. This was 32% higher than the average for IEA European countries. In 2002, Sweden's TFC/GDP was 0.15 toe per US$ 1 000, or 31% higher than the IEA European average, and its TPES per capita was 5.7, or 54% higher then the IEA European average. At the same time, Swedish energy intensity figures are comparable to or even better than those of other countries with similar climate and industrial structure. For example, Swedish TPES per GDP is 9% less than the average of the figures for Norway, Finland and Canada. Its TFC/GDP is 19% below the average of those three countries and its TPES per capita is 16% below. Figure 5 shows how Sweden compares in these national intensity measures to the overall IEA Europe average as well as to its neighbours, Denmark and Finland.

Figure 5

Energy Intensity in Sweden and in Other Selected IEA Countries, 1973 to 2010

(toe per thousand US$ at 1995 prices and purchasing power parities)



* excluding Norway from 2002 to 2010.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2003; *National Accounts of OECD Countries*, OECD Paris, 2003; and country submissions.

Sweden's aggregate energy intensity figures have improved in line with the rest of the IEA. From 1990 to 2002, Swedish TPES/GDP decreased by 12% compared to an IEA average of 9% and an IEA Europe average of 10%. The average decrease in TPES/GDP for Norway, Finland and Canada was also 11%.

Sweden's TFC has stayed almost constant from 1973 to 2002, falling by just 1.1% over that time. This is in contrast to other countries such as Finland which have seen their TFC rise by as much as 30% over the same time. While part of this is due to general decreases in energy intensity, as noted above, it also has to do with the change in the Swedish energy supply structure over that time. In general, on-site oil used was replaced with electricity. From 1973 to 2002, electricity TFC rose by 90%, while oil TFC fell by nearly 50%. Electricity when used on-site is nearly 100% efficient while oil is generally not. Owing to this difference in efficiencies, less electricity was needed to get the same amount of useful energy than oil. This structural change also increases TPES since energy losses in thermal plants (either oil-fired or nuclear) have to be taken into account. Another factor limiting Swedish TFC growth has been the rate of economic growth compared to other countries. From 1973 to 2002, Sweden's GDP (measured on a PPP basis) grew by 76% while neighbouring Finland and Norway grew by 105% and 169% respectively, and the IEA as a whole grew by 111%.

While such aggregate intensity measures are useful, they can at times paint a somewhat distorted picture of the true efficiency levels of a country's economy and society. Sweden has two characteristics that substantially increase its energy usage. The first is the country's cold climate. Sweden has more heating degree days (weighted by population) than any other IEA country except Finland and Canada. The second factor is the large number of energy-intensive industries. The basic metals, pulp and paper, chemicals and non-metallic minerals industries play a large role in Sweden's economy. In recent years, structural shifts in the economy have lessened the effect such energy-intensive industries have on national energy intensity, but they remain an important component of the economy and act to raise Sweden's energy intensity figures.

Data on Swedish space heating demonstrate how it can achieve admirable energy efficiency despite a high energy intensity resulting from the cold climate. Without adjusting for climate, space heating energy use per unit of floor space in Sweden is almost 5% below the average space heating in a selection of IEA countries[7]. If one makes an effort to adjust for climate, Swedish space heating use is more than 22% below the average in those other countries, the second-lowest behind Japan.

7. Canada, Denmark, France, Japan, Norway, Sweden, UK and US. Space heating efficiency measured as the amount of energy used per square metre of heated space.

In the pulp and paper industry, Sweden's energy efficiency is comparable to other countries. In 1999, Swedish companies consumed 51.6 MJ of energy per 1995 US$ of value-added product. This falls within the range of values from other countries with large pulp and paper industries: (72.0 MJ per US$), Norway (54.1 MJ per US$) and Finland (41.7 MJ per US$).

In the short term, industrial energy demand is mostly affected by the development of the production volume. In the long run, however, energy demand also depends on factors such as the development of energy prices and taxes, energy efficiency, technical development and structural change.

Between 1983 and 2002, industrial energy consumption grew by 0.8% per annum on average. The recession in the beginning of the 1990s was followed by a period of high economic growth resulting in an average growth in industrial energy consumption of 1.7% between 1993 and 2000, before falling in 2001 owing to the economic slow-down. At the same time, energy intensity as measured as the ratio between energy consumption and value added in industry, has decreased by 2.4% per annum between 1983 and 2000.

The most important energy consumers in industry are the pulp and paper, iron and steel, and the engineering sectors. In 2000, pulp and paper used 50% of the total industrial energy consumption, iron and steel used 13% and metal products and equipment goods made up 7% of total industrial energy consumption. Energy consumption in pulp and paper consists mainly of bio-fuels (60%) and electricity (30%). In the iron and steel industry, the primary energy sources are coal and coke (55%, blast- and coke-oven gas included) and electricity (25%). The engineering industry is not regarded as energy-intensive, although it does use a considerable quantity of energy in absolute terms owing to its high output volume. The most important energy carrier is electricity.

DISTRICT HEATING AND COMBINED HEAT AND POWER

Combined heat and power (CHP) technology is widely used in Sweden. In 2002, there was 2 462 MW of CHP capacity for district heating purposes and 957 MW of capacity for industrial purposes.

In 2002, district heating met 47% of Sweden's space heating requirements. It supplied approximately 75% of the heating needs for apartments, 50% of the heating needs of commercial establishments and 8.5% of the heating needs of detached homes. District heating networks are present in every Swedish community with more than 10 000 residents. The country has approximately 12 000 km of district heating pipelines.

The fuel mix used for district heating has changed considerably over the last 20 years. In 1980, oil products accounted for over 90% of the fuel input for district heating and CHP plants. Currently, the fuel mix is considerably more varied. In 2001, biofuels accounted for 50% of the fuel input, surplus heat 17%, fossil fuels 15%, electricity 7% and other fuels 12%. The switch away from oil use to biomass use has been prompted largely by the tax system that favoured biofuels.

INDUSTRY STRUCTURE, PRICING AND REGULATION

Until the early 1980s most district heating systems were operated directly by local municipalities. During the 1980s and 1990s, however, most systems have been restructured as limited liability companies owned by the local authorities. Currently, there are about 220 companies supplying heat in Sweden, although many of these have common owners. Sixty-seven per cent of these district heating systems are owned by local authorities through limited liability companies, 8% are owned and operated directly by the local authorities, 6% are owned by the Swedish government (through Vattenfall) and 20% are privately owned (primarily through Fortum and Sydkraft).

In 2001, the average price paid by consumers of district heating was slightly above SKr 0.4 per kWh (VAT included). However, the range of district heating prices varied widely by locality with customers attached to the highest price systems paying twice as much as customers attached to the lowest price systems. These differences result from the following factors:

- Geographical differences, including heating load density and difficulties in installing and maintaining the distribution networks.
- Degree of amortisation of the equipment.
- Company ownership structure, with public companies less likely to seek high profits than private companies.
- System size and resulting economies of scale.
- Efficiency of operations.

In 1996, when the electricity market was deregulated, the district heating companies were also deregulated as a way of ensuring competition neutrality between district heating and electric heating. As a result of this liberalisation, district heating companies are free to charge customers any tariffs they wish. In the spring of 2003, the government launched a commission of inquiry to determine whether the current system offered customers adequate levels of protection in what amounted to provision of a *de facto* monopoly service. The commission will report in the autumn of 2004 on the following matters:

- Measures to better protect consumers against unreasonable district heating prices.
- Feasibility of introducing third-party access (TPA) to district heating networks.
- Advantages and disadvantages of regulations separating a company's district heating business from its electricity business.

GOVERNMENT TREATMENT OF DISTRICT HEATING

The energy policy programme of 1997 included several measures to support CHP technology. In particular, the programme introduced grants for investment in district heating systems. While few companies took advantage of this opportunity in its first few years, it gained in popularity in the years prior to its termination at the end of 2002. In the two years ending 31 December 2002, 223 MW of new CHP capacity was installed (198 MW for district heating and 25 MW for industrial purposes), all of which took advantage of the government grants.

A change in the tax policy effective on 1 January 2004 is also intended to encourage CHP use. Previously, tax on heat production was subject to 100% of the CO_2 tax and 50% of the electricity tax. As of 2004, all fuel used for CHP regardless of the final product (*i.e.* heat or electricity) will be subject to 21% of the CO_2 tax and none of the energy tax. The government hopes this tax change will encourage production in the existing CHP plants and investments in new plants.

DISTRICT COOLING

District cooling has made strong advances in Sweden since being introduced in 1992. As of 2001, there were over 500 sites using district cooling systems, consuming a total of approximately 425 GWh of cooling. At the start of 2002, 26 companies offered district cooling, some operating more than one system. Sweden currently has over 118 km of distribution lines for district cooling.

GOVERNMENT ENERGY EFFICIENCY POLICIES

The 2002 bill entitled "Co-operation for a secure, efficient and environment-friendly energy supply" (2001/02:143) set out many of the government's energy efficiency programmes. Through this bill, a total of SKr 1 billion is allocated to energy efficiency for the period 2003 to 2007. SKr 540 million will go to local and regional initiatives, SKr 325 million will be spent for technology procurement and SKr 135 million will be spent on information, training and testing.

INDUSTRIAL SECTOR ENERGY EFFICIENCY PROGRAMMES

Industrial energy efficiency programmes are based on the support of research, development, technology procurement and activities stimulating the introduction of new technology and spreading of knowledge, such as demonstration and information.

One major aspect of the government's push to increase industrial energy efficiency is a national programme to this effect. The principles for this programme have been outlined in a Swedish Commission report (Ds 2003:51) but the detailed design of the programme is still under consideration. The objective of this work is to design a system for voluntary agreements that could be implemented as a complement to other policy instruments (mainly taxes and emissions trading).

The Swedish government is aiming at starting a programme for energy efficiency on 1 July 2004. The primary goal of the programme is to promote an efficient and environmentally sound use of energy. Companies engaging in the programme will be exempted from a new tax on electricity that is proposed to enter into force on 1 July 2004. Companies that participate in the programme are committed to implement an Energy Management System and will conduct an energy analysis, which considers the whole of the companies' energy consumption in a system perspective. Companies will also have to implement energy efficiency measures that have a pay-off period up to three years. While energy audits are mandatory for participating companies, the latter will not be obliged to meet any fixed quantitative targets on reduced energy use or greater efficiency.

In addition to this programme, the Technology Procurement Programme aims to improve the energy efficiency of products by using companies' competitive abilities to make better products. The government canvasses potential buyers of selected technologies to determine their criteria for the products regarding performance, energy efficiency and price. Suppliers can then choose to compete to manufacture these products if they can meet the criteria established by the potential buyers. If one or more suppliers can meet these criteria, they proceed with manufacture in the knowledge that buyers are prepared to purchase their output. One new technology procurement project with industrial application, automation of sawmill plants, has recently been launched. Dissemination of information to promote a wider uptake of products from the Technology Procurement Programme was undertaken from 1999 to 2002.

TRANSPORT SECTOR ENERGY EFFICIENCY POLICIES

In 1998, the Swedish parliament adopted the Governmental Bill "Swedish Transport Policy for Sustainable Development", which includes objectives, principles and guidelines for the national transport policy. The overall objective of the national transport policy is to ensure socially, economically efficient and long-term sustainable transport resources for the public and industry throughout Sweden. The environmental objectives of the transport policy include reduction of air pollution, CO_2 emissions and noise. The intermediate objective for emissions of CO_2 from the transport sector is a stabilisation of emissions at 1990 levels by the year 2010.

The use of economic instruments is emphasised in the transport policy. The socio-economic marginal costs attributed to transport (*e.g.* wear and tear of transport infrastructure, accidents, air pollution) are covered by variable taxes and charges.

Late in 2001, the Riksdag adopted the government's Infrastructure Policy Bill. The bill provides an overall framework for investments in the transport infrastructure during the period 2004–2015. The government proposes that over the 2004 to 2015 time frame, SKr 363 billion be spent in the following way:

- SKr 150 billion is to be set aside for maintaining and conserving the existing road and railway system.
- SKr 169 billion is to be used to develop and modernise the transport system. SKr 100 billion of these funds is to be used for railways and SKr 69 billion for roads.
- SKr 45 billion to be spent on other transport-related capital expenditures.

Sweden levies annual vehicle tax, user charges, energy tax and CO_2 tax. The annual vehicle tax is differentiated according to vehicle weight and fuel. New electric cars and electric hybrid vehicles are exempted from the annual vehicle tax for five years. Only heavy goods vehicles are charged user fees on the Eurovignette road network. The Eurovignette[8] charge is differentiated according to the environmental performance of the vehicles.

As of the year 2000, the taxation of company cars has been adjusted in order to facilitate the introduction of more environmentally compatible cars on the market. During a limited time period, the annual preferential value, which in turn is the basis for the income tax paid by the user, will be adjusted. For electric and electric hybrid vehicles, the value is reduced by 40% compared to a comparable conventional car. For cars running on alcohol the reduction is 20%.

Rail transport is excluded from all energy taxation. Instead, a user fee system is applied. Parliament reduced this fee in 1998 in order to increase the relative competitiveness of rail transports. No energy taxes are levied on fuels used for

8. The Eurovignette is a fixed annual charge for heavy vehicles calculated in accordance with the damage caused to the environment and road infrastructure, necessary for using the roads in EU countries that do not levy tolls on motorways.

marine or aviation transport although there is a maritime fairway charge associated with sulphur emissions.

Sweden has no energy efficiency targets for vehicles other than the general agreement between the European Commission and the European car industry. However, several government agencies are actively disseminating information on vehicle energy efficiency. The Swedish Consumer Agency and the Swedish National Road Administration provide consumer information concerning the energy consumption of vehicles. The Swedish National Road Administration and the Swedish National Energy Administration co-operate with driving teachers' associations in order to speed up the learning of more energy-efficient driving behaviour – EcoDriving.

Information campaigns are also undertaken to stimulate companies to greater efficiency in their logistics and transport planning. The Swedish National Road Administration runs a project on quality assurance of transport services from an environment and transport safety perspective. In 2002 this project included co-operation and agreements with 18 county administrations, 117 municipalities and 74 companies.

A new authority has been created, Rikstrafiken, in order to promote the long-distance public transport system. The authority will support public transport and stimulate a better and more widely used public transport system.

RESIDENTIAL/COMMERCIAL SECTOR ENERGY EFFICIENCY POLICIES

Swedish building regulations focus on building performance that meets minimum energy efficiency standards. Implementation of the EU Directive on Building Performance is currently under way. The National Energy Agency has also participated in the European programme "Green Light" on energy-efficient lighting. Both the National Energy Agency and the Swedish Research Council for Environment (FORMAS) play active roles in several IEA tasks on energy efficiency.

Energy efficiency programmes are based on the support of research, development, technology procurement and activities stimulating the introduction of new technology and spreading of knowledge, such as demonstration and information. The Technology Procurement Programme aims to improve the energy efficiency of products by using companies' competitive abilities to make better products. This process, described also above under Industrial Sector Energy Efficiency, brings together the requirements of potential buyers prepared to place an order if specified conditions are met. Suppliers then voluntarily choose to compete on the basis of performance, design and price. This programme has resulted in the introduction of more than 25 new technologies targeting the residential/commercial sector during the last 12 years. Recent technology procurements since the last Swedish in-depth IEA report include resource efficient tap-water mixers, building automation systems, integrated systems for solar screening and linking of daylight, ventilation filters and energy-efficient stoves.

Sweden participates in a Nordic labelling scheme on windows and a labelling scheme on ventilation and fan systems. Work on high-quality indoor environment-friendly and energy-efficient ventilation has also taken place.

Research on energy efficiency in the building sector is supported both by the National Energy Agency and by FORMAS. FORMAS supports scientifically significant research related to sustainable development in the building sector. FORMAS is in this effort supporting research, development and experiments, for instance aiming at solar cells in buildings.

Two separate purchasers networks promote energy efficiency measures and the installation of high-performance products. In addition to a network representing a majority of residential real estate owners, a new commercial real estate owners network has recently been established. These networks serve as platforms for the development of new energy-efficient technologies, dissemination of information and demonstration projects. Another network supporting energy efficiency is the Building, Living and Real Estate Administration for the Future. Members of the administration, including real estate owners and administrators, building contractors and government agencies, have agreed to join efforts towards sustainable development within the building sector.

CRITIQUE

While Swedish energy intensity is high compared to other IEA countries, this is mostly explained by the country's cold climate and energy-intensive industry. Swedish energy intensity is comparable to other countries with similar circumstances and it compares well on more specific energy efficiency parameters. National energy intensity has been decreasing steadily, at about the same rate as OECD Europe as a whole.

Further improvements in energy efficiency still offer a promising means of meeting energy goals, including reduced GHG emissions, energy security and international economic competitiveness. However, demand-side activity in Sweden has traditionally received less attention than the supply side. For example, after the construction of the nuclear plants, government programmes encouraged greater electricity use amongst customers, particularly by switching from oil to electric heating. In addition, there are no energy efficiency targets on the national level or for particular industries, as found in some other countries. While such targets can be difficult to measure on a national scale, they can also help motivate government and industry.

The transport sector represents an area where energy efficiency gains could have important benefits. Controlling transport energy efficiency poses special problems for government since energy users in the sector are so diffuse, compared, for example, with industry where there are considerably fewer energy users. Sweden's primary tool to reduce transport demand has been taxation, which can be and has been effective. The coming investment programme in transport infrastructure offers an excellent opportunity to undertake projects that lower energy use in the sector. Sweden's goal of keeping transport sector emissions at 1990 levels by 2010 is admirable. However, emissions have already risen approximately by 9% from 1990 to 2000, so the country will have to undertake more aggressive energy efficiency activity to meet this goal.

More clearly defined targets throughout Sweden's energy efficiency policies could help improve the efficacy of the government programmes. The complexity involved with measuring energy intensity and energy efficiency makes the use of parameters to measure progress especially important. As mentioned above, there is no target for improvements in national energy efficiency. In addition, the programme for energy efficiency that is under consideration within the Swedish government includes no fixed quantitative efficiency improvement targets for the companies to meet, even though participation in the programme exempts the companies from electricity tax. So long as there are tangible benefits such as exemption of electricity tax in participating in the agreement, some quantitative benchmarks would merit consideration even though the *scope for improvement varies substantially by company and by sector*. In doing so, the relation between the long-term agreements (LTAs) and other energy efficiency policies, such as the forthcoming European emissions trading scheme and domestic measures, needs to be carefully clarified. It is important to avoid duplication or overlap of measures and over-reliance on LTAs with no firm quantitative targets while abandoning other efforts.

Combined heat and power technology, used primarily for district heating facilities, has been one means for Sweden to improve its energy efficiency. Changes in the ownership structure of district heating operations have not reduced its use or expansion although they have altered the profit motivation of certain companies. As municipally owned and operated facilities in the early 1980s, district heating facilities were not driven by profit-seeking. In addition, the companies were responsive to the concerns of the customers who were also voters. Therefore, the price setting was partly driven by political considerations. Transfer of operations to limited liability companies and, in certain cases, of ownership to private companies has to a certain extent removed this tendency.

While district heating does compete with other heating options such as electric heating and individual boilers, in many cases it is clearly the favoured economic option and thus not subject to direct competition from other technologies. This is especially true in dense urban areas with apartment complexes. Despite this *de facto* monopoly status in many areas, district heating is subject to no regulation and companies are free to set the prices and tariffs as they wish. While there have been no widespread complaints about excessive pricing, such a system will not produce operational efficiencies that can be brought to bear through either competition or regulation. The current Commission of Inquiry is examining whether the present pricing and regulatory system can be improved. The commission is looking at ways to use competitive forces in the district heating market such as introducing TPA to distribution networks and separating heating from electricity operations within companies to remove the threat of cross-subsidisation. However, this may be ineffective given the natural monopoly of the distribution network, the economies of scale in the heat supply systems and the entrenched incumbency of the heating companies. If competition cannot be introduced into district heating, the commission should suggest the implementation of some form of regulation to improve the operational efficiency of the systems and lower prices to consumers by extending regulatory authority of the Swedish National Energy Agency to district heating.

Individual metering may provide another area for improved efficiencies in the district heating system. In most cases, metering for district heating occurs at the building level where either the building owner pays or the residents pay a percentage of the total based on their share of the building area. In either case, individuals do not directly pay for their usage. This lowers the motivation to reduce heat demand, either through insulation or lowering the thermostat level. While such metering does represent an initial expenditure, it is worth considering whether the benefits in reduced demand would outweigh this cost over the medium term.

RECOMMENDATIONS

The government of Sweden should:

- *Make use of additional measures to encourage more efficient and rational energy use in the transport sector.*
- *Negotiate quantitative targets for companies participating in the long-term agreements, keeping in mind the forthcoming EU emissions trading scheme.*
- *Consider the benefits of extending regulation over the district heating sector.*
- *Examine the possibilities for developing heat metering in individual apartments.*

CURRENT AND HISTORICAL PRODUCTION

Renewable energy plays an important role in Sweden's energy mix In 2002, Sweden produced and consumed 14.4 Mtoe of renewable energy, representing 28.3% of the country's TPES. Renewables' contribution to TPES has risen gradually since the early 1990s. The average contribution of renewables from 1989 to 1991 was 24% of TPES while the average contribution from 1998 to 2002 was 30%. Much of this rise comes from increased biomass use owing to the introduction of taxation more favourable to biomass in the early 1990s.

Biomass and hydropower dominate renewable energy production in Sweden. In 2001, biomass accounted for 54% of all renewable production, hydropower accounted for 45% and solar and wind power accounted for 0.3%. Historical trends in renewable energy are shown in Figure 7.

GOVERNMENT POLICY AND SUPPORT MECHANISMS

Sweden has a target of increasing its annual electricity generation from renewable sources by 10 TWh from 2002 to 2010. Reaching this target will require a quadrupling of the rate of renewables development seen under the previous renewable support policy from 1997 to 2002. Half of the 10 TWh increase is expected to come from greater production at existing plants, and the other half from production at new plants.

As noted above, taxes have already played an important role in increasing biomass production over the past ten years and they will continue to do so in the future. More information on taxes can be found in Chapter 3, but Figure 8 shows the effect of taxation on the choice of different fuels. Without taxation, biomass is the least competitive against coal, fuel oil and gas oil, whereas with taxes included it becomes the most competitive.

The other main tool the government will use to reach its 10 TWh target is an electricity certificate quota obligation system. The law on electricity certificates was proposed in the 2002/03:40 bill and was decided by the parliament in April 2003. It has been in force since 1 May 2003.

Under the system, all Swedish electricity generators using eligible technology receive a certificate for each MWh of electricity produced. Eligible technologies are:

- Wind power.
- Solar power.

- Geothermal energy.
- Biofuels.
- Wave energy.
- Hydropower with capacity equal to or less than 1.5 MW.

Suppliers of electricity are required to obtain electricity certificates equivalent to a certain percentage of the total electricity they supply. This certificate quota obligation began at 7.3% of total electricity supplied in 2003 and will increase to a level of 16.9% in 2010 according to a pre-arranged schedule as shown in Table 6. The government estimates that Sweden currently has generation from eligible plants approximately equal to the quota requirement for the first year, or 7.3% of total generation. About 90% of the certificates in the first year will come from biomass plants.

Table 6

Certificate Quota Obligation, as % of Total Electricity Supplied

Year	*Certificate quota obligation*
2003	7.3%
2004	8.1%
2005	10.4%
2006	12.6%
2007	14.1%
2008	15.3%
2009	16.0%
2010	16.9%

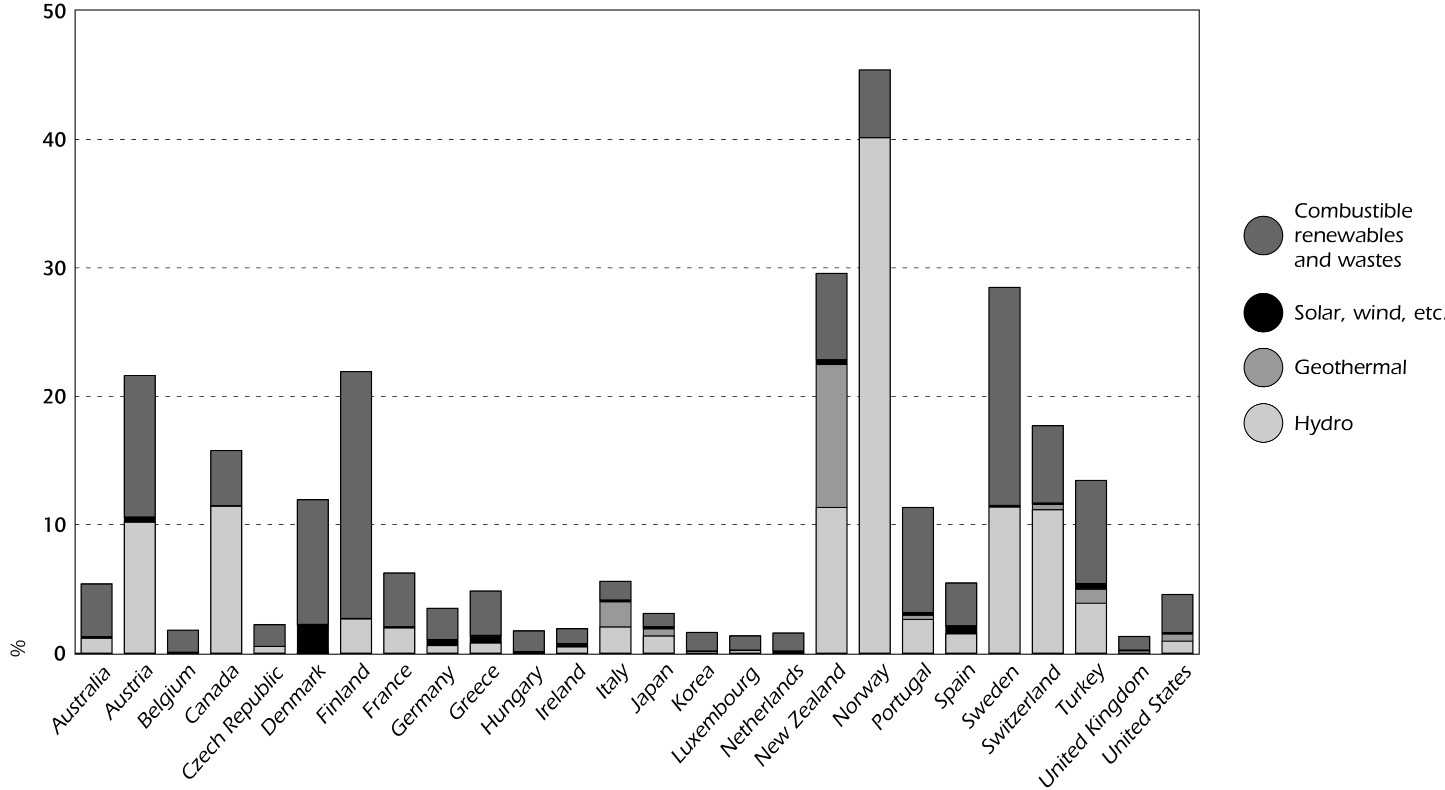
Source: Swedish Energy Agency.

Suppliers may obtain the needed certificates through generation from their own eligible plants, or they can purchase certificates from other companies which generate electricity using eligible technologies. Suppliers need not contract with renewable generators for the purchase of the electricity itself, only the certificates. In this way, they are free to purchase all their electricity from a non-renewable generator as long as they acquire sufficient certificates from other companies using eligible technologies. Suppliers can pass the cost of certificates on to their customers, although they are required to list it as a separate explicit component of the bill.

The government will set the terms and regulatory framework for trading in electricity certificates. It expects, and will encourage when possible, the development of financial instruments linked to electricity certificates such as

Figure 6

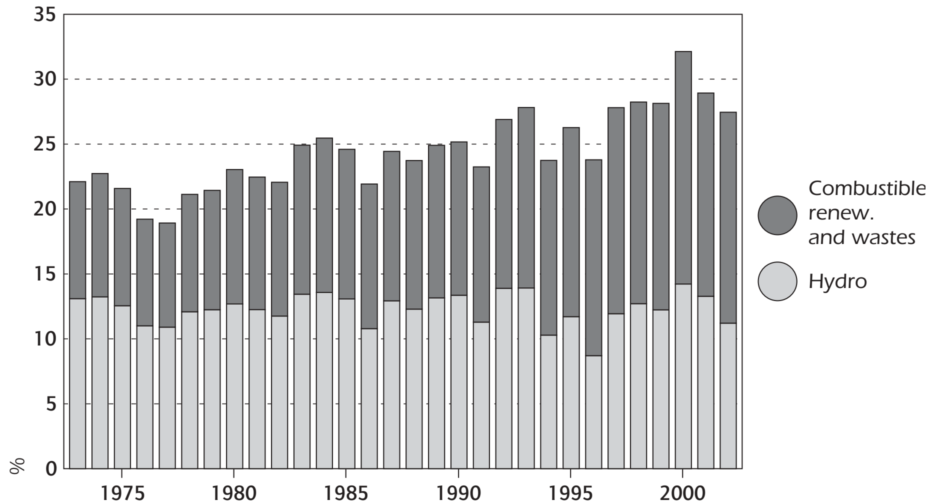
Renewable Energy Contributions to Total Primary Energy Supply in IEA Countries, 2002



Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2003.

Figure 7

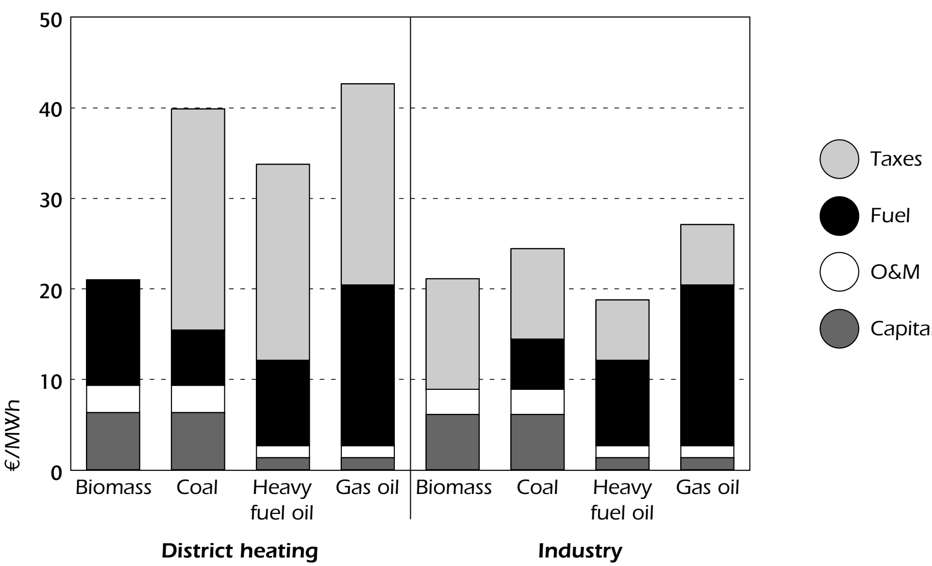
Renewable Energy Contributions to Swedish Total Primary Energy Supply, 1973 to 2002



Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2003.

Figure 8

Cost of Heat Production for Different Technologies



Source: Swedish National Energy Administration, 2000.

futures and derivatives. Large customers who deal directly with generators and not with intermediate suppliers are required to obtain certificates relating to their electricity consumption. A study is currently under way to examine if and how energy-intensive industries will be included in the certificate scheme. Currently, all electricity consumed in manufacturing processes is exempt from the quota obligation with the following sectors benefiting from this exemption:

- Mining.
- Wood products.
- Pulp and paper.
- Chemicals.
- Basic metals.
- Non-metallic mineral products.

During the first five months of the system (*i.e.* from May 2003 through September 2003) the cost of obtaining the certificates being passed on from suppliers to customers has ranged from 1.3 to 2.5 öre/kWh. For an average residential customer with yearly consumption of 2 000 kWh, the annual additional cost relating to certificates at such prices would be SKr 3 to SKr 6, including VAT charges[9]. Certificate prices and resulting costs to consumers are expected to rise as the quota obligation increases over the years.

The government has established both a floor and a ceiling on the price of the certificates. For the floor, electricity certificates issued to eligible generators that have not been sold can be redeemed to the government for a set price. This redemption price is set at SKr 60 per certificate in 2003 and declines according to a pre-arranged schedule as shown in Table 7.

Table 7

Guaranteed Price for Electricity Certificates

Year	*Guaranteed price*
2003	60
2004	50
2005	40
2006	30
2007	20
2008 +	0

9. Charge to customer dependent on certificate price, annual consumption and supplier quota obligation percentage which will rise over time.

The ceiling on the price of the certificate comes in the form of a non-compliance penalty for suppliers who do not acquire sufficient certificates to meet their quota. Prices for certificates cannot rise above the non-compliance penalty. If they did, suppliers would no longer buy them and just face the penalty when they fail to meet their quota. The penalty for 2003 is equal to SKr 175 for each certificate not provided by a supplier. However, since the costs of the certificates are deductible for income tax purposes, while the non-compliance penalties are not, the SKr 175 penalty is equivalent to a certificate price of approximately SKr 243[10]. In 2004, the non-compliance penalty will rise to SKr 240 (equivalent to a certificate price of SKr 333 when income tax effects are considered). In 2005, the non-compliance penalty will be set equal to 150% of the average price paid for the certificates throughout the previous 12 months. The government is currently examining whether to change the non-compliance penalty calculations for 2005 and beyond.

While the current system is a domestic one, where only certificates issued in Sweden can be used to achieve the target, Sweden is considering if and how to trade renewable certificates in an international context. The Renewable Energy Certificate System (RECS) is an international voluntary system for trading in electricity certificates. It was started in 1999 as a collaboration between the Netherlands, Denmark and the UK. Along with several other European countries, Sweden has been trading RECS certificates on a trial basis. The electricity transmission system operator (TSO), Svenska Kraftnät, issues the certificates within Sweden and monitors the eligible plants. As more experience is gained with the domestic certificate system, Sweden may explore ways to expand into international trading.

In addition to the certificate system, Sweden will continue to offer subsidies for selected renewable energy technologies. For wind power, the environmental bonus subsidy will continue until 2009 according to the schedule in Table 8.

Table 8

Subsidies for Wind Power Plants

Year	*Land-based (SKr/MWh)*	*Offshore (SKr/MWh)*
2004	120	170
2005	90	160
2006	65	150
2007	40	140
2008	20	130
2009	0	120

10. The corporate income tax rate is 28% so the payment of a SKr 175 penalty has the same net effect as 175 / (1 – 28%) = 243.

The government hopes this subsidy and the effect of the certificate system can help the country reach its non-binding target of adding 10 TWh of wind power by 2015. Sweden is also supporting solar heating with a subsidy running from 1 June 2003 to the end of 2005.

BIOFUELS FOR TRANSPORT

In July 2003, the government appointed a commission to study the promotion of biofuels in Sweden. Its final report, due 31 December 2004, will address the following issues:

- Propose national objectives and strategies for the future introduction of renewable motor fuels.
- Investigate the possibility of having all gas stations supply at least one renewable fuel by 2005.
- Analyse the possibility of introducing a fuel certificate system.

Sweden already has a strong biomass and bioenergy programme, including participation in IEA research networks on bioenergy, alternative fuels and electric and hybrid vehicles. There has been an increase in ethanol in the last years. A 5% admixture of ethanol in unleaded petrol (95 octane) has been sold at the gas stations in the Stockholm surroundings for a couple of years. This is now spread out in other parts of Sweden at the Statoil and OK-Q8 gas stations. Approved pilot projects amount to 220 000 m^3 of ethanol. Most of the ethanol used is made at the agroethanol plant in Norrköping. Tax incentives and R&D subsidies are provided for the development of liquid biofuels for transport with Sweden currently producing around 44 million litres of fuel ethanol[11] per annum. The ethanol is blended with petrol at rates of 10%, 85% and 95%. Whereas taxation on automotive fuels is about 55 euro cents/litre for gasoline, fuel ethanol is currently tax exempt in accordance with the European so-called Mineral Oil Directive, and blends are taxed at rates commensurate with their percentage shares of ethanol. The tax regime will be modified following the implementation of the EU taxation of energy products directive.

CRITIQUE

Sweden's natural resources support contributions from mainly two forms of renewable energy: hydropower and biomass. Like all renewables, these energy sources contribute to energy diversity and reduced GHG emissions.

11. As a rough approximation, this is about 1% by volume of the total automotive fuels consumed in Sweden.

Hydropower was developed over the years as the least-cost supply option for electricity generation and will continue to be a crucial component of Sweden's energy mix although environmental concerns will prohibit any substantial expansion of hydropower capacity.

Biomass also developed as the least-cost option in many cases, particularly in conjunction with the pulp and paper industry. In the 1990s, however, biomass started to receive government support in the form of a favourable tax treatment. Largely as a result, its share of national TPES rose from 11.8% in 1990 to approximately 16.3% in 2002. Government policies will become increasingly favourable towards biomass as the "green tax shift" continues and the newly introduced certificate system provides another revenue source for biomass-fired electricity generation.

While expanded biomass production can help Sweden lower its GHG emissions, there may be limits to the amount of biomass use in Sweden. Current policies already make it more economical in most cases to burn biomass than to burn fossil fuels, so added supports may have limited impact. At the same time, other industries such as the wood products and the pulp and paper industries compete for the use of timber and wood. Demand for energy-related biomass will likely drive up the price for wood and timber and could adversely affect these other industries.

The electricity certificate system introduced in May 2003 has a strong market component that will be effective in promoting the least-cost renewable energy solution among the eligible plants. It will also foster competition between plants of the same and different technologies, which will promote efficiencies and lower costs and prices to consumers. This approach is more compatible with a liberalised electricity market. On the other hand, this system is relatively new and its real effectiveness still remains to be seen. Noting that such certificate trading schemes have been introduced in other countries, Sweden could certainly benefit from studying and learning from those programmes and exchanging experiences with such countries.

The decision to exempt energy-intensive industries from the certificate system on the grounds of international competition is understandable. Including Swedish companies in the system while other countries offer exemptions to their industry could harm the Swedish economy. Nevertheless, industry is a big driver in energy consumption and by exempting it from the certificate requirements, the country misses a big opportunity to promote renewable energy technologies. The most practical avenue is to engage on the international level – at the EU and other venues – as discussed below.

The effectiveness of the quota obligation system will depend on the firmness of the targets, including the level of obligation and the penalties for non-compliance. The level of penalty needs to be high enough to induce the achievement of the target. If the level of penalty is lower than the price needed to achieve the certificate quota, the quota will simply not be met since suppliers will choose to pay the non-compliance penalty rather than purchase the high-price quotas.

While the fixed level of penalty is set at SKr 175 in 2003 and SKr 243 in 2004, these absolute price ceilings are to be abandoned from 2005 when the penalty will be set at 150% of the average price of the certificates over the previous 12 months. In principle this does not in fact establish a ceiling and, depending on the difficulty of achieving the certificate quota, the level of penalty (*i.e.* the ceiling price) may soar and consumers will have to pay substantial portions of their bills to support renewable energy technologies. This could induce pressures on politicians to cap the certificate prices, thus impeding the certificate market and placing the entire system in danger. The certificate prices are the clear signals of the costs for achieving renewable targets and they should not be capped at artificially low levels. If the certificate price reaches "politically unacceptable" levels, the realism and the costs of the 16.9% target level in 2010 should be reconsidered rather than simply capping prices. Such high certificate prices would also indicate that other means could be found to achieve the same emissions reduction, notably energy efficiency.

One possibility is to address this issue on the international level. To the extent that international certificate trading emerges under the RECS or other programmes, Sweden should explore the possibilities it offers for achieving renewables targets at the lowest possible costs. So long as the target set in the EU directives is the share of consumption instead of production, such an international approach could be feasible and would most likely lead to lower compliance costs to the Swedish public. Such an international approach would also create a level playing field within the EU through greater policy harmonisation. Some progress on harmonisation has already been made in the field of energy taxation in the EU.

Such an international approach to certificate trading may not, however, result in the expansion of domestic production of renewable energy and promotion of domestic renewable industry. For example, in the case of the Netherlands, certificate trading resulted in a large inflow of green electricity from neighbouring countries and a large outflow of taxpayers' money. Therefore, before moving to an international certificate trading system, the objectives of the renewable energy policy need to be clarified. If the primary objectives are the promotion of domestic production of renewable energy rather than the reduction of global GHG emissions, then international certificate trading may not be an optimal solution even though a domestic trading system could result in higher cost to the economy.

Ninety per cent of the certificates have thus far come from biomass, and the economics, supported by favourable taxation, indicate biomass will make up a majority of the electricity produced under the certificates programme.

In other words, investors will choose biomass since it is the cheapest. While this is desirable in that the least-cost renewable option is being promoted, Sweden also aims to promote other renewable energy technologies, namely wind, and is doing so through a continuation of subsidies. Biomass and wind power bring many of the same advantages (*i.e.* emissions reduction and energy security) and the benefits of supporting wind which is, at least at present, more expensive have not been made explicit. Sweden's experience and capability with biomass have been established and it suits the country's natural resources. Sweden's wind resources are only average with the best sites along the coast where wind plants are difficult to site. Again, the choice of optimal policy rests on the benefits to be derived from renewables. If the primary objective of renewables policy is to achieve the targets set out in the EU directive which do not specify the types of renewable energy required, subsidies for wind power may not be cost-effective considering the relative economic advantages of competing renewable sources such as biomass. The government needs to pay careful attention to costs and benefits of all renewable support policies to the national economy.

With the forthcoming EU emissions trading scheme, Sweden will have four major policy tools for supporting renewable energy, including taxation, the certificate scheme and subsidies for wind power. A streamlining of these tools may make it clearer to understand and hence more effective while at the same time maintaining the goals of supporting renewable energy generation in general and advancing less mature renewable technologies in particular. Such efforts at simplifying the renewable support scheme could be beneficial in clarifying the targets and the costs for industry players and the public alike.

Energy demand in the transport sector continues to rise in both absolute terms and relative terms as a share of the country's TFC. While energy efficiency policies can and should be employed to curb this consumption, biofuels also offer a means of minimising the environmental implications of motor fuel use. The country's existing biofuels production capabilities and its natural resources make biofuels especially attractive to Sweden. Favourable tax treatment is currently the main tool to increase biofuels consumption, but this can only be effective up to a point and the other measures being reviewed by the commission on biofuels could effectively complement the tax schemes in increasing biofuel usage. As with all renewable support schemes, any biofuel measures should be structured to increase the efficiency of production and distribution of the fuel with the ultimate goal of making it competitive without government intervention.

Direct or indirect government support for renewables is sound policy since renewables carry positive externalities not captured by the market. Ultimately, however, the goal cannot be a renewable energy sector supported indefinitely by non-market support. All government schemes must seek to gradually reduce their support for the preferred technologies (*i.e.* renewables) with the goal of making them sustainably competitive with other energy sources within a framework that captures the externalities of energy production and use. Progress towards this end should be continuously monitored and assessed.

RECOMMENDATIONS

The government of Sweden should:

- *Share information and experiences with other countries introducing electricity certificate systems to support renewables.*
- *Monitor the cost-effectiveness of the electricity certificate system in achieving environmental and security of supply goals in comparison with measures to improve the efficiency in electricity consumption.*
- *Explore ways to move towards competitive renewable motor fuels.*
- *Assess progress towards a sustainably competitive renewable energy sector.*

COAL

In 2002, coal accounted for 5% of Sweden's TPES. This percentage share has stayed relatively stable from 1990 to 2002 over which time the average coal share of TPES was 5.6%. Sweden has no domestic coal production with all supply coming from imports.

Iron and steel producer SSAB, a privately owned Swedish company with facilities in Luleå and Oxelösund, is the major importer of metallurgical coal and the only producer of coke. Cementa is the dominating cement producer with foreign (German) ownership. LKAB mining (iron-ore products) is 100% government owned. Two major CHP plants located in Västerås and Stockholm use coal as a fuel. The plant in Västerås is owned by the municipality while the municipality and Fortum own the plant in Stockholm.

There are no policies governing the import of coal which is left to market players. Coal does face heavy taxation, especially in the form of CO_2 tax which continues to rise, although industrial companies enjoy tax exemptions with coal as they do with all other fuels.

PEAT

In 2002, peat accounted for 0.7% of Sweden's TPES. This percentage share has been stable from 1990 to 2002 over which time the average peat share of TPES was also 0.6%. The large majority of Swedish peat is produced domestically. In 2001, Sweden produced 2 500 000 m^3 of peat for energy use and another 1 400 000 m^3 for horticultural use. Net import of peat was 470 000 m^3. Peat is used primarily for domestic heating and power production.

Peat is regarded as a biofuel for tax purposes and, as such, it is exempted from CO_2 and energy taxes. A special official report on peat was published at the end of 2002 (SOU 2002:100). While this report classified peat neither as fossil fuel nor as biofuel, it did recommend that peat should continue to be treated as a biofuel when it comes to taxation and any future changes in means of control.

OIL

SUPPLY AND DEMAND

In 2002, oil accounted for 29% of Sweden's TPES. This percentage share has remained fairly constant from 1990 although it represents a much lower figure than seen in the 1970s. In 1973, oil and oil products represented 72% of Swedish TPES. After the oil crises of that time, the government made a concerted effort to decrease dependence on oil. This effort was largely successful and by 1983, oil's share of TPES had fallen to 43% before reaching its current level between 28% and 30% in the early 1990s.

In 2002, transport accounted for 60% of oil TFC, followed by industry (22%), residential (6%) and non-energy use (6%). Transport continues to increase its share of oil TFC, rising from 50% in 1996 and, over the long term, from 21% in 1973. At the same time, the share of oil use for home heating and, to a lesser extent, in industry has fallen. Oil use for power generation has also declined over the long term. In 1973, oil produced 19% of all Swedish electricity whereas by 1990, it had fallen to 0.8% and in 2001, was 1.7%.

INDUSTRY STRUCTURE

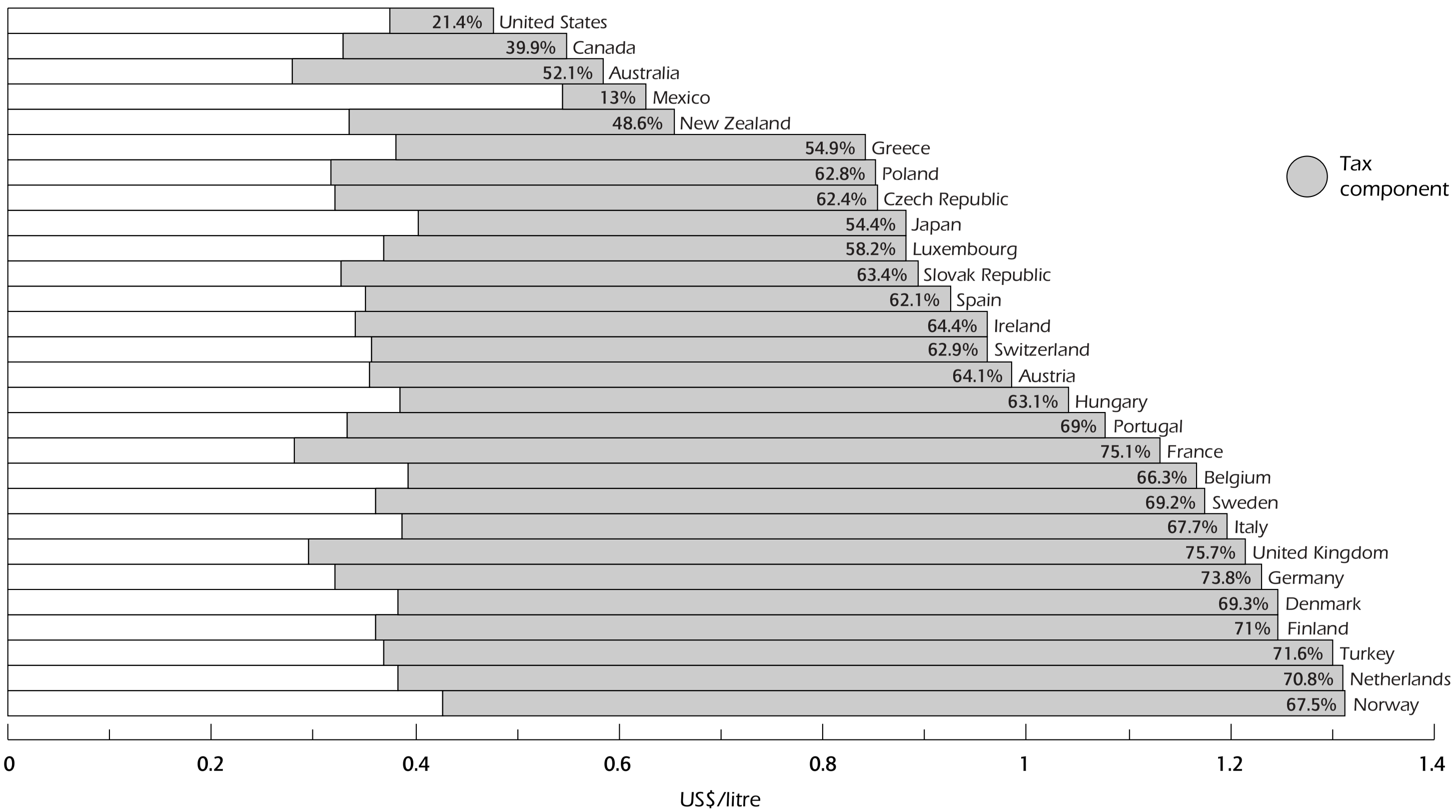
The Swedish oil markets have undergone significant structural changes during the last three decades. As mentioned above, part of this shift comes from consumer demands. In 1970, crude oil and oil products accounted for 77% of the total energy supply, compared to 28% by 2001. In 1970, most of the oil supply went to the residential and service sectors and today, the majority goes to the road transport sector. In the gasoline retail market, the number of marketing companies has been more than halved. Today six companies dominate the gasoline market, of which four companies, OK-Q8 (27%), Statoil (23%), Shell (13%) and Preem (11%) represent around 75% of the gasoline market. Two other companies, JET and Hydro each represent around 10%. The Swedish government has no ownership stakes in the oil sector.

Sweden has a significant capacity in oil refining with total output exceeding domestic demand. In 2002, total oil imports were 28 248 000 m^3, of which 21 359 000 m^3 was crude oil and the remainder oil products. The Swedish imports of crude oil in 2002 come from Norway (34 %), Russia (20%), Denmark (15%), Great Britain (13%), Iran (11%), Venezuela (5%) and others (2%). In the same year, Sweden exported 10 670 000 m^3 of oil products. There are four main large-scale refineries: Nynäs Refining AB, Preemraff, Scanraff and Shell Refining AB. There is no special regulation for the sector other than environmental legislation.

While there is no regulation on oil pricing, the general competition rules are applicable in the oil and oil products industry. On 29 April 2003, five petrol companies were found guilty by a Swedish court of operating as a cartel in the autumn of 1999. The Swedish Competition Authority, which brought the case to court, says the fines imposed on the companies were too low and it appears likely that this case will continue at the Swedish Market Court. Figures 9 and 10 below with prices of petrol and diesel fuel show Sweden to be in the mid-range among European countries. Figure 11 shows the historical development of prices.

Figure 9

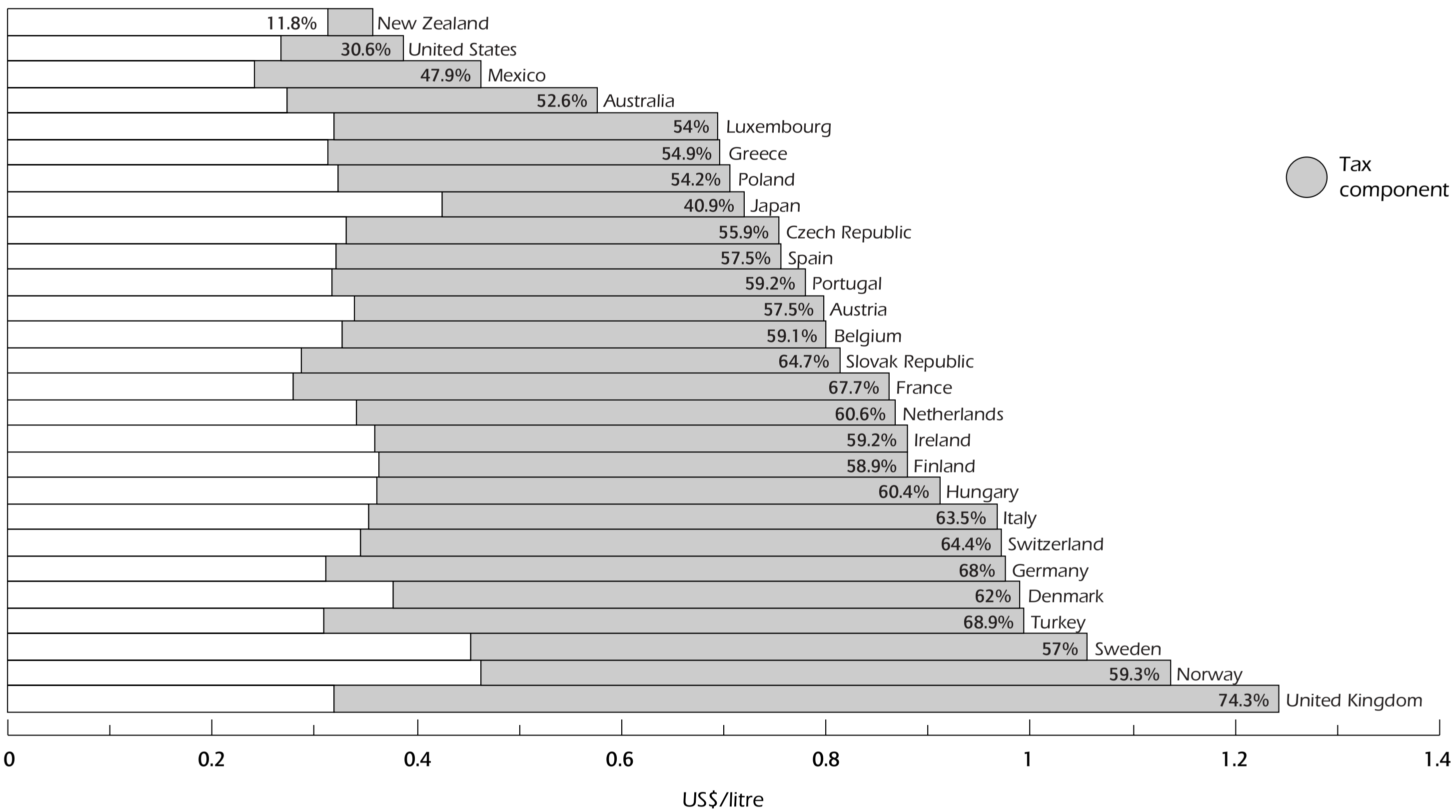
OECD Unleaded Gasoline Prices and Taxes, Third Quarter 2003



Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2003.

Figure 10

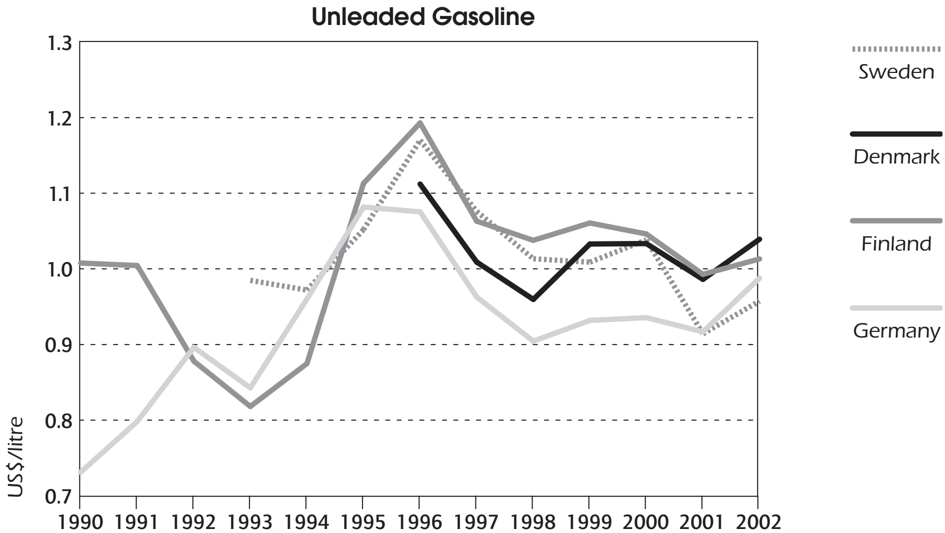
OECD Automotive Diesel Prices and Taxes, Third Quarter 2003

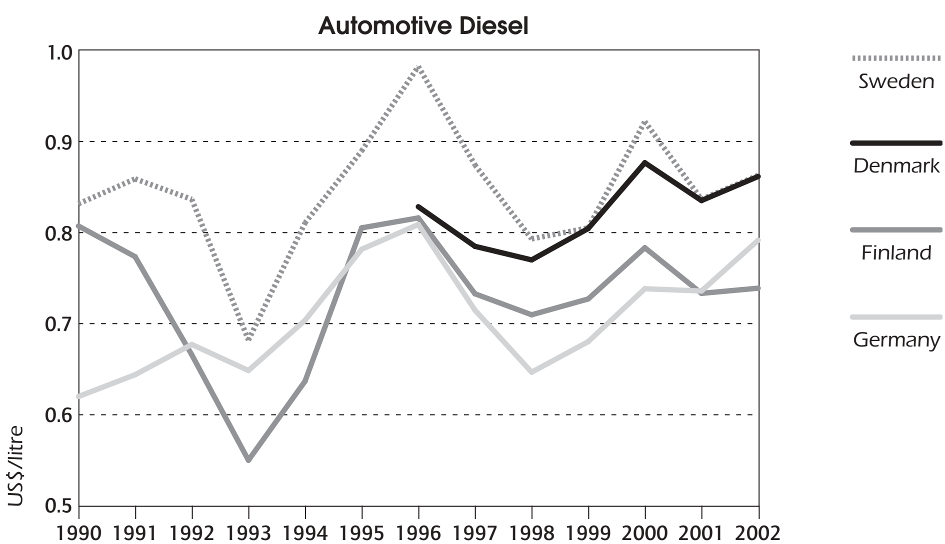


Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2003.

Figure 11

Motor Fuel Prices in Sweden and in Other Selected IEA Countries, 1990 to 2002





Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2003

Policy, Legal Authority and Emergency Organisation

Since its oil requirements are met entirely by imports, Sweden is especially vulnerable to oil supply disruptions. The government, therefore, gives high priority to maintaining well-prepared emergency response measures and has promoted oil substitution policies and energy conservation programmes. This has augmented oil security by considerably reducing the share of TPES coming from oil.

The Swedish Energy Agency has the main responsibility for emergency response. It prepares oil emergency measures to be decided by the government. The Ordinance with Instruction for the Swedish Energy Agency is the legal authority for establishing and operating the Swedish National Emergency Sharing Organisation (NESO) for IEA emergency response measures. The Department for Sustainable Energy Management of the Swedish Energy Agency is the core of Sweden's NESO. In an emergency, industry experts would participate in NESO activities. Currently, the Swedish Energy Agency is reviewing the organisation and function of NESO.

The legal framework for emergency response measures in Sweden consists of the following instruments:

- The Contingency Storage of Oil and Coal Act of 1984 with amendments and the Contingency Storage of Oil and Coal Ordinance of 1995 with amendments.
- The Oil Crisis Act of 1975.
- The Rationing Act of 1978.

Emergency Reserve

The Contingency Storage of Oil and Coal Act and Ordinance enable the government to create sufficient oil stocks in non-emergency periods to meet the IEA emergency reserve commitment. Stockholders are oil companies and large consumers such as manufacturing plants and heating stations. The stockholding obligation is 25% of the previous year's net imports or consumption. Although Sweden has no oil production, consumption and imports are quite different, since one-third of oil refining is exported.

The act provides the government with the legal power to draw down stocks under the relevant articles of the International Energy Program. Since there is no threshold in terms of depth or duration of a disruption in the Swedish legislation, use of emergency stocks is at the discretion of the stockholders. In 2003, as the oil companies and the Swedish Petroleum Institute have agreed a new plan for oil stockdraw, an agreement between the Swedish Energy

Agency, the Swedish Petroleum Institute and the oil companies is expected to be signed in due course.

Sweden has bilateral stockholding agreements with the governments of Denmark, Finland, Ireland and the United Kingdom and is in negotiations with the Netherlands.

Demand Restraint Measures

Demand restraint measures are carried out in accordance with the Rationing Act. The Swedish Energy Agency has the authority to implement a variety of demand restraint measures with government approval and without parliamentary ratification, except for rationing. Sweden regularly reviews and updates its implementation plans of demand restraint measures, including the Information and Saving Campaign programmes.

Sweden considers that demand restraint is an effective measure on an equal footing with stockdraw. Given the importance of stockdraw as an effective response in the early stage of a crisis, Sweden is reviewing the combined use of demand restraint and stockdraw, especially in situations not requiring the full range of measures defined in the International Energy Program.

NATURAL GAS

SUPPLY AND DEMAND

Natural gas accounts for only a small percentage of Swedish energy supply. In 2002, gas made up 1.5% of the country's TPES. Official Swedish government forecasts show gas's share of TPES falling to 1.4% by 2010. However, in areas where natural gas has been introduced, it has captured between 20% and 25% of the available market. Gas was first introduced to Sweden in 1985 and reached 1.4% of TPES by 1992 after which its share has remained constant. Industry accounts for 44% of Swedish gas consumption, followed by CHP and district heating (17%), residential, commercial and service sector (17%) and transportation (1%).

Sweden has no indigenous gas resources and imports all of its supply through Denmark. The import pipeline has an annual capacity of 2.0 billion cubic metres (bcm) although it is currently being used for only 0.98 bcm of transport. The interconnector capacity could be expanded to 2.9 billion cubic metres (bcm) without substantial cost through the introduction of additional compressors and other measures.

INDUSTRY STRUCTURE

Under current legislation, companies are required to keep separate accounts for all their transmission, distribution and retail/trading activities. The requirement under the new EU Gas Market Directive to impose legal separation is at present in the implementation process.

All natural gas in Sweden is imported from the Danish gas supply company, DONG. The dominating import company in Sweden is NOVA Naturgas AB, which is owned by Ruhrgas (30%), Statoil (30%), DONG (2 %) and Fortum (20 %). It imports 0.9 TWh of gas annually, or more than 90% of all Swedish imports.

There is only one pipeline transmitting natural gas into the Swedish gas grid and it is owned and operated by NOVA. It adjoins the Danish grid at Dragør just south of Copenhagen, crosses the Öresund between Denmark and Sweden and lands in Klagshamn at Malmö. Sydkraft (owned 55% by E.On and 45% by Statkraft) has recently applied to the Swedish government for a subsea pipeline that would stretch from Rostock on the northern coast of Germany to the south coast of Sweden. The project is referred to as the Baltic Gas Interconnector, or BGI, and the licence is currently under consideration by the government.

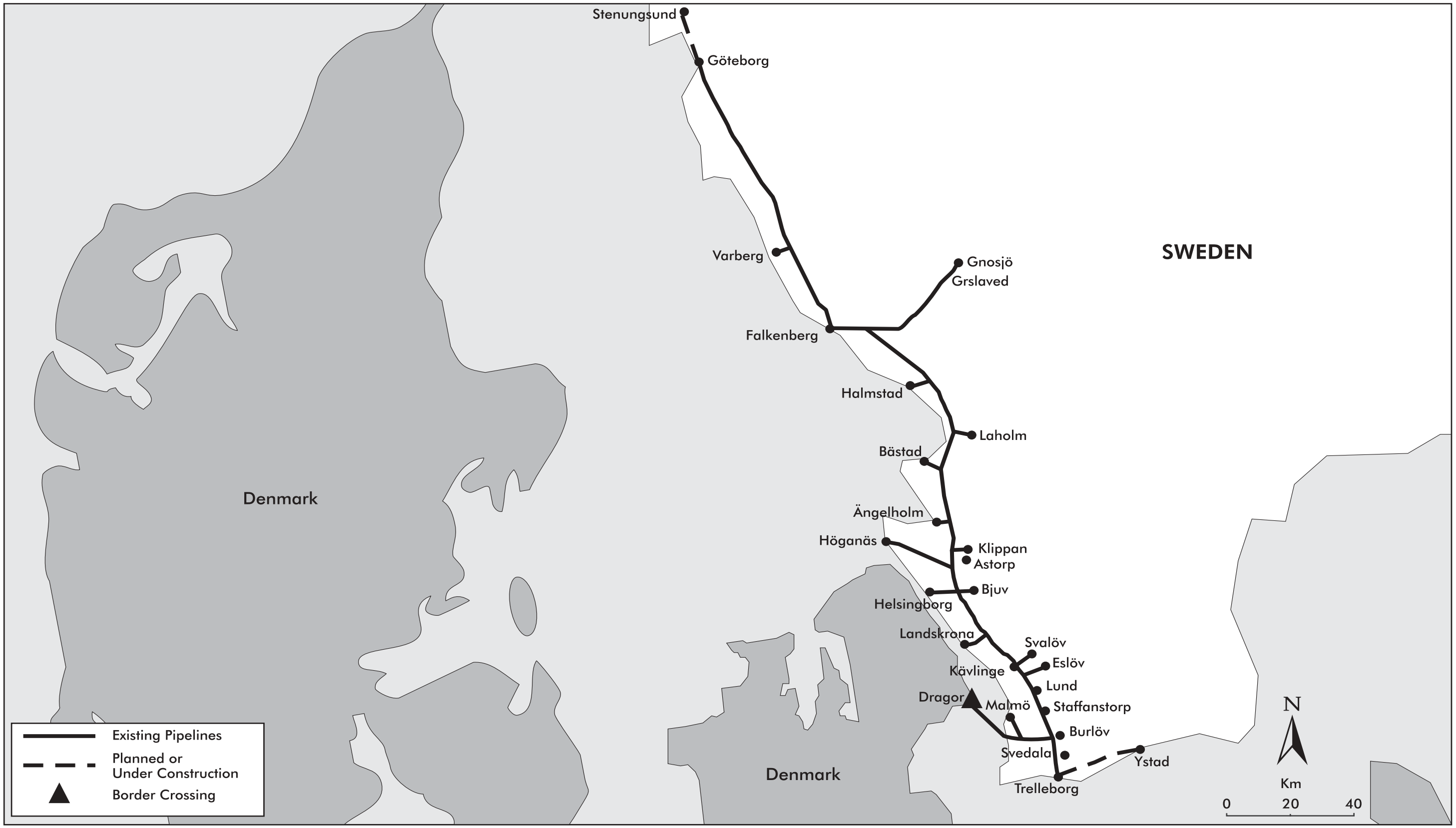
There are also plans for a North European Gas Pipeline (NEGP) that would be 5 000 km long and run through the Baltic Sea from Vyborg in Russia to the German coast and across Dutch territory. A spur would connect to the Stockholm area. According to Gazprom, the pipeline could begin transporting natural gas in 2007 and be running at full capacity by 2009 although these dates seem over-optimistic. The pipeline project, included in EC TEN projects, received an important boost as Russian and UK energy ministers signed a preliminary agreement in July 2003 pledging to co-operate to bring the pipeline on stream. Sweden has no LNG facilities.

The domestic transmission line stretches from Malmö to Göteborg 280 km further north on the west coast of Sweden. The total length of the line, including spurs, is 478 km. In addition, there are 2 060 km of distribution lines. While many cities and towns in Sweden once had town gas distribution networks, these have since been shut down and could not therefore be used for urban natural gas distribution. The exception to this is Stockholm, where the town gas network is still being used to distribute gas produced by the cracking of naphtha, and Göteborg and Malmö, where mixtures of air and natural gas are distributed in the town gas network. Figure 12 shows the high-pressure transmission network.

The main trunk of the high-pressure transmission system could easily reach a capacity of 2.9 TWh with minimal upgrades although now only one-third of the capacity is used. Fortum and Sydkraft Gas are investigating the possibilities of extending the grid to the Stockholm-Mälardalen area. In case of Sydkraft Gas, this extension would be realised in connection with the Baltic Gas Interconnector. Fortum has recently presented plans for a spur line from the North European Gas Pipeline into the Stockholm area. The majority of the

Figure 12

Map of High-pressure Gas Transmission Network



Source: *Natural Gas Information 2003*, IEA/OECD Paris, 2003.

transmission pipeline is owned and operated by NOVA with the remainder owned and operated by Sydkraft.

Sydkraft Gas buys all its gas from NOVA. Downstream suppliers, the municipal utilities of five towns, buy their gas from either of those two with the exception of Göteborg Energi, the local distribution company for Göteborg, which in May 2003 switched supplier from NOVA and contracted directly with DONG.

There is no gas transmission system operator (TSO) in Sweden. However, as NOVA is the only owner for the whole length of the Swedish main trunk, NOVA fills the role of TSO by default. The organisation of the TSO is at present under consideration in the process of implementing the new EU Gas Market Directive.

For geological and technical reasons, gas storage has not been deemed feasible in Sweden. Sydkraft Gas has recently completed the building of a storage plant for demonstrational purposes. It was put into use in the autumn of 2003, with a capacity for 10 million m^3 (mcm).

Sydkraft Gas is the distributor/supplier in the city of Malmö as well as in a number of smaller municipalities. NOVA is the owner of the transmission grid and imports the main part of gas to the Swedish market. In addition, NOVA has some distribution assets and is planning for an extension of the network to the petrochemical industry at Stenungsund. Göteborg Energi AB is owned by the municipality of Göteborg, Lunds Energi AB by the municipality of Lund, Ängelholms Energi AB by the municipality of Ängelholm, Varberg Energi by the municipality of Varberg and Öresundskraft AB by the municipality of Helsingborg.

The total number of customers in Sweden is 55 000, half of which are households using gas for cooking only. Table 9 below shows the number of connection points for the outtake of gas and volumes distributed.

Table 9

Number of Connection Points and Volumes Distributed

	Nr of connections	*Volumes distributed*
Nova Naturgas AB	9	57.1 mcm
Sydkraft Gas AB	25 300	538.4 mcm
Göteborg Energi AB	342	190.5 mcm
Lunds Energi AB	2	20.9 mcm
Öresundskraft AB	1 835	81.4 mcm
Varberg Energi AB	359	11.8 mcm
Ängelholms Energi AB	106	1.1 mcm

Source: Swedish government.

REGULATION

The goal for the Swedish natural gas policy is the development of a competitive natural gas market. The Natural Gas Act (2000:599) transposes the EU Gas Market Directive into Swedish law. As of 1 August 2003, customers with a (contracted) consumption of 15 mcm per annum or who are using natural gas for fuel in a CHP plant are eligible to choose their supplier. All non-household customers will become eligible on 1 July 2004 and all customers regardless of size, on 1 July 2007. Since the opening of the market in 2000, only one of the seven eligible customers in Sweden has switched supplier.

TPA to transmission pipelines is regulated. The owner of a pipeline is obliged to provide for connection and access to the network for the transport of gas on behalf of an eligible customer or a natural gas undertaking. While these services must be offered on reasonable terms, the methodologies underlying the tariffs differ. In cases where the supplier transports gas to customers along his own pipeline, the law does not demand that the customer tariff be split into separate transportation and supply components. On the contrary, it is common practice for the customer to negotiate one price for gas that includes both supply and transport. In cases where a specified transportation tariff is required (*e.g.* third-party gas is being transported), the method of calculating it varies between the four companies concerned. NOVA uses an entry/exit tariff, whereas Sydkraft Gas's tariffs are zonal. The two local distribution companies with one eligible customer each, Göteborg Energi and Öresundskraft, both apply a postage-stamp tariff.

Regulation of the natural gas market takes place at the Regulator's Office which constitutes a separate department within the Swedish Energy Agency. The regulatory method is generally light-handed. Pipeline owners are free to set transmission tariffs without gaining approval from the regulator. The Swedish Natural Gas Act and Ordinances stipulate only that "the proprietor of a natural gas pipeline is obliged to transport natural gas on reasonable terms." The tariffs and terms are subject to no *ex ante* review by the regulator. The tariffs must be published and the separate accounts (*i.e.* supply and transport activities) of each pipeline company must be provided to the regulator. Upon review of this material, or prompted by the complaints from customers, the regulator can require the company in question to lower the tariffs and give the customers a refund. He can also administer fines to companies with unreasonable tariffs.

The Swedish Competition Authority also has a responsibility in the natural gas market. Insofar as the provisions in the Directive 98/30 aiming to hinder anti-competition behaviour by the natural gas companies are implemented in the Swedish Natural Gas Act, the observance of which is monitored by the regulator, the Competition Authority would not act, applying the principle of *lex specialis*. The regulator has no legal authority regarding the supply function, which at the moment is not legally separated from transportation services. In practice, there has been no overlap of laws applied on the natural gas market by the two bodies.

Siting of pipelines must be in accordance with environmental law, avoiding archaeological damage, not unnecessarily impinging on the property rights of others, and not leading to pipeline-to-pipeline competition. In the case of transmission lines, this is monitored in the licensing process under the Natural Gas Act. In the case of distribution lines, for which licensing is not required, the environmental, archaeological and other issues are monitored by the regional state agency, the county council and by the municipalities.

CRITIQUE

Coal has been a steady supplier to the Swedish energy sector, regularly providing approximately 5% of the country's TPES. Coal provides a secure, low-cost energy supply for industry. However, its high emissions create problems as the country tries to reach its various emissions targets. One of the most potent tools for tackling emissions has been taxation and coal faces heavy tax rates given its carbon content. However, since many large coal users are industries, their tax exemptions and reductions render taxation much less powerful. Coal is also used as a fuel for electricity generation, which is exempted from taxation. Coal use may be discouraged, however, by the introduction of the emissions trading scheme, which could give industrial companies and power generators incentives to curb coal use.

Peat provides another reliable source of power, although its contribution at less than 1% of TPES is minimal. Peat's CO_2 emissions are the greatest of any fossil fuel and yet it is treated like biomass for taxation purposes and thus exempted from all taxes. This inconsistency between supporting a domestic fuel and targeting GHG emissions warrants further examination.

Sweden's long-term plan of reducing its reliance on oil has successfully lowered oil's share of TPES, thus improving energy security. Opportunities to further reduce oil's share of TPES are limited, as evidenced by its stable contribution to the energy mix over the last 12 years. The consolidation within the motor fuels retail market bears close monitoring and the current case involving alleged cartel activities should be pursued within the Swedish legal system. At the same time, the price of Swedish motor fuels at the retail levels is now within the median of prices in the EU, indicating that the market is working to assure competitive price levels.

While the natural gas market still plays a minor role in the Swedish energy sector, a number of proposed projects are seeking to expand its use throughout the country. This includes two major international pipelines to Sweden and a number of projects for expansion of the domestic grid.

Expanded gas use would add supply diversity to the country's fuel mix, lower GHG emissions if it displaces other fossil fuels and provide economic advantages if it proves to be the lowest-cost fuel option. The outcome of negotiations on nuclear phase-out will also have a large impact on the future role of natural gas. Since it would be difficult to replace the lost nuclear generation solely with energy efficiency and renewable energy, natural gas will be the only economically acceptable alternative for domestic replacement capacity.

Despite these advantages, natural gas in Sweden faces a number of challenges to expansion. These include the need to import all gas supplies, a single import interconnector, limited domestic transport pipelines, geographically dispersed demand for gas, lack of growth for TFC and taxation that favours biofuels. While these challenges are considerable, gas has been able to capture between 20% and 25% of the available market in regions where it has been introduced, suggesting its expansion would be welcomed in other parts of the country.

The Swedish government has not taken a strong position on the future of natural gas in the country. On the one hand, it has established a suitable regulatory structure to foster a competitive market that is free to expand while in no way taking any active stand opposing gas use. On the other hand, the tax system favours biofuels and electricity over gas and the government has not taken any actions or made any statements in support of expanded gas use. This unwillingness to commit by the government, coupled with uncertainty over the future of nuclear power and energy taxation, could act to deter companies from entering the gas supply business.

While Sweden should continue to let the market decide if, where and to what extent gas expansion should occur in Sweden, there are a number of government actions that could remove harmful and unnecessary barriers. The first such barrier is the complexity of gas transport. There is no official network operator, a responsibility which falls by default to NOVA, the largest pipeline owner. Users who move gas through NOVA's pipeline and then through Sydkraft's pipeline face pancaking of rates. Each network owner seems to use a different pricing methodology (*e.g.* postal stamp, zonal, etc.), further adding complexity to the system. There is no clear regulatory structure for integrating new pipelines that may be built into the existing system. Providing regulatory consistency to natural gas transport in the form of a single transmission operator will increase transparency and simplicity of network use. Any such plan should clearly outline how new transport pipelines would be integrated into the existing system.

The cross-ownership between gas companies and between gas and electricity interests may also discourage gas expansion. Sydkraft is majority owned by E.On which itself owns Ruhrgas, the largest owner of NOVA. At the same time that Sydkraft seeks to expand gas use, it is competing as an electricity producer and supplier and would not, of course, want to cannibalise its electricity sales with expanded gas use. Fortum is also a major owner of NOVA and has the same conflicts of interest between expanded gas use and maintaining its electricity operations. While there has been no evidence of collusion arising from these apparent conflicts of interest, the implications for such cross-ownership should continue to be monitored.

The tax structure favouring biofuels is in place to reduce GHG emissions. While this is a legitimate economic policy tool, the uncertainty over future rates will favour incumbent fuels as much as or more so than the relative levels of taxation. Sweden's tax structure has changed in recent years and looks to continue changing. Such instability strongly discourages the new investment needed in pipelines. Even if the economics favour such investment in the long term, the riskiness of the investment caused by uncertain future tax rates makes it safer to go with the choices already present, namely biofuels, electricity and fossil fuels other than gas. A stable tax structure, at whatever tax levels, will give necessary comfort to investors to make investments based on the most economic option.

There appears to be some concern that natural gas is a direct competitor with biofuels and increased gas use will lead to decreased biofuel use. Biofuels are favoured because they represent a domestic resource and have fewer GHG emissions than gas. Nevertheless, there are indications that biomass is facing supply constraints, which would limit its use more than any competition from gas. At the same time, gas can also displace fossil fuel or electricity use and meet new demand, although this is growing slowly. In short, gas can play an important role in a diversified Swedish fuel mix. While the government has been wholly correct thus far in letting the market decide the future of gas, taking steps to clarify and simplify the gas sector would remove distortions in making that decision.

RECOMMENDATIONS

The government of Sweden should:

- *Establish a stable, appropriate tax regime for fossil fuels.*
- *Consider establishing a single gas transmission system operator.*
- *Consider the effects of current ownership of major gas utilities on the efficient functioning of a liberalised gas market.*
- *Establish a clear and stable policy framework to facilitate access to the system network and to allow for the development of network infrastructures by interested parties.*

POLICY AND REGULATORY FRAMEWORK

Electricity market reform was introduced in Sweden through the *Electricity Act 1996* (the Act), which took effect on 1 January 1996. The main objectives of the legislation were to promote efficiency and facilitate customer choice. The legislation introduced competition in trading and generation of electric power while maintaining regulation of network services. The legislation also required physical separation of the national transmission network and legal separation of the remaining network activities from contestable activities.

The Act provides the statutory framework for regulating the electricity market. Detailed rules and interpretations are contained in various codes issued by the government and regulations issued by the Office of the Electricity and Gas Regulator (the Regulator). Obligation to supply provisions are also contained in the Act.

A range of electricity market issues have been addressed in recent legislation, including a performance-based definition for determining the reasonableness of network tariffs (which took effect in July 2002); management of peak capacity reserves (which took effect in July 2003); thresholds for hourly and monthly meter reading (to take effect in July 2006 and July 2009 respectively); and the framework for certification of renewable energy production (which took effect in October 2003). Legislative developments relating to renewable energy certificates and the process for negotiating the closure of nuclear facilities are addressed elsewhere in this report.

The 1996 EU directive influences the policy and legislative environment. The 2003 amendment to the Electricity Directive, which includes a requirement for EU member States to implement a form of *ex ante* regulation, may result in further changes to the legislative framework.

GOVERNANCE AND REGULATORY ARRANGEMENTS

Electricity policy matters are managed by the Ministry of Industry, Employment and Communications (the Ministry), which is responsible for implementing the government's policy agenda. The Ministry monitors market developments, prepares legislation and issues guidelines for the work of the Swedish Energy Agency, on behalf of the government. The Ministry is also responsible for granting concessions for the transmission network, based on advice from the Regulator.

The Regulator acts as a separate body within the Swedish Energy Agency, responsible for regulating network access undertakings and tariffs and advising government on applications for network concessions. The Regulator has 30 staff. Regulatory decisions can be appealed, with decisions relating to tariffs and other conditions reviewed by the administrative court and decisions relating to network concessions reviewed by the Ministry on behalf of the government.

The regulatory regime emphasises light-handed, self-regulation in both the generation and network components of the electricity sector. It relies on the combination of information transparency, legal separation of network services and *ex post* regulation to create strong incentives for operational efficiency.

The Act seeks to facilitate transparency by empowering the Regulator to collect and annually publish relevant information, including: network tariffs and charges; network costs; technical information; and key indicators focusing on financial and physical performance. The Regulator has sought to further enhance regulatory certainty and transparency by publishing guidelines on how it interprets and applies the regulatory provisions.

The Swedish Competition Authority (the Authority) is responsible for supervising the market and investigating potential abuse of dominant position or other related discrimination. The Authority also scrutinises mergers and has power to block mergers or attach conditions to their approval. Financial trades are supervised by the Swedish Financial Supervisory Authority.

PRODUCTION AND WHOLESALE MARKET

GENERATION

In 2002, Swedish generating capacity totalled around 32 200 MW, with hydro plant representing nearly half the installed capacity, nuclear nearly 30%, and thermal plant making up most of the remainder.

Total capacity has fallen by around 10% since liberalisation, with strong competition leading to the closure of several thermal peaking plants, reducing capacity by around 2 800 MW. The closure of the Barsebäck I nuclear reactor in 1999 reduced capacity by a further 600 MW. Construction is progressing on two combined heat and power (CHP) plants with total capacity of around 470 MW. They are due to be commissioned in 2005. An additional 400 MW CHP plant has been proposed with earliest likely commissioning around 2007. Overall it appears that less efficient domestic peaking capacity has been and will continue to be replaced with imports.

Swedish generators produced 143.4 TWh during 2002, down around 14 TWh from the post-liberalisation production peak recorded in 2001. Hydroelectric and nuclear generation each accounted for around 46% of total production in 2002, with the balance largely provided by thermal generators, principally CHP generation.

Precipitation levels are a key determinant of production levels and of the production mix in all power systems dominated by low-cost hydro plant. 2000 and 2001 were unusually wet years in Sweden with record-breaking levels of hydroelectric production and substantial electricity exports. By contrast, 1996 and 2002 were dry years with significantly lower hydro production and significant electricity imports. This relationship is reflected in production trends since the introduction of market reform as shown in Table 10.

Table 10

Swedish Electricity (TWh) Generation, 1996 to 2010

Technology	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*[1]	*2002*[1]	*2010*
Hydro	51.2	68.2	73.8	70.9	77.8	78.6	66.0	68.6
Nuclear	71.4	66.9	70.5	70.2	54.8	69.2	65.6	63.6
Thermal[2]	14.0	10.0	10.1	9.4	8.9	9.6	11.2	11.8
Wind	0.0	0.2	0.3	0.4	0.5	0.5	0.6	3.9
Total[3]	**136.6**	**145.3**	**154.7**	**151.0**	**142.0**	**157.8**	**143.4**	**147.8**

(1) Preliminary data.
(2) Includes CHP for industry and district heating.
(3) Net generation excluding in-house consumption. Errors owing to rounding.
Source: Swedish Energy Agency.

MARKET STRUCTURE AND COMPETITION

Power generation in Sweden is characterised by few firms with large market shares. Table 11 shows that three generators produced nearly 86% of total

Table 11

Large Generator Market Shares in Sweden, 1999 to 2002

(% of total Swedish generation)

Generator	*1999*	*2000*	*2001*	*2002*
Vattenfall	52.7	48.8	48.5	49.0
Sydkraft	18.2	19.2	20.7	19.9
Birka[1]	13.9	15.1	14.1	0.0
Fortum[2]	4.0	4.5	4.6	17.1
Skelleftea	2.0	2.0	2.3	2.4
Graninge	1.7	2.3	2.3	1.7

(1) As of 1 March 2002, Birka Energi became a wholly-owned subsidiary of Fortum Power and Heat AB.
(2) Birka merger creates some uncertainty in relation to the 2002 figures for Fortum.
Source: Swedish Energy Agency.

Swedish output in 2002, with Vattenfall accounting for 49% of total Swedish generation, Sydkraft accounting for 20% and Fortum accounting for 17%. Vattenfall is also the largest generator in the Nordic market with 18% of total generation in 2002, followed by Fortum at 12%, Statkraft at 11%, Sydkraft at 7% and Pohjolan Voima Oy (PVO) at 4%.

Ownership of these generators is dominated by Nordic governments. Vattenfall is wholly owned by the Swedish government, while Norwegian government-owned generator Statkraft holds 43.4% of Sydkraft (with E.On of Germany holding the majority share), and Fortum is a wholly owned subsidiary of the Fortum Oy energy group, which is 70% owned by the Finnish government. There is also considerable joint ownership with all nuclear facilities jointly owned by the largest Swedish generators and the river regulating companies in charge of hydro plants also under joint ownership.

Since market reform, there have been several mergers mostly involving the larger generators purchasing relatively small competitors. As a result, individual mergers have not typically raised regulatory concerns to date, but the overall effect of this activity has been to reduce the number of local competitors and increase concentration of ownership. Merger and acquisition activity has been observed in other reformed markets, often as a commercial response to maximise economies of scale and financial viability in a capital-intensive sector that is exposed to considerable volatility.

Although there has been no evidence of market manipulation by generators in Sweden to date, increasing generator concentration has raised concerns about the potential for individual or collective exercise of market power.

A recent report (*A Powerful Competition Policy*, June 2003) by the Nordic competition authorities examining generator concentration and its potential implications for competition in Nordic electricity markets concludes that although the Nordic market as a whole is only moderately concentrated, the individual geographic regions within the market can be very concentrated, increasing the potential for participants to exercise undue market power. In particular, the report notes that the Swedish market is highly concentrated, with an adjusted HHI index of 3 169[12]. It also notes that the effects of any anti-competitive business practices in one regional market are likely to reduce efficiency and increase costs across the entire Nordic market.

12. The Herfindahl-Hirschman Index (HHI) is defined as the sum of the squares of the market shares of all firms in the relevant market. An index of 0 implies a perfectly atomistic market, while an index number of 10 000 implies a perfect monopoly. Results above 1 800 to 2 000 imply relatively high levels of concentration. The figure quoted above has been adjusted to reflect the effect of cross-ownership and the related capacity of owners to co-ordinate the behaviour of jointly-owned facilities. In the absence of these adjustments, the Swedish electricity market would still be regarded as highly concentrated with a HHI index of 2 893.

Increasing integration of the Nordic electricity market is likely to reduce the potential for exercise of market power in Sweden and throughout the Nordic market. However, it may not be sufficient to eliminate this risk. Several obstacles to competition remain in addition to high levels of concentration, including the relative inelasticity of demand and relatively high entry costs.

The report recommends that Nordic governments pursue more co-ordinated competition supervision, including more integrated evaluation of merger activity and strengthening information exchange between Nord Pool, Nordic energy agencies, financial authorities and competition authorities. Other key recommendations are summarised in the box below. The recently concluded Nordic agreement on information exchange between competition authorities represents a positive step in this direction.

A Powerful Competition Policy
Summary of Key Recommendations

The report proposed several actions to strengthen competition within the Nordic electricity market including:

- Careful review of mergers that increase market concentration, taking account of broader Nordic market implications.
- Consideration of the potential for creating more competitive company and ownership structures.
- Improving effective capacity utilisation of transmission networks.
- Ensuring that evaluation of transmission network investment proposals takes appropriate consideration of the benefits for competition.

WHOLESALE POWER EXCHANGE AND TRADE

Wholesale Power Exchange

Sweden is part of the Nordic power market – Nord Pool – along with Norway, Finland and Denmark. Nord Pool has over 300 participants including power producers, retailers, grid owners, brokers, traders and industrial companies. Nord Pool provides several market services including:

- A spot market for physical contracts, Elspot.
- A financial derivatives market – futures and option contracts.
- Clearing services for contracts traded in over-the-counter and bilateral markets.

Standard bilateral contracts remain the preferred instrument for buying and selling electricity. However, a growing proportion of contracts are traded in Nord Pool's physical and financial derivatives markets. Physical trade between Nordic countries is based on the Nord Pool spot market. Nord Pool's financial derivatives market includes futures, forwards and option products, providing a means for market participants to hedge purchases and sales of power up to four years in advance. Nord Pool market trading has risen steadily since its introduction in 1996, as shown in Table 12.

Table 12

Nord Pool Market Development, 1996 to 2002

(volumes in TWh)

	1996	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*
Physical market	41	44	57	76	97	112	124
Financial market	43	53	89	216	359	910	1 019
Bilateral contracts	*	147	373	648	1 180	1 748	2 089

* Introduced in 1997.

Source: Nord Pool Annual Report.

In 2002, physical spot market trading on Nord Pool amounted to 124 TWh, representing 32% of total consumption in the Nordic market. Trade on the spot market has increased every year since liberalisation and increased by a further 11% in 2002. Similarly, trade on the financial market increased to 1 091 TWh in 2002 (increase of around 12%), while 2 089 TWh were cleared through the standard bilateral contract market (increase of around 20%). However, the tight power situation in early 2003 reduced market liquidity and was reflected in a fall in financial market trading volumes.

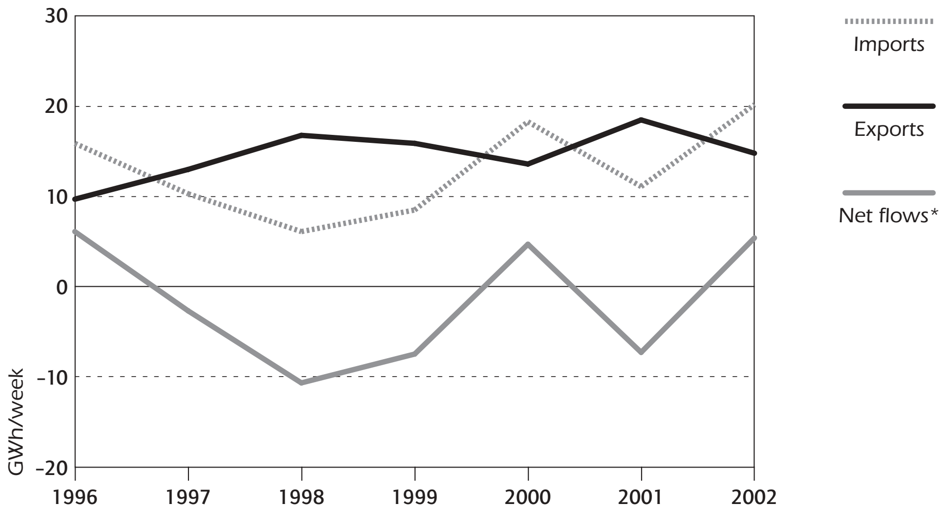
Trade

Trade in electricity has delivered efficiency benefits for Sweden and the Nordic region, including deepening of wholesale competition, more efficient utilisation of existing infrastructure enabling capital expenditure on new generating plant to be deferred and increasing the potential for efficient sharing of capacity reserves.

Water inflows are the key determinant of Swedish and Nordic electricity trade patterns. During wet years with strong water inflows, Sweden is a net exporter of electricity, reflecting the relatively low marginal cost of hydro generation, while during dry years Sweden becomes a net importer. Sweden's net electricity trade since liberalisation has generally been closely correlated to water inflows as shown in Figure 13.

Figure 13

Net Electricity Trade, 1996 to 2002



* errors due to rounding.
Source: Swedish Energy Agency.

However, forecasts contained in the Nordel Grid Master Plan 2002 suggest that Sweden may become a net importer by around 2005, demonstrating that net capacity additions will be unable to keep up with demand growth and emphasising the growing importance of regional trade to Sweden, to ensure continued access to reliable and efficiently priced electricity.

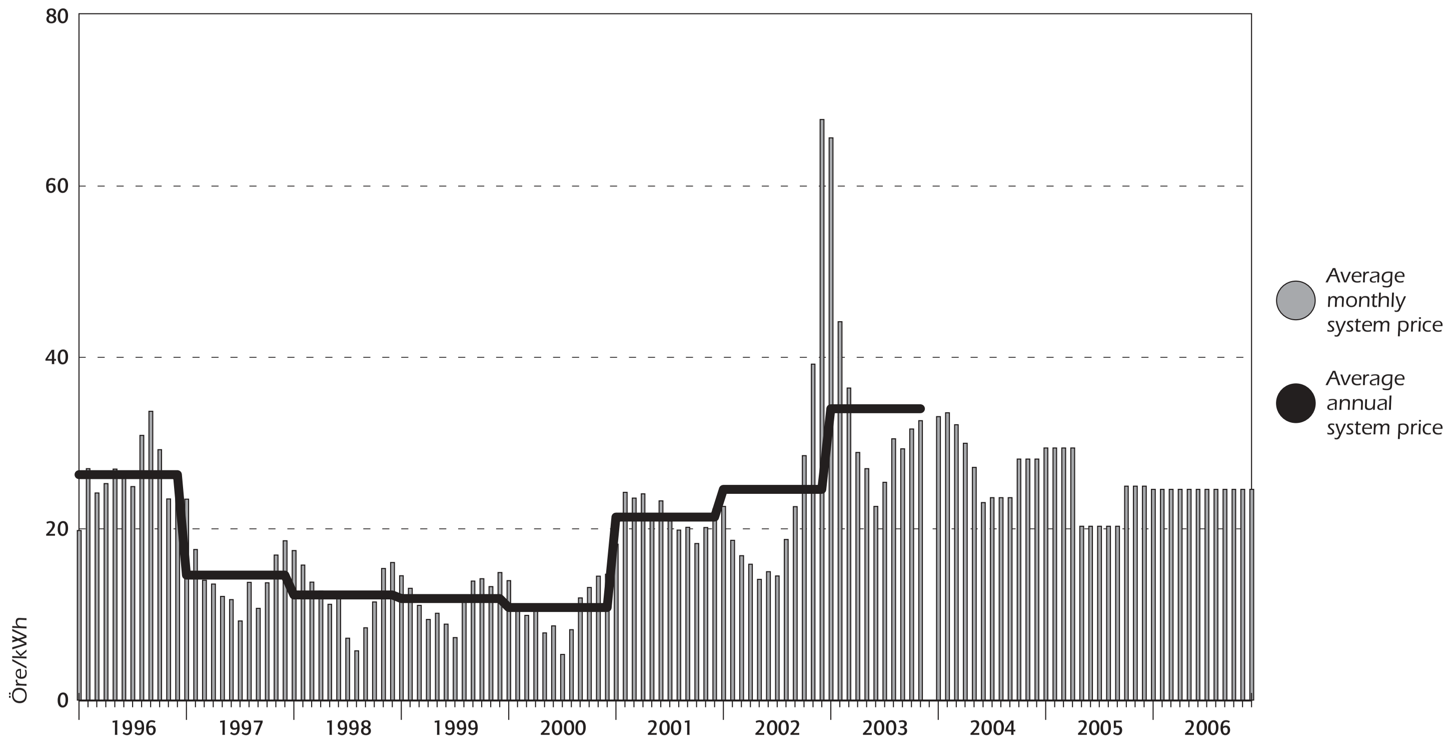
WHOLESALE PRICES

In Sweden and other Nordic countries electricity prices are highly dependent on variations in hydroelectric generation. Hydroelectricity represents the lowest-cost form of large-scale generation and accounts for around 50% of total installed capacity in the Nordic region. Hence, prices in a given year are largely dictated by hydroelectric production levels.

Annual average Nord Pool prices rose significantly in 2001 and have continued to rise, with an average annual system price of 24.6 öre/kWh recorded in 2002, and an average monthly system price between January and April 2003 of 43.8 öre/kWh. Price rises have reflected dry conditions resulting in relatively less hydro generation, initially in Norway and then in Norway and Sweden from 2002. Rising spot prices are beginning to be reflected in financial contract prices, with an average monthly forward price for 2004 of 24.7 öre/kWh as at 30 April 2003. Movements in the average monthly

Figure 14

Nord Pool Average Monthly System Prices , 1996 to 2003 and Forward Prices, 2004 to 2006



Note: Nord Pool future closing prices as at 16 December 2003.
Exchange rate of €1 = SKr 9.02331 applied to quoted future prices.

Source: Nord Pool monthly and yearly average data.

system prices on the Nord Pool spot market and some indicative forward contract prices are presented in Figure 14.

Hydroelectric reservoir levels had fallen to a 50-year low by the end of 2002, as a result of an extremely dry autumn, raising concerns at that time about water shortages limiting hydroelectric generation during the winter of 2002/03. Nordic spot prices rose to unprecedented levels as a result of these concerns combined with particularly cold weather. Between 8 and 17 December 2002 system prices averaged over 70 öre per kWh, sometimes spiking to over 90 öre per kWh, while prices peaked between 4 and 8 January 2003 at an average of around 100 öre/kWh. By way of comparison, the average wholesale prices in 2001 and 2002 were less than 25 öre/kWh. The impact is reflected in the spike in monthly average prices recorded for December and January in Figure 14.

Importantly, it should be noted that the market responded effectively to these extreme conditions. Imports increased, particularly from the continent, and thermal peaking plant returned to service. Demand was restrained in the face of high prices, although this occurred more so in Norway which was experiencing similar high prices. Supply was sufficient to meet demand throughout this period without intervention. However, a tightening supply-demand balance since the introduction of competition reform is likely to be reflected in higher and more volatile wholesale prices in the future.

NETWORKS

Swedish networks consist of a national and regional transmission system and local distribution networks. The national transmission system includes 15 050 km of 220 kV and 400 kV lines and most of the interconnectors with neighbouring regions. It has been constructed to facilitate the flow of power from the major hydroelectric generating centres in the north to the main consumption centres in the south. The national grid is owned by Svenska Kraftnät, which is wholly owned by the Swedish government. Figure 15 identifies the main Swedish transmission lines and interconnectors.

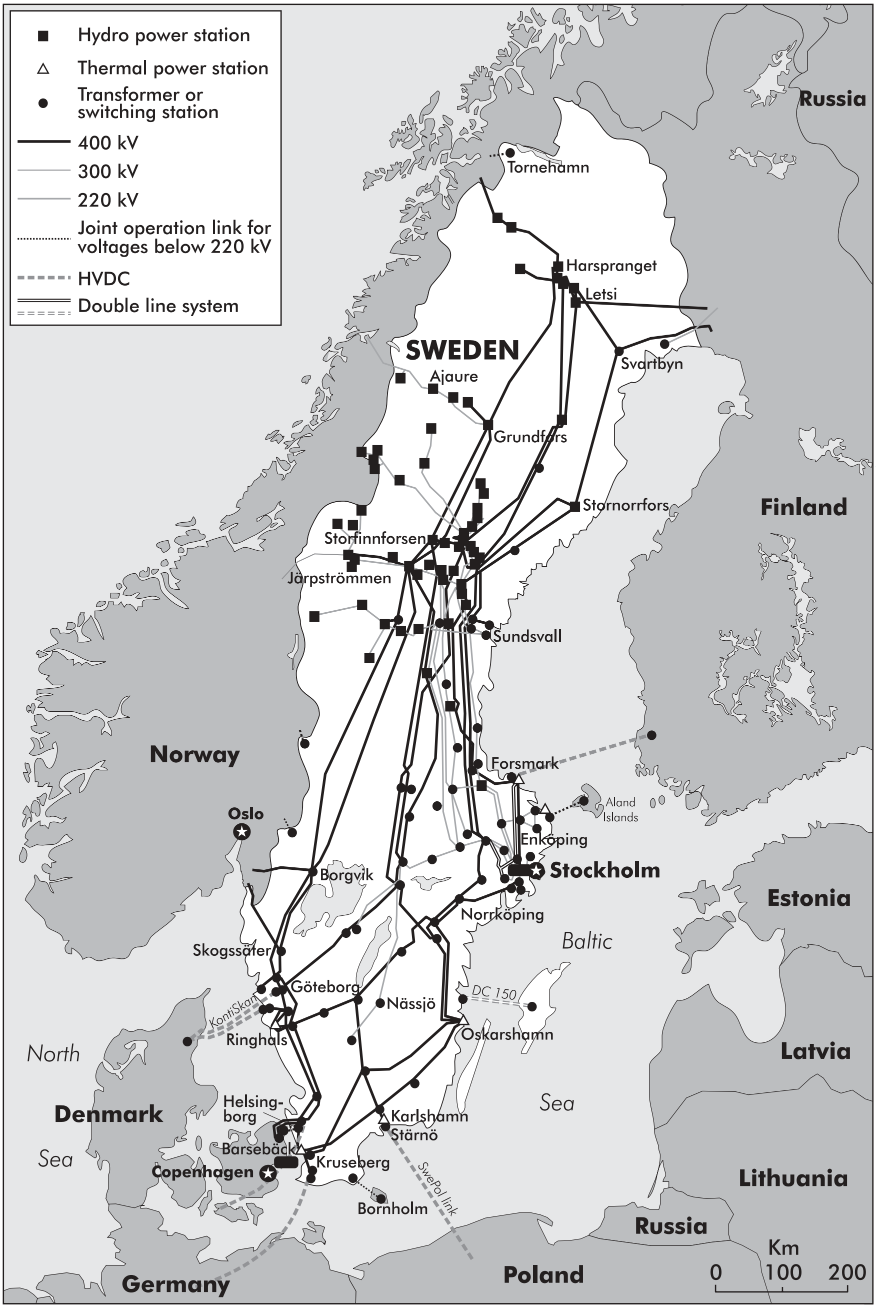
The regional transmission network typically consists of 70 kV to 130 kV lines. It transports electricity from the national transmission grid to local distribution networks and directly to some larger electricity users. There are 13 regional networks, most of which are owned by the large generators.

Local distribution is provided by over 200 local networks, which are owned by private, state and municipal companies or co-operative associations. There has been significant rationalisation of distribution companies since liberalisation as companies seek to minimise the costs of servicing customers.

Several interconnectors facilitate trade between Sweden, and Germany, Poland and the other Nordic countries. The capacity of these interconnectors is provided in Figure 16.

Figure 15

Swedish Transmission Network



Source: Nordel.

Figure 16

Swedish Trading Capacity

(MW)

Sources. Swedish Energy Agency and Nordel.

SYSTEM OPERATION

Svenska Kraftnät is the Swedish transmission system operator (TSO). Its responsibilities include co-ordinating and balancing generation and consumption, maintaining a capacity reserve and domestic transmission planning and development.

Svenska Kraftnät maintains system balance through a three-tiered mechanism that includes automatic generator controls, a 1 300 MW quick response generation disturbance reserve and through contracts with balance service providers. Svenska Kraftnät has also recently acquired a transitional responsibility for providing a peaking reserve in addition to its disturbance reserve. This programme is described in the Security of Supply section below.

Internal domestic bottlenecks in the transmission system arise periodically and are managed through counter-trading. Counter-trading involves Svenska Kraftnät purchasing more expensive generating capacity on the consumption side of a network constraint and cancelling generating capacity on the other side, with the objective of allowing all market participant transactions to proceed without being affected as if there were no physical constraints. The costs are borne by Svenska Kraftnät, which provides a financial signal for it to pursue investments to alleviate congestion.

Effective co-ordination of system operation across the Nordic region is essential to maintain efficient and reliable outcomes, given the highly integrated nature of the Nordic electricity market. Considerable co-operation has already been achieved through the association of the five Nordic system operators – Nordel – and as a result of the 1999 Nordic System Operating Agreement. Nordel is continuing work to facilitate Nordic system-wide planning and development, and to develop guidelines and protocols for seamless system operation within the Nordic region. Key initiatives include: implementation of a common Nordic regulating power market; scoping the potential for a Nordic Grid Code to further harmonise system operation and network planning arrangements; progressing assessment of potential interconnector augmentations identified in the Grid Master Plan 2002; and investigating mechanisms for consistent management of network congestion.

NETWORK PRICING AND REGULATION

Network Pricing

All domestic network services are priced using a system of spot tariffs. The principle is that a user pays to feed in or take out electricity at a particular point in the network, thus obtaining an entitlement to access the entire domestic network. Spot tariffs can vary considerably depending on class of customer, but must be applied uniformly to all customers within a customer class, irrespective of their location. Tariffs are also adjusted to reflect transmission losses on the network. In northern Sweden, the charge for feeding in electricity is relatively high, given that such activity increases the load on the transmission network, whereas off-take charges are lower. The reverse applies in southern Sweden.

By law, network tariffs must be cost-reflective and non-discriminatory. However, the proportion of fixed and variable charges is not prescribed in legislation. In recent years, several network companies have modified their tariff structure to recover a greater proportion of network costs through the fixed component.

Transmission spot tariffs on the national transmission network are divided into an annual power charge and an hourly per unit transportation charge. The average cost of transmitting electricity on the national transmission system is around 1.4 öre/kWh.

Between 1996 and 2003, network charges rose by between 6% and 13% for median households and small business users, while charges for medium-sized businesses rose by around 4% and charges for larger industrial users rose by around 15% over the same period. Swedish inflation from 1996 to 2003 rose by 9%, so the real price changes in network charges ranged from a decrease of 5% to an increase of 6%.

Inter-Nordic trade is no longer subject to cross-border network charges, with the last of these charges removed when Sweden abolished its cross-border tariff on flows to Denmark in March 2002. However, electricity flows between the Nordic region and continental Europe continue to attract a cross-border charge of €1/MWh.

From January 2002, Nordel TSOs introduced harmonised transmission tariffs and implemented a transit agreement to provide compensation for losses associated with inter-Nordic electricity flows. Nordel is working to further develop the transit agreement mechanism to address the full cost of transit flows, including capital costs. At present, Svenska Kraftnät retains any settlement residue surpluses that may accrue when separate Nordic price regions emerge owing to physical congestion on interconnections between Sweden and other Nordic countries. These revenues may provide some compensation for other costs associated with cross-border electricity flows that are not explicitly recovered.

Tariff Regulation

All domestic network tariffs are regulated on an *ex post* basis, which involves the network utilities setting tariffs with the Regulator monitoring tariffs and intervening only to protect the consumer interest where tariffs are considered unreasonable. To date the Regulator has interpreted "unreasonable" to mean any increase in tariffs that does not reflect special circumstances. The Regulator has yet to intervene to set network tariffs.

From 1 July 2002, new regulations came into force, which modified the criteria for assessing the reasonableness of network tariffs to focus on network performance. As a result, network tariffs will be assessed in terms of service delivery effectiveness as well as cost. Consistent with the new focus, the Regulator is developing a model – the electricity network utility model – to assess the reasonableness of tariffs from the perspective of network performance and cost. The new model is expected to apply from 2004.

NETWORK DEVELOPMENT

Svenska Kraftnät is responsible for the planning and development of the national transmission network, while individual service providers are responsible for the development of regional transmission and local distribution networks.

To date some augmentation has been undertaken to address network congestion on the main north-south transmission grid, including augmentations to help alleviate key bottlenecks between northern and central Sweden and between central and southern Sweden. Although total investment in the national transmission network increased from SKr 363 million in 2001 to SKr 460 million in 2002, investment was still less than depreciation of existing assets in 2002.

The most pressing development challenges may relate to strengthening interconnection between countries in the Nordic region. Congestion on interconnectors led to price separation at some point in the Nordic region around 50% of the time in 2001, and around 65% of the time in 2002. Price separation occurs when the interconnection capacities are insufficient to transfer electricity from a lower-priced market to a higher-priced market. In such instances, the export and the importing markets split, with different prices established for each one.

Efficient interconnection between Sweden, the other Nordic countries and continental Europe is vital for achieving the government's efficiency and reliability objectives. Analysis published by Nordel in its Nordic Grid Master Plan 2002 projects that by 2005 significant congestion could emerge on Swedish interconnectors during a dry year, which may have the potential to substantially restrict the flow of electricity from Finland to Sweden, from Denmark to Sweden and from Sweden to Norway. Furthermore, the results of benefit-cost analysis presented in the Master Plan suggest that there is likely to be a significant positive net present value associated with investment to alleviate most of these potential congestion points with new or expanded interconnectors.

Nordel is undertaking a more detailed analysis of the benefit-cost of investment to alleviate six priority points of congestion identified in the Master Plan. Four of these relate to interconnections between Sweden and either Norway or Denmark. However, the task has proven difficult with progress on the more detailed social-economic analysis slower than originally anticipated.

CONSUMPTION AND RETAIL MARKET

In 2002, domestic electricity consumption totalled 148.7 TWh. Nordel figures indicate that industrial consumption accounted for around 60.1 TWh (40.4%), while households accounted for 41.9 TWh (28.2%) and trade and services for 26.5 TWh (17.9%) over the same period. Smaller shares of electricity consumption went to the government, transport and the agricultural sectors. Swedish electricity consumption is at around 16 500 kWh per person, compared to an IEA average of around 8 700 kWh. This reflects the electricity-intensive nature of Swedish industry and the cold climate.

Swedish demand is winter peaking, reflecting the cold climate and high proportion of electrically heated residences. The highest hourly peak is usually around three times higher than the hourly minimum. Peak consumption has remained relatively constant since liberalisation. Further information on electricity consumption by customer class is provided in Table 13.

Table 13

Swedish Electricity Consumption, 1996 to 2002 and forecast to 2010 (TWh)

Customer class	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2010*
Industry	51.5	52.7	53.9	54.5	56.9	56.2	56.0	58.6
Residential, commercial, services, etc.	71.6	69.6	69.9	69.1	69.0	73.0	73.4	74.2
Transport	3.1	3.0	2.8	3.0	3.2	2.9	2.7	3.2
district heating, refineries	6.3	6.8	6.6	6.3	6.5	6.7	5.0	4.6
distribution losses	10.2	10.7	10.9	10.6	11.1	11.6	11.6	11.4
Total net consumption	**142.7**	**142.6**	**144.0**	**143.5**	**146.6**	**150.5**	**148.7**	**152.0**

Source: Swedish Energy Agency.

Consumption remained relatively stable in Sweden during the 1990s, growing by just 7.6% between 1990 and 2001, implying a compound growth rate of around 0.66% per annum. Growth in consumption is expected to remain quite moderate, with forecast growth of just 0.3% per annum between 2002 and 2010. Similarly, peak consumption is forecast to grow moderately, by around 4% between 2000 and 2010.

RETAIL PRICES

Electricity prices for end-users include the wholesale price of electricity, network charges and taxes. As of 1 January 2003, the wholesale price accounted for around 40% of the final price, while network charges accounted for around 20% and taxes for 40%.

Final prices for domestic customers are considerably higher than final prices for large industrial users, reflecting a substantial increase in taxes since 1997 from which industrial users were largely exempt. As at 1 July 2002, domestic customers were paying between 85.8 öre per kWh (larger users) and 103.4 öre per kWh (smaller users), while industrial users were paying between 23.5 öre/kWh (larger users) and 31.4 öre per kWh (smaller users). Network charges have remained relatively stable since 1997. Table 14 shows Swedish retail prices for various customer classes in 2001 and 2002 and compares them with those of other Nord Pool countries.

Table 14

Retail Prices in Nord Pool Countries, 2001 and 2002

(öre/kWh, all taxes included)

	Sweden			
	2001		*2002*	
	01-Jan	*01-Jul*	*01-Jan*	*01-Jul*
Small industrial plant	33.0	39.0	31.9	31.4
Medium industrial plant	24.1	30.8	26.1	25.6
Large industrial plant	20.7	27.8	23.5	23.1
Domestic (3 500 kWh)	91.6	100.7	104.5	103.4
Domestic (20 500 kWh)	74.8	84.2	86.9	85.8
	Norway			
	2001		*2002*	
	1-Jan	*1-Jul*	*1-Jan*	*1-Jul*
Small industrial plant	36.0	41.7	46.1	44.9
Medium industrial plant	26.5	32.8	34.5	36.2
Large industrial plant	19.6	25.4	26.2	26.9
Domestic (3 500 kWh)	102.1	117.1	119.5	116.5
Domestic (20 500 kWh)	65.3	76.9	77.8	71.8
	Finland			
	2001		*2002*	
	1-Jan	*1-Jul*	*1-Jan*	*1-Jul*
Small industrial plant	41.6	43.9	45.4	46.0
Medium industrial plant	36.6	39.0	40.8	41.1
Large industrial plant	26.4	28.2	30.3	30.5
Domestic (3 500 kWh)	76.7	83.2	86.4	87.4
Domestic (20 500 kWh)	48.0	51.0	53.7	54.6

Source: Eurostat, *Statistics in Focus.*

The price rise seen in the wholesale market at the end of 2002 and beginning of 2003 was reflected in retail prices. On 1 January 2003, electricity-only prices for households (*i.e.* retail prices excluding network charges and taxes) with until-further-notice contracts had risen by between 46% and 51% compared to the prevailing prices on 1 January 2002. Prices for larger industrial customers also increased sharply, although long-term bilateral contracts helped to moderate the immediate impact for these users.

RETAIL MARKET DEVELOPMENTS

Small Customer Choice

Active consumers who are able to effectively exercise choice are essential to the development of competitive retail markets for electricity. In Sweden, around 43% of households have been active in the market since 1996. Of these, around half have switched supplier while the other half have renegotiated agreements with their existing supplier. Activity has increased among small consumers since 1999, with the abolition of regulations requiring switching customers to install expensive interval meters. Switching has been further encouraged with recent improvements by the utilities to enable more efficient processing of customer transfer requests.

However, some barriers to participation may remain for small customers. In particular, small consumers who struggle to assess the available options, and the related risks and obligations, may be less willing to actively participate in the market. Problems with customer transfer processes and concerns about settlement by estimation also appear to have contributed to some dissatisfaction with electricity market reform among small customers. Despite these challenges, a recent survey commissioned by Swedenergy (the trade association for generators and suppliers) suggests that around 60% of Swedes support electricity market reform.

The Swedish government has initiated information campaigns to improve small customer understanding and to help increase participation in the market. It has also sought to improve incentives for participation and to address consumer concerns about settlement by estimation through recent legislation to reduce the threshold for hourly metering from 2006 and to require monthly meter reading by 2009.

Competition in Retail Markets

Strong competition between retailers will help ensure that reform benefits are passed through the value chain to end-users in the form of greater choice, more innovative products and efficient prices. Current law requires legal separation of distribution and supply activities, consistent with the provisions of the EU Electricity Directive (as amended).

Vattenfall, Fortum and Sydkraft, the largest generators in Sweden, also dominate the retail market, with around 50% of sales to end-use customers, and around 70% of sales when minority holdings and partnership agreements are included. At the same time, the number of independent electricity suppliers is declining, and retail margins appear to be increasing. Concerns have been raised about these developments, which may be symptomatic of a lessening of effective competition between retailers, with the potential to erode benefits passed through to small end-users.

SECURITY OF SUPPLY

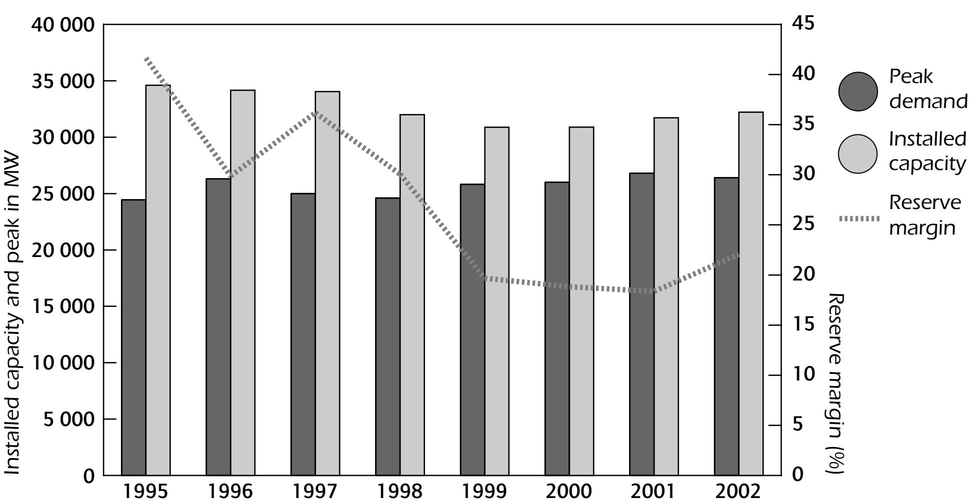
SUPPLY-DEMAND BALANCE

Although peak demand has remained relatively stable since liberalisation, generating capacity has diminished significantly, leading to a tightening supply-demand balance in Sweden. The narrowing of the supply-demand balance is illustrated in Figure 17.

Nordel's Grid Master Plan 2002 suggests that Sweden will experience an electricity deficit by 2005. According to the Nordel projections, Sweden will need to import approximately 6 TWh per annum by 2005 (or around 4% of total consumption) to balance supply and demand, assuming a normal year

Figure 17

Movements in Peak Load and Generating Capacity, 1995 to 2002



Source: Nordel Annual Statistics.

of hydroelectric production and no further nuclear plant closures. During a one-in-ten dry year, the import requirement is projected to rise to around 16 TWh per annum or 9.9% of total consumption, while the requirement during an extremely dry year or during a period of successive dry years is projected to be in the order of 19 TWh per annum by 2005 or 11.8% of total consumption. Nordel also estimates that by 2005, Sweden could experience a capacity shortfall of around 2 000 MW during a one-in-ten-year winter peak compared to their peak in 2001 of 27 000 MW. However, Nordel also considers that imports should be sufficient to meet Sweden's balancing requirements during the projection period to 2010.

SECURITY OF SUPPLY ISSUES AND INITIATIVES

Growing concerns about security of supply have been highlighted by recent supply disruptions in North America and Europe. Sweden experienced a substantial supply disruption on 23 September 2003, the most severe disturbance to the Nordic system in 20 years. The southern part of Sweden and the eastern part of Denmark were blacked out as a result of two severe faults which occurred in quick succession. A summary of the event is provided in the following box.

Summary of September 2003 Blackout

The following summary draws on material published by Svenska Kraftnät.

Scheduled annual maintenance resulted in two 400 kV transmission lines being taken out of service and limited nuclear generation in the affected area on the day of the disruption. Similarly, the high-voltage direct current (HVDC) links to Poland and Germany were unavailable owing to annual inspections and minor maintenance.

Triggering Events

At 12.30 pm on 23 September 2003, Unit 3 of the Oskarshamn nuclear power plant shut down automatically in response to internal valve problems in the feedwater circuits, reducing generating capacity by 1 175 MW. This loss was within the contingency standard established by the Nordic TSOs.

At 12.35 pm, a unique event led to the failure of a double bus bar in a 400 kV substation on the west coast of Sweden. As a result, circuit breakers for the transmission lines linking two 900 MW units at Ringhals immediately tripped, effectively reducing generation by a further 1 750 MW and severing the transmission path along the west coast.

(continued)

The south-east and south-west sections of the Swedish transmission network became heavily overloaded, with no major generation available in these regions to maintain reactive power. Voltage levels began to drop, reaching critical levels as demand in the region began to recover from the initial generation outages. Voltage collapsed in a section of the 400 kV transmission network south-west of Stockholm, which triggered automatic circuit breakers leading to a cascading failure of the entire southern portion of the transmission network. The interconnector between Sweden and Denmark (Zealand) also tripped.

System Impact

All supplies south of a line linking the cities of Norrköping in the east and Varberg in the west were disrupted. The total loss was around 3 000 MW in Sweden and 1 850 MW in Denmark.

Following emergency restoration procedures, lines and substations were energised to rebuild the network from north to south. The 400 kV grid was re-energised throughout the southern region and to Denmark within an hour. Regional and local networks were subsequently restored. By 7.00 pm almost all supplies in Sweden and Denmark had been restored.

Analysis

The initial failure was manageable within the normal system operating contingencies established by the n–1 reliability standards[13] applied throughout the Nordic Power System. However, the standards were designed around a minimum recovery period of 15 minutes between major events. In this case, the events occurred only five minutes apart. This highly improbable coincidence created a system operating environment closer to n–3 than n–1, leading to unmanageable conditions beyond the operational limits of the system and the resulting blackout.

Sweden's security of supply needs to be understood in the context of the Nordic electricity market as a whole. Increasing trade and regional integration resulting from electricity market reform have enabled Sweden to effectively draw on the reserves of other Nordic countries to enhance its security of supply, despite a continuing decline in excess Swedish generating capacity over the period.

The underlying growth in the electricity demand of the Nordic countries will continue to shift the region to increased reliance on imports of electricity, even in normal years. Nordel's energy balance analysis concludes that the entire region will still be able to cope with a single dry year out to 2006 to 2007 without serious difficulties through reliance on imports. Nordel forecasts also

13. n–1 reliability refers to a system that can continue to operate in the event of one linkage failure. n–3 is a system that can continue to operate with three linkage failures.

suggest that while peak demand can be met throughout the region on normal winter days, exceptionally cold winter days will require a very high reliance on imports into the Nordic region. However, the combination of a dry year and an unusually cold winter could seriously stretch security of supply, placing substantial stresses on market mechanisms.

Recognising that a harmonised solution to concerns about adequate supply was needed, Nordel and the electricity group for the Nordic Council of Ministers organised a seminar held in October 2002 to address this issue. A consensus emerged at the meeting regarding peak production capability and peak load in the Nordic electricity market wherein it was agreed that the long-term objective was to further develop the elasticity of demand in the market-place. At the same time, transitional arrangements might be needed until this elasticity was adequately developed. It was important that these transitional arrangements and the legal frameworks for security of supply be harmonised. Studies are under way to identify opportunities for increasing demand elasticity as well as the development of new financial instruments for hedging capacity shortages.

In the interim, the Swedish government has implemented a transitional arrangement to address immediate concerns over an emerging shortage of Swedish peaking capacity. This measure is embodied in recent legislation which took effect from 1 July 2003 and will remain in force until March 2008. Under this legislation, Svenska Kraftnät is required to contract for a capacity reserve of up to 2 000 MW per annum to be financed by balance providers. An objective of the programme is to encourage the development of commercially sustainable solutions to efficiently manage Swedish peak capacity needs beyond the transitional period. Accordingly, the programme will seek to be a catalyst for the development of commercially-driven products, particularly those promoting greater demand-side responsiveness. Svenska Kraftnät will determine the criteria for activating the capacity reserve, which is expected to be related to movements in the spot price.

Concurrently, Svenska Kraftnät will initiate work with industry on the development of financial risk management products to encourage the development of appropriate capacity reserves, while an R&D project will be commissioned to investigate demand sensitivity to price signals during peak periods. The government will conduct a review before the transition arrangements expire to determine whether voluntary, market-driven arrangements are likely to provide an effective response. If doubts persist, then the government has indicated that other policies may be considered, including regulation.

CRITIQUE

Access to reliable and affordable electricity services are central goals of Swedish economic and energy policy, and the country has historically been able to achieve these goals. In the 1990s, Sweden fundamentally reformed its electricity sector, in co-operation with other Nordic countries as well as in the context of the EU. The resulting Nordic electricity market has proven to be very successful, delivering considerable efficiency benefits for the Swedish economy and consumers, including relatively low and stable wholesale prices, strengthened reliability and efficient trading opportunities. The resilience and effectiveness of these arrangements were demonstrated during the 2002/03 winter when market prices encouraged efficient use of the electricity system, enabling the market to maintain reliable services despite an extreme combination of a one-in-70-year water shortage and an unusually cold winter. Sweden is to be commended both for the pioneering and far-sighted spirit in which it liberalised its electricity market and for its continued efforts to improve the system as it evolves and as more experience is gained.

Challenges that the Swedish government is now addressing include:

- A tightening of the supply-demand balance throughout the Nordic market, and particularly in Sweden, increasing the probability of reliability problems emerging during dry years and cold winters, and increasing the need for efficient market responses. Further nuclear plant closures would make this challenge more pressing.
- Growing concentration of ownership, particularly among generators, with the potential to reduce competitive pressure in the electricity market and to increase the potential for market power to be exercised in extreme circumstances.
- Emergence of significant constraints on the Nordic transmission network, particularly on interconnectors, with the potential to segment the Nordic market, effectively reducing system reliability and market efficiency, and increasing the potential for market power.
- Continuing inconsistency in the policy and regulatory framework applying to the Nordic market. Such inconsistencies, including use of *ex post* and *ex ante* regulation in different countries, different investment approval procedures inhibiting interconnector build, and different internal congestion management, can create uncertainty which in turn could undermine efficient market operation and development.

The combination of these issues could erode the sustainability and effectiveness of the Nordic electricity market and consequently its capacity to continue to deliver a reliable and affordable electricity service in the future.

Further strengthening of the regulatory and institutional framework may help to address some of these issues. It is important to ensure that regulatory institutions have clearly defined and adequate powers and resources to perform their supervisory roles. This will be particularly relevant if and when regulation in Sweden switches to *ex ante* regulation instead of *ex post* to comply with the EU directive. The current Regulator staff of 30 may be insufficient to undertake this significant shift. In addition, the government should ensure that staff and resources within the Ministry monitoring competition in the electricity market are adequate, especially as its focus continues its shift from a national to a Nordic perspective.

Appropriate harmonisation and co-ordination of regulation within the Nordic region is also necessary given the integrated nature of the Nordic electricity market. Further consideration should be given to clarifying roles and responsibilities of regulatory and market institutions in the Nordic context, also keeping in mind developments in the EU. The several initiatives currently being pursued by Nordel, particularly to strengthen co-ordination of system operation and whole-of-market network planning are positive steps. The recent agreement for closer co-operation between competition authorities within the Nordic market is also a positive step.

A critical factor determining whether the Nordic electricity market can continue to deliver affordable and reliable outcomes is the degree to which it remains an integrated market. Market splitting as a result of undue transmission congestion can undermine effective competition, reduce reliability, increase the cost of electricity and create opportunities for market power abuse. The frequency of congestion on the interconnected Nordic network is increasing, and work undertaken by Nordel indicates that there is likely to be a net benefit from alleviating the major constraints affecting flows to and from Sweden.

However, the continued prevalence of interconnection congestion suggests that insufficient investment has been made in this area to date. Effective regulatory arrangements supported by efficient, transparent and cost-reflective pricing could help to remove uncertainty and strengthen signals for timely, well-located new transmission investment. In particular, there is currently no clear responsibility for translating the Nordel planning process into timely and efficient investment. No single TSO is responsible for transmission development from a Nordic perspective, while the regulatory provisions governing transmission investment vary across the region and different regulators have incomplete responsibility for supervising interconnector investment processes. Nordel acts as a co-ordinating body but it does not have the force of law and cannot effectively provide a means of resolving issues where agreement cannot be reached. Concerns have also been expressed about the economic incentives TSOs have to efficiently strengthen interconnection with some suggestion that efficient augmentation from a Nordic market perspective may not always be in a TSO's commercial interest. The potential for auctioning rights to settlement residue surpluses could be examined in this context as a means of strengthening price signals for investment to alleviate interconnection congestion, and of promoting the development of related risk management products to support efficient inter-regional trade.

Ensuring sufficient peak power capacity, particularly during dry years, is a common concern. Svenska Kraftnät administers a capacity mechanism that involves contracting 2 000 MW of peak capacity until 2008 to address these concerns. The programme is transitional and an evaluation will be made in 2006/07 to determine whether a market-based response is likely to emerge. There is a need to ensure that such intervention is not unduly extended beyond this transitional period.

Notwithstanding the broad support this initiative appears to have among market participants, the mechanism has the potential to crowd out an efficient private response to peak demand requirements, adding to the cost of providing peak power and making it difficult for authorities to effectively evaluate the potential for a market-based response. Practical difficulties may increase where the trigger for intervention is not clearly prescribed. Basing intervention solely on spot price movements may add to this uncertainty and possibly lead to inappropriate intervention, given the inherent volatility of spot prices and potential for high spot prices to emerge for a variety of reasons that are not always related to underlying capacity balances. Consideration could be given to reducing any uncertainty by clearly identifying the trigger conditions for intervention in advance and by placing greater reliance on movements in the underlying capacity balance rather than on movements in spot prices in this context.

Substantial restructuring of the electricity sector was undertaken as part of the reforms implemented during the 1990s. These reforms included physical separation of the national transmission network from the competitive components of the value chain and legal separation of distribution from generation and retail businesses. However, concerns have emerged over growing concentration of ownership of generation and retail businesses, and its implications for weakening effective competition and increasing the potential for undue exercise of market power. Existing vertical integration may also warrant further examination, given the potential for integrated incumbents to use their vertical structure to exercise undue competitive advantage over potential new entrants and competitors, despite legal separation, possibly leading to a net reduction in benefits for consumers.

RECOMMENDATIONS

The government of Sweden should:

- *Explore opportunities for greater harmonisation within the Nordic market in relation to economic regulation, system operation and competition surveillance in the electricity sector, possibly in the context of the electricity group of the Nordic Council of Ministers and through Nordel.*

- *Monitor the evolution of production capacities in case of nuclear phase-out.*

- *Review closely all arrangements and responsibilities in relation to system operation and network planning to ensure that efficient and transparent development of the transmission network can proceed without undue delay. In this context, take steps to improve price signals for new investment and for expediting investment to strengthen interconnections where clear economic cases exist.*

- *Monitor the peaking power contracting by Svenska Kraftnät to ensure it does not undermine the development of efficient, market-based demand response or peak generation investment. Consider clearly identifying the trigger conditions for intervention and strengthening the link between the trigger conditions and movements in physical reliability balances.*

- *Examine options for further structural reform to strengthen competition and reduce the potential for undue exercise of market power, including options to manage concentration of ownership among generators and retailers. Examine whether strengthening the separation of transmission and distribution networks from generation and retail businesses is warranted.*

NUCLEAR POWER CAPACITY AND OPERATION

There are four nuclear power sites in Sweden – Barsebäck, Forsmark, Orskarshamn and Ringhals. Together they represent a total installed capacity of 9.4 GWe net, or approximately 30% of the total electricity generating capacity of the country. The eleven nuclear units in operation on those four sites produced some 66 TWh in 2002, *i.e.* nearly 46% of total Swedish electricity generation. Nuclear electricity is the second-largest domestic electricity supply source of Sweden just after hydropower and both are major contributors to the low carbon intensity of the Swedish energy sector. The ownership of the nuclear power plants is dominated by state-owned Vattenfall and privately-owned Sydkraft.

Table 15

Nuclear Units in Operation in Sweden as of October 2003

Name	*Capacity (MWe net)*	*Type* [(1)]	*Commercial operation*	*Owner*
Oskarshamn-1	445	BWR	1972	Sydkraft (55%), Fortum (45%)
Oskarshamn-2	605	BWR	1975	
Oskarshamn-3	1 160	BWR	1985	
Ringhals-2	875	PWR	1975	Vattenfall (74%), Sydkraft (26%)
Ringhals-1	830	BWR	1976	
Ringhals-3	915	PWR	1981	
Ringhals-4	915	PWR	1983	
Barsebäck-2	600	BWR	1977	
Forsmark-1	968	BWR	1980	Vattenfall (66%), Mellansvensk (26%), Sydkraft (8%)
Forsmark-2	964	BWR	1981	
Forsmark-3	1 155	BWR	1985	

(1) BWR = boiling water reactor; PWR = pressurised water reactor.

Source: Nuclear Energy Agency.

After Barsebäck-1 was closed down in 1999 according to the 1998 "Act on the Phasing-out of Nuclear Power", eight BWRs and three PWRs remain in operation (see Table 15). Put into commercial operation between the early 1970s and the mid-1980s, the Swedish nuclear units have an average age of around 25 years. According to the Swedish regulatory framework, all nuclear units have received a licence to operate as long as safety problems are not identified by the nuclear safety authority (Statens Kärnkrafinspektion – SKI). Several units have been refurbished in order to upgrade safety features and increase generating capacities. Today, both Vattenfall and Sydkraft plan upgrading their nuclear units to enhance safety, increase capacity and extend their lifetimes.

In 2001, the average availability factor for Swedish nuclear plants was 86.3%, compared to a world average of 83.4%. In 2002, the figures were 81.6% for Sweden and 83.8% for the world. The availability factors are sensitive to specific events such as reloads, maintenance and upgrades, so single-year availabilities can only provide a limited means of plant comparisons.

FUEL AND WASTE

Uranium production ended in Sweden by the end of the 1970s. Swedish utilities import uranium and enrichment services from abroad. A fuel fabrication plant, processing imported enriched uranium and producing fuel assemblies, owned and operated by Westinghouse Atom AB, has been in service since 1971 at Västerås; it supplies fuel to Swedish and foreign utilities while some Swedish utilities buy part of their fuel from foreign companies.

A repository for low and intermediate-level waste (SFR-1), located near the Forsmark nuclear power plant, has been in operation since 1988. The facility, built and operated by SKB (Svensk Kärnbränslehantering AB – Swedish nuclear fuel and waste management company – jointly owned by Swedish nuclear power plant operators), has a capacity sufficient to receive operational and decommissioning waste arising from all Swedish nuclear units.

SKB also operates the interim storage facility for spent fuel (CLAB), located near the Oskarshamn power plant which has a capacity adequate for receiving spent fuel for some 50 years of cooling and radioactive decay, after which it will be conditioned for final disposal. SKB pursue R&D on encapsulation of spent fuel and on the implementation of a repository for its final disposal. According to the present schedule, the spent fuel repository should be commissioned by 2015.

According to the law (1992 Act on the Financing of Future Expenses on Spent Fuel), generators of nuclear electricity are responsible for the costs of radioactive waste management and disposal and of decommissioning of facilities. The nuclear power utilities collect a fee on each unit of nuclear electricity generated and contribute to a fund – the Nuclear Waste Fund – placed under regulatory supervision. The fund must cover all expenses for the management and disposal of spent fuel, dismantling and decommissioning of facilities and R&D undertaken by SKB. The fund amount was considered sufficient to cover its responsibility so that the levy was reduced several years ago. The average fee is currently SK_2 0.005 per kWh, based upon the assumption that each reactor will generate electricity for 25 years.

GOVERNMENT BODIES

Two governmental authorities have a regulatory and supervisory role in connection with safety and radiation protection, the Swedish Nuclear Power Inspectorate (SKI) and the Swedish Radiation Protection Institute (Statens Strålskyddsinstitut – SSI).

SKI is the regulatory body in charge of making sure that licensees actually assume their responsibilities. The regulatory role of SKI applies to all nuclear facilities, including research reactors and interim storage facilities for spent fuel. SKI conducts inspections at nuclear facilities, analyses reports submitted by operators and can, wherever appropriate, request the operator to take actions for enhancing the safety or to close down a facility. SSI is responsible for ensuring and controlling the application of the 1988 Radiation Protection Act.

The nuclear safety authority is facing a number of challenges in the context of electricity market liberalisation enhancing the drive to lowering costs, and uncertainties about the future of nuclear energy that may reduce the motivation for safety culture and the quality of staff. However, so far, the safety records of Swedish nuclear units have remained very high with no major incidents or accidents occurring in the nuclear power plants in operation.

Nuclear fission R&D is financed mainly by the industry, either directly or indirectly through the safety authority. SKI and SSI carry out research in the field of nuclear safety and participate in international programmes on safety enhancement. The scope of R&D focuses on support to present technology, enhancing its safety and performance, maintaining competence (education), and waste management and disposal.

Sweden is party to a number of international conventions, including third-party liability in the field of nuclear energy; early notification of a nuclear accident; assistance in the case of a nuclear accident or radiological emergency; nuclear safety and safety of spent fuel and radioactive waste management.

PROPOSALS FOR NUCLEAR ENERGY PHASE-OUT

Nuclear power has been a political issue in Sweden since the general election of 1976, when concerns about radioactive waste issues were expressed by one political party. Nevertheless, a rather large nuclear power programme was developed in the late 1970s on the grounds of its economic competitiveness and as a means to ensure energy independence in the long term.

After the Three Mile Island accident in the United States, increased concerns were raised on safety issues by political parties and the public. In 1980, the Swedish voters opted by referendum for a delayed phase-out of nuclear energy and the parliament passed a legislation setting 2010 as the date for completion of the phase-out, under certain conditions, while authorising the completion of five reactors which were still under construction. This was followed by a decision to close two reactors in 1995 and 1996.

The main conditions attached by the parliament to the closing-down of nuclear units, in both the 1980 and 1988 decisions, are that welfare of society and level of employment be maintained; use of oil and gas should not increase; and renewable energy sources should be available. Recognising that the conditions were not met, the government appointed an Energy Commission, which delivered its report at the end of 1995, although the nuclear policy was not substantially changed.

The 1997 parliament decision on energy policy stated that two reactors would be closed down in 1998 and 2001, and removed the 2010 deadline for complete phase-out. The 1998 Act on the Phasing-out of Nuclear Power allows the government to decide on closing down a nuclear power plant at a certain point in time, irrespective of safety issues, provided losses incurred by the owner are compensated by the State.

After a series of decisions and negotiations with the owner, Barsebäck 1 was shut down on 30 November 1999 according to the 1998 Act. In 2000, it was decided that the conditions for closure of Barsebäck-2 will not be fulfilled before 2003. In 2002, a "negotiator" was appointed with a mandate to discuss with the industry and other stakeholders the conditions of a gradual phase-out of nuclear power, including the closure of Barsebäck-2, and other issues in relation to securing long-term cost-effective and sustainable energy supply for Sweden. The negotiator will report on the Barsebäck-2 closure by the end of April 2004 with the understanding that the principles for the overall future of the nuclear phase-out will follow shortly thereafter. The prerequisite to shut down any nuclear unit remains securing long-term cost-effective alternative energy supply sources as replacement.

CRITIQUE

More than two decades after the referendum on nuclear phase-out, the future of nuclear energy remains a key issue at the forefront of Swedish energy policy. The significant role of nuclear in security of supply and GHG emissions mitigation, and the political dimension of the debate about nuclear energy are contributing to the complexity of the decision-making process and the difficulties to find a robust solution.

The government negotiator, appointed in 2002, is in charge of reaching an agreement with stakeholders on the condition of a progressive nuclear phase-out, including the closing-down of Barsebäck-2. He will report at least on Barsebäck-2 closure issues, by the end of April 2004. The prerequisite to shut down any nuclear unit remains the securing of long-term cost-effective alternative energy supply sources as a replacement.

Uncertainties regarding the future operation of nuclear power make it more difficult to reach national energy policy goals such as achieving security of energy supply, CO_2 emissions reductions and economic efficiency.

While the owners/operators of nuclear units have made the necessary investments to guarantee a safe and reliable operation of the plants, uncertainties on the phase-out scheme to be adopted by the government prevent investments in refurbishment and upgrade that could be economically effective in a competitive market if the lifetime of plant could be predicted with reasonable certainty. Similarly, adequate investments in alternative sources require a stable framework that would allow an assessment of potential market demand taking into account future nuclear electricity generation.

Progress has been made since 1991 on government strategy to secure long-term sustainable energy supply through support to the development of alternatives to nuclear power, including renewable sources, energy efficiency and demand-side response. However, it is essential that, in their negotiations, the parties reach an agreement with a credible implementation plan.

The national energy policy implications of the nuclear phase-out are significant. Replacing nuclear energy currently providing 46% of electricity generation and 35% of TPES will pose serious challenges to the three fundamental pillars of national energy policy, namely, economic growth, security of energy supply and environmental protection. Depending on the final agreement, the impact of phasing out nuclear may be limited in terms of reaching the target under the Kyoto Protocol, but it will definitely have a large implication in achieving Sweden's long-term vision to reduce total GHG emissions per capita to less than 4.5 tCO_2. It will be extremely difficult to fill the gap of nuclear with energy efficiency and renewables. While natural gas could be a competitive alternative to nuclear without its perceived safety and environmental problems, moving from carbon-free nuclear power to a fossil fuel would necessarily incur environmental costs. Increased imports may be an option, but it should be noted that Nordic electricity markets are showing signs of undercapacity.

It is essential for the government to develop a reliable estimate of the short-, mid- and long-term consequences of the phase-out. This would include the costs and benefits of such a plan as well as the options to replace lost nuclear power in the light of energy security, climate change mitigation and economic growth. Such information should be widely disseminated to the general public.

The Swedish policy on radioactive waste management and disposal is coherent and comprehensive. Satisfactory solutions are in place for low-level waste disposal but, while scientific and technical feasibility studies have already been completed on high-level waste disposal, decisions have not been taken yet on selecting a site for constructing a final repository.

RECOMMENDATIONS

The government of Sweden should:

- *Pursue the negotiations with the industry to reach an agreement on phasing out nuclear power with a credible and commonly agreed implementing plan.*
- *Ensure that the nuclear power plants in service continue to be operated safely.*
- *Pursue the implementation of a final repository for high-level radioactive waste.*

ENERGY RESEARCH AND DEVELOPMENT

OVERALL POLICY OBJECTIVES

The overall objective of Swedish energy research and development (R&D) policy is to build a scientific and technical foundation of competence in university and industry so that the development and realignment of the energy system can proceed in accordance with the guidelines decided by parliament in 1997. Energy research is expected to contribute to the basic conditions enabling competitive industry and industrial development. Energy research should also play a role in the broadened collaboration on energy, environment and climate in the Baltic Sea region.

Government uses R&D to promote commercial applications where possible, particularly for new technology with higher efficiency and lower environmental effects. Among the areas that parliament has highlighted are combined heat and power (CHP) production using biofuels, biofuel production, new processes for the production of ethanol from woody biomass, alternative fuels, large-scale utilisation of onshore and offshore wind, photovoltaics, as well as efficient use of energy in buildings, industry and transport.

Sweden has had government-funded energy R&D programmes since 1975. The current programme was initiated by the government bill, A Sustainable Energy Supply (Prop. 1996/97:84), adopted by the Swedish parliament in 1997. In accordance with this bill, government efforts to promote energy technology development were reinforced and concentrated. The 1997 energy policy decision established two programmes: a short-term programme (1998 to 2002) focusing on ways to increase the supply of renewable electricity and reduce electricity consumption in a shorter perspective, and a long-term programme focusing on energy RD&D (1998 to 2004).

The 1997 short-term programme ended in December of 2002. In accordance with the government bill, Co-operation for a Secure, Efficient and Environment-friendly Energy Supply (Prop. 2001/02:143), a new five-year programme of more short-term and market-oriented measures was decided upon. This decision confirms that the long-term energy policy from 1997 is still active and that the new programme constitutes a continuation of the 1997 energy policy programme.

In December 2001, the government assigned the Commission on Energy Research, Development and Demonstration (ERDD) with the task of examining the results achieved and proposing guidelines for the forthcoming planning period. The commission funded several project evaluations, including a major review of the programme by five international experts. The nature and result from this conclusion are discussed in the section "Commission Findings". After consultations taking into account the commission's findings, a government bill will be prepared and submitted to parliament by March 2004. This will make it possible for a new long-term energy policy programme to be introduced from 2005.

GOVERNMENT AND PRIVATE RESEARCH STRUCTURE

The 1997 long-term programme received a total funding of SKr 5 070 million for the seven-year period. The Swedish National Energy Agency was established on 1 January 1998 and given the overall responsibility for administration of the programme. The bulk of the funding is also allocated to the National Energy Agency, although some funds are allocated to other government agencies for work in their specific areas of responsibility.

The structure of the Swedish government R&D funding agencies was changed on 1 January 2001. The Swedish Transport and Communications Research Board (KFB), the Swedish Council for Building Research (BFR), the Swedish Natural Science Research Council and the Swedish Research Council for Engineering Sciences were all abolished. The responsibilities of these agencies in relation to the long-term energy policy programme are now carried out by the Swedish Research Council (Vetenskapsrådet), the Research Council for Environment, Spatial Planning and Agricultural Services (FORMAS), and the Swedish Agency for Innovation Systems (VINNOVA).

Sweden has developed a smaller number of research centres than other European countries. Instead, the universities are given the task of providing more applied research and industrial collaboration. In order to strengthen this system, a number of "hubs" or "competence centres" were established by the Swedish National Board for Industrial and Technical Development (NUTEK). There are currently five energy-related competence centres:

- Competence Centre for Combustion Engines Research (CERC).
- Competence Centre for High Temperature Corrosion (HTC).
- Competence Centre for Catalysis (CTK).
- Competence Centre in Electric Power Engineering.
- Competence Centre for Combustion Processes.

In addition, the Consortium for Gas Turbines fulfils a similar role while not meeting all the criteria for a centre of competence. These centres are all co-financed by the Swedish Energy Agency, various industrial alliances and the university itself, each one contributing about one-third of the budget.

Sweden participates in 27 IEA Implementing Agreements. In addition, Sweden is involved in the European Community's Sixth Framework Programme for research, technology development and demonstration activities. Moreover, Sweden is engaged in Intelligent Energy for Europe, the new programme which has four fields of action; SAVE, ALTENER, STEER and COOPENER. Sweden participates in the European Research Area (ERA), in the fields of bioenergy and photovoltaics and the Swedish Energy Agency is also a member of the European Energy network, EnR.

In addition to government-financed energy R&D, a number of private companies and organisations are active in this area. Among them are Elforsk, which is owned by Swedish electricity suppliers and network operators. The total funding for all electricity companies on R&D is SKr 500 to SKr 600 million per annum, of which approximately SKr 90 million goes to Elforsk. The total Elforsk funding, including government contributions and other co-financing amounts to SKr 200 million per annum. Other private R&D actors in the energy field include ABB, Vattenfall, Sydkraft, the Swedish Steel Producers' Association (Jernkontoret), Scania and Volvo.

RESEARCH ACTIVITIES

The total financing of energy RD&D from the government (through the Swedish Energy Agency, FORMAS, VINNOVA and the Swedish Research Council) during 2002 amounts to SKr 853 million. At the same time, industry spent SKr 760 million for a total of over SKr 1 600 million for energy RD&D during 2002. Table 16 shows the breakdown of government funding by sector for 2002.

Table 16

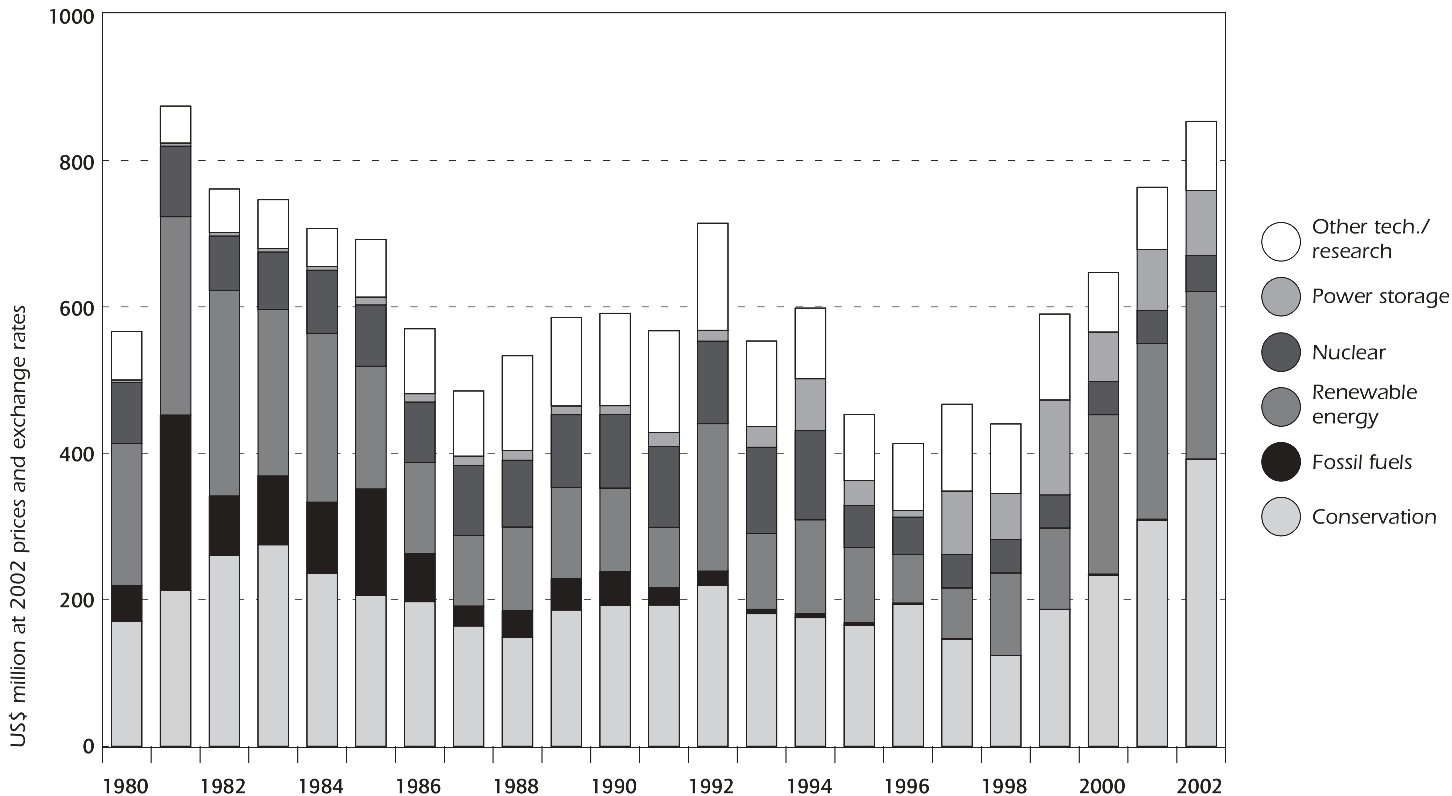
Government Spending on Energy R&D, 2002

Research areas	*Amount (SKr million)*	*% of total*
Total conservation	**391**	**46%**
Industry	72	
Residential	41	
Transport	249	
Other	29	
Total fossil fuels	**1**	**0.1%**
Coal	1	
Total renewables	**229**	**27%**
Biomass	133	
Geothermal	35	
Wind	28	
Solar	25	
Hydro	8	
Total nuclear power	**49**	**6%**
Nuclear fission	39	
Nuclear fusion	11	
Total power & storage technology	**89**	**10%**
Total other energy	**94**	**11%**
TOTAL ENERGY R&D	**853**	

Source: IEA.

Figure 18

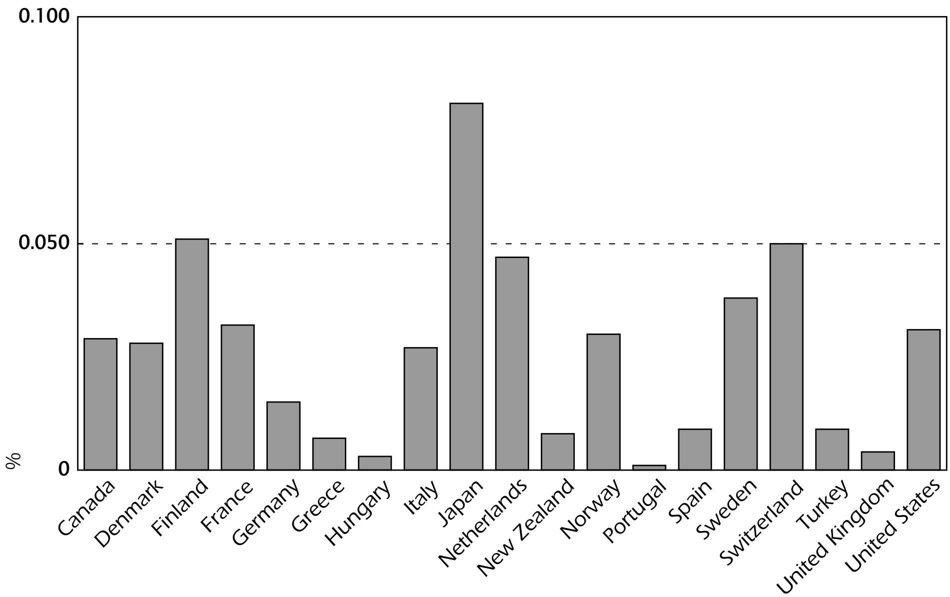
Energy R&D Budget by Sector, 1980 to 2002



Source: Country submission.

Figure 19

Energy R&D Budget as Percentage of GDP in IEA Countries, 2001



Note: data not available for Australia, Austria, Belgium, Czech Republic, Ireland, Korea and Luxembourg.
Source: Country submissions.

It is worth noting that while the large majority of IEA countries have reduced government expenditure on energy R&D, Sweden has increased its spending in both absolute terms and as a percentage of GDP. Figure 18 shows Sweden's historical spending on energy R&D by sector and Figure 19 shows the share of government energy R&D per GDP for IEA countries.

BIOFUELS FOR TRANSPORT

The new Swedish R&D programme for alternative fuels will run from 2003 to 2006 and projects within the programme are still being decided. The total budget is SKr 56 million, half for research and half for development projects. The programme involves both alternative fuels and activities related to hydrogen.

The second phase of the ethanol programme from woody biomass is running from January 1998 to December 2004. The annual budget is SKr 30 million, or SKr 210 million for the seven-year programme period. The programme supports basic research, development projects and work in pilot plant scale. The main goal is to demonstrate ethanol production at large scale within the programme period. A pilot plant for ethanol from woody biomass is currently being built at Örnsköldsvik, in the north of Sweden. The plant allows processes based on dilute acid hydrolysis and enzymatic hydrolysis to be studied.

HEAT AND POWER PRODUCTION

Combustion and Gasification of Solid Fuels for CHP is a four-year research programme running from July 2000 to June 2004. The total budget for the programme is SKr 60 million. The long-term goal is to improve the competitiveness of biofuel-based power heat production.

Thermal Processes for Electricity Production runs from 1999 to 2003 and has a total budget of SKr 60 million. The programme is focused on the development of effective processes for power or CHP production based mainly on biofuels and natural gas.

The Consortium for Material Technique for Thermal Energy Processes is an industry consortium for long-term research. Their current programme runs from January 2001 to December 2004. The programme budget is SKr 67 million, half of which comes from the government. The goal is to improve thermal processes for energy transformation through advanced material developments.

A number of other Swedish R&D programmes are active in heat and power production, including:

- The Competence Centre for Combustion Processes has a budget of SKr 62 million.
- The Competence Centre for High Temperature Corrosion has a budget of SKr 55 million.
- Värmeforsk's Basic Programme – a three-year development programme for power and heat production installations running from January 2002 to December 2004. The government supplies 40% of the SKr 50 million total budget.
- Swedish Gas Turbine Centre programme from 2001 to 2004 has a budget of SKr 48 million of which 50% comes from the government.
- Centre of Combustion Science and Technology has a budget of SKr 76 million, 50% of which comes from the government.

INDUSTRIAL PROCESSES

The second period of the Process Integration Programme is broken down into two parts. The first is for basic research and runs from July 2000 to June 2004 with a total budget of SKr 12.4 million. The long-term goal is to decrease the energy consumption and harm caused to the environment by the Swedish industry. The second part is devoted to development and has a total budget of SKr 32 million of which the government contributes up to SKr 16 million.

The first period of the Separation Process Programme will run from 2002 to 2005. The goal is to gather competence and strengthen the knowledge about different sorts of separation techniques in Sweden. The research component of this programme has a total budget of SKr 16 million. The development component of the programme has an estimated total budget of SKr 32 million of which the government contributes up to SKr 16 million.

TRANSPORT

Research activities in Swedish transport are motivated by three factors:

- In Sweden, 66% of all oil consumption was for transport (2001).
- The Swedish parliament's goal to reduce GHG emissions by 4% relative to 1990 as a mean value over the period 2008 to 2010.
- The voluntary agreement between the European automotive industry and the European Commission to reduce CO_2 emissions from new passenger cars by 25 % by 2008, relative to the 1995 levels.

In April 2000, an agreement was signed between the Swedish government and the vehicle industry, establishing a Co-operative Programme on Environment-friendly Vehicles. The programme began in 2000 and is to run for six years. It has a total budget of approximately SKr 1 800 million of which the government will provide SKr 500 million and the automotive industry the rest. The programme focuses on environmental issues, including the climate, and comprises work on more efficient internal combustion engines and drive trains, fuel flexibility, hybrid and fuel cell vehicles, flexible and lighter vehicles, and road traffic information systems.

The programme Energy Systems in Road Vehicles is centred on the training of PhD candidates working in this area. It will run for four years with a budget of SKr 119 million. The long-term goal is to pursue co-operative research to develop and deploy automotive technologies to reduce fuel consumption in new cars by 50% and heavy-duty vehicles by 20%.

The Emissions Research Programme (EMFO) is a joint programme between the automotive industry and the government. The programme was decided during 2002 and will primarily deal with research on emissions from road transport. In addition, there are two competence centres – both at Chalmers University of Technology – doing work in this field, the Combustion Engines Research (CERC) and the Competence Centre for Catalysis (CTK).

BUILDINGS

A four-year programme, Emissions and Air Quality, ran from 2000 to 2003 and was government-financed with a total budget of SKr 30 million. The long-term goal is to achieve the environment targets and at the same time ensure that the use of renewable fuels can increase in conjunction with energy conversion. This is achieved by supporting projects carried out by research institutes, authorities, county councils, municipalities and industry, whose purpose is to provide better knowledge about air quality, as well as about the spread of pollution.

A three-year programme, District Heating, ran from 2001 to 2003 with a total budget of SKr 49.5 million of which the government provided 40% and the Swedish District Heating Association provided the remaining 60%. The long-term intention is to strengthen the competitiveness of district heating by a co-operation between, among others, universities and the private sector; and the short-term goal is to improve new installation and maintenance so that the life span, energy effectiveness and economy of the plants are optimised

A three-year applied R&D programme, Efficient Heat Pumping Systems (Eff-Sys) ran from March 2001 to February 2004 with a budget of SKr 54 million. Financing was shared by the government and industry in equal measures.

RENEWABLE ENERGY

Government R&D activity takes place in the following renewable energy technologies:

- **Hydropower.** Two major programmes seek general improvements in hydropower technology and improvement of the water environment used for hydropower generation.
- **Photovoltaic cells.** One major programme seeks to develop thin film solar cells, Grätzel solar cells and "smart" windows, while another focuses on a user-oriented development of complete solar cell systems.
- **Wind power.** A number of research programmes focus on how to integrate wind plants into the Swedish energy system without negatively impacting the environment.
- **Biomass.** The government spends about 16% of its total energy R&D research in the field of biomass. Various programmes look at fuels from agricultural lands, carbon balances, biomass and the environment, and refined solid biomass.
- **Solid waste (including biogas).** There is one government-sponsored research programme in this area looking at achieving energy production with minimal environmental consequences.
- **Geothermal.** The government is supporting a programme to examine possibilities for deep geothermal energy in southern Sweden (Skåne) and another to look at deep drilling for geothermal energy in Lund.

NUCLEAR POWER

Nuclear safety research is mainly financed by the Swedish Nuclear Power Inspectorate (SKI) with an annual research budget of SKr 71 million. These funds are used to finance research in Reactor Safety, Nuclear Waste Safety and Non-Proliferation, including participation in international projects such as the EU framework programmes on nuclear fission safety.

The nuclear utilities, through the jointly-owned company SKB AB, are pursuing an RD&D programme aimed at a final geological repository for spent fuel. The annual budget is about SKr 920 million, including costs for operation and construction of an extension of the interim storage facility for spent fuel (CLAB). The cost for this waste programme, including decommissioning, is included in the selling price of the kWh for nuclear electricity. Major R&D installations include the Äspö hard rock laboratory, built in 1990 to 1995 and in operation since then, and the Canister laboratory, inaugurated in 1998 and aimed at developing encapsulation technology.

Sweden also participates in the integrated European Fusion Programme. The Swedish Research Council is responsible for the support to fusion research in Sweden. The European and the national programmes will now be adapted to the implementation of the large international fusion project ITER.

HYDROGEN AND FUEL CELLS

Government support is given to the Stationary Fuel Cell Programme running from 2002 to 2005. The overall goal of that work is to increase the competence within academia to render possible and efficient the introduction of fuel cells into the Swedish energy system.

COMMISSION FINDINGS

As mentioned above, the government recently tasked an evaluation of long-term R&D policy to the Commission on Energy Research, Development and Demonstration (ERDD).

The major findings of the commission were broken down into five major points:

- The orientation of Swedish ERDD appears to be reasonable although there are problems in the form of fragmentation and insufficient focus on commercialisation.

- The scientific quality of the ERDD projects appears to be reasonable. However, there is some doubt regarding the relevance of the projects, especially concerning the capacity of ERDD to lead to commercialisation of products.
- The organisation of ERDD is sound although the commission considers that there should be greater organisational concentration of resources to establish critical masses of capabilities in the most relevant R&D sectors.
- The impact of the R&D programme would be greater if a single arena for the administration of state ERDD measures were created. At the same time, regarding administration of the programme, the work now being carried out by the four public agencies responsible is going well.
- The objectives of the long-term R&D programme have largely been filled, although they could benefit from greater clarification.

The commission's conclusion based on these results is that no fundamental changes need to be made in the scale or the approach of Swedish ERDD policy. It notes that, while improvements are possible, they can very well take place within the existing ERDD framework.

As to areas of focus, the commission concluded that it would be more beneficial to divide the measures more clearly into the two following separate categories:

- Sectors where Sweden will maintain just the minimal national capacity to stimulate innovative ideas that largely originate elsewhere.
- Sectors where Sweden should provide more substantial contributions in both basic research and the involvement of industry in product commercialisation. These sectors would be those where Sweden has comparative advantages, those where the country is expected to establish industrial clusters and those which can contribute to Sweden meeting its energy policy objectives.

While the commission did not specify which technologies would fall into which of the two categories above, it did recommend that the future RD&D programmes establish priorities and focus on the sectors that are more likely to contribute to the attainment of the Swedish energy policy objectives. These sectors are the ones where research efforts are more likely to contribute to the development of competitive commercial products.

The commission also recommends the adoption of an improved project selection method based on the relevance and the quality of the proposed projects. Relevance here relates to the potential impacts of science and technology such as CO_2 offsets, other environmental benefits or generated business activity. Quality includes factors, such as team composition, that influence the likelihood of reaching the project goals, and the inclusion in the team of partners that have the ability to commercialise the developed technology.

CRITIQUE

Swedish government R&D spending in the energy field has expanded dramatically in recent years. From a recent low of SKr 413 million in 1996, spending has risen over 100% to SKr 853 million in 2002. While some of this increase has to do with expenditure cycles related to the long-term programmes of government agencies, it nevertheless signals a welcome trend in the country's approach to energy R&D.

Sweden's R&D spending is generally at or above that of other countries when measured as a percentage of national GDP. In 2002, Sweden spent 0.038% of its GDP on energy R&D. Of all the IEA countries, only Finland, Switzerland, the Netherlands and Japan invested more in energy R&D as a share of their GDP.

Sweden's participation in the numerous IEA Implementing Agreements is commendable. This allows the country to leverage its R&D spending by co-ordinating with researchers in other countries.

The recent commission report evaluating Swedish R&D programmes offers a worthwhile assessment of the country's strategy. While noting, correctly, that the essential framework and orientation are sound, the report at the same time raises a number of valuable recommendations, two of which may be particularly helpful.

The first recommendation is to define those sectors that need only a minimum level of competence and those in which Sweden can truly excel. It is unreasonable to expect Sweden to produce advances in every energy sector and therefore inefficient to use resources in trying to achieve this. By maintaining just enough expertise to assimilate technological advances made elsewhere, more resources could be marshalled into those areas where Sweden has a distinct interest. As the report points out, these latter areas are those where Sweden has a comparative advantage (through natural resources and/or historical expertise) or those that can help the country meet its energy and environmental goals.

This is not to suggest, however, that the current allocation of Swedish R&D funding is fundamentally flawed. Nearly one-half of the money is directed towards conservation, which complements the country's growing attention to this area and of that amount over 60% is going to the transport sector. This is particularly sound since transport represents the sector with the highest rate of energy and emissions growth and which is most resistant to certain policy measures, such as emissions trading. Another sector receiving significant funding is biomass, which is consistent with Sweden's already high level of expertise in this field and its abundant biomass resources.

The second key recommendation of the commission report is to improve the commercialisation yield of energy R&D. Commercialisation is always a delicate area in R&D since it often represents the nexus of government and industry participation. Nevertheless, it appears that the Swedish system has something of a gap between the public and the private actors and could benefit from some of the recommendations in the commission report. In particular, the National Energy Agency's objectives should more explicitly include bringing products to market, the agency should be more active in promoting commercialisation and the government should do more to bring venture capital to promising technologies arising from the more basic research. These objectives need not be accomplished by directing more government funding towards commercialisation efforts at the expense of basic research. Commercialisation still remains largely the domain of industry, with government handling basic research. Nevertheless, more effective liaisons between government and industry both in the planning and the implementation phases should be pursued as a means of increasing the commercialisation yield.

RECOMMENDATIONS

The government of Sweden should:

- *Renew the RD&D programme funding at a comparable level.*
- *Implement the recommendations of the Commission on Energy Research, Development and Demonstration (ERDD), including increasing the proportion of projects that will lead to the commercialisation of new energy efficiency and renewable energy technologies.*

ANNEX

ENERGY BALANCES AND KEY STATISTICAL DATA

Unit: Mtoe

SUPPLY		1973	1990	2001	2002	2010	2020	2030
TOTAL PRODUCTION		**9.3**	**29.8**	**34.3**	**32.4**	**33.7**	**..**	**..**
Coal[1]		0.0	0.0	–	–	–	..	..
Peat		–	0.2	0.3	0.3	0.3	..	..
Oil		–	0.0	–	–	–	..	..
Gas		–	–	–	–	–	..	..
Comb. Renewables & Wastes[2]		3.5	5.5	8.0	8.3	9.5	..	..
Nuclear		0.6	17.8	18.8	17.6	17.2	..	..
Hydro		5.1	6.2	6.8	5.7	6.0	..	..
Geothermal		–	–	–	–	–	..	..
Solar/Wind/Other[3]		–	0.0	0.4	0.4	0.8	..	..
TOTAL NET IMPORTS[4]		**29.6**	**16.7**	**16.7**	**17.6**	**19.9**	**..**	**..**
Coal[1]	Exports	0.0	0.0	0.0	0.0	–	..	..
	Imports	1.7	2.6	2.4	2.3	2.4	..	..
	Net Imports	1.7	2.6	2.4	2.3	2.4	..	..
Peat	Exports	–	–	–	–	–	..	..
	Imports	–	–	–	–	–	..	..
	Net Imports	–	–	–	–	–	..	..
Oil	Exports	1.4	8.7	10.2	9.5	–	..	..
	Imports	30.4	23.1	25.7	24.8	18.3	..	..
	Bunkers	1.1	0.7	1.4	1.2	1.9	..	..
	Net Imports	27.8	13.8	14.2	14.1	16.4	..	..
Gas	Exports	–	–	–	–	–	..	..
	Imports	–	0.5	0.8	0.8	0.8	..	..
	Net Imports	–	0.5	0.8	0.8	0.8	..	..
Electricity	Exports	0.4	1.3	1.6	1.3	–	..	..
	Imports	0.5	1.1	1.0	1.7	0.4	..	..
	Net Imports	0.1	–0.2	–0.6	0.5	0.4	..	..
TOTAL STOCK CHANGES		**0.5**	**0.2**	**0.2**	**1.0**	**–**	**..**	**..**
TOTAL SUPPLY (TPES)		**39.3**	**46.7**	**51.2**	**51.0**	**53.7**	**..**	**..**
Coal[1]		1.6	2.7	2.5	2.5	2.4	..	..
Peat		–	0.2	0.3	0.3	0.3	..	..
Oil		28.4	13.8	14.3	14.9	16.4	..	..
Gas		–	0.5	0.8	0.8	0.8	..	..
Comb. Renewables & Wastes[2]		3.5	5.5	8.0	8.3	9.5	..	..
Nuclear		0.6	17.8	18.8	17.6	17.2	..	..
Hydro		5.1	6.2	6.8	5.7	6.0	..	..
Geothermal		–	–	–	–	–	..	..
Solar/Wind/Other[3]		–	0.0	0.4	0.4	0.8	..	..
Electricity Trade[5]		0.1	–0.2	–0.6	0.5	0.4	..	..
Shares (%)								
Coal		*4.1*	*5.8*	*4.9*	*4.9*	*4.4*	..	..
Peat		–	*0.5*	*0.5*	*0.7*	*0.5*	..	..
Oil		*72.2*	*29.6*	*27.9*	*29.2*	*30.6*	..	..
Gas		–	*1.1*	*1.5*	*1.5*	*1.4*	..	..
Comb. Renewables & Wastes		*9.0*	*11.8*	*15.7*	*16.3*	*17.8*	..	..
Nuclear		*1.4*	*38.1*	*36.7*	*34.5*	*32.1*	..	..
Hydro		*13.1*	*13.4*	*13.3*	*11.2*	*11.1*	..	..
Geothermal		–	–	–	–	–	..	..
Solar/Wind/Other		–	–	*0.8*	*0.9*	*1.4*	..	..
Electricity Trade		*0.2*	*–0.3*	*–1.2*	*0.9*	*0.7*	..	..

0 is negligible, – is nil, .. is not available.

Unit: Mtoe

DEMAND

FINAL CONSUMPTION BY SECTOR

	1973	1990	2001	2002	2010	2020	2030
TFC	**35.3**	**32.1**	**34.7**	**35.0**	**37.3**	**..**	**..**
Coal[1]	0.9	1.0	0.7	0.9	0.7	..	..
Peat	–	0.0	0.0	0.0	–	..	..
Oil	24.8	14.0	13.4	13.4	14.5	..	..
Gas	0.1	0.4	0.5	0.5	0.5	..	..
Comb. Renewables & Wastes[2]	3.5	4.6	4.7	4.9	6.2	..	..
Geothermal	–	–	–	–	–	..	..
Solar/Wind/Other	–	0.0	0.0	0.0	–	..	..
Electricity	6.0	10.4	11.4	11.3	11.7	..	..
Heat	–	1.7	4.0	4.0	3.8	..	..
Shares (%)							
Coal	*2.6*	*3.3*	*2.2*	*2.7*	*1.9*	..	..
Peat	–	–	–	–	–	..	..
Oil	*70.4*	*43.7*	*38.5*	*38.1*	*38.8*	..	..
Gas	*0.3*	*1.1*	*1.4*	*1.4*	*1.3*	..	..
Comb. Renewables & Wastes	*9.8*	*14.4*	*13.5*	*14.0*	*16.5*	..	..
Geothermal	–	–	–	–	–	..	..
Solar/Wind/Other	–	–	–	*0.1*	–	..	..
Electricity	*16.9*	*32.2*	*32.9*	*32.3*	*31.3*	..	..
Heat	–	*5.3*	*11.5*	*11.4*	*10.1*	..	..
TOTAL INDUSTRY[6]	**15.5**	**13.3**	**13.9**	**14.5**	**15.9**	**..**	**..**
Coal[1]	0.9	1.0	0.7	0.9	0.7	..	..
Peat	–	0.0	0.0	0.0	–	..	..
Oil	8.3	3.5	3.4	3.9	4.1	..	..
Gas	0.0	0.3	0.3	0.3	0.3	..	..
Comb. Renewables & Wastes[2]	2.9	3.7	4.1	4.0	5.2	..	..
Geothermal	–	–	–	–	–	..	..
Solar/Wind/Other	–	–	–	–	–	..	..
Electricity	3.4	4.6	4.9	4.9	5.1	..	..
Heat	–	0.2	0.4	0.4	0.4	..	..
Shares (%)							
Coal	*5.7*	*7.6*	*5.4*	*6.6*	*4.5*	..	..
Peat	–	–	*0.1*	–	–	..	..
Oil	*53.4*	*26.5*	*24.6*	*26.8*	*26.0*	..	..
Gas	*0.1*	*1.9*	*2.4*	*2.4*	*2.0*	..	..
Comb. Renewables & Wastes	*18.9*	*27.7*	*29.4*	*27.8*	*32.7*	..	..
Geothermal	–	–	–	–	–	..	..
Solar/Wind/Other	–	–	–	–	–	..	..
Electricity	*21.9*	*35.0*	*35.4*	*33.7*	*32.1*	..	..
Heat	–	*1.3*	*2.8*	*2.8*	*2.7*	..	..
TRANSPORT[7]	**5.5**	**7.4**	**8.2**	**8.2**	**8.3**	**..**	**..**
TOTAL OTHER SECTORS[8]	**14.3**	**11.5**	**12.6**	**12.3**	**13.1**	**..**	**..**
Coal[1]	0.0	0.0	–	–	–	..	..
Peat	–	–	–	–	–	..	..
Oil	11.2	3.3	2.0	1.5	2.3	..	..
Gas	0.1	0.1	0.2	0.2	0.2	..	..
Comb. Renewables & Wastes[2]	0.5	1.0	0.6	0.9	1.0	..	..
Geothermal	–	–	–	–	–	..	..
Solar/Wind/Other	–	0.0	0.0	0.0	–	..	..
Electricity	2.4	5.5	6.3	6.2	6.3	..	..
Heat	–	1.5	3.6	3.6	3.3	..	..
Shares (%)							
Coal	*0.3*	*0.4*	–	–	–	..	..
Peat	–	–	–	–	–	..	..
Oil	*78.7*	*28.9*	*15.7*	*12.3*	*17.6*	..	..
Gas	*0.7*	*1.0*	*1.3*	*1.3*	*1.4*	..	..
Comb. Renewables & Wastes	*3.6*	*8.4*	*4.7*	*7.1*	*7.4*	..	..
Geothermal	–	–	–	–	–	..	..
Solar/Wind/Other	–	–	–	*0.2*	–	..	..
Electricity	*16.6*	*47.9*	*49.7*	*50.1*	*48.2*	..	..
Heat	–	*13.4*	*28.6*	*29.0*	*25.5*	..	..

Unit: Mtoe

DEMAND

ENERGY TRANSFORMATION AND LOSSES

	1973	1990	2001	2002	2010	2020	2030
ELECTRICITY GENERATION[9]							
INPUT (Mtoe)	**8.2**	**26.7**	**30.6**	**28.7**	**28.6**	**..**	**..**
OUTPUT (Mtoe)	**6.7**	**12.6**	**13.9**	**12.6**	**13.0**	**..**	**..**
(TWh gross)	78.1	146.0	161.6	146.0	151.3	..	..
Output Shares (%)							
Coal	*0.6*	*1.2*	*1.9*	*2.6*	*1.8*	..	..
Peat	–	*0.0*	*0.0*	*0.1*	*0.1*	..	..
Oil	*19.4*	*0.8*	*1.6*	*2.0*	*2.1*	..	..
Gas	–	*0.3*	*0.2*	*0.4*	*0.4*	..	..
Comb. Renewables & Wastes	*0.5*	*1.3*	*2.5*	*2.8*	*3.7*	..	..
Nuclear	*2.7*	*46.7*	*44.6*	*46.3*	*43.7*	..	..
Hydro	*76.7*	*49.7*	*48.9*	*45.6*	*45.7*	..	..
Geothermal	–	–	–	–	–	..	..
Solar/Wind/Other	–	*0.0*	*0.3*	*0.4*	*2.6*	..	..
TOTAL LOSSES	**3.4**	**15.2**	**16.3**	**16.3**	**16.3**	**..**	**..**
of which:							
Electricity and Heat Generation[10]	1.5	12.3	13.3	12.6	12.0	..	..
Other Transformation	1.0	0.2	0.4	1.3	2.1	..	..
Own Use and Losses[11]	1.0	2.8	2.6	2.5	2.2	..	..
Statistical Differences	**0.6**	**–0.7**	**0.2**	**–0.3**	**–**	**..**	**..**

INDICATORS

	1973	1990	2001	2002	2010	2020	2030
GDP (billion 1995 US$)	170.32	239.25	293.87	299.51	351.84	..	..
Population (millions)	8.14	8.56	8.90	8.93	9.18	..	..
TPES/GDP[12]	0.23	0.20	0.17	0.17	0.15	..	..
Energy Production/TPES	0.24	0.64	0.67	0.63	0.63	..	..
Per Capita TPES[13]	4.83	5.45	5.75	5.72	5.84	..	..
Oil Supply/GDP[12]	0.17	0.06	0.05	0.05	0.05	..	..
TFC/GDP[12]	0.21	0.13	0.12	0.12	0.11	..	..
Per Capita TFC[13]	4.34	3.76	3.90	3.92	4.07	..	..
Energy-related CO_2 Emissions (Mt CO_2)[14]	84.9	51.2	48.5	50.1	47.8	..	..
CO_2 Emissions from Bunkers (Mt CO_2)	3.9	3.0	6.6	5.6	7.8	..	..

GROWTH RATES (% per year)

	73–79	79–90	90–01	01–02	02–10	10–20	20–30
TPES	1.5	0.8	0.8	–0.3	0.6	..	..
Coal	1.6	3.9	–0.8	0.6	–0.7	..	..
Peat	–	–	1.4	25.7	–3.5	..	..
Oil	–1.3	–5.7	0.3	4.3	1.2	..	..
Gas	–	–	3.6	1.7	–0.1	..	..
Comb. Renewables & Wastes	1.8	3.1	3.5	3.5	1.8	..	..
Nuclear	46.7	11.3	0.5	–6.3	–0.3	..	..
Hydro	0.3	1.6	0.8	–15.9	0.5	..	..
Geothermal	–	–	–	–	–	..	..
Solar/Wind/Other	–	–	25.1	51.1	21.4	..	..
TFC	0.4	–1.1	0.7	0.9	0.8	..	..
Electricity Consumption	3.5	3.2	0.9	–0.8	0.4	..	..
Energy Production	8.0	6.6	1.3	–5.5	0.5	..	..
Net Oil Imports	–0.2	–6.1	0.3	–0.3	1.9	..	..
GDP	1.8	2.1	1.9	1.9	2.0	..	..
Growth in the TPES/GDP Ratio	–0.3	–1.4	–1.0	–2.2	–1.4	..	..
Growth in the TFC/GDP Ratio	–1.3	–3.2	–1.2	–1.0	–1.2	..	..

Please note: Rounding may cause totals to differ from the sum of the elements.

FOOTNOTES TO ENERGY BALANCES AND KEY STATISTICAL DATA

1. Peat is shown separately.
2. Comprises solid biomass, biogas, industrial waste and municipal waste. Data are often based on partial surveys and may not be comparable between countries.
3. Other includes ambient heat used in heat pumps.
4. Total net imports include combustible renewables and wastes.
5. Total supply of electricity represents net trade. A negative number indicates that exports are greater than imports.
6. Includes non-energy use.
7. Includes less than 1% non-oil fuels.
8. Includes residential, commercial, public service and agricultural sectors.
9. Inputs to electricity generation include inputs to electricity, CHP and heat plants. Output refers only to electricity generation.
10. Losses arising in the production of electricity and heat at public utilities and autoproducers. For non-fossil-fuel electricity generation, theoretical losses are shown based on plant efficiencies of 33% for nuclear and 100% for hydro.
11. Data on "losses" for forecast years often include large statistical differences covering differences between expected supply and demand and mostly do not reflect real expectations on transformation gains and losses.
12. Toe per thousand US dollars at 1995 prices and exchange rates.
13. Toe per person.
14. "Energy-related CO_2 emissions" have been estimated using the IPCC Tier I Sectoral Approach. In accordance with the IPCC methodology, emissions from international marine and aviation bunkers are not included in national totals. Projected emissions for oil and gas are derived by calculating the ratio of emissions to energy use for 2002 and applying this factor to forecast energy supply. Future coal emissions are based on product-specific supply projections and are calculated using the IPCC/OECD emission factors and methodology.

INTERNATIONAL ENERGY AGENCY "SHARED GOALS"

Member countries* of the IEA seek to create the conditions in which the energy sectors of their economies can make the fullest possible contribution to sustainable economic development and the well-being of their people and of the environment. In formulating energy policies, the establishment of free and open markets is a fundamental point of departure, though energy security and environmental protection need to be given particular emphasis by governments. IEA countries recognise the significance of increasing global interdependence in energy. They therefore seek to promote the effective operation of international energy markets and encourage dialogue with all participants.

In order to secure their objectives they therefore aim to create a policy framework consistent with the following goals:

1. **Diversity, efficiency and flexibility within the energy sector** are basic conditions for longer-term energy security: the fuels used within and across sectors and the sources of those fuels should be as diverse as practicable. Non-fossil fuels, particularly nuclear and hydro power, make a substantial contribution to the energy supply diversity of IEA countries as a group.

2. Energy systems should have **the ability to respond promptly and flexibly to energy emergencies.** In some cases this requires collective mechanisms and action: IEA countries co-operate through the Agency in responding jointly to oil supply emergencies.

3. **The environmentally sustainable provision and use of energy** is central to the achievement of these shared goals. Decision-makers should seek to minimise the adverse environmental impacts of energy activities, just as environmental decisions should take account of the energy consequences. Government interventions should where practicable have regard to the Polluter Pays Principle.

4. **More environmentally acceptable energy sources** need to be encouraged and developed. Clean and efficient use of fossil fuels is essential. The development of economic non-fossil sources is also a priority. A number of IEA members wish to retain and improve the nuclear

* Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States.

option for the future, at the highest available safety standards, because nuclear energy does not emit carbon dioxide. Renewable sources will also have an increasingly important contribution to make.

5. **Improved energy efficiency** can promote both environmental protection and energy security in a cost-effective manner. There are significant opportunities for greater energy efficiency at all stages of the energy cycle from production to consumption. Strong efforts by governments and all energy users are needed to realise these opportunities.

6. Continued **research, development and market deployment of new and improved energy technologies** make a critical contribution to achieving the objectives outlined above. Energy technology policies should complement broader energy policies. International co-operation in the development and dissemination of energy technologies, including industry participation and co-operation with non-member countries, should be encouraged.

7. **Undistorted energy prices** enable markets to work efficiently. Energy prices should not be held artificially below the costs of supply to promote social or industrial goals. To the extent necessary and practicable, the environmental costs of energy production and use should be reflected in prices.

8. **Free and open trade** and a secure framework for investment contribute to efficient energy markets and energy security. Distortions to energy trade and investment should be avoided.

9. **Co-operation among all energy market participants** helps to improve information and understanding, and encourage the development of efficient, environmentally acceptable and flexible energy systems and markets worldwide. These are needed to help promote the investment, trade and confidence necessary to achieve global energy security and environmental objectives.

(The Shared Goals were adopted by IEA Ministers at their 4 June 1993 meeting in Paris.)

GLOSSARY AND LIST OF ABBREVIATIONS

b/d	barrels per day
BGI	Baltic gas interconnector
BWR	boiling water reactor
C	degree Celsius
CDM	Clean Development Mechanism
CERC	Competence Centre for Combustion Engine Research
CHP	combined heat and power
CO_2	carbon dioxide
CO_2-eq.	CO_2-equivalent
CTK	Competence Centre for Catalysis
EC	European Commission
EMFO	Emissions Research Programme
ERA	European Research Area
ERDD	energy research, development and demonstration
EU	European Union
euro	European currency
FORMAS	Swedish Research Council for Environment
GDP	gross domestic product
GHG	greenhouse gas
GW	gigawatt, or one watt $\times 10^9$
GWh	gigawatt $\times$ one hour
HTC	Competence Centre for High-Temperature Corrosion
IEA	International Energy Agency
IEP	International Energy Program
JI	Joint Implementation
kcal	a thousand calories
kWe	a kilowatt of electric power

kV	kilovolt, or one volt $\times 10^3$
kWh	kilowatt-hour, or one kilowatt $\times$ one hour, or one watt $\times$ one hour $\times 10^3$
km	kilometre
LNG	liquefied natural gas
LTA	long-term agreement
MJ	megajoule, or one million joules
Mmt	million metric tonnes
Mt	million tonnes
MTI	Ministry of Trade and Industry
Mtoe	million tonnes of oil equivalent
MW	megawatt of electricity, or one watt $\times 10^6$
MWh	megawatt-hour = one megawatt $\times$ one hour, or one watt $\times$ one hour $\times 10^6$
MWe	a megawatt of electric power
NAP	National Allocation Plan
NEGP	North European Gas Pipeline
NESO	National Emergency Sharing Organisation
NO_x	nitrogen oxides
Nord Pool	Nordic Power Market
OECD	Organisation for Economic Co-operation and Development
PJ	petajoule, or one joule $\times 10^{15}$
PPP	purchasing power parity
PWR	pressurised water reactor
RECS	renewable energy certificate system
R&D	research and development
RD&D	research, development and demonstration
SKGS	Federation of Swedish Industry
SKI	Sweidsh Nucelar Power Inspectorate
SKr	Swedish krona
SO_2	sulphur dioxide
STUK	Radiation and Nuclear Safety Authority
SSI	Swedish Radiation Protection Inspectorate

TFC	total final consumption of energy
TJ	terajoule
toe	tonne of oil equivalent, defined as 10^7 kcal
TPES	total primary energy supply
TSO	transmission system operator
TWh	terawatt x one hour, or one watt $\times$ one hour $\times$ 10^{12}
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
UK	United Kingdom
US	United States
VAT	value-added tax
VINNOVA	Swedish Agency for Innovation Systems
VOCs	volatile organic compounds

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