INTERNATIONAL ENERGY AGENCY

Energy Policies of IEA Countries

DENMARK 2002 REVIEW

OECD

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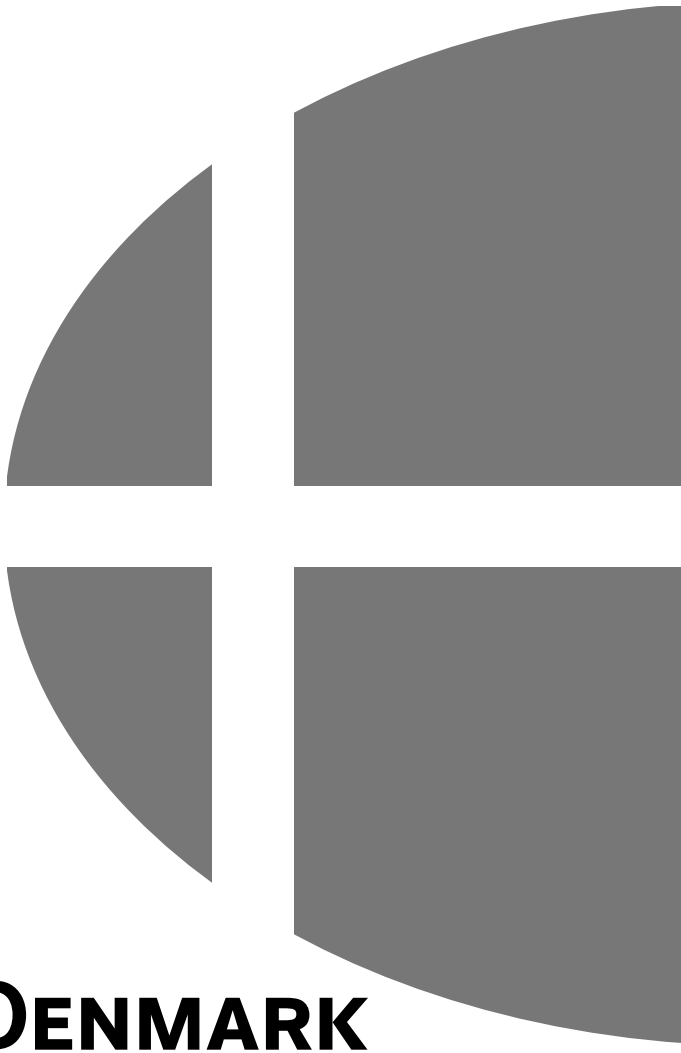

DENMARK 2002 REVIEW

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

SUMMARY

Throughout the last few decades, Danish energy policy has been strongly influenced by environmental policy objectives. Until November 2001, one minister was responsible for both energy and environmental policy. Denmark also has many policy goals that are inspired by both energy and environmental considerations. The country promotes energy efficiency, renewables and combined heat and power production (CHP). It has set itself the target of producing 20% of its electricity from renewables. Denmark also has several greenhouse gas targets. Among them there is the Kyoto commitment to reduce greenhouse gas emissions (six gases) by 21% in the first budget period 2008-2012, compared to 1990. There is also the stringent national commitment to reduce CO_2 emissions by 20% by 2005, compared to 1988. Denmark's Parliament approved ratification of the Kyoto Protocol on 30 May 2001.

If these energy policies are measured against their objectives, Denmark has been very successful. Denmark has the highest share of electricity generated in combined heat and power plants in the world, as well as with one of the largest district heating systems. In 2000, 12.6% of electricity generation was from wind turbines, also the highest of any nation. According to government forecasts, Denmark will come very close to meeting its multiple CO_2 and greenhouse gas emissions commitments, provided a national system of tradable CO_2 quotas for power plants remains in place. The system was introduced on 1 January 2001 to render climate change abatement in the power industry market-compatible. The quota system will be in force provisionally until full retail competition becomes effective in 2003. Should the quota system lapse without replacement, electricity exports could soar after 2003, and national CO_2 emissions could fall short of the Kyoto target by more than 19%. The report recommends that a decision about the future of the quota system be taken as soon as possible.

The decisive step towards full liberalisation of the Danish power industry was taken in 1999, when the Electricity Supply Act was adopted. Since 1 April 2000, final customers of 10 GWh or more per year have been eligible to choose their electricity supplier in the free market. On 1 January 2001 the threshold was lowered to 1 GWh. On 1 January 2003, all final consumers will become eligible. Electricity generation, ownership of the transmission grid, operation of the grid, distribution and electricity supply must each be organised in separate legal entities. Electricity market reform in Denmark goes beyond the requirements of the EU directive.

Disclaimer

The review visit on which this report is based took place in October 2001, before the new Danish government took office in November 2001. Most of the drafting of this report was completed before the details of the new government's policy were known. For this reason, the report reviews exclusively the policies of the previous government. Where policy changes became known before the publication, they are mentioned briefly in the body of the report.

However, the government requires CHP and wind energy to be given priority in dispatching. Therefore, only about 60% to 65% of the power market is governed by competitive price signals. This "priority" dispatch requirement causes excess generation during certain periods, a situation which may lead to losses for utilities. The Danish government should encourage more trade, competition and interconnection, and adapt environmental policies to the realities of the power market.

In the gas market, Denmark has opted for more restrictive provisions, in line with the minimum requirements of the EU Gas Directive. Since 10 August 2000, 30% of the market has been open to competition. This will increase to 38% in 2003 and 43% in 2008. The Danish government also reserves the right to deny access of some potential competitors to the gas grid if such access would cause serious financial difficulties for the state-owned natural gas pipeline company DONG. This right is permitted under a derogation in the directive. Originally, the Natural Gas Supply Act of 2000 provided for negotiated third party access, but this was changed to regulated third party access in October 2001. From 2003 onwards, network operation and gas trading activities will have to be separated.

Between July 1999 and July 2000, DONG acquired two of the five Danish gas distribution and supply companies, and also the right to supply the largest customers of two others. This consolidation was carried out partly in response to the high indebtedness of the Danish gas sector. But it means that DONG now directly controls nearly 95% of the Danish gas market. The Danish Competition Authority has taken note of this strong dominant position. The government should prevent DONG from becoming a monopoly supplier along the entire gas chain. It should create incentives for new suppliers, foreign and domestic, to enter the Danish market. The new government has decided that the gas market should be fully competitive by 2004 and that DONG should be privatised at a time to be determined in the future.

RECOMMENDATIONS

The Government of Denmark should:

Energy Market and Energy Policy

- ☐ Review the existing policy measures with a view to developing more cost-effective policies. Government interventions should be analysed on a

continuing basis for cost-effectiveness and should be prioritised accordingly. Market-oriented approaches should receive priority.

- ☐ Ensure that both domestic and international policies are adequately assessed in order to meet environmental objectives cost-effectively.

- ☐ Further review the tax and subsidy system with a view to reducing its complexity and administrative costs.

- ☐ Work to reconcile free market rules and environmental policies to send the right investment signals to the market; in particular, develop as soon as possible a market-based successor mechanism to the CO_2 quota system for the period after 2003.

Energy and the Environment

- ☐ Finish the assessment of the economic implications of basing climate change policy almost exclusively on domestic mitigation strategies. In particular, consider the advantages that the Kyoto mechanisms and the extension of the quota/trading system to other sectors may offer in closing the remaining emissions gap.

- ☐ Decide urgently the fate of the CO_2 quota system for the electricity sector beyond 2003; determine the quota levels; reassess the low penalty for non-compliance; and determine whether international trading and credits can be incorporated.

- ☐ Make further adjustments to the car registration fee and pursue road pricing and other cost-effective policy instruments in the transport sector.

Energy Efficiency and Renewables

- ☐ Continue to review the performance of existing energy efficiency programmes with a view to developing market-based and more cost-effective policies. Loan payback schemes could substitute for outright subsidies in some cases.

- ☐ Continue to place time limits on subsidy schemes, particularly on those to boost market penetration of new energy-efficient technologies.

- ☐ Improve the transparency of the costs and trade implications of the various renewables support measures, in particular "priority" production.

- ☐ Investigate the consequences of greater penetration of imported biomass in terms of CO_2-neutrality, cost, and Denmark's security of supply objectives.

- ☐ Take steps to move to market-based policies as soon as possible, including the introduction of the green certificates programme, or some other instrument to offset the costs of current subsidies for renewable energy. In the transitory period, subsidies need to be reduced further to reflect current market conditions for wind energy and CHP.

Fossil Fuels

☐ Review the hydrocarbon tax to eliminate distortions in upstream investment and to establish a clear and simple upstream taxation system.

☐ Facilitate effective competition in the Danish gas market by preventing DONG from becoming a monopoly supplier along the entire gas chain. The Competition Authority should monitor DONG's behaviour closely.

☐ Create incentives for new suppliers to enter the Danish market.

Electricity and Heat

☐ Strive to increase competition by:
- Working towards further opening of Denmark's interconnection with other countries for competitive power trade, especially spot purchases.
- Encouraging the removal of internal bottlenecks in the transmission system and striving for a similar approach in Nordel.
- Encouraging more market-oriented behaviour among power companies, and especially among small distribution and supply companies.
- Encouraging the transformation of consumer co-operatives into commercial companies, and facilitating the privatisation of municipal utilities.

☐ Through the Competition Authority, monitor the electricity market and deal with abuses rapidly.

☐ Continue to adapt the environmental policies aimed at the power industry to the realities of competition.

Energy Research and Development

☐ Complete a comprehensive energy research strategy covering the full spectrum of innovation, and domestic and international programming.

☐ Clarify responsibilities and improve the co-ordination between the Danish Energy Agency and the electricity system operators that administer the Public Service Obligation. This also applies to the electricity end-use R&D requirement.

2

ORGANISATION OF THE REVIEW

REVIEW TEAM

An IEA review team visited Denmark in October 2001 to review the country's energy policies. This report was drafted on the basis of information received during, prior to and after the visit, including the Danish government's official response to the IEA's 2001 policy questionnaire and the views expressed by various parties during the visit. The team greatly appreciated the openness and co-operation shown by everyone it met.

The members of the team were:

Miklós Poós
Team Leader
Ministry of Economic Affairs
Hungary

Ove Flataker
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Ministry of Petroleum and Energy
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Policy Expert
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Bryan Cook
Policy Expert
Natural Resources Canada
Canada

Johannes Enzmann
EU Observer
Commission of the European Communities

Shigetaka Seki
IEA Secretariat

Kristi Varangu
IEA Secretariat

Gudrun Lammers
IEA Secretariat

ORGANISATIONS VISITED

The Danish Energy Agency (then part of the Ministry of Environment and Energy)
The Ministry of Transportation
The Ministry of Taxation
The Danish Energy Regulatory Authority
The Danish Competition Authority

Dansk Olie og Naturgas (DONG)
Dansk Energi
Elfor
Elkraft
Elsam
Eltra
Energi E2
Mærsk Oil and Gas

The Danish Consumer Council
The Danish Forum of Electricity Traders
The Danish Wind Industry Association
The Federation of Danish Industries
The Danish Technological Institute
The Institute of Local Government Studies (AKF)
Risø National Laboratory

The Council for Sustainable Development
The Economic Council of the Labour Movement
The Danish Organisation for Renewable Energy (OVE)
Greenpeace
World-Wide Fund for Nature (WWF)

3

ENERGY MARKET AND ENERGY POLICY

ENERGY MARKET

The Kingdom of Denmark is a country of 5.3 million people with a land area of about 43 000 square kilometres in the north of Europe, between the North Sea and the Baltic Sea. Population growth is far below 1% (2001 estimate: 0.3%). About 85% of the population lives in cities. The largest cities are the capital Copenhagen (København) (1.78 million inhabitants in Copenhagen and surrounding regions), Århus (280 000), Odense (180 000) and Aalborg (160 000).

The country comprises the peninsula of Jutland (Jylland) to the west, the islands Zealand (Sjælland) and Funen (Fyn) to the east and hundreds of smaller islands. The world's largest island Greenland (2 175 600 square kilometres) is part of Denmark's national territory but became self-governing following a referendum in 1979. The same administrative solution applies to the Faeroe Islands in the northern Atlantic. Denmark has been a member of the European Union and its predecessors since January 1973. But in 1982 Greenlanders voted to leave the European Communities. Greenland's withdrawal was completed in 1985.

Denmark has a mild oceanic climate with limited temperature variation (40-year mean temperature in February –0.4°, in July 16.6°C) and low altitude: Denmark's highest altitude is 170 metres. Land use is primarily agricultural (64%), and built-up areas occupy about 15%. The remainder is forest (10%) and natural areas.

The country comprises 14 counties (*amtskommuner*) and 275 municipalities (*kommuner*). Social concerns are a priority for Danes, and there are extensive government welfare measures. Economic, energy and environmental policy is often the result of agreements between the largest political parties in the Parliament.

Since 1993 Denmark has had three centre-left coalitions led by social democrats. This changed in November 2001, when a new government was elected. The new government is a coalition of liberals and conservatives, led by the liberals. The political situation has changed since the new liberal-conservative coalition took over. It is too early to report any detailed policy changes, but it is clear that the government's overall priorities will change. The new government is unlikely to reverse past policies entirely, as large parts of Danish energy policy are based on joint political agreements across the parliamentary spectrum. However, the change of government will entail shifts in the relative weight of policy objectives. For example, the new government has already split the Ministry of

Environment and Energy into two ministries, one for economic and business affairs, including the energy sector, and one for the environment. Moreover, the government has stated that energy policy will focus more on economic efficiency, market-based solutions and international approaches to environmental issues, and lower energy prices for industry. It should be noted that this report was prepared and drafted before the change of government. Therefore it focuses on the previous government's policies except when it expressly refers to the new government.

The Danish economy is characterised by high-tech agriculture, modern industry and high dependence on foreign trade. Denmark is a net exporter of food and energy and has both a balance of payments and a budget surplus. Denmark meets, and even exceeds, the economic convergence criteria for participating in the third phase of the European Monetary Union (EMU), but in a referendum held in September 2000, the electorate reconfirmed its decision not to join the euro zone. However, the Danish crown (DKK) remains pegged to the euro (€)[1].

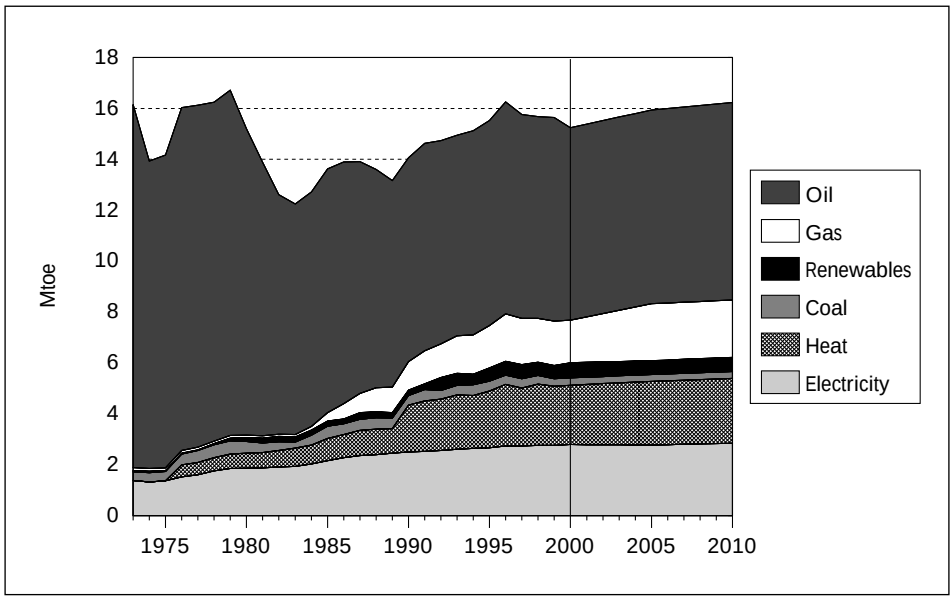
The labour force is 2.9 million. In 1999, unemployment was 5.3%, down from 8.25% in 1996. Inflation was 2.9% in 2000 and GDP growth 2.8%. Principal industries are food processing, machinery and equipment, textiles and clothing, chemical products, electronics, construction, furniture and other wood products and shipbuilding. In 2000, agriculture, forestry and fishery accounted for 3.8% of GDP, industry 25% and services, including government services, 72%. The main export commodities are machinery and instruments, meat and meat products, dairy products, fish, chemicals, furniture and wind turbines. Denmark's principal trading partners are the European Union (66.5%), Norway (5.8%), and the United States (5.4%).

ENERGY DEMAND

Total final consumption (TFC) of energy was 15.24 million tonnes of oil equivalent (Mtoe) in 2000. As can be seen in Figure 1, this was somewhat lower than consumption in 1973 (16.15 Mtoe) and also below the two other demand peaks in 1979 and 1996. Danish energy consumption contracted very sharply after the 1973 and 1979 oil crises. Demand development in the 1980s showed no clear trend. However, Denmark experienced nearly a decade of uninterrupted economic growth in the 1990s, which led to TFC growth of 11% between 1990 and 1999. The small demand peak in 1996 was largely due to exceptionally cold weather. Energy demand showed negative growth of 2.6% between 1999 and 2000.

1. One Danish crown (DKK) comprises 100 øre. In 2000, one Danish crown averaged US$ 0.123 and € 0.134228.

Figure 1
Total Final Consumption by Source, 1973 to 2010

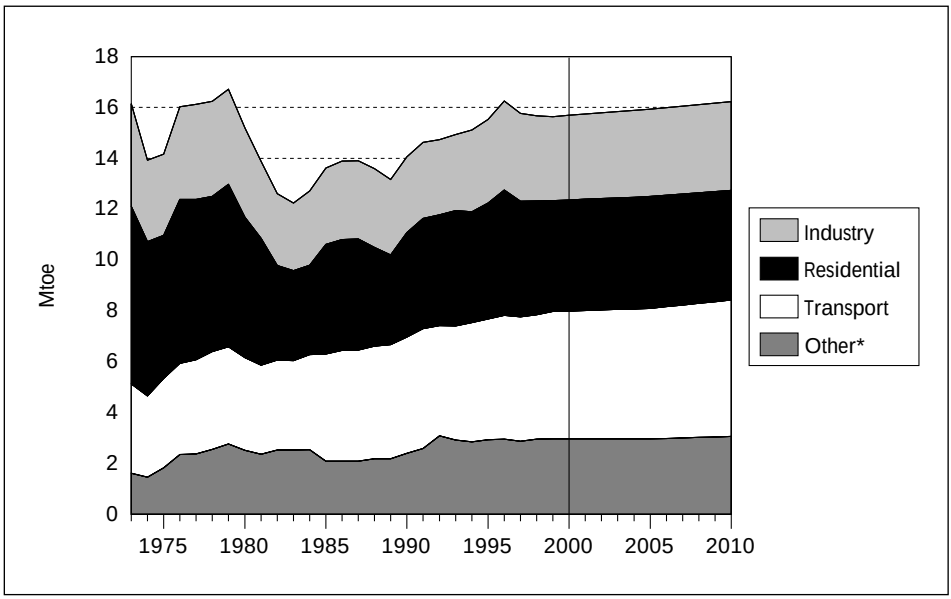


Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001, and country submission.

Oil accounts for about one-half of energy consumption, and more than half the oil is used for transport. The share of heat in TFC is unusually high at 15.3%. The reason for this is Denmark's vast use of district heating. District heating (DH) was promoted after 1979 through the national Heat Supply Act. This included a national heat plan and the possibility for local governments to mandate connection to the district heating network for new and existing buildings. Most of the densely-populated areas of the country are now covered by the district heating network, and in 1981, more than 50% of all heating installations in Danish households used district heat, up from one-third in 1981. In total, 2.33 Mtoe of district heat were delivered to Danish households and businesses in 2000 (2.87 Mtoe in 1998 according to Danish statistics); this represents an increase of 27% over 1990 and is one of the highest amounts in the world.

A large and increasing portion of the district heat is produced through combined heat and power production (CHP). Between 1980 and 1998, the portion of heating-only plants declined from 55% to 13%; the remainder was CHP or other forms of waste heat. In fact, with about half of electricity generation from CHP plants, Denmark has the highest CHP share in power generation in the world. The use of CHP combined with district heating is and has long been Denmark's main instrument to limit primary energy use and its environmental effects, and has benefited from strong government support. More detail is provided in Chapter 7.

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, 2001, and country submission.

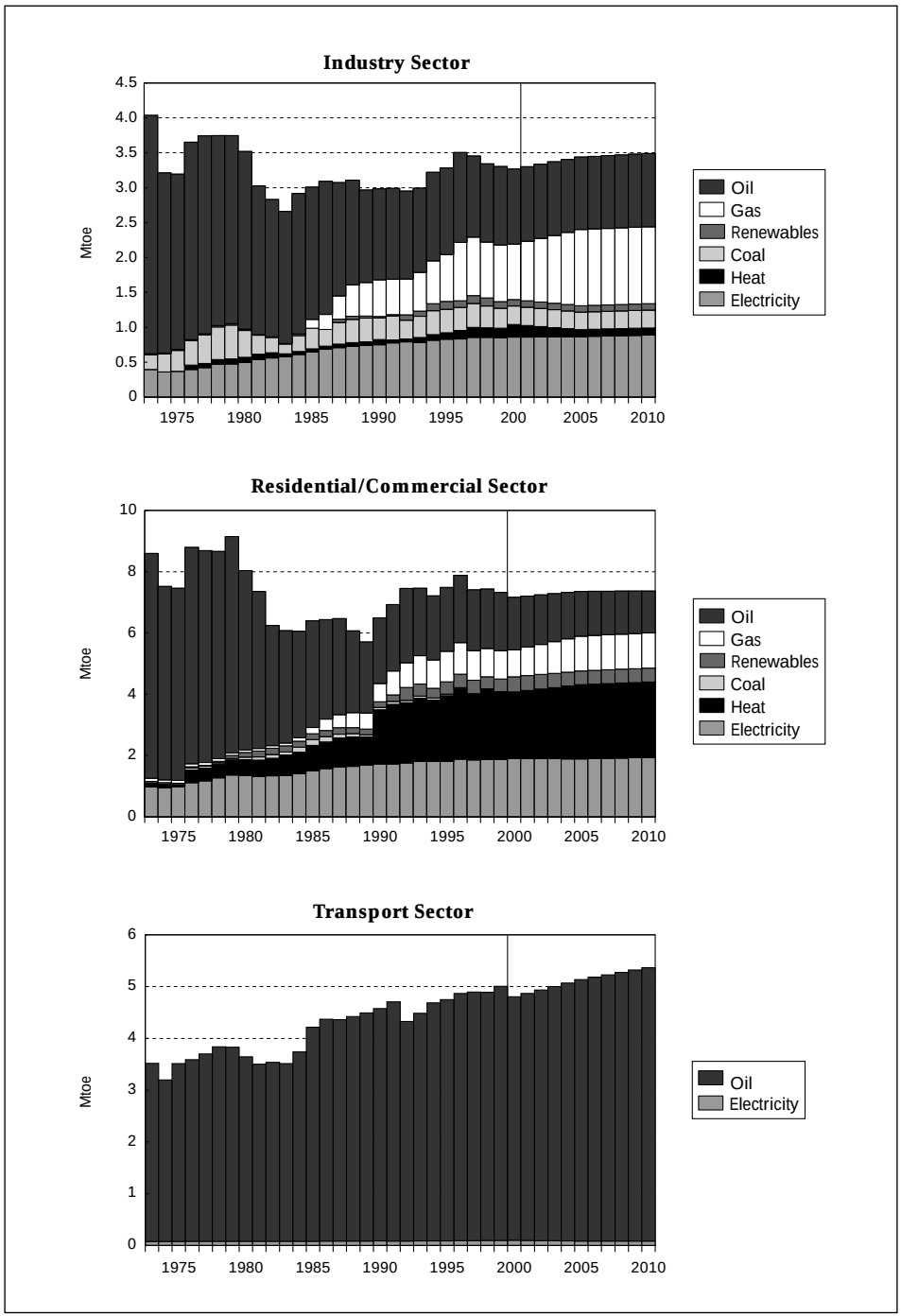
Denmark's industrial structure, which is oriented towards light industry and especially towards services, is reflected in the comparatively low industrial share of 21% in total final energy consumption. Whereas residential energy demand was responsible for most of the demand fluctuations of the past 25 years, energy demand for transport has shown steady growth almost unaffected by past price fluctuations and policy measures. In 2000, TFC for transport was 4.8 Mtoe, or 31%, very close to the European average.

Total final energy consumption is expected to increase slightly until 2010, but is not expected to exceed its absolute peak of almost 17 Mtoe in 1979. The Danish government expects primary energy demand to change very little over the next decade and to remain slightly below its 1988 value at 19.1 Mtoe[2].

2. The IEA produces its own set of data for each Member country. However, these IEA data are *not* based on an independent IEA data collection or modelling exercise. They are based on statistics submitted annually by Member governments, which are then adjusted to IEA definitions to render them internationally comparable. Owing to definitional discrepancies, national and IEA data can nevertheless differ significantly. The IEA's World Energy Model is a regional model that does not yield results for individual countries. This report uses IEA data unless otherwise indicated.

Figure 3

Final Consumption by Sector and by Source, 1973 to 2010

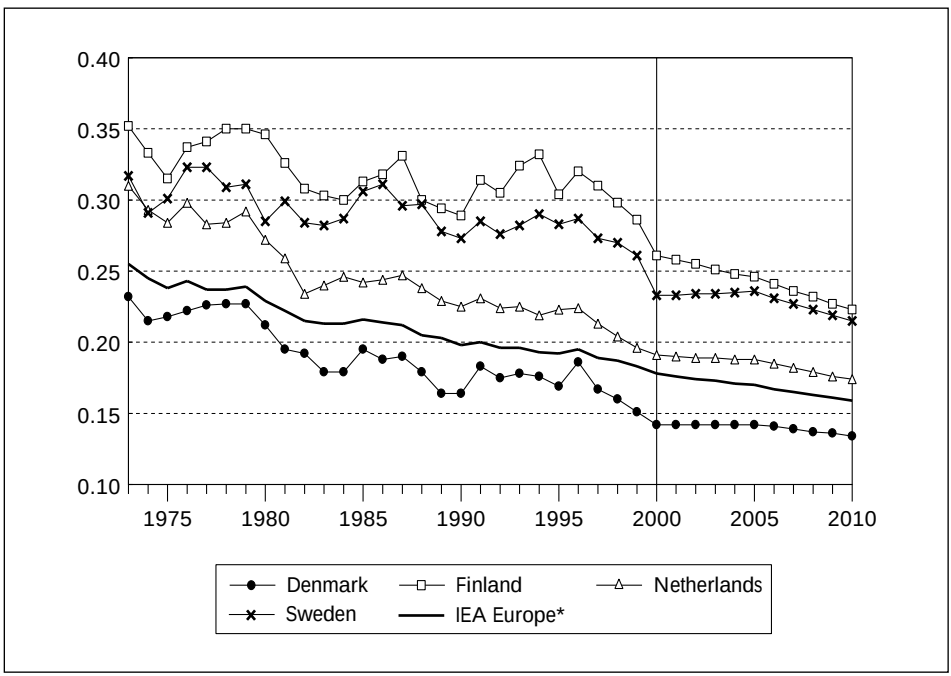


Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001, and country submission.

Figure 4 shows Denmark's energy intensity compared to IEA Europe and other selected countries. Denmark's energy intensity is lower than the IEA Europe average and lower than most of its neighbours (Sweden and Finland) or comparable countries (the Netherlands). The main reason for this is Denmark's industry structure, producing high value-added commodities using low energy-intensive processes. With 0.10 tonne of oil equivalent per thousand US dollars, Danish primary energy intensity (TPES/GDP) was only half that of IEA Europe (0.20 toe/$1 000) and only 42% of the IEA average (0.24 toe/$1 000) in 1998. Final energy intensity in Denmark was 0.8 toe/$1 000, 57% of the average of 0.14 toe/$1 000 in IEA Europe. This differential reflects the greater conversion efficiency from CHP in Denmark.

Overall, Danish energy intensity has declined but over the long term this decline occurred at the same pace as in the IEA Europe region. Energy intensity is expected to decline further, again broadly in line with IEA Europe.

Figure 4
Energy Intensity in Denmark and in Other Selected IEA Countries, 1973 to 2010
(Toe per thousand US$ at 1995 prices and purchasing power parities)

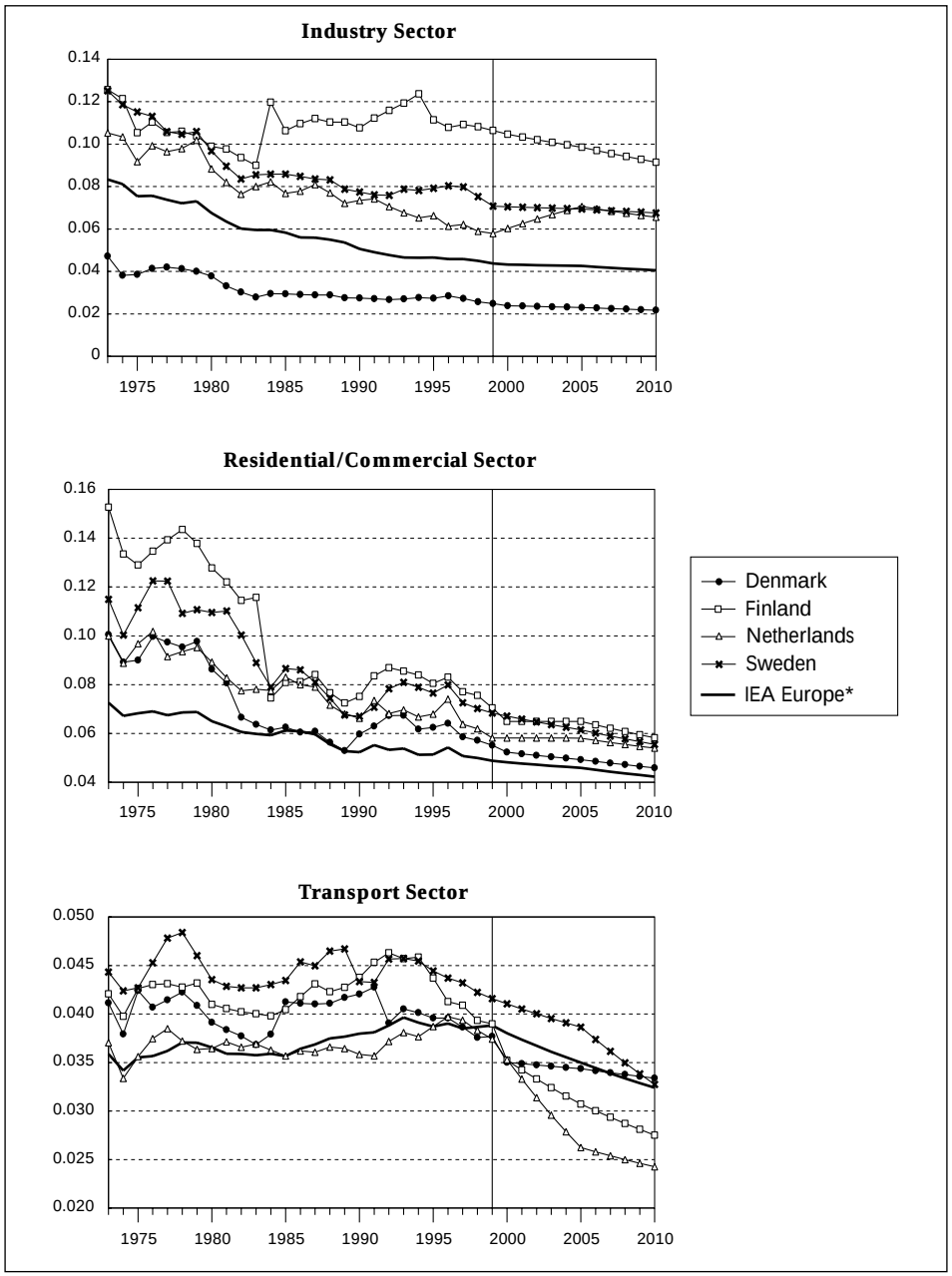


* Excluding Norway from 2001-2010.
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001; *National Accounts of OECD Countries*, OECD Paris, 2001; and country submissions.

Figure 5

Energy Intensity by Sector in Denmark and in Other Selected IEA Countries, 1973 to 2010

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



* Excluding Norway from 2000-2001.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001; *National Accounts of OECD Countries*, OECD Paris, 2001; and country submissions.

Energy Supply

Overview

Denmark has fossil energy resources, as well as uranium at Kvanefjeld in south-west Greenland. The uranium resources are significant – with more than 40 000 tonnes of estimated reserves, Denmark ranks third in Western Europe, behind France but ahead of Spain. However, the Danish resources are low-grade and far from commercial at present uranium prices. Moreover, there are environmental issues that would need to be resolved, and as part of the 1979 home rule system, the government of Greenland has a right of veto regarding the exploitation of such resources.

In the second half of the 1960s, Denmark discovered oil and gas on its continental shelf in the North Sea. The first finds were the Anna (1966, now named Kraka), Cora (1968, now Tyra), Bent (now Roar), Dan (1971) and Gorm fields. The reserves are much smaller than those of the Netherlands, but Denmark's smaller population entails smaller domestic demand. Thus, Denmark achieved self-sufficiency in oil and gas in 1991 and in energy for the first time in modern history in 1997. This situation is currently expected to last until 2006.

Oil production from the Dan field began in 1972, but was disappointing. Therefore a number of years elapsed before the next oil fields, located in the same geological formations, came on stream. The Gorm field eventually started production in 1981, and the Skjold field in 1982. Gas production from the Tyra field began only in 1984.

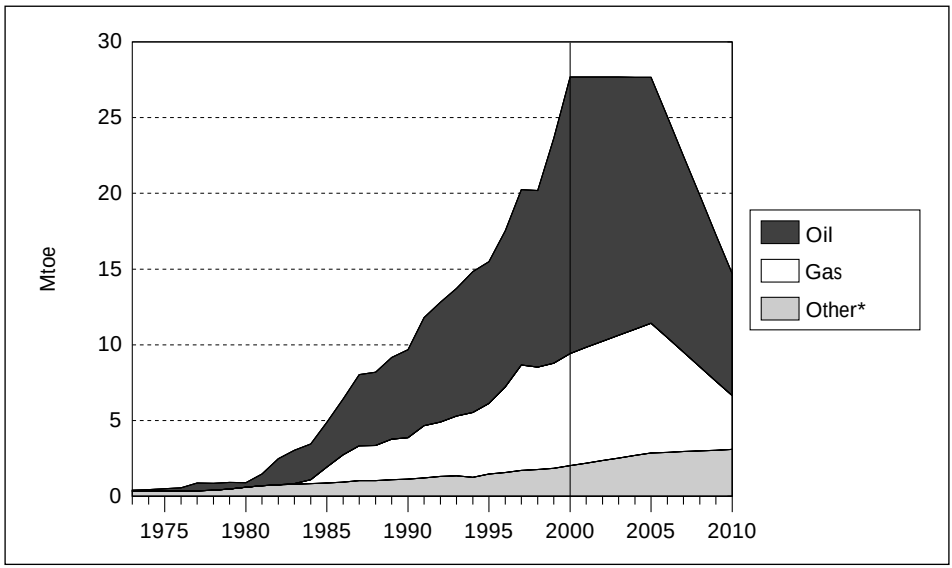
In the following years, oil and gas production expanded rapidly. In 2000, the country produced 18.26 Mtoe of oil, more than twice its domestic total primary energy supply (TPES) of oil, and 7.41 Mtoe of natural gas, 66% more than its gas TPES of 4.46 Mtoe. Denmark exports crude oil to surrounding European countries, especially to the Netherlands (3.6 million tonnes in 2000), Sweden (3.5 million tonnes) Finland (2.2 million tonnes, and the United Kingdom (1.7 million tonnes). Small amounts of gas are exported to Germany (2.3 bcm in 2000) and Sweden (0.8 bcm). In addition, Denmark produces 1.65 Mtoe of combustible renewables and 0.46 Mtoe of wind energy.

The only major energy resource that Denmark has to import entirely is coal. In 2000, net coal imports amounted to 3.78 Mtoe. In that year, Denmark imported its coal mainly from South Africa, Poland, Colombia and Russia, and smaller quantities from a range of other countries. Despite these coal imports, the country was 142% self-sufficient in energy in 2000.

However, the picture was not always as favourable as it is today. In 1973, oil accounted for 88.7% of TPES. Consequently, the Danish economy was severely affected during both oil crises. This gave rise to government intervention in the energy market in order to reduce oil demand and TPES as a whole, through various types of energy efficiency measures and the development of combined heat and power production and renewables.

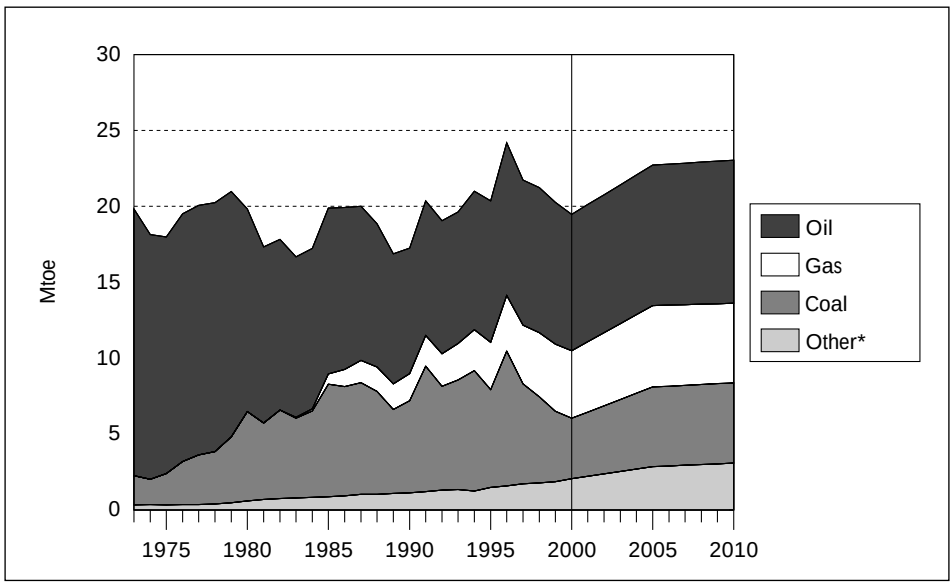
Consequently, the share of oil in TPES nearly halved between 1973 and 2001, when it stood at 45.8%. Danish energy supply has changed from being based on oil to a

Figure 6
Energy Production by Source, 1973 to 2010



* Other includes solar, tide, wave and ambient heat used in heat pumps.
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001, and country submission.

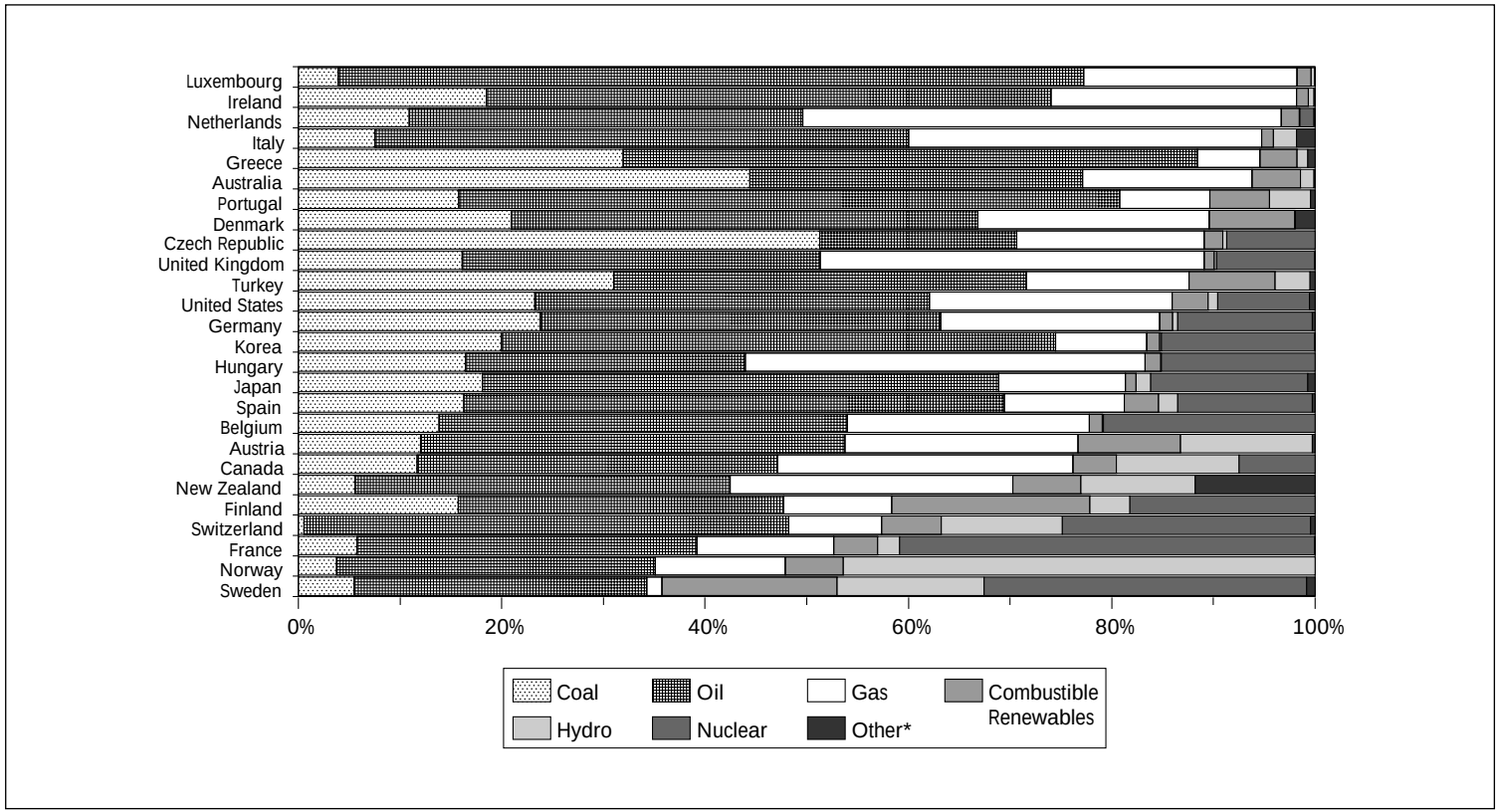
Figure 7
Total Primary Energy Supply, 1973 to 2010



* Other includes solar, tide, wave and ambient heat used in heat pumps.
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001, and country submission.

Figure 8

Total Primary Energy Supply in IEA Countries, 2000



* Other includes solar, tide, wave and ambient heat used in heat pumps.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001.

mix of oil, coal, gas and renewables. Coal was phased in quickly after 1973 to replace oil, but its share dropped substantially after 1995 owing to substitution policies in the power industry because of its environmental impact. In 2000, the share of coal stood at 20.3% of TPES and this share is expected to rise again slowly in future. Gas accounted for 22.7% of TPES, and renewables for almost 11%. The proportion of coal is close to the IEA average (21% in 2000), and the proportion of natural gas is very close to the IEA Europe average (22.8% in 2000). Gas use has risen as it has substituted for coal in power generation and especially in CHP.

Further change is under way, as can bee seen from Figures 6 and 7. First, 2000 is expected to mark the peak for Danish oil production. Resources are expected to become exhausted rapidly and total energy production to be halved to about 1990 levels. Natural gas production is currently expected to peak in 2005. However, the high oil and gas prices of the last two years have led to significant exploration efforts and have resulted in new finds (see Chapter 6).

Simultaneously, the government had ambitious plans to develop renewable energy resources, reflected in the steady increase of renewables. Denmark had more than 1 500 MW of wind turbine capacity installed in 1998, and almost 10% of its power generation was from wind. According to Danish statistics, installed wind power capacity was more than 2 400 MW in 2000, and wind generation corresponded to 12.6% of electricity demand. This is the highest share in any IEA country. The previous government intended to increase this portion even further. Natural gas use is expected to grow steadily, with gas imports necessarily rising after the anticipated gas production peak in 2005.

ENERGY POLICY

Energy Policy Objectives

Like other IEA Member countries, the Danish government tries to strike a balance between the three objectives of free and open energy markets, security of energy supply and environmental protection. At times, the particular weight that Danish voters and governments attached to each of these objectives has differed somewhat from most other Member countries.

Denmark was very hard hit by the first and second oil crises: in 1973, imported oil accounted for 88.7% of the country's TPES. Denmark saw itself as extremely vulnerable to external shocks, and conservation of primary energy became the priority objective in Danish energy policy. At that time, oil and gas had been discovered in the Danish sector of the North Sea, but development of the reserves was not advanced enough to change this situation.

Denmark's first energy plan, *Danish Energy Policy*, was established in 1976. Its main goal was to render Denmark independent of imported oil and to build up energy preparedness in case of a supply failure. For the sake of clarity, only the

most important plans and policy documents are mentioned in this chapter. One of the measures suggested in the 1976 plan was the country's massive programme of district heating and combined heat and power production. This measure was put into practice as of 1979. Under ideal circumstances, CHP can more than double the amount of useful energy extracted from each unit of primary energy.

Whereas Danish gas production began in 1984, extending available supplies, several follow-up documents had the objective of reducing primary energy demand. In the earlier documents, the main concern was security of supply as well as limiting the outflow of national resources for energy imports. Over time, environmental considerations gained importance among Danish energy policy goals, and now have high priority[3]. The Danish Parliament adopted a fundamental decision against nuclear power in 1985.

The *Energy 2000* (*Energi 2000*) plan of 1990 contained a national commitment to reduce Danish CO_2 emissions by 20% by 2005, compared to 1988 levels[4]. This is still one of Denmark's main policy objectives in energy and environmental policy. The plan contained ambitious programmes to expand the use of renewables, especially wind, to achieve sustainable development and reduce CO_2 emissions. Denmark also has some long-term objectives, notably halving CO_2 emissions by 2030, and reducing SO_2 and NO_x emissions by 30% and 45%, respectively, compared to 1988. This target was confirmed and maintained in the fourth energy action plan, *Energy 21* (*Energi 21*), approved by the Parliament in April 1996. The plan sets a very ambitious target for renewable energy sources: the share of renewables is to rise from 8% of Danish energy consumption in 1996 to 30% in 2025.

Under the 1997 Kyoto Protocol and the European Union's internal burden-sharing agreement of 17 June 1988, Denmark is committed to reducing greenhouse gas emissions (six gases) by 21% in the first budget period 2008-2012, compared to the 1990 adjusted baseline[5]. Denmark's Parliament approved ratification of the Kyoto Protocol on 30 May 2001. However, Denmark's actual ratification of the Treaty will take place along with that of other European Union member states at an unspecified later date. To summarise, Denmark has two greenhouse gas targets:

3. For this reason, some overlap between this section and Chapters 4 and 5 is unavoidable. This chapter contains a broad overview. Denmark's targets for the abatement of greenhouse gas emissions are discussed in detail in Chapter 4. Energy efficiency measures and support policies for renewables are discussed in Chapter 5.

4. Corrected for net electricity exports. The CO_2 data exclude Danish electricity generation for export. The largely fossil-fuelled Danish power industry acts as "hydro-firming" capacity for the largely hydro-based Nordic market. When rainfall in the Nordic countries is low, Denmark exports its fossil electricity. The government considers the emissions thus generated as caused by foreign, not Danish, demand and therefore excludes them from its national calculations.

5. 1990 was an exceptionally wet year, which reduced domestic (fossil) electricity generation and caused large hydro-based imports from Sweden and Norway. For this reason, Denmark is pressing for adjustments in its baseline to normalised values.

- The *national commitment* to reduce CO_2 emissions by 20% by 2005, compared to 1988.

- The *Kyoto commitment* to reduce greenhouse gas emissions (six gases) by 21% in the first budget period 2008-2012, compared to 1990.

In June 1999, a forecast for energy consumption and carbon dioxide emissions until 2012 was published in the report *Follow-up on Energy 21: Status of Energy Planning*. A 16.4% reduction in carbon dioxide emissions was forecast for the period 1988 to 2005. On this basis, the *national* objective would not be fulfilled. As a result, a follow-up document to *Energy 21* was issued in March 2000 under the name *Climate 2012* (*Klima 2012*). This document outlines the steps needed to meet the government's obligations. These steps include:

- Submitting a new action plan for the transport sector. In May 1990, a first Transport Sector Action Plan had already been adopted, advocating stabilisation of CO_2 emissions from the transport sector by 2005 and a 25% reduction by 2030, compared to 1988 levels. In the light of the fast and persistent actual growth of the transport sector, the government realised that the earlier objectives were unrealistic.

- Updating the 1996 action plan *Energy 21*.

- Establishing a programme for analysis, development and testing of the Kyoto mechanisms.

- Analysing and assessing greenhouse gas reduction potentials in the agricultural sector.

- Determining future regulation of industrial greenhouse gases.

The new action plan for reducing CO_2 emissions in the transport sector was submitted by the government in April 2001. The action plan announces new objectives and measures, including:

- A 7% reduction in CO_2 emissions from the transport sector by 2010 compared to the reference scenario. Thus, CO_2 emissions in 2010 would be 22% above their 1988 level.

- A 25 % reduction of CO_2 emissions from the transport sector in 2030 compared to 1988 levels.

To strengthen energy conservation efforts, a new Energy Savings Act (Act No. 450 of 31 May 2000) was adopted in May 2000. This act is a framework law that lays down rules for the co-ordination and prioritisation of savings efforts in all sectors; concrete objectives and measures are currently being elaborated.

As a result of the reinforced efforts, an emissions forecast published by the Danish government in April 2001 appears to confirm that the national objective of reducing

CO_2 emissions from Danish energy consumption by 20% by 2005 can be met. According to preliminary figures published by the government, CO_2 emissions in 2000 were 11% below their 1988 values.

The new forecast presents a less certain picture for the longer term. Denmark would fall short of its Kyoto Protocol commitment by 2% to 3% in the first budget period 2008 to 2012 if all current policy measures were retained and all anticipated policy measures were introduced. However, one of Denmark's CO_2 control measures, the CO_2 quota system for electricity generation, is currently under discussion. The CO_2 quota system is a system of individual CO_2 permits for power plants that was introduced on 1 January 2001 to apply the government's climate change policies to the power industry in a market-compatible manner. The permits are tradable in principle, although so far limited trading has taken place. The quota system will be in force provisionally until 2003. Should the quota system fade away without replacement, electricity exports could soar after 2003 and national CO_2 emissions would fall short of the Kyoto target by more than 19%.

Energy market liberalisation became an important policy objective in Denmark as of 1996 under the European Union's Electricity and Gas Directives. The transition towards competition began with a 1996 amendment to the former Electricity Supply Act and the ensuing opening of the power market for consumers over 100 GWh annual consumption on 1 April 2000. As of 1 January 2001, consumers of one GWh or more are free to choose their supplier, and as of 1 January 2003, competition will extend to all consumers. In December 1999, a new Electricity Supply Act (Law no. 375 of 2 June 1999) came into force. This, together with several agreements between Denmark's political parties, forms the basis for competition in the Danish power market.

Liberalisation of the gas market under the new Natural Gas Supply Act followed on 1 July 2000 with the opening of the gas market for consumers of more than 350 million cubic metres (mcm) of natural gas per year. This corresponded to 30% of the Danish gas market in 2000. The opening will be extended to 38% of the market in 2003 and to 43% in 2008. Power plants and the largest of the small-scale CHP plants and industrial enterprises will be among the eligible consumers, but not the regional distribution companies. According to a reform follow-up agreement among political parties concluded in March 2000, the gas infrastructure is to remain in public ownership. The new government announced in early 2002 that full retail competition was to be introduced to the Danish gas market in 2004 and that the state-owned gas transmission company DONG was to be privatised at a time to be determined in the future.

Energy Policy Institutions

Until recently, Denmark was the only IEA country that combined energy and environmental affairs in the same ministry. The Ministry of Environment and Energy had been created in autumn 1994 through the merger of two separate

ministries. It was responsible for the development and implementation of energy and environmental policy and research and development in these areas for Denmark as a whole. With the change of government in 2001, that ministry was split into a ministry responsible for industry and energy and a separate ministry for the environment. Regional and local authorities continue to have a large degree of responsibility for energy administration and co-operate closely.

Aside from the Minister's Department, the ministry had three agencies in charge of legislation, implementation and monitoring of policy: the Danish Energy Agency (*Energistyrelsen*, DEA), the Danish Environmental Protection Agency and the Danish Forest and Nature Agency. In addition, it comprised three research agencies that gather and process the information upon which Danish environmental policy is based. Furthermore, the ministry co-operated with three independent appeals boards for energy tax policy, environmental policy and nature protection. Overall, the ministry employed 3 000 people, of which more than 1 000 work in the state forests and 150 in the central office. Following the change of government, about one-quarter of the Danish Energy Agency's staff were made redundant.

The Danish Energy Agency continues to be the key institution for development and implementation of energy legislation and policy. The agency was founded in 1976 to implement the objectives of Denmark's first energy plan. It had 16 divisions as set out in Figure 9. These divisions mirrored its traditional areas of responsibility:

- Overall planning of power, heat and natural gas through the Electricity Supply Act, the Heat Supply Act and the Natural Gas Supply Act.

- Surveillance of oil and gas exploration and production. The agency regulates the exploitation of the Danish subsoil under the Subsoil Act, prepares and implements licensing rounds, and issues licences for exploration and production of oil and gas. It implements legislation concerning offshore installations, pipelines, storage of natural gas, and the continental shelf.

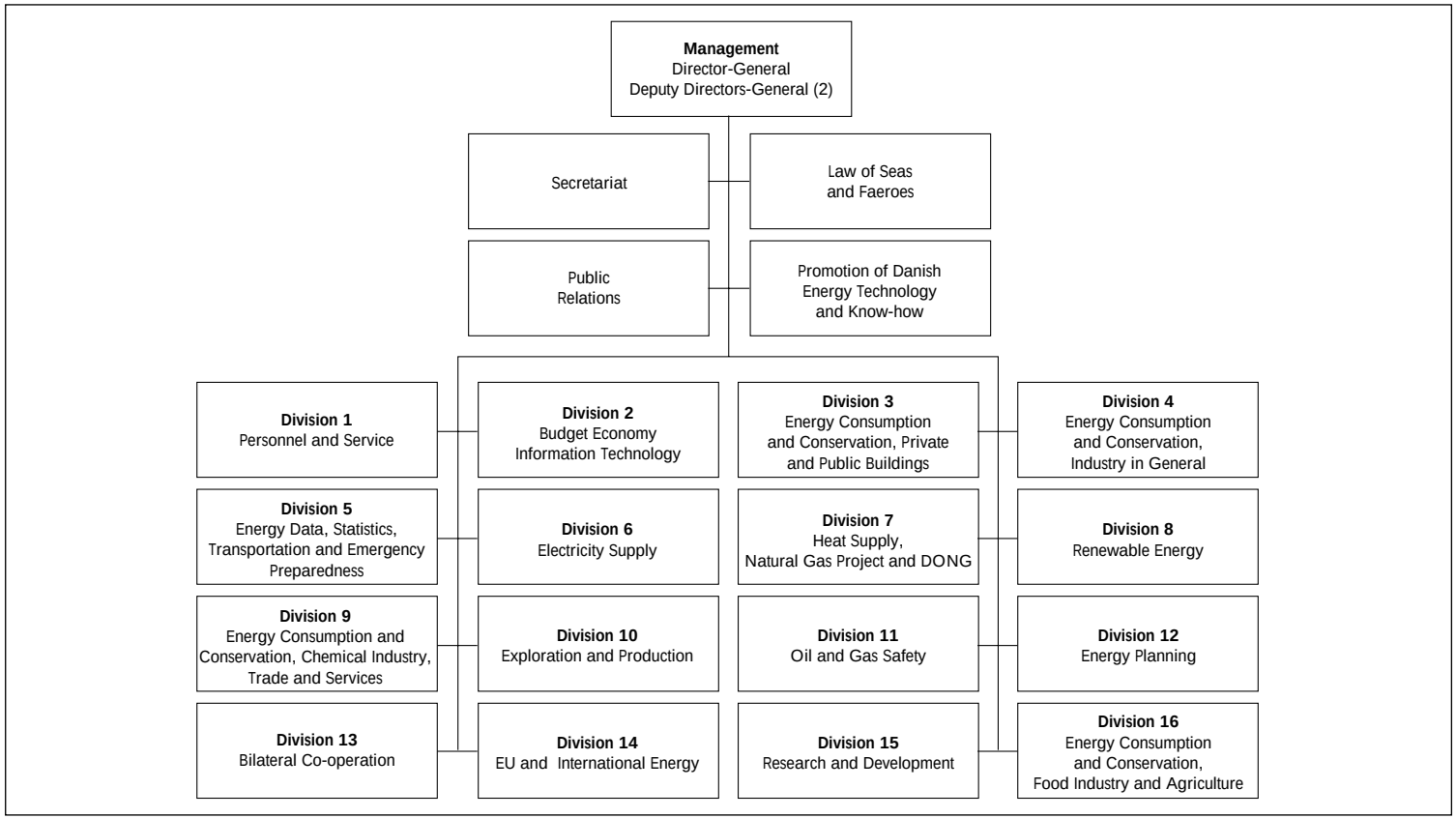
- Promoting technological development and utilisation of renewable energy sources such as wind energy, solar heating, biomass and wave energy, through the Development Programme for Renewable Energy.

- Promoting energy efficiency through energy conservation campaigns, appliance labelling and various subsidy schemes. This includes administration of a scheme launched in 1997 to energy-label all buildings, to undertake systematic energy auditing and management of most public institutions, and to provide subsidies for conversion of electrical heating in areas where heat or natural gas networks are available. The subsidies are in many cases granted through the Electricity Saving Fund, founded in 1997 to enhance the efficiency and reach of energy conservation efforts. The Danish Energy Agency sets the general conditions for this fund.

- Negotiating voluntary agreements for investment in energy efficiency programmes with energy-intensive industries, in return for rebates on the carbon tax. The agency can also pay subsidies for specific projects in the framework of this programme.

Figure 9

Structure of the Danish Energy Agency



Source: Danish Energy Agency.

- Administering the Energy Research Programme to fund research and development in a number of fields, including further recovery of oil and natural gas, combustion and gasification of biomass, development of large-scale, low-noise wind turbines, and fuel cell and superconductor research.

- Representing Denmark in international discussions on energy policy within the UN, the OECD, the IEA, the EU and the Nordic Council of Ministers. The agency continues to participate in international negotiations on climate change. It also seeks to promote exports of know-how and energy technology by Danish companies on a commercial basis. By means of various support and development assistance programmes, the agency contributes to the transfer of technology to countries in Central and Eastern Europe and to the developing countries.

The role of the Danish Environmental Protection Agency is to administer environmental legislation designed to protect air, water and soil as well as "good living conditions" for people, animals and nature. Its authority is based on the Environmental Protection Act, which lays down the fundamental objectives, the means by which to meet these objectives and the administrative principles by which the agency works. The act is a framework, containing no concrete recommendations on quality requirements or threshold values. It is supplemented by guidelines and regulations issued by the Ministry of Environment and Energy and the Danish Environmental Protection Agency.

Following introduction of competition into the electricity and gas industries in 1998 and 1999, respectively, an Energy Regulatory Authority (*Energitilsynet*) was established as part of the Danish Competition Authority. The regulator supervises network tariffs and electricity, heat and natural gas prices for various consumer groups.

Energy Taxes and Subsidies

Taxation of energy products has a long history in Denmark, dating back to the first tax on petrol introduced in 1917. Taxation was extended to cover other oil products and electricity in 1977, and coal in 1982. Gas was also temporarily taxed but at very low rates. As of 1980, taxation of a large and growing number of products throughout the economy was motivated in part by environmental considerations and a striving to save resources, especially energy. In 1986, oil product taxes were raised substantially to compensate for the fall in oil prices.

In 1991, energy taxes were reformed into an energy and carbon tax, designed to reflect the country's environmental concerns. A large share of the tax revenues was used for energy conservation and efficiency measures. This tax system came into effect in 1992 and has been expanded since then. The environmental approach towards taxation received renewed impetus in 1994, when Denmark embarked upon a "green" tax reform, shifting the tax burden away from income and towards resource use and environmentally harmful activities. This tax reform

was put into practice between 1994 and 1998. As a result, a number of environmental taxes were introduced, e.g. on water, waste water, the use of plastic and paper bags, etc. Energy taxes were raised progressively, particularly on coal and electricity consumption, leading to an average increase in taxation on heating and power of 30% from 1994 to 1998. The main consequence of this reform was that households paid lower income taxes and higher environmental taxes.

The "green" tax reform of 1991 had left the tax burden on businesses and industry unchanged. This was to change through another reform of the tax system undertaken between 1996 and 2000, based on the policy document *Green Tax Package 1995*. The goal was to increase energy conservation in businesses and industry. The main features were higher carbon dioxide taxation, introduction of a substantial tax on natural gas, differentiation of the energy and carbon taxes according to energy use, and phase-in of a sulphur tax. The tax structure has remained unchanged since, but the tax rates have increased. These taxes are described in more detail below.

In line with the principles of "green" tax reform, the government transfers a large part of the additional tax revenues from the *Green Tax Package 1995* back to companies through reduced taxation on labour, special subsidies for small companies, and subsidies for energy efficiency measures. The European Commission approved these subsidies in 1995. The largest part of the revenue re-transfer occurs through reductions in employers' labour market contributions. 1997 was the first year for such reductions; they amounted to 0.11% of companies' total contributions. By 2000, they had reached their plateau level of 0.53% of those contributions or about DKK 2 billion. Another DKK 200 million were transferred back in 2000 through reduced employers' contributions to a supplementary labour market pension called ATP. This corresponds to an annual reduction of DKK 159 per full-time employee. Small businesses with limited payrolls received re-transfer in the form of reimbursement of administrative costs of DKK 295 million in 2000, up from DKK 180 million in 1996.

Finally, DKK 1.8 billion was set aside to be spent on energy efficiency subsidies for the period 1996 to 2000. Earlier tax reform in 1993 had already made it possible for businesses to obtain subsidies for energy efficiency investment. But under the *Green Tax Package 1995* the funding was extended significantly. Generally speaking, the subsidy can amount to up to 30% of the investment, but for small- and medium-sized enterprises (SMEs) it can go up to 40%. SMEs are defined as having no more than 250 employees and a turnover up to €40 million or a balance sheet of up to €27 million.

Eligible investment projects must lead to increased energy efficiency, or reduced CO_2 or SO_2 emissions, or must be of developmental character. The Danish Energy Agency has established a list of 40 standard solutions for energy efficiency improvements and determines which projects qualify as developmental projects. The latter can receive subsidies of up to 100% in certain exceptional cases.

Companies can also suggest individual solutions. They are eligible for support if their payback time ranges between two and nine years, and if they save more than 0.15 kg of CO_2 per Danish crown invested. To discourage free-riding, highly profitable investment projects are excluded from support.

Between 1996 and 1999, the annual spending from the subsidy budget rose from DKK 366 million to 575 million. It is estimated that the entire budget will be spent as anticipated. The total number of applications for support rose from 2 800 in 1996 to 7 000 in 2000. Standard solutions dominated with 4 000 applications, followed by individual projects (2 500) and developmental and other projects (500).

In an evaluation carried out in 2000[6], the government estimated that the total additional tax revenue from the *Green Tax Package 1995* will amount to DKK 3.495 billion in 2000. The amount transferred back in the same year was estimated to total DKK 3.830 billion. This sum takes into account that old CO_2 taxes from before 1996 were abolished, reducing the overall tax burden by DKK 1.060 billion. Following this calculation, the *Green Tax Package 1995* results in a net decrease of the overall tax burden by DKK 335 million. It was estimated that the CO_2 emissions from Danish industry in 2005 will be reduced by 4 million tonnes below their 1988 values, largely thanks to the effects of the tax package.

Following a parliamentary decision in 1998, energy taxes were to continue rising after the end of the phase-in period of the *Green Tax Package 1995*. The so-called "Whitsun" package for the period 1998 to 2002 foresees further rises as specified in Tables 1 to 3. Households' energy taxes on stationary fuel use, for example, rose by 15% to 25% between 1998 and 2000, as did petrol taxation.

CO_2 Tax

The standard carbon tax rate in force since 1996 amounts to DKK 100 per tonne of CO_2. As the net carbon emissions from fuel combustion differ, the standard tax rate varies between DKK 9.6 per GJ (DKK 402 per tonne of oil equivalent, toe) for coal, DKK 7.9 per GJ (DKK 331 per toe) for fuel oil, DKK 5.6 per GJ (DKK 235 per toe) for natural gas and 0 for combustible renewables. The rate for electricity was set at DKK 27.8 per GJ (DKK 1 164 per toe or 10 øre per kWh).

The CO_2 tax applies to almost all energy users, including industry. Fuels for electricity generation are exempt, but domestic electricity consumption is taxed. For industry, the CO_2 tax is differentiated according to two principles: the process the energy is used for and whether or not the company has entered into a voluntary agreement to apply energy efficiency measures. Table 1 details the rates of the carbon tax between

6. Danish Energy Agency: *Green Taxes for Trade and Industry – Description and Evaluation*, Copenhagen, June 2000.

1996 and 2002. The proposal for higher tax rates in 2002 was made by the previous government; the new government has stated that it will not put this raise into practice. Companies first pay carbon taxes at the basic rate but can obtain reimbursement down to the rate given in Table 1 if they meet the required criteria. In Danish terminology this is also sometimes referred to as a tax subsidy.

The differentiation between "heavy" and "light" industrial processes was introduced to protect energy-intensive companies that need to maintain national or international competitiveness. A production unit of a company is defined as a "heavy" industrial process if its tax burden would amount to more than 3% of its value-added or more than 1% of its sales value applying the "light process" tax rate. Danish tax law defines 35 specific processes as energy-intensive, covering one-third of industrial energy use. The category of "light" industrial processes includes fixed lights, office machines, refrigeration and air-conditioning.

Since Denmark's industrial structure is based mainly on light industry and services, companies producing 90% of gross added value are responsible for half of the country's CO_2 emissions. The other half stems from energy-intensive firms producing about 10% of gross added value.

All industrial companies can conclude voluntary agreements. Since the agreements cover individual production processes, a single company can conclude several agreements, both "heavy" and "light". Collective agreements, for example with an industrial association, where standards are set for all the enterprises in the group, are also possible.

In order to conclude an agreement, companies must submit an energy audit prepared by an independent certified consultant. On the basis of this audit, they must develop an action plan containing a commitment to invest in energy-efficient equipment and to implement energy management. Energy-efficient investments with payback times up to four years must be accepted if recommended by the audit. The company can dispute the audit or propose alternative measures to achieve equivalent CO_2 results. Following this, the companies sign three-year agreements with the government and are guaranteed a partial reimbursement of carbon taxes, provided the obligations in the action plan are fulfilled. The companies must submit regular reports to the Danish Energy Agency. If the reports are found to be lacking, the Agency can cancel the agreement and require that the company pay back the tax subsidy.

At end 1998, 101 individual voluntary agreements were active. The average payback period for recommended energy investments was about two years. In early 1999, three group agreements had been signed, covering 129 companies, most of them greenhouse growers. This brought the total number of companies with voluntary agreements to 230. The agreements signed in early 1999 covered a combined energy demand of some 1.12 million tonnes of oil equivalent or 6% of Denmark's TPES in 1999. In 1998, companies with voluntary agreements were able to reduce their combined energy and carbon tax burden by DKK 70 million. The Danish government estimates that the number of firms with agreements reached 370 in 2000.

Table 1
Effective Carbon Tax Rates, 1996 to 2002
DKK per tonne of CO_2

	1996	*1997*	*1998*	*1999*	*2000*	*Proposal (2002)*
			Basic rate			
Industrial space heating	100	100	100	100	100	135
			"Light" industrial processes			
Basic rate	50	60	70	80	90	135
With voluntary agreement	50	50	50	58	68	105.30
Resulting tax subsidy	0	10	20	22	22	29.70
			"Heavy" industrial processes			
Basic rate	5	10	15	20	25	33.75
With voluntary agreement	3	3	3	3	3	4.05
Resulting tax subsidy	2	7	12	17	22	29.70

Source: Ministry of Taxation.

As shown in Table 1, the differential between the tax rate with and without voluntary agreement grew very significantly between 1996 and 2000, from DKK 2 to DKK 22 per tonne of CO_2 in the case of "heavy" processes. This has contributed greatly to the increasing success of these agreements. Large companies concluded agreements early on, whereas smaller companies began doing so only more recently. Most of the agreements are for "heavy" processes. In 1998, there were only 30 agreements for "light" processes. Of these, 27 were with companies that also had a "heavy" process agreement in place.

Energy Taxes

All energy taxes under the *Green Tax Package 1995* were phased in by 2002. The sole exception, the new tax on natural gas, was to be phased in more gradually, rising slowly until 2009. The high oil prices and the resulting increased profitability of the natural gas companies led the government to review its decision and to raise natural gas taxation to the full plateau level already in 2002. From 1 January 2001 the energy tax rate on natural gas corresponded to the tax level on oil products (based on the energy content).

The energy tax is differentiated even more than the CO_2 tax, different tax rates applying both for different energy products and for different uses of the same product. For the sake of clarity, Table 2 details a selection of energy tax rates for the period 1998 to 2009. Fuels for electricity generation are exempt from the tax, as it applies as an output tax on electricity.

Table 2
Energy Tax Rates, 1998 to 2002

	Unit	*1998*	*1999*	*2000*	*2001*	*2002 to 2009*
Coal	DKK/toe	1 717	1 884	1 968	2 051	2 135
Natural gas	DKK/toe	1 549	1 549	1 675	2 052	2 136
	DKK/m^3	1.47	1.47	1.58	1.94	2.02
Oil products:						
Automotive diesel	DKK/toe	2 429	2 429	2 429	2 429	2 429
Fuel oil		1 968	1 968	2 010	2 051	2 093
Electricity:						
For heating	Øre/kWh	40	42	47	49	50
Other		46	48	54	55	57
Waste:						
For CHP		838	1 131	1 131	1 131	1 131
For district heating	DKK/toe	1 047	1 298	1 298	1 298	1 298
Heat from waste		0	209	335	419	544
Other combustible renewables	DKK/toe	0	0	0	0	0

Source: Ministry of Taxation.

Sulphur Tax

The third major element of the *Green Tax Package 1995* is the sulphur tax. Denmark is committed to sulphur emissions limits under several international agreements concluded in the framework of the United Nations Economic Commission for Europe (UNECE), and under the EU directive on large combustion plants. For several years now, Denmark has overcomplied with the agreements.

However, to encourage further shift from sulphur-rich to sulphur-poor fuels in combustion processes, e.g. from high-sulphur to low-sulphur coal or to natural gas, the sulphur tax of DKK 10 per kg SO_2 was phased in over the period 1996 to 2000. The tax is differentiated only according to the sulphur content of fuels, not energy uses. Fuels used for electricity generation were exempt from the tax until the end of 1999, but the tax rate for electricity was calculated according to individual power plants' sulphur quotas. As a special concession, the 1996 rate will apply to coal used in certain highly energy-consuming boilers and furnaces for a maximum transition period of 20 years.

Table 3
Sulphur Taxes, 1996 to 2000 and After

	SO_2 %	Unit	1996	1997	1998	1999	2000+
Fuel oil	0.5	DKK/tonne	20	40	60	80	100
Fuel oil	1.0	DKK/tonne	120	140	160	180	200
Gas oil	0.1	DKK/tonne	8	8	8	8	17
Coal	0.6	DKK/tonne	58	70	83	95	108
Electricity	–	Øre/kWh	0.9	0.9	0.9	1.3	0
Straw*	> 0.05	DKK/tonne	0	0	4	12	20

* For boilers with a capacity over 1 000 kW. The rates are for 100% dry straw.

Source: Danish Energy Agency.

CRITIQUE

Protection of the environment is very important to Danish voters and in the policies of their governments. The environment has never been the only important energy policy issue in Denmark, but throughout the 1990s environmental considerations affected most aspects of energy policy and came close to being an overriding objective. For this reason, the discussion in the preceding section has focused on Denmark's various environmentally-inspired objectives. The following chapters will discuss similar issues in greater depth, as they permeate the entire range of energy policies. This discussion necessarily focuses on the priorities and policies of the previous government. The new government has announced that it will focus more on cost efficiency, market solutions and lower energy prices for industry.

If the energy policies of the last ten or fifteen years are measured against their objectives, Danish energy policy has been very successful. The country has built up the world's largest CHP district heating system, has the highest share of wind power connected to the power grid of any nation and will come very close to meeting its multiple CO_2 and greenhouse gas emissions commitments, provided the CO_2 quota system remains in place.

For the sake of this high degree of environmental protection and energy conservation, the Danish electorate has accepted major restrictions on their freedom of choice compared to other wealthy democratic countries, such as the national heat plan that prescribes for certain parts of the country which heating energy citizens have to use. These restrictions are self-imposed through a democratic process, and the government is therefore fully justified in pursuing this path as long as the electorate accepts it. This does not necessarily mean that there is unanimous acceptance of these restrictions throughout the country. However, for decades it has meant that those who may have found the burden of such measures excessive were a minority.

It is important to note that the environment is not the only policy objective that ranks high in the views of Danish voters. Security of supply also plays a very strong role and was in fact the main motivation for the far-reaching policies that were put in place after the two oil crises. The aim of these policies was to save as much primary energy as possible. They were very effective but came at high cost, both economic and in terms of freedom of choice. Although environmental motivations certainly already played a role, it was the perception of tremendous import dependence and vulnerability to shocks from the outside that made Danes accept this cost.

The fact that Denmark has now become self-sufficient in energy supply has helped reduce this vulnerability. Once developed, the Danish oil and gas reserves provided greater security of supply for Denmark, but they are much too small to have any effect on regional security of supply comparable to, say, the Dutch Groningen field.

Once the security of supply threat subsided, the notion that permanent and strong government intervention to alter market results was acceptable, necessary and even beneficial had already taken strong root in Denmark. From there, it was a small, and logical, step to address the environmental threat that then emerged with a similar set of policy tools. Support for energy conservation and substitution of renewables for fossil energies were seen as effective responses to environmental challenges. It is also important to understand that the outgoing Danish government considered climate change as the single most important challenge of the twenty-first century. For those with this view, it is simply a matter of consistency that this issue should enjoy priority over most other policy considerations.

Moreover, Danish energy and environmental policy has long attempted to serve as an example to other countries. To do this, Denmark initiated domestic environmental measures even if they were comparatively costly. The same measures might have had the same impact at lesser cost if carried out elsewhere. An example is a programme that provided significant support for solar energy in the past. Solar energy is clearly less competitive in Denmark than it is in Southern Europe. In a European market for renewables, such as is envisaged by the European Union, investment would move to the most competitive resource. But the Danish people have the political will to carry out such programmes, and have long feared that political will may be lacking in other countries. A majority of Danes appear convinced that their economy is robust enough to bear the extra costs. Therefore, Denmark has decided to go as far as possible in implementing such programmes, if only to demonstrate that they are feasible.

Whether the Danish experience of the last one or two decades really is applicable elsewhere is questionable, however. Few other countries have electorates that would accept similar government intervention in private decisions, unless environmental damage becomes much more visible. Danish support policies have however been successful enough to act as a positive example for like-minded countries. The support from the Danish government has spurred development in wind turbine technology that has led to very significant reductions in the cost of wind power generation. But the costs of conventional power generation technology

have also come down thanks to the introduction of competition, as well as technological advances such as the aero-derivative gas turbine. Despite the impressive cost reductions achieved, wind turbines still require substantial subsidies.

Serving as an effective example to a wider audience might require further efforts. These would have to focus on demonstrating that a high degree of environmental protection is possible at moderate extra cost[7] and in a fully market-based environment. Otherwise, appreciation of Denmark's experience could be restricted to a limited group of countries with similar characteristics.

Denmark should focus its attention on achieving greenhouse gas abatement at minimal cost by investing where the marginal cost of emissions abatement is lowest, including abroad. The Danish government is conscious of this and is seeking international co-operation. It co-operates with and supports the Baltic States on environmental issues. This action could and should be expanded in future. In the absence of an operational international framework for such co-operation, Denmark continues to rely heavily on its domestically-oriented efforts. Denmark should continue pressing for rapid establishment of clear international rules for the flexibility instruments under the Kyoto Protocol. Both Denmark and the international community could benefit if Denmark focused more of its attention on international greenhouse abatement efforts.

Over time, the government has also adjusted its environmental policy to rely more on market-compatible instruments. The most important example is the "green" tax reform. This is a welcome move. Shifting away from income and corporate taxes, and towards taxes on energy and resource use and polluting activities is in principle more economically efficient than regulation. The government has also made attempts to increase the cost-effectiveness of support measures. But in Denmark, as in like-minded countries, the largest energy users, energy-intensive industries, must be exempted or partially exempted from energy and carbon taxation to protect their international competitiveness, in the absence of an international environmental framework. This provides another reason why Denmark should work towards an international solution.

Denmark was not among the front runners of energy market liberalisation, and the impetus for market opening clearly had to come from the European Union. But once power market opening had been decided upon, Denmark implemented the reforms without major delays. The country will go beyond the current EU minima of market opening in the electricity market with full retail opening in 2003. The introduction of competition into the gas market is proceeding at a noticeably slower pace in order not to destabilise the current compromise between market and environmental policy. The previous government made it clear that in its view the environment and energy security would remain priority objectives. The new

7. In principle, the cost of avoiding environmental damage should not exceed the cost of the damage, or externality. Whereas this principle is widely accepted, the uncertainty surrounding the size of externalities is such that this principle alone does not allow generally accepted optimal protection levels to be established.

government appears to attribute greater importance to free markets. Some of the past national achievements are incompatible with the more competitive market place. Chapter 7 discusses the difficulties that the high share of intermittent wind capacity creates for Jutland's power grid, and the problems of integrating these factors into market prices. Nevertheless, the previous Danish government insisted that existing national programmes have to be maintained as long as there is no international or at least European framework for similar policies.

But if past achievements are to be maintained, more work lies ahead. Once the power market is fully open in 2003, the current system of CO_2 quotas will need to be renewed, and new quotas set. The current uncertainty about the future of the CO_2 quota system and the introduction of a green certificates system has already dampened investment. Therefore, the government should develop the framework for its future interventions as quickly as possible.

In the longer run, all existing and future policies and programmes should be reviewed with respect to their market-compatibility and cost-effectiveness. The system of energy taxes and subsidies, for example, is complex. The complexity arises because the government has tried to adapt the systems to a multitude of criteria, notably environmental effectiveness, social and political acceptability, international competitiveness of companies, and revenue neutrality. Simplicity does not seem to rank high among these criteria. It has also been standard procedure to raise tax rates every time the government's emissions projections show that emissions might overshoot the corresponding target, which adds to the complexity. In the medium term, following a period of stability, the energy tax system would benefit from an overhaul to reduce its complexity and administrative burden.

RECOMMENDATIONS

The Government of Denmark should:

- ☐ Review the existing policy measures with a view to developing more cost-effective policies. Government interventions should be analysed on a continuing basis for cost-effectiveness and should be prioritised accordingly. Market-oriented approaches should receive priority.

- ☐ Ensure that both domestic and international policies are adequately assessed in order to meet environmental objectives cost-effectively.

- ☐ Further review the tax and subsidy system with a view to reducing its complexity and administrative costs.

- ☐ Work to reconcile free market rules and environmental policies to send the right investment signals to the market; in particular, develop as soon as possible a market-based successor mechanism to the CO_2 quota system for the period after 2003.

4

ENERGY AND THE ENVIRONMENT

CLIMATE CHANGE

Background

Danish energy policies are based on a principle of sustainable development: balancing the economy, environment and security of supply. Energy and environment are strongly linked in Danish policy-making and the reduction of CO_2 emissions is a main objective. For this reason, a number of the chapters in this book touch upon climate change policies in the energy sector. In particular, the chapters on electricity and renewable energy and efficiency, as well as the section on the energy/CO_2 taxation system in Chapter 3, describe important policies that Denmark has instituted in order to reduce greenhouse gas emissions, both on the supply side and the demand side. This chapter should thus be read in conjunction with Chapters 3, 5 and 7 in order to fully understand the breadth of Danish energy/ climate change policy.

Denmark has taken the climate change challenge very seriously and has set a series of targets through significant policy initiatives and legislation. In 1988, the Danish government presented its *Plan of Action on Environment and Development* as a follow-up to the recommendations set out in the report from the World Commission on Environment and Development, the Brundtland Report, and in the United Nations' Environmental Perspective to the Year 2000. This action plan set the targets to be reached and the initiatives to be implemented in all sectors in order to obtain sustainable development.

The energy action plan, *Energy 2000*, followed in 1990 based on a political agreement of 20 March 1990. It introduced the goal of sustainable development in the energy sector and formulated the national objective of a 20% reduction in CO_2 emissions by 2005 compared to 1988. *Energy 2000* focused on savings in energy consumption, increased efficiency of the supply system, conversion to cleaner sources of energy, and research and development. Action in these areas has been followed up by political agreements and legislation.

The *Energy 2000 – Follow-up* of 1993 contained a review of trends and policies together with a number of other initiatives. The energy action plan, *Energy 21*, approved by the Danish Parliament in April 1996, deals with international market conditions and long-term environmental issues as the overall challenges to the energy sector. The major environmental challenge is to achieve convergence of emissions of industrialised countries at a globally sustainable level. The plan sets out the framework for a number of initiatives focusing especially on reducing the requirements for resources and on the impact of the energy sector on the environment.

In March 2000, the government presented *Climate 2012 – Status and Perspectives for Denmark's Climate Policy*, which offered a complete overview of Danish climate

policy and laid the required groundwork for Parliament to decide on Denmark's ratification of the Kyoto Protocol. To fulfil its national and international obligations, the government would:

- Update the 1996 energy action plan, *Energy 21*.
- Submit an action plan for the transport sector.
- Establish a programme for analysis, development and testing of the Kyoto mechanisms.
- Determine future regulation of industrial greenhouse gases.
- Submit analysis and assessments of greenhouse gas reduction potentials in the agricultural sector.

On 29 May 2001, a new political agreement was reached on natural gas and energy savings. In this agreement special attention is paid to energy savings in the public sector and product taxes. The purpose of product taxes is to influence the market in order to increase the market share of the most energy-efficient products.

On 30 May 2001, Denmark's Parliament gave the go-ahead by a sizeable majority for the government to ratify the 1997 Kyoto Protocol on global warming. Denmark's actual ratification of the Treaty will take place along with that of other European Union member states, anticipated in advance of the World Summit on Sustainable Development to take place in Johannesburg in September 2002.

Climate Change Commitments

In summary, Denmark has made a commitment to fulfil four national and international greenhouse gas emission targets:

- A national commitment to reduce its greenhouse gas emissions by 5% by 2000 as compared to 1990 levels.
- A national target to reduce total Danish CO_2 emissions by 20% by 2005 from 1988 levels.
- A commitment to reduce its greenhouse gas[8] emissions by 21% from 1990 levels over the period 2008-2012. This is the Danish contribution to helping achieve

8. The Kyoto commitment entails a combined reduction of six greenhouse gases: carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs); and sulfur hexafluoride (SF_6), which are converted to CO_2 equivalent on the basis of their contributions to the greenhouse effect, i.e. global warming potentials. The base year for CO_2, CH_4 and N_2O is 1990, and 1995 for HFCs, PFCs, and SF_6.

the European Union's international commitment to an overall reduction of greenhouse gases by 8% under the Kyoto Protocol adopted in December 1997. The political agreement on the internal redistribution of the total commitment is commonly referred to as the EU Burden-Sharing Agreement.

- Denmark has also set a longer-term target to halve its CO_2 emissions before 2030, on the condition that international efforts in technological development and design of market conditions and mechanisms are further developed.

It is important to note that Denmark uses as its reference level for the 1990 base year 76.4 million tonnes of CO_2 equivalent (thus its Kyoto commitment would entail a reduction of emissions to an average of 60.4 million tonnes of CO_2 equivalent). This number has been adjusted to account for annual differences in electricity trade. The variations in year-to-year electricity trade are primarily due to changes in precipitation in Norway and Sweden, which rely about 100% and 50% respectively on hydropower. Denmark is thus a net exporter of electricity in dry years and a net importer in wet years. As 1990 was a wet year, Denmark imported more electricity than in an average year. Consequently, its thermal electricity production was lower, leading to reduced CO_2 emissions.

Denmark's Kyoto commitment based on an adjusted 1990 base year represents a reduction of 21% by 2008-2012. When compared to a non-adjusted 1990 base year, further reductions would have to be achieved at a level of approximately 5 million tonnes of CO_2 equivalent or about a further 7%.

Historical Greenhouse Gas Emissions Trends

The total sectoral contributions of greenhouse gas emissions in 1997 were: 46% from the energy sector; 18% from agriculture; 16% from the transport sector; 12% from trade and industry; 6% from households; and less than 2% from waste.

CO_2 is the most significant greenhouse gas, representing about 77% of total Danish emissions in 2000. The main source of CO_2 emissions from Denmark is the use of fossil fuels. The only other source of CO_2 is from processing minerals in the production of cement, burned limestone and yellow bricks, and from the use of organic solvents.

Carbon dioxide emissions by fuel and by sector, using IEA data, are illustrated in Figures 10 and 11. In 1999, 53.64 million tonnes of CO_2 in Denmark originated from fuel combustion. Of these emissions, 24.99 million tonnes are from the combustion of oil, 18.40 million tonnes are from the combustion of coal, and 10.25 million tonnes from the combustion of natural gas. There has been a significant shift over the period 1990 to 1999. With the reduction of electricity produced from coal generation, the contribution of coal to emissions has fallen commensurately by more than 22% over the period) and the contribution of natural gas has risen (by close to 150%).

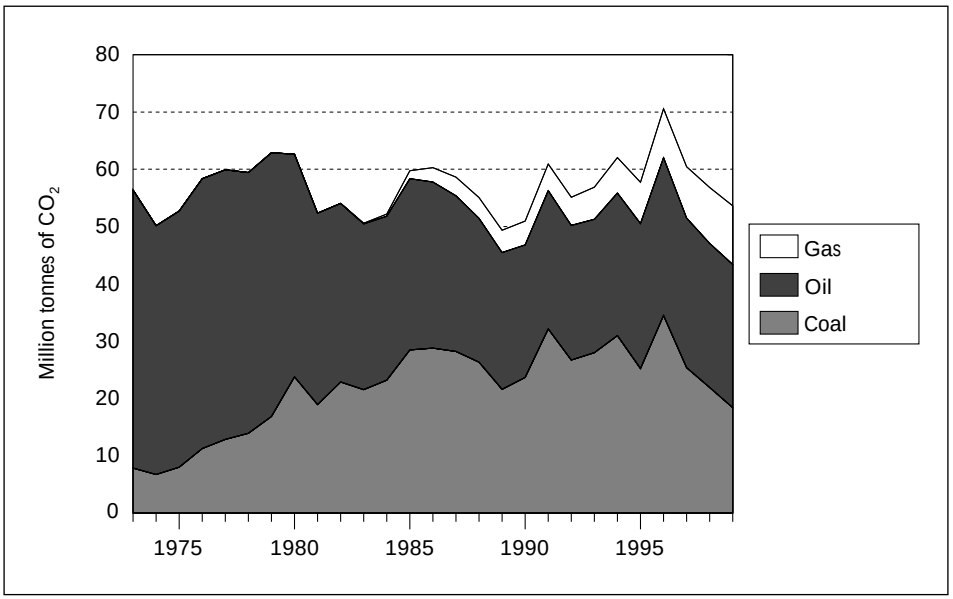
On a sectoral basis in 1999, electricity and heat production resulted in 46.3% of total energy sector emissions, transport contributed 23.4%, manufacturing industries and construction contributed 9.5%, the residential sector 8.7% and other energy industries 4.1%. Here again there have been some interesting results over the period from 1990. Both the residential and the manufacturing industries/construction sector reduced emissions over the period (by 17.2% and 5.5% respectively). This reflects the reduced importance of direct fuel use, which has largely been replaced by electricity in homes and industry, increased energy efficiency and the shift in economic activity from heavy industry to services. There has been a significant increase in emissions from the transport sector and in particular from road transport, where emissions increased by over 20% between 1990 and 1999 as a result of growing demand for mobility. This trend is consistent with other OECD countries (where overall transport emissions grew by 19%).

The 5.3% increase in Danish CO_2 emissions from fuel combustion over the period 1990 to 1999 should be seen in light of a total increase of 12.4% in total primary energy supply (TPES) and a 22.1% increase in GDP. CO_2 intensity of GDP (kg CO_2 per 1995 US$)[9] thus showed a significant drop of 10.0% while CO_2 intensity of energy supply (kg CO_2 per TJ) also fell over the period by 4.6%. This partial decoupling of energy use from CO_2 emissions and of GDP from CO_2 can be attributed to a number of factors. Energy saving in end uses and economic growth that has taken place in "energy-light" activities have contributed to the fall in energy intensity, which has contributed to the fall in CO_2 emissions. During the 1990s, the expansion of CHP and the increased use of natural gas resulted in increased efficiency from the production of electricity and district heating. The increased use of natural gas and renewable energy has also reduced the average CO_2 content in primary energy consumption in Denmark.

Overall CO_2 emissions levels peaked in 1996, and have been falling consistently since then. This can be attributed to the significant policy measures undertaken by the Danish government, and in particular to measures reducing the contribution of coal in electricity generation. On the other hand, CO_2 per capita actually rose by 3.5% owing to a relatively low population growth of 3.6% from 1990 to 1999. Denmark maintained a lower than OECD average CO_2 per capita in 1999 (10.01 tonnes of CO_2 per capita versus 12.07 tonnes of CO_2 per capita) but its CO_2 per capita is significantly higher than its Nordic neighbours Sweden (5.44 tonnes of CO_2/capita) and Norway (8.32 tonnes of CO_2/capita). This is due to Denmark's still significant share of coal in its generating mix whereas Sweden and Norway rely heavily on hydroelectric power.

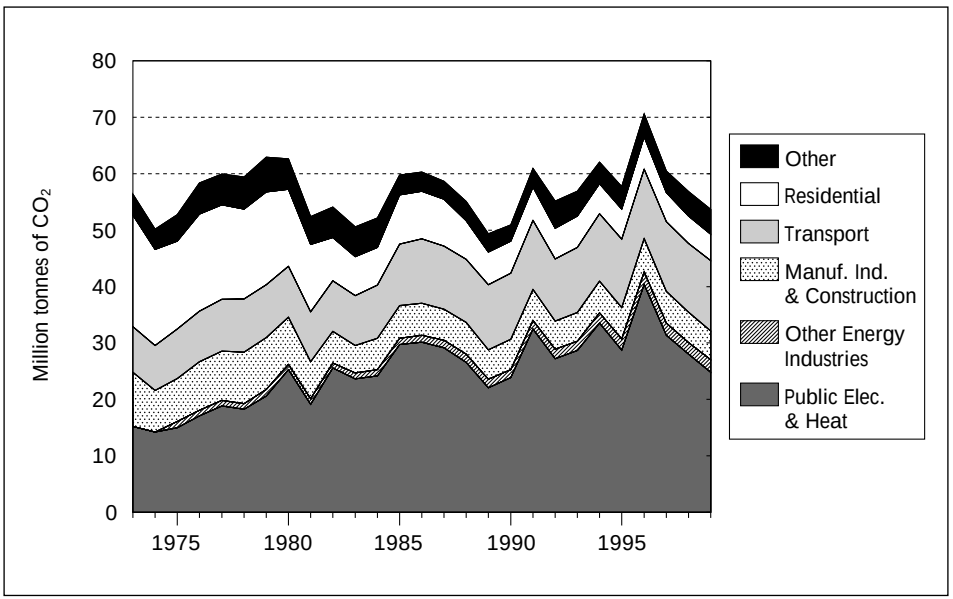
9. Ratios are based on the Reference Approach.

Figure 10
CO_2 Emissions by Fuel, 1973 to 1999



Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2001.

Figure 11
CO_2 Emissions by Sector, 1973 to 1999



Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2001.

Methane (CH_4) emissions represent about 9% of Danish greenhouse gas emissions. The main part of methane emissions originates from animals in the agricultural sector. The second largest emitter is landfills. The CH_4 from energy combustion has increased since the introduction of decentralised power plants using gas engines, which do not combust all the natural gas. There are also some emissions from oil and gas extraction, gas networks leakage, refineries and coal storage. CH_4 emissions from all sources other than agriculture and landfills represented about 15% of the total methane emissions in 2000, the majority from energy-related activities.

Nitrous oxide (N_2O) emissions represent 13% of greenhouse gas emissions. The major part of this originates from agricultural soils. Although there are some emissions from power plants and road transport (where emissions are forecast to increase with the introduction of 3-way catalytic converters on gasoline cars), the agricultural sector is again the main source, representing about 91% of N_2O emissions in 2000.

The three industrial gases are: perfluorocarbons (PFCs), which are by-products of aluminium smelting and uranium enrichment; sulphur hexafluoride (SF_6), which is largely used in heavy industry to insulate high-voltage equipment and in the manufacturing of cable-cooling systems; and hydrofluorocarbons (HFCs), which are largely used in refrigeration and semi-conductor manufacturing. The total contribution of these gases in Denmark is anticipated to be below 1 million tonnes of CO_2 equivalent by 2010, remaining steady at about 1% of Danish greenhouse gas emissions over the period from 2000.

Future Greenhouse Gas Emissions Trends

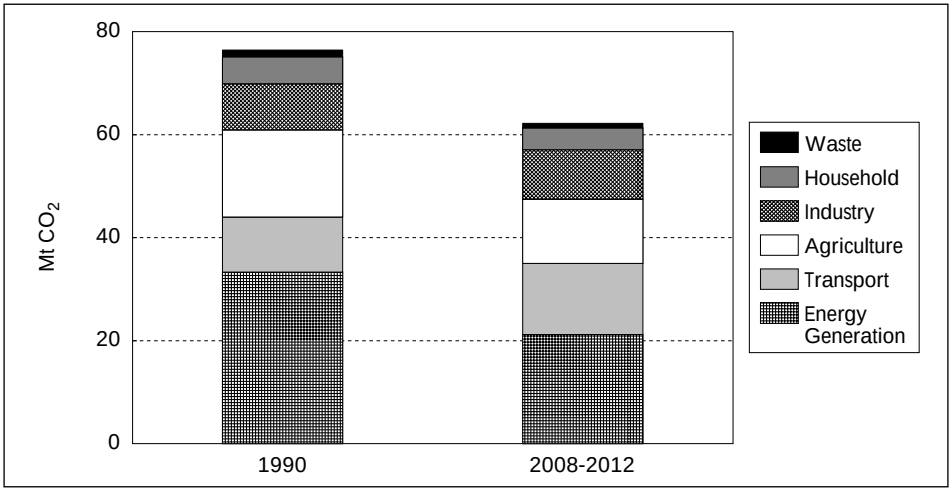
Preliminary figures for 2000 showed that overall CO_2 emissions in Denmark have been reduced by 11% since 1988, and that the country is on track to meeting its 2005 commitments for a 20% CO_2 reduction with initiatives already launched[10].

In *Climate 2012* published in 2000, Denmark estimated that it will achieve a reduction of 16.6% of CO_2 (to 63.6 million tonnes of CO_2) by 2008-2012 with existing policies and measures. A further 3.2 million tonnes of CO_2 would need to be reduced to meet the Danish target of 21% (adjusted) for the period.

Based on updated and consolidated projections prepared in connection with the ratification legislation for the Kyoto Protocol, total Danish emissions of greenhouse gases are now projected to be reduced to 18.6% below 1990 levels during 2008-12 (to 62.2 million tonnes of CO_2). The projection is based on the adjusted 1990 baseline, and on policies and measures already implemented and adopted.

10. This total is only for CO_2 and is calculated somewhat differently from the formula used for the Kyoto Protocol target which includes six greenhouse gases.The Danish national target also includes emissions from international transport (aviation and marine bunkers are excluded from Kyoto numbers). It excludes emissions from cement, lime and yellow brick production and from flaring, and plastics in incinerated waste as well as removal by sinks: all these are included in the Kyoto calculations.

Figure 12
Sectoral Greenhouse Gas Emissions Trends, 2008 to 2012



Source: *Proposal for a Parliamentary Resolution on Ratification of the Kyoto Protocol to the United Nations Framework Convention on Climate Change.* Submitted on 25 April 2001.

Denmark's expected gap has thus been reduced since the estimate in *Climate 2012*, and now stands at 1.8 million tonnes of CO_2 (adjusted). Along with initiatives already enacted, this forecast incorporates proposals for an action plan to reduce ammonia evaporation from agriculture. Among other assumptions, it presumes that the quota system for electricity generation will be continued after 2003, and that the biomass action plan (for use of 1.4 million tonnes of biomass) and the plan for construction of 750 MW of new offshore wind turbines will be fulfilled by 2008.

Table 4
Emissions Trends for Individual Greenhouse Gases, 1990 to 2008-2012
Million tonnes of CO_2 equivalent

	1990/95	*1990/95 %*	*2008-2012*	*2008-2012 %*	*1990 to 2008-2012 %*
CO_2	59.3	78	47.8	77	- 19
Methane	5.9	8	4.9	8	- 17
Nitrous oxide	11.0	14	8.6	14	- 22
Industrial gases	0.2	0.3	0.9	1	238
Total	76.4	100	62.2	100	- 18.6
Objective			64.4		- 21
Shortfall			1.8		2.4

Source: *Proposal for a Parliamentary Resolution on Ratification of the Kyoto Protocol to the United Nations Framework Convention on Climate Change.* Submitted on 25 April 2001.

Abatement Programmes and Institutions

Denmark developed numerous sectoral plans in the 1990s to limit greenhouse gas emissions. Some of these were in the agriculture sector, which is not addressed in this report. Others, such as energy conservation measures for industry and households and renewable energy development, are addressed in other chapters. The following examines some of the most recent initiatives proposed and implemented by Denmark: market mechanisms, including domestic emissions trading and the Kyoto mechanisms; international initiatives; and initiatives in the transport sector.

Market Mechanisms

The Danish CO_2 emissions trading system for the period 2000-2003 was adopted by the Parliament in 1999 (Act on CO_2 Quotas for Electricity Production). The launch of the programme was delayed one year to 1 January 2001, because of delays in approvals required at the EU level. The EU concerns about the original proposal, which grandfathered the CO_2 allowances, were accommodated by giving allowances free of charge to existing domestic and foreign producers and to new entrants to the system. Denmark will reserve quotas on a non-discriminatory basis for possible new producers should such companies initiate production before the end of 2003.

The power companies receive a free permit that comprises a share of their historic emissions for the period 1994-1998. The overall cap for CO_2 emissions was set at 22 million tonnes in 2001, 21 million tonnes in 2002 and 20 million tonnes in 2003. To give some perspective on the "tightness" of the cap, the 2003 level represents 76% of the 1994-1998 level of emissions. However, that was a period of higher than average emissions owing to increased electricity exports. The legal entities that receive emission allowances are the large power producers – those with historical emissions over 100 000 tonnes of CO_2 per year. Power producers with annual emissions below 100 000 tonnes of CO_2 are exempted from the system. The programme excludes producers relying totally on renewable energy. Thus, of the approximately 500 producers, only eight are in the scheme (representing over 90% of total emissions). The market is dominated by the country's two main electricity producers, Energi E2 A/S and Elsam A/S, which were allocated 18 754 000 tonnes of the 22 million tonnes for 2001.

The emission allowances are tradable, and trading will be done on a bilateral basis rather than setting up an independent trading market at this time under the assumption that there would be limited trading in the initial phases. Unused emission allowances can be accumulated (banked) and used in following years although the act also establishes a saving limit below the legally binding cap. This saving limit is set at 20 million tonnes and only reductions below this level can be banked. As the act does not fix the quota after 2003, in principle the allowances saved cannot be used after 2003 unless new rules are established. If the electricity producer exceeds the CO_2 emission allowance, taking into account traded CO_2 allowances and banked CO_2, he must pay a fixed penalty of DKK 40 (about $5 or €6) per tonne of excess CO_2.

If the quota system is not continued after 2003, Denmark estimates that it will exceed its Kyoto commitment by 14.8 million tonnes of CO_2. The act also leaves

open the possibility for Danish electricity producers to participate in future international trading systems and for crediting of reductions achieved through Joint Implementation and the Clean Development Mechanism.

International Initiatives

In addition to its efforts under the Baltic Sea Region Energy Co-operation initiative, Denmark continues to administer a number of support programmes for the development of energy sectors in Central and Eastern Europe. These programmes focus strongly on achieving environmental improvements in the energy sector. The areas of activity include cleaner fuels, effective energy production and supply, end-use energy savings, and institutional development and training.

The Ministry of Foreign Affairs (DANIDA) is responsible for Danish development aid, although special environmental aid is administered by the environment and energy ministries. The energy element of this has been a focus in about nine developing countries. Denmark's environmental assistance focuses on countries in South-East Asia and Southern Africa. Energy assistance is designed to contribute to the countries' fulfilment of international conventions, and in particular the climate and desertification conventions.

Transport Sector

Denmark established a target to stabilise emissions from the transport sector at the 1988 level by 2005 in the 1990 *Transport Action Plan for Environment and Development*. The target for 2030 was to reduce emissions by 25%. Based on a re-evaluation of targets, policies and measures (including a cost evaluation) and the fact that emissions from the sector continued to rise – they were about 14% higher in 1999 than in 1988 – Denmark proposed additional measures in a March 2000 report entitled *Limitation of CO_2 Emissions from the Transport Sector – Possibilities, Policies and Measures*. Without new initiatives, it was estimated that CO_2 emissions would be 27% higher in 2005 and 31% higher in 2010 than in 1988. Policies have not been successful in halting the upward trend in transport emissions, owing in part to higher than anticipated economic growth and commensurate increases in transport needs.

On 1 January 2000, the registration fee (purchase tax) for cars was changed in order to provide more incentive to purchase new, more energy-efficient vehicles. The registration tax for fuel-efficient gasoline cars consuming less than 4 litres/100 km has been reduced, as has the registration tax for diesel cars consuming less than 3.6 litres/100 km. The reduction in the registration tax varies from 1/6 to 4/6 of the existing fee. In connection with this decision, the range of diesel cars qualifying for the annual "green owner fee" has also been expanded. On 1 January 2000, another four categories qualified for the green owner fee, and the lowest tax category is now for diesel cars which consume less than 3.1 litres/100 km[11].

11. The VW Lupo 1.2 litre diesel is an example of such a car.

In April 2001, the Danish government published a new action plan for reducing CO_2 in the transport sector, drawing on earlier recommendations. The targets were revised significantly downward. CO_2 emissions are now to be reduced by 7% in 2010 below business-as-usual trends (representing an actual increase in emissions of 22% over 1988 levels or 19% over 1990 levels). The 2030 target remained as established earlier – 25% below actual 1988 levels. The two main strategies in the action plan are increased energy and transport efficiency. The first strategy is being implemented through:

- A feasibility study on promotion of environment-friendly transport technology through adaptation of the tax system.
- An information campaign about new cars' energy efficiency to supplement the energy labelling on new cars in place since April 2000.
- Eco-driving and enforcement of speed limits.

The second strategy is to be implemented through information programmes, including promotion of public transport, bicycling and environment-friendly freight transport, and other pilot projects.

The rise in energy consumption has been greatest for road traffic and aviation. The government estimates that the new measures in the action plan, when implemented, will allow the achievement of the 7% reduction from business-as-usual by 2010. Another new initiative also mentioned in the action plan is a proposal to develop a national road pricing scheme with the main objective of reducing motor traffic in major Danish cities. DKK 7 million will be allocated annually from 2001 to 2003 for the promotion of road pricing projects to prepare the way for the political decision on the pricing system. One element of these projects will be to investigate the effects of road pricing on carbon dioxide levels. It should be noted that the new liberal-conservative government has accepted the objectives in the action plan but is still considering the proposed measures for implementation.

OTHER ENVIRONMENTAL ISSUES

At regional and local levels, emissions of sulphur dioxide (SO_2) from the combustion of fossil fuels and nitrogen oxides (NO_x) from power plants and transport also create significant problems if not addressed adequately. Denmark has been highly successful in reducing these emissions.

The UNECE SO_2 target of an 80% reduction between 1980 and 2000 was adopted by Denmark and the target was reached by 1998. Total SO_2 emissions from electricity and district heating production decreased by about 60% between 1994 and 1999 (from 95 600 tonnes to 37 800 tonnes) mainly owing to the introduction of more efficient desulphurisation plants and the conversion from coal and oil to fuels with a lower sulphur content such as natural gas and renewable energy. An SO_2 tax was introduced in 1996.

The UNECE NOx Protocol, which set a voluntary target of a 30% reduction by 1998, was almost fulfilled by Denmark, which reduced its emissions by 28% by 1998. Total NO_x emissions from electricity and district heating production have fallen substantially: about 38% between 1994 and 1999 (from 88 500 to 54 500 tonnes). This is primarily due to the introduction of low NO_x burners or de-NO_x plants in power stations.

The policy instruments used by Denmark to achieve these reductions include the establishment of quotas for power plants with a production capacity of more than 25 MW. The size of the quotas is fixed so that Denmark as a whole can meet the national quota under the UNECE Convention. Note that, as with CO_2 emissions, Denmark adjusts its SO_2 and NO_x baselines to take into account electricity trade. The Danish government adopted goals to lower emissions of SO_2 by about 30% and NO_x by 45% by 2010 compared to 1989 levels.

The Danish government has also developed a national strategy for sustainable development. The strategy attaches high importance to the challenge of climate change. It focuses on:

- Breaking the correlation between economic growth and growth in resource consumption and environmental pressure ("decoupling").
- Investigating integration of the environment into sectoral policy-making, including energy.
- Establishing sustainable development indicators.
- Ensuring co-ordination between Danish and international sustainable development initiatives.

The draft strategy had been opened to consultation with stakeholders until 1 May 2001 and the final strategy was expected by end 2001.

GREENLAND AND THE FAEROE ISLANDS

Denmark's commitments under the Kyoto Protocol apply to the entire Kingdom of Denmark. Neither Greenland nor the Faeroe Islands are members of the EU. The Faeroe Islands Home Rule government has announced that it does not accede to having the Kyoto Protocol enter into force in its jurisdiction. Consequently, Denmark's ratification will include a geographic reservation regarding the Faeroe Islands. Greenland's Parliament has not yet adopted a position on the issue, but was expected to in the autumn of 2001. Greenland's emissions of CO_2 correspond to about 1% of Danish emissions. If Greenland wishes to accede to the ratification, Denmark will be committed to an 8% reduction in greenhouse gases in Greenland from 1990 levels over the Kyoto commitment period. If Greenland does not accede, a reservation similar to that of the Faeroe Islands will be required.

CRITIQUE

Denmark now projects meeting its domestic CO_2 target in 2005 with measures already in place. For the first time, the target appears clearly achievable. In addition, the government believes the basis exists for meeting Denmark's Kyoto target within the framework of policies implemented and under consideration. The existing gap is forecast to be only 2-3% (adjusted) by 2008-2012. The monitoring of results achieved and the country's past willingness to introduce new measures reinforce the likelihood of this positive outcome. Nevertheless, a number of important issues remain to be resolved.

The 1990 baseline adjustment for CO_2 emissions remains an issue because of incompatibility with the international norms established to inventory emissions. It is Denmark's prerogative to calculate its emissions inventory in this manner for domestic purposes, but this adjustment is problematic in an international framework. The Danish Parliament has agreed to a 21% reduction of greenhouse gases under the EU burden-sharing agreement conditional upon using the 1990 adjusted baseline, which is a premise not yet accepted by the EU. Given Denmark's April 2001 parliamentary resolution, it cannot legally ratify the Protocol unless it is allowed the adjusted 21% reduction (the real unadjusted reduction is closer to 28% from actual 1990 emissions levels). The EU as a whole cannot ratify the Kyoto Protocol without ratification by all of its members. Hence, some political compromise must be attained between Denmark and the other EU member states for ratification to occur.

Transportation emissions continue to grow, and meeting emissions targets in this sector remains difficult despite the fact that the government's transportation sector target was adjusted significantly downward in 2001 from a goal of stabilising emissions at 1988 levels by 2005 (an absolute reduction) to a 7% reduction from business-as-usual (an actual increase of 19% over 1990 levels) by 2008-2012. Apart from taxation, policies in place in this sector appear to be mainly voluntary agreements and information campaigns. The reductions forecast will be hard to achieve using current measures. Denmark is studying various tax policy options (review to be completed in about two years). Other short-term measures which could bring significant reductions should be considered, e.g., encouraging inherently clean fuels such as compressed natural gas (CNG) and liquefied petroleum gas (LPG), which have multiple environmental benefits, especially for bus and taxi fleets. Car registration fees are still very high although they have been adjusted. The main objective of the registration fee is to reduce the fleet and encourage more fuel-efficient vehicles. However, the fee discourages car owners from purchasing new vehicles and encourages them to use a car for many years. To accelerate fleet renewal, the registration fee should be further adjusted. There is also a need for a long-term transport strategy, which may offer effective reduction opportunities from technology advancements, e.g. in hybrid-electric and hydrogen-powered vehicles.

The burden of CO_2 emissions reductions falls more strongly on the electricity sector than in the previous IEA review, when measures in the transport sector were

expected to be more significant. Plans for greenhouse gas reductions in non-energy sectors such as agriculture are still under development and the cost-effectiveness of these measures versus continued burdening of a single sector (energy and particularly electricity) needs to be addressed more completely. The Danish Energy Agency (DEA) is currently analysing and comparing costs of various mitigation instruments, for all greenhouse gas emissions and in several sectors.

In fact, the cost-effectiveness of existing and planned measures has been difficult to pinpoint. For example, in *Climate 2012* it is noted that the costs of climate change initiatives in the energy area were evaluated as averaging DKK 100 to 800 per tonne of CO_2 in 1999 (US$ 10 to 100 per tonne). The Kyoto ratification documents note that the average socio-economic cost to address the 1.8 million tonnes gap would be about DKK 300/tonne of CO_2 equivalent, corresponding to about DKK 500 million per year. Preliminary estimates of analysis of future measures range from a low of DKK 82/tonne of CO_2 equivalent for the electricity sector CO_2 quota scheme to DKK 296/tonne for offshore wind and DKK 2 038/tonne for taxes imposed in the transport sector. It is not clear which figures are the most accurate or on what assumptions they were based. Consequently, the Danish government's efforts to assess and report in a readily understandable format will make cost-benefit assessment and hence policy-making more transparent.

Given that many other IEA Member countries still have a long way to go towards meeting their own Kyoto objectives, the mitigation successes of the Danish government are worth further analysis. It is also important for domestic policy-making to have a better grasp of the costs associated with historical policies, in order to assess whether any modifications in approach should be made. For example, it is difficult to determine exact costs and benefits associated with the aggressive wind penetration policies (discussed further in Chapter 5). An overall concern regarding the Danish policy approach is that environmental objectives are so central to energy policy that more economic solutions or impacts on fair trade and other economic activities may not have been assessed as completely as they should have been. It is possible that a more balanced and economically effective approach could be found to meet the fundamental policy objective of sustainable development.

The Danish government has stated that it is open to the use of the Kyoto mechanisms – emissions trading, joint implementation (JI) and the clean development mechanism (CDM) as a supplement to domestic actions – if these mechanisms result in real emissions reductions and once clearer international frameworks are established. Denmark was one of the first countries to implement a domestic emissions trading system by initiating the quota system for the electricity sector. But there are considerable uncertainties associated with the future of this programme as rules for the post-2003 period have yet to be established. The government should consider reaffirming its future policies as soon as possible. Furthermore, as similar trading systems have not yet been established in neighbouring countries, Danish power companies are considering new investments abroad where electricity sector emission caps have not yet been established. More study is needed on the implications of the quota system for future investment and

trade patterns. In addition, Denmark needs to continue to work closely with other governments in the region for a good understanding of evolving emissions trading programmes in those countries and in the context of the potential EU trading scheme.

Denmark's forecasts show that significant exports of electricity could take place after 2003 should the CO_2 quota system for electricity production not be continued. Rather than facing a 2-3% gap in meeting its Kyoto objectives, Denmark would instead face a shortfall of more than 19% in 2008-2012 (exceeding its target by 14.8 million tonnes). Thus, the importance of the quota system for the overall Danish climate change programme should not be underestimated. Denmark also needs to consider whether some elements of the existing programme, such as the relatively low penalty for non-compliance, will need to be adjusted after 2003.

Furthermore, the uncertainties associated with the postponement of the Green Certificates programme (discussed in more detail in Chapter 5) compound the challenges faced by the electricity industry in Denmark. It is important to co-ordinate goals and instruments in order to achieve the desired economic and mitigation results. It is commendable that after the initial decision, Denmark moved quickly to develop programmes to implement market instruments for the electricity industry. However, implementation has often been postponed. This has been particularly troubling with respect to the renewable energy certificates programme, which will be an important complement to the cap and trade (quota) system. When combined with the "priority" purchasing system[12] and continued renewable energy subsidisation, the quota system cannot operate as effectively as it could in a fully integrated market. This reduces the economic advantages that could potentially accrue from the domestic trading market.

Denmark has been slower to embrace and assess the cost-effective potential of JI (emissions reduction projects implemented jointly with those countries with quantitative emission targets under the Protocol) and CDM (emissions reduction projects in countries without quantitative reduction targets), but is now beginning to take some proactive steps in this direction. The government is working with regional governments on developing the Baltic region as a testing ground for JI. This latter initiative arose within the inter-governmental Baltic Sea Region Energy Co-operation (BASREC) forum. Energy ministers of the region have concluded that a regional approach may make an effective contribution to climate change mitigation. The initiative will also contribute to enhanced understanding in the region regarding the Kyoto mechanisms, and develop experience on operational aspects through a trading simulation. A team of consultants has also been contracted to produce a "manual" for domestic JI and CDM project developers and suggestions for the necessary administrative procedures for these investments.

12. The priority system requires that renewables and CHP must be dispatched first, regardless of their price. In other words, when the wind blows and the wind turbines generate electricity, the network utility has to purchase this electricity even if it has to take cheaper fossil-fired power plants off the grid as a consequence.

Nevertheless, questions remain concerning Danish views regarding to what extent (and how) to use the Kyoto mechanisms in meeting Denmark's Kyoto target. The initiation of a study on this topic is welcome. The market value of traded tonnes is by no means certain. However, many analyses have shown that there are significant opportunities for low-cost reductions through CDM and JI projects, as well as through international emissions trading. Denmark should consider using these market mechanisms towards meeting any shortfalls as additional domestic measures are likely to be more expensive. It will be necessary to move in a timely manner to implement the consultants' recommendations on administrative procedures for this to occur. The use of these mechanisms would add another policy tool to the Danish portfolio. With current policies and measures focused so heavily on domestic interventions such as taxation and regulation, there is a risk of consumer saturation and resistance. A glimpse of this consumer resistance to high fuel prices was revealed by demonstrations calling for gasoline price reductions when oil prices surged in 2000.

The production of oil and gas accounts for 3% of Danish CO_2 emissions. According to Danish figures, overall flaring will decrease by 2010. However, evidence from the production side does not necessarily support this assumption, particularly if reserve additions of small-field production continue. It will be important to continue monitoring emissions from flaring to ensure that all means are taken to minimise this activity.

RECOMMENDATIONS

The Government of Denmark should:

- ☐ Finish the assessment of the economic implications of basing climate change policy almost exclusively on domestic mitigation strategies. In particular, consider the advantages that the Kyoto mechanisms and the extension of the quota/trading system to other sectors may offer in closing the remaining emissions gap.

- ☐ Decide urgently the fate of the CO_2 quota system for the electricity sector beyond 2003; determine the quota levels; reassess the low penalty for non-compliance; and determine whether international trading and credits can be incorporated.

- ☐ Make further adjustments to the car registration fee and pursue road pricing and other cost-effective policy instruments in the transport sector.

5

ENERGY EFFICIENCY AND RENEWABLES

ENERGY EFFICIENCY

Background

One of the targets contained in *Energy 21* was the improvement of energy intensity (defined as final energy consumption in the end-use sector per unit of GNP) by 20% by 2005 in relation to 1994 figures. The June 1999 follow-up of *Energy 21* projected that energy intensity would improve by 25% in 2005 and by 34% by 2012, more than fulfilling the established targets.

On average, Denmark is examining ways to reduce final consumption by an average of 0.5% per year. Sectoral targets were proposed in a September 2000 report of the DEA entitled *Promotion of Energy Savings*. The savings target of 2.1 million tonnes of CO_2 is 3.5% of the total Danish national objective to reduce CO_2 emissions by 20% by 2005 from 1988 levels.

Table 5
Energy Efficiency Targets to 2005

Sector	*Energy Consumption in 1988*	*Energy Conservation Target PJ*	*CO_2 Reduction 1000 tonnes*	*Energy Conservation Target %*	*Result in 2005 PJ*
Households	188	8	940	- 4	176
Poblic service	26	2	330	- 8	24
Commercial sector	50	3	490	- 5	55
Industry	154	2	380	- 1	164
Total excluding transport	**418**	**15**	**2 140**	**- 3**	**419**

Source: *Promotion of Energy Savings*, DEA Copenhagen, September 2000.

In 1997, the Danish Electricity Saving Trust (Act on the Danish Energy Saving Trust, 27 December 1996) was established with the primary goal of supporting the substitution of electrical heating by district heating or heating by natural gas in households and the public sector. The trust is managed by an independent board that comprises representatives of consumer interest groups and utilities, as well as experts in energy savings and economics. The fund has been financed since 1998 by a fixed amount of DKK 0.006 per kWh sold, levied on the electricity

consumption of households and public institutions. Through instruments such as subsidies, procurement strategies, agreements and demonstration projects, the trust influences pricing of energy-efficient appliances. For example, "Buy A-products" is a campaign for energy-efficient lights and electrical household appliances and the establishment of buyers' clubs to facilitate purchasing. It is expected that trust activities will result in total savings of 600-700 GWh by 2005, or about 600 000 tonnes of CO_2.

As the first step in strengthening energy-saving initiatives necessary to reach long-term energy and environment policy targets, the Danish government passed a new act in May 2000 concerning the promotion of energy conservation – The Energy Saving Act. The act provides the overall framework for co-ordination and priority given to both centralised and decentralised savings initiatives for all sectors, actors and measures. It enables the appointment of local energy conservation committees to co-ordinate local efforts to save energy, and establishes new initiatives for energy conservation in the public sector. The act complements requirements for energy savings in the Electricity Supply Act, the Natural Gas Supply and Energy Savings Bill, and amendments to the Heat Supply Act.

The Natural Gas Supply and Energy Savings Agreement of 29 May 2001 sets out an action programme for the promotion of energy savings until 2005. The central elements include:

- Establishment of energy savings targets in 2005 for individual sectors, including the public sector, private trade and service, households and manufacturing.
- Introduction of product taxes that promote the sale of more energy-efficient products.
- Translation of state energy-saving initiatives, including subsidy schemes, into framework programmes for which tenders are invited.
- Expansion of the activities of the Electricity Saving Trust to develop purchase agreements and other schemes to promote energy-efficient electric appliances.
- Strengthening efforts in the public sector, including green energy accounts and procurement policies, and negotiation with municipalities to develop similar programmes.
- Utilisation of the remaining funds from the Electricity Saving Fund for energy savings in the business sector.
- Implementation of measures by natural gas and district heat producers to promote energy savings.

This political agreement also stipulates that other economic incentives for energy savings will be discussed with a view to adoption prior to the Energy Saving Review in September 2002.

The following sections highlight some of the major programmes established to increase supply-side efficiency, for energy saving and increased end-user efficiency, and for demand-side fuel substitution. Transport sector initiatives are dealt with more broadly in Chapter 4.

Residential / Commercial Sector

Initiatives to reduce energy consumption include attempts to induce behavioural changes, increasing efficiency of appliances and buildings, and integrating energy-awareness into consumer decision-making.

Building Codes

New building codes entered into force for large buildings in 1996 and small buildings in 1998. These codes reduce net heating demand by 25%, to about 70 kWh per square metre per year. The codes also set limits on electricity consumption for ventilation and will require low-temperature heating systems in order to increase the efficiency of various heat supply systems, such as district heating systems, condensing boilers, solar energy and heat pumps. A further reduction of net heating demand to 45 kWh per square metre is planned for around 2005. Buildings are already being built to this standard through the combination of passive solar techniques, insulation and coated glazing.

Energy Labelling for Buildings

A mandatory labelling scheme for small buildings (less than 1 500 m^2) was implemented in January 1997 and refined in 1998 following an independent audit describing energy conditions and recommending possible energy-saving measures in building shells and heating equipment. All residential and public buildings, and buildings used for trade and private service, are to have a label prior to sale. Although the scheme is mandatory, only around 50% of buildings sold have a label. The largest group of labelled buildings is single family homes. From 40 000 to 50 000 buildings are labelled every year.

The mandatory scheme for large buildings came into effect in 1997-1998. All buildings with a surface of more than 1 500 m^2, except industrial buildings and those with very low energy consumption, must register their consumption of heat, electricity and water every month. Once a year, a consultant performs an audit which includes an Energy Label (rating energy consumption relative to comparable buildings) and an Energy Plan (recommending long-term and short-term saving measures).

The schemes for small and large buildings were independently evaluated in 2000-2001, with the conclusion that a large potential remains for profitable investments for energy efficiency in existing buildings. Only 45% of labelled houses actually had invested in heat-saving measures. The scheme for large buildings operates well for those who participate, but about half of the buildings did not fulfil the

requirements. Lack of awareness of the existence of the schemes contributed to non-participation. The DEA has developed an action plan to improve the implementation of both schemes as well as further measures.

Subsidies

Pensioners with low incomes and relatively high bills for heating can obtain subsidies of up to 50% of the investment costs (to a maximum US$ 3 600 per dwelling) for energy-saving measures. Since its institution in 1993, the yearly budget for this scheme has been DKK 40-70 million, representing grants to about 5 000 houses per year.

Conversion from electric to district heat or natural gas heating requires substantial investments in buildings for the installation of central heating systems. Subsidies have been initiated to overcome this barrier to conversion. Houses constructed before 1950 that are situated in district heating areas are eligible for subsidies for installation of central heating and hot tap water. The purpose is to use excess heat at the central CHP plants efficiently. About 50% of qualifying houses had been converted by 1997. Subsidies may be applied for until the end of 2002. Total funds for subsidies amount to DKK 1 300 million and the plan is expected to save 100-150 thousand tonnes of CO_2.

The Danish Electricity Saving Trust has also made agreements with more than 200 district heating companies using CHP and biomass to convert electrically heated dwellings to collective district heating systems. Local information activities are also eligible for DKK 50-60 million in subsidies annually. During the period to 2007, 50 000 dwellings are expected to be converted (although the potential is 90 000), resulting in reductions of 555 000 tonnes of CO_2.

Since 1997, subsidies can be provided for the development of more effective products, their marketing and installation. The DEA determines the product, on the basis of saving potential and a study of barriers for its implementation. The subsidy is typically limited to a few years. Energy-efficient windows, efficient gas and oil boilers, demonstration products in public buildings and environment-friendly insulation products have received support.

In 1998, Denmark introduced a specific programme to promote energy-efficient windows in households and the public sector. The programme has supported the development and marketing of new and energy-efficient products, and resulted in an energy labelling system for windows. From 1998 to 2000, the DEA initiated projects amounting to DKK 25-30 million. The market share for energy-efficient windows has increased to about 60%. The government anticipates that the annual energy saving will reduce CO_2 emissions by about 150 000 tonnes by 2005.

Subsidies for energy-efficient boilers fuelled by natural gas in private houses were provided from 1999 to 2001. A subsidy of DKK 2 500 was given to increase the market share of boilers with an annual efficiency of more than 95%. Figures indicate that the market share of these boilers increased from below 10% to about 50%.

Subsidies to promote efficient oil-fired boilers through labelling and promotion started in 2000 and are expected to run to 2003. The goal is to increase the current 10-15% market share for efficient boilers and encourage replacement of the oldest and least efficient boilers.

Other Initiatives

There are numerous additional programmes to improve energy efficiency for consumers. Some of the more recently implemented include:

- Mandatory annual inspections of 700 000 small oil burners, with chimney heat loss reduced as a result from 19% to 12-13%.
- Efficiency standards for refrigerators/freezers effective in 1999, bringing efficiency improvements of 15% compared to 1992.
- The "energy arrows" programme to inform consumers of the electricity consumption of various appliances, and to facilitate comparisons between competing products. The programme was developed by the utilities with government support, as a complement to EU-wide labelling directives.

Public Sector

Total energy consumption in this sector has remained relatively constant since 1996. However, consumption per m^2 has decreased by about 10% for overall heat and electricity. Since 1992, energy management, annual reporting of energy consumption, and efforts to undertake efficiency improvements have been mandatory. Until eliminated in 1999, a grant scheme for financing energy-saving measures ($1.4 million/year) and a special tax of 10% on government institutions' energy expenses were in place. New agreements with public organisations are under negotiation, with priority given to green accounts, energy management and buying policies.

Industry, Trade and Services Sectors

The primary instrument for improving energy efficiency in the industry, trade and services sectors has been the *Green Tax Package*, which entered into force in January 1996. The package had three elements consisting of an energy tax, a CO_2 tax and an SO_2 tax, which are discussed in more detail in Chapter 3. The taxes were part of a larger tax scheme where revenue is used to lower taxes on labour and income. It is worth noting that enterprises with specific energy-intensive activities or with an energy tax exceeding 3% of value added can reduce their tax rate through a voluntary energy saving agreement. The enterprise must commit to implementing the energy efficiency investments resulting from their independently

certified energy management. By 2001, more than 300 enterprises accounting for about 60% of total energy consumption by industry (VAT-registered companies) had concluded an agreement with DEA. The *Green Tax Package* also contained a number of reimbursement programmes for the industry, private trade and services sectors. There are three main categories:

- Investment grants for energy-saving measures in enterprises. The grants are for up to 30% of the initial outlay on projects with payback periods between two and nine years.

- Reductions in labour taxes and employers' contributions to the Additional Labour Market Pension Fund.

- Funds for small and medium-sized enterprises, which only benefit to a limited extent from the reduced employers' contribution.

From 1996 to 2000, subsidies for investments in energy efficiency amounted to DKK 1.8 billion. About 80% of the subsidies went to the energy-intensive industries. From 2000 onward, an additional DKK 175 million/year has been allocated to the subsidy scheme, but the scheme is now open only to industry (excluding agriculture and the trade and services sector). It provides grants for three areas: investments in energy savings or efficient equipment, use of consultants, and information about energy savings. In 2001 efforts in trade and services will focus on a strategy to develop, market, purchase and use more energy-efficient products. The emphasis will be on lighting, cooling equipment, ventilation, office equipment and buildings. Each year an action plan is formulated and different categories of products are given priority. For industry, the main focus in 2001 was on energy management, energy-efficient design, development of energy-efficient technology, standardised solutions and projects in selected industry subsectors.

The tax, subsidy and voluntary agreements package was evaluated in 2000. The conclusion was that reductions of CO_2 had met forecasts – in 1995 it was estimated that the package would reduce emissions by 3.9% versus an actual reduction of 3.8%. Sulphur reductions were better than expected (34 000 tonnes versus 32 000 tonnes anticipated). The evaluation resulted in the following assessments:

- The green taxation system for agriculture, trade and industry is an appropriate instrument for attaining the environmental objective, is economically effective, and takes international competitiveness into account.

- The administrative costs related to the voluntary agreement scheme are too high.

The voluntary agreements were consequently adjusted in 1999 by replacing the mandatory audits with a requirement to implement an independently certified energy management system. The certifying body controls compliance with the agreement, thus reducing administrative costs.

International Initiatives

Under the BASREC initiative of Baltic energy ministers, a working group on energy efficiency (including CHP and district heating) was formed – the Baltic Energy Efficiency Group (BEEG). The BEEG assesses energy efficiency options and potentials with a focus on CHP and district heating, and includes assessment of technologies, financing and legislation. The BEEG in 2000 focused on new financial instruments, co-ordination and follow-up on activities taken by other international institutions and organisations, and development of CHP. In its May 2001 report, the working group concluded that: the establishment of a financial clearinghouse was essential; the potential for CHP is significant; and the creation of a common regulatory framework for district heating in the region would support its development.

RENEWABLES

In order for Denmark to meet its climate change commitments, renewable energy – in particular wind energy – will play an important role. Renewable energy represented 10% of Danish energy consumption in 1999. The Danish goal is to increase this to 12-14% by 2005 and to 35% by 2030. This will entail expanding renewables' share of total consumption by about 1% per year from 2005 onward.

The law promoting green energy consumption entered into force in 2000. All renewable electricity has priority access to the grid ("priority production"). Under the new electricity legislation, the share of electricity generated from renewable sources is expected to rise to 20% by the end of 2003. In order to promote the use of renewable energy, subsidies are available for installation of solar heating, biomass-fuelled burners and heat pumps.

Green Certificates Programme

A number of IEA countries, including Denmark, are planning to introduce a tradable renewable energy certificate programme to support the development of alternative energy sources in more competitive electricity markets. In 1999, the Danish Parliament agreed under the Electricity Reform Agreement to implement a national renewable energy quota system for electricity generation using a green certificates scheme. This reform would result in the termination of the existing fixed tariff scheme for electricity from renewable energy. That tariff averages DKK 0.60 per kWh.

Under the new system, feed-in prices would be used and a minimum fixed price would be guaranteed for renewable electricity. Green certificates would be issued to producers of electricity and consumers would be required to buy 20% of their electricity from renewable energy suppliers by 2003. The renewable energy obligation would apply to all electricity consumers, but they could turn to their electricity suppliers to meet this obligation. System operating companies (Elkraft and Eltra) will thus redeem certificates at the regulator, testifying that they have met the mandated percentage output from renewable energy sources. These sources

include wind power, and electricity generated from biomass and biogas. Large hydro and waste incineration plants are excluded because of the non-profit requirements on companies owned by municipalities. Conditions for including existing biomass have yet to be determined.

Turbine owners signing contracts for new installations starting on 1 January 2000 until the start of the renewable energy certificate market (RECM) will receive a fixed minimum price (DKK 0.33) for approximately the first ten years after installation, and market prices afterwards. In addition to the fixed minimum price, they will receive DKK 0.1/kWh (before the start of the RECM) or a green certificate with a dedicated minimum price of DKK 0.1 and a maximum of DKK 0.27 (after the start of the RECM). At most, renewable energy generators would obtain the equivalent of the fixed price applied earlier (DKK 0.33 + DKK 0.27 = DKK 0.6 per kWh). If consumers do not fulfil their quotas, they will have to pay a tax of DKK 0.27 per kWh.

Not all renewable energy sources will be issued certificates at the outset. Wind plants installed before 2000 will receive a fixed feed-in price and a subsidy depending on age and full-load hours, and will access the certificate system after 2003 when they have operated for ten years. The transitional arrangements – which included the exemption for "existing" turbines, i.e. those which had planning permits and had been ordered by 1999 – resulted in a significant surge in installed wind capacity in 1999. Plans currently call for the Danish green certificate market to come into effect by 2003. However, concerns have been raised by NGOs as well as the Danish wind energy industry about some of the elements proposed under the existing terms of reference: the system is seen as too complex; other countries are adopting different systems that may not be compatible with the Danish system; the renewables market in Denmark is too small; and the introduction of green certificates for large offshore wind production will distort the market. On the basis of these concerns, the new government is considering a further postponement of the renewable energy certificates programme.

Wind Power

The expansion of wind power is a central element in Danish energy policies. Government-supported wind power development dates back to the 1970s. At that time, the primary support mechanism for wind power was adopted by the Parliament: power utilities had to buy wind power offered to them from privately-owned wind turbines at a purchasing price roughly equivalent to 85% of the retail price of electricity. From about 1979 to 1989, the government also had a programme of capital grants for the installation of wind turbines. Since about the mid-1980s, the government had the objective of raising the share of wind power in total power generation to 10%; this objective was met and exceeded in the year 2000.

The number of new onshore locations for wind turbines is limited as there are already many onshore wind sites and the visual impact of wind turbines on the landscape is becoming an issue. Wind turbines are also becoming larger and more difficult to site. Capacity on land will thus increase by renovating existing wind turbines as well as by decommissioning and replacing old smaller turbines by new

larger units, and not by any significant new developments. Denmark also has some small household wind turbines, producing electricity for heat and power. A large number of the wind turbines that were installed early are small and have outdated technology. These are viewed as supplementary to the general development of wind power. In order to encourage the installation of larger, more efficient wind turbines, when the existing unit is scrapped, the owner of the turbine can purchase shares in a new collectively-owned wind turbine producing three times the electricity generated by the dismantled turbine.

The government's target under the1996 *Energy 21* programme is for wind to supply 45% of electricity consumption by 2030. This requires 5 500 MW of capacity. An intermediate target of installing 1 500 MW of onshore wind capacity by 2005 was already met in 1999. Total capacity for 2001 has been estimated to be close to 2 500 MW; of this, 50 MW is offshore in three small pilot projects.

The major part of wind power expansion will be offshore. The Danish government has targeted 750 MW to be supplied by offshore wind farms by 2008. The 750 MW are expected to be installed in five large wind farms which together will produce 8% of Denmark's electricity consumption (8 800 TJ), and represent an annual saving of up to 2.1 million tonnes of CO_2 or 3% of total CO_2 emissions in Denmark. The objective is to investigate the technical, financial and environmental aspects of offshore wind energy. All five wind farms had planning permit as of August 2001.

The Danish power companies are in the final phase of planning for the first of the two large-scale farms which are the first step in this large-scale demonstration project. In 2000, the power company Elsam applied for final permission to establish a wind farm 14 km offshore at Horns Reef in the North Sea. Construction of this first project of 160 MW is planned for in 2002. In eastern Denmark, the power company SEAS on behalf of Energi E2 has received final permission to establish a farm at Rødsand, 10 km from the coast of Lolland. The latter wind farm is expected to consist of 64-96 turbines – in 8 rows of 8-12 turbines – with a combined total of 150 MW. The farm will produce about 500 GWh annually, corresponding to the annual consumption of 110 000 homes. The annual environmental returns are estimated at 302 000 tonnes of CO_2, 490 tonnes of SO_2 and 440 tonnes of NO_x, on the assumption that wind power will replace coal-fired power generation. The Rødsand turbines are expected to be erected in summer 2003. Meanwhile, the new Danish government has annulled the obligation on power suppliers to construct the offshore wind farms. As a consequence, the two least advanced offshore wind projects were cancelled.

The most recent cost estimates available for offshore wind power were included in the document *Action Plan for Offshore Wind Turbines* (1997), in which costs for the demonstration projects are estimated at DKK 0.35-0.38/kWh (based on 20-year depreciation and 5% interest per annum). While the competitiveness of offshore wind production is progressing, Denmark still provides considerable subsidies for the production of electricity from wind power. An installation subsidy of 30% of total project costs was granted to wind turbines from 1979 to 1989, resulting in a total of 2 567 turbines receiving subsidies of DKK 275.72 million (at current

prices). Direct production subsidies have continued; all existing turbines are paid DKK 0.6 per kWh for a specified number of full-load hours.

To encourage replacement of the small, old wind turbines by large, modern turbines, windmills existing before 1 January 2003 are paid a subsidy of DKK 0.43 per kWh for at least a ten-year period. In addition, DKK 0.17/kWh is paid for a specific number of full-load hours. Consequently, existing windmills will not enter the green certificates market until after they have operated for ten years. New wind turbines will be guaranteed a fixed settlement price of DKK 0.33 per kWh for the first 22 000 full-load hours, corresponding to about ten years of production. When these hours have been used up, the remaining electricity produced by the wind turbine is to be settled at "market price", although a further premium of DKK 0.10 per kWh is added to the market price. The premium will be replaced by green certificates for electricity production once the green market for renewable energy comes into effect.

The utilities are required by law to connect private wind turbines to the grid and to receive and pay for wind-generated electricity. Figures provided by the Danish Association of Wind Turbine Manufacturers show that Denmark's wind power industry posted a turnover of about DKK 13 billion (€1.5 million) for 2000, a 4% increase over 1999. Danish manufacturers and their international subsidiaries maintained their 50% world market share (rising to about 65% when joint ventures are included). This raised the total output of Danish wind power technology to 2 875 MW. Danish wind turbine production was down 5% from 1999 levels, at 2 140 MW, although this is attributed to statistics-keeping changes. Germany remains the leading market for Danish wind turbine manufacturers. The Danish wind turbine industry is regarded in the country as an important strategic exporting industry.

Biomass

The Danish government established a target for construction of combined heat and power plants to be fired with domestic fuels like straw, wood, waste, biogas and natural gas. The goal was to reach an installed capacity of 450 MW by 1995. The following are estimates of domestic biomass potential.

Table 6
Domestic Biomass Potential

Biomass Fuel	*Approximate Biomass Potential (PJ/year)*
Straw	42
Wood and wood chips	8
Waste from wood industry	8
Biogas	31
Municipal solid waste	30
Total	**119**

Source: DEA.

The Biomass Agreement of June 1993 implies that by the year 2000 electric utilities must incorporate the use of 1.2 million tonnes of straw and 0.2 million tonnes of wood (total about 20 000 TJ) annually. This was amended by the supplementary agreement of 1 July 1997. Implementation of the agreement has been difficult and has taken longer than planned.

The Biomass (political) Agreement of March 2000 (along with the Electricity Reform Agreement) provides the framework for future electricity supply from this fuel source. On the basis of this agreement, the target is to be reached by 2004 and two or three large biomass plants are to be established by the end of 2005. Over a ten-year production period, a minimum price (settlement price) of DKK 0.33 per kWh is to be established as well as a minimum price of DKK 0.10 for green certificates. Individual plants will receive a further negotiated permanent supplement. A tendering process is to be used to ensure that more than the initial two or three plants are constructed. Electricity from biomass-based plants is currently settled at a price of about DKK 0.60 per kWh. This will continue to apply until further notice.

In addition to the use of biomass in large-scale power plants, other programmes have been established to support private initiatives for biomass-fired heating plants. These programmes support the extension of biomass to district heating areas and areas not served by the collective supply system. For example, regional subsidies were offered (until 1 November 2001), for up to 21% of costs of installations in households, and 26% for installations in companies, for a total cost of about DKK 25 million/year. Currently Denmark has 50 heating plants operating on wood chips, 25 on wood pellets and 75 straw-fired plants.

Denmark anticipates submitting proposals for assessing the further economic situation of biomass-based electricity production for consideration in the autumn of 2001. The most recent assessment provided for the parliamentary ratification process for the Kyoto Protocol shows biomass use at about 0.6 million tonnes or just under half the target, which is now assumed to be attained by 2005 (1.4 million tonnes target first established for 2000).

Solar Energy

In 1998, *The Solar Action Plan 1998-2000* was developed by the Solar Energy Committee, which advises the DEA on development and use of solar energy systems in Denmark. *Energy 21* set out objectives of 15 000 individual photovoltaics, as well as collective solar heating systems covering one million m^2. The sum of DKK 57 million per year was set aside in the 1995-1997 plan in the form of a basic subsidy, a standard subsidy and funds from the Development Programme for Renewable Energy.

To increase the numbers of large solar heating systems, for example in public buildings, and in connection with biomass-fired district heating systems, Denmark provides a subsidy. The cost of this initiative was about DKK 6 million annually between 1998 and 2000. In addition, Denmark provides subsidies up to 30% of the

cost of investment for solar heating systems for household heating outside areas with district heating. This amounted to approximately DKK 20-25 million during the period 1998 to 2000, plus subsidies of about DKK 2 million/year for information campaigns.

To promote the use of solar cell systems, Denmark provided about DKK 6 million annually from 1998 to 2000 from the DEA, and DKK 40 million/year from electricity companies to subsidise demonstration projects and installations. Three hundred systems were installed in 2000, representing electricity production of 600 MWh per year (2.2 TJ). Denmark has also implemented and enforced an act requiring solar heating be used in any new public buildings.

Geothermal

Denmark began investigating geothermal energy projects in 1984 in the Danish town of Thisted. A small geothermal plant was constructed as a co-operative effort between the engineering company Houe and Olsen and DONG A/S. Since then, considerable effort has focused on investigating opportunities in Central and Eastern Europe, where Danish environmental assistance has provided US$ 7 million in support for geothermal projects valued at more than US$ 150 million in four countries – Poland, Lithuania, Slovakia and the Czech Republic.

Recently the Danish government has also started to investigate further the potential for domestic geothermal energy, although there is currently only the one demonstration plant mentioned above. The Danish Parliament appropriated US$ 2.3 million in 2000 as part of its *Energy 21* action plan for this effort. DKK 10 million were allocated in both 2000 and 2001 for the promotion and utilisation of geothermal heat. Reservoirs for suitable geothermal exploitation are assumed so far to exist under 12 large Danish towns and cities, including Copenhagen. Geothermal Corporation in Greater Copenhagen has received a subsidy to carry out preliminary seismic investigations with a view to assessing the potential for exploiting geothermal heat in the area. The corporation has been granted an exclusive concession for recovery of geothermal energy in the area. If the planned trial drilling shows positive results, some heating in Copenhagen may be provided by geothermal as soon as 2004.

CRITIQUE

Energy Efficiency

In December 2000, Denmark produced a report entitled *Energy Efficiency in Denmark - An Analysis Based on the OEDYSSEE Data Base from the SAVE Project - Cross-Country Comparison on Energy Efficiency Indicators, Phase 6*. This report shows recent energy efficiency trends in final energy consumption, assessing macro level energy efficiency trends, as well as disaggregated trends within sectors. At the macro level from 1988 to 1999, primary (gross) and final energy intensities fell by about 13% and 12% respectively.

Denmark has made great strides towards decoupling energy demand growth and economic growth in many sectors. However, there seems to be a moderating trend in some sectors, and room for further improvement remains. In the period from 1988 to 1999, energy intensity in Danish industry increased by about 1.5%, although this can be split into a strong increase in the first five-year period offset by a strong decrease in the second. Whether this can be attributed to the introduction of the *Green Tax Package* or simply to the business cycle, is not evident. A similar pattern can be shown for the manufacturing sector – a strong increase in energy intensity of 7.5% from 1998 to 1993 and a decline of 12.5% from 1993 to 1999.

In the tertiary sector (wholesale and retail trade, private and public services), from 1988 to 1999, energy intensity (after climate adjustments) shows a significant reduction of 16.5%. In the household sector, after significant declines in unit energy consumption per dwelling after the second oil price shock, the trend tapered off. Between 1987 and 1999 the decline was only 2%. A main driver of energy consumption in households is the number of dwellings or the number of heated square metres. From 1990 to 1999, these increases were about 5% and 7% respectively. Although the relative size of houses did not change appreciably over the period, the average size of a single family house (131 m^2) and an apartment (75 m^2) remains relatively high in Denmark vis-à-vis the European average.

In terms of policy instruments, Denmark continues to rely heavily on a system of taxation/tax exemptions and subsidies to improve energy efficiency. When some subsidies are phased out, others are introduced to replace them. The still complex subsidy arrangements to achieve energy efficiency objectives should be examined further. Other policy tools that could be less distorting, more cost-effective and less cumbersome – such as loan payback schemes or third party financing – should be given further consideration. Such measures would place less of a burden on government finances – since consumers must pay back the money they receive from the government – and would induce the market players, such as financial institutions, to shoulder some of the administrative requirements. In some successful examples, the contractor pays the initial costs of the investment and the customer pays him from the energy (and consequent financial) savings attained through the investment over a number of years.

Nevertheless, a positive step has been the introduction of phasing-out provisions for a number of the subsidy programmes. This time-limited support should be implemented more broadly. Such action would ensure, for example, that once penetration of a more costly, yet more energy-efficient product has reached a reasonable level, market price competition can take over. Otherwise the subsidy could block market penetration of other, possibly better, technical options (always a risk when supporting one technology over another).

The introduction of a large amount of combined heat and power production improved the conversion efficiency of primary energy, and was a major contributing factor in the reduction in primary energy intensity over the period.

Renewables

Denmark has a very strong objective of promoting renewable energy and CHP. The government's objective is to increase the contribution of renewable energy to electricity production to 50% by 2025 (35% of fuel share by 2030). This is an ambitious target. Renewable energies have increased their share in energy supply, particularly in electricity generation, in the past years thanks to strong incentives given by the government through favourable pricing and a priority for renewables in power production. The penetration of wind power has been greater than anticipated and targets have been surpassed. This has in part been because the cost of wind generation has fallen. But the subsidy reduction has not kept pace, resulting in even more generous subsidisation of wind power.

On the other hand, biomass targets have not been met (0.6 million tonnes in 2000 compared to a target of 1.4 million tonnes). This is primarily because the introduction of large-scale CHP has been slower than anticipated. District heating plants have been slow to convert to CHP production based on straw, chips and the like owing to technical and financial obstacles. A number of demonstration plants show that the technical problems are close to resolution, but financial obstacles remain, for example, owing to uncertainty with respect to payments for heat and electricity deliveries. Similar obstacles apply for greenfield projects based on biofuels. It is also anticipated that Danish power companies will rely more on imported wood pellets as domestic supply has not been adequate. Hence, one of the original objectives of the biomass policy – to provide secure domestic renewable energy – seems to be in question.

"Priority" production[13] reduces the market opening for retail competition substantially as wind power plants will only enter the market when ten years old. There are no actual plans to remove the prioritisation of small-scale CHP plants. "Priority" production has consequences in the electricity sector overall, but also specifically in the renewables industry. It seems to "over-stimulate" renewable energy, and a reduction of subsidies should be considered. The rules seem complicated and unclear.

The government would be well advised to develop a long-term vision as to what types of renewable energies should be developed and what policy instruments should be used. These instruments should be brought into existence. By further investigating other renewable energy sources besides wind power, Denmark can seek opportunities to diversify its renewable electricity production. The past policy of large subsidies for renewables needs further cost-benefit analysis. The full cost to society of this policy should be made more transparent to ensure real agreement of the public.

13. CHP plants and wind turbines enjoy "priority dispatch" in Denmark. This means that the power suppliers must buy their production whenever they produce, even if this means that cheaper fossil generating plants have to be taken off the grid.

The Danish Energy Agency has begun taking steps towards a more market-oriented and transparent policy approach. Further analysis could also confirm whether some producers are getting excessive benefits from this system (e.g. large CHP). Alternatives for more market-based solutions should be tried, including tendering procedures for offshore wind units (at least once, to reveal their costs) or reimbursable loans, as part of a policy mix for this sector. Whatever the decision, it is important to provide some planning security to investors.

There is considerable uncertainty as to the future of the proposed renewable energy certificates programme. However, the political initiative taken to consider moving away from the current subsidy scheme for renewable energies to a more market-oriented approach is laudable and should be encouraged, even if the current proposals require some modifications before being implemented. The introduction of the green certificates system should be made compatible with the systems used by potential trading partners and the EU.

RECOMMENDATIONS

The Government of Denmark should:

- ☐ Continue to review the performance of existing energy efficiency programmes with a view to developing market-based and more cost-effective policies. Loan payback schemes could substitute for outright subsidies in some cases.

- ☐ Continue to place time limits on subsidy schemes, particularly on those to boost market penetration of new energy-efficient technologies.

- ☐ Improve the transparency of the costs and trade implications of the various renewables support measures, in particular "priority" production.

- ☐ Investigate the consequences of greater penetration of imported biomass in terms of CO_2-neutrality, cost, and Denmark's security of supply objectives.

- ☐ Take steps to move to market-based policies as soon as possible, including the introduction of the green certificates programme, or some other instrument to offset the costs of current subsidies for renewable energy. In the transitory period, subsidies need to be reduced further to reflect current market conditions for wind energy and CHP.

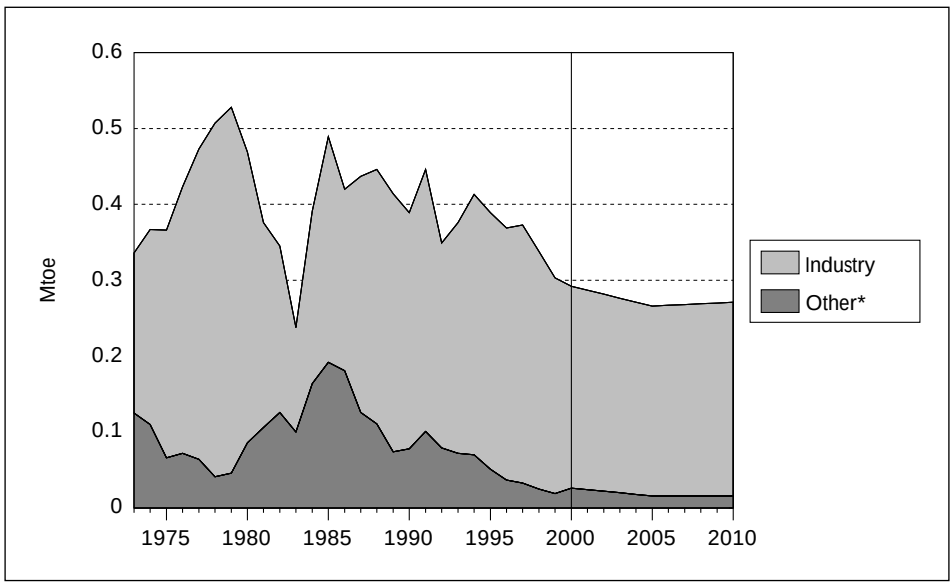
6

FOSSIL FUELS

COAL

Denmark has no coal production. Imported coal constituted 20.3% of TPES in 2000, most of which was used in large-scale combined heat and power plants. Coal accounted for 46.3% of Danish electricity generation in 2000, down from 90.6% in 1990. Coal imports and trade are free from government intervention, and the primary users in the power industry have free access to cheap overseas supplies in large carriers. However, the previous government issued a ban on construction of coal-fired power plants as a result of the climate change policy.

Figure 13
Coal Consumption by Sector, 1973 to 2010



* Includes residential, commercial, public service and agricultural sectors.
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001, and country submission.

UPSTREAM HYDROCARBONS

Industry Overview

The first Danish oil concession was awarded as early as 1935. After numerous dry wells had been drilled by a series of foreign, mainly American, companies, the concession for oil and gas exploration in the entire Danish area was awarded to the Danish company A. P. Møller on 8 July 1962. The concession was for 50 years

with an initial exploration period of ten years to make discoveries and start production. In the same year, A. P. Møller and the American company Gulf founded Dansk Undergrunds Consortium (DUC). Shell joined shortly afterwards. When the concession was extended to the continental shelf and thus to the Danish part of the North Sea, Chevron and Texaco joined DUC. Gulf withdrew from the consortium in 1974; Chevron in 1986. Today, DUC comprises Mærsk Olie og Gas A/S, a company established in 1962 as part of the A. P. Møller group, plus Shell and Texaco. Mærsk is the operator and holds 39% of DUC's shares; Shell holds 46% and Texaco 15%.

DUC discovered the first oil field in the North Sea in 1966 in a field later named the Kraka field. Gas was discovered in 1968. The somewhat larger Dan field was discovered in 1971, and in July 1972 production commenced from this field 204 kilometres off the Danish west coast. The Dan field was the first oil field in the North Sea with production from permanent facilities. Between 1980 and 1982, the Gorm and Skjold fields were developed. After the Dan field, these are the most important Danish oil fields. In the 1980s, DUC relinquished large concession areas. These were subsequently licensed out to other companies. Other firms have been active in exploration since 1984 and in production since 1998. Additional fields have been discovered and brought on stream since, including the Lulita field in 1998 and most recently the Halfdan field, discovered in early 1999 and producing since March 2000.

In 1972, the Danish government established Dansk Naturgas A/S, which became Dansk Olie og Naturgas A/S (DONG) only one year later. DONG is a fully state-owned company with the primary responsibility for pipeline transportation of oil and gas. Following a 1979 parliamentary resolution to introduce natural gas to Denmark, DONG was granted the sole right to import, transport, store and sell natural gas in Denmark. In the same year, DONG signed the first long-term contract with DUC for the delivery of 55 billion cubic metres of natural gas over 25 years, beginning 1 October 1984 from DUC's Tyra field in the North Sea.

The offshore pipeline systems for oil and gas were completed before 1 October 1984, and DONG began delivering gas that year to the first Danish distribution company, as well as to the German companies Ruhrgas and BEB. Exports to Sweden began one year later. Development of the Danish gas market had begun in the south of Jutland with the establishment of the first distribution company in 1979 and with deliveries from Ruhrgas as of 1982.

Until 1998 DUC was the sole producer of oil and gas in Denmark. Three new fields have come on stream since, and these were developed by other, mainly private, investors. On 1 January 2001, 11 companies received and sold oil and gas from Danish fields. Among them were the foreign private producers Shell, Texaco, Amerada Hess, Statoil, Enterprise & Philips, and the Danish private companies Denerco, Danoil and LD Energi, and DONG. In 2000, companies other than DUC accounted for slightly more than one-fifth of Danish oil production and just under 10% of Danish gas sales.

Exploration and Production

The Danish Energy Agency (DEA) produces annual assessments of Danish oil and gas reserves. On 1 January 2000, Denmark's total oil reserves were estimated at 206.3 Mtoe. The assessment published by the DEA on 1 January 2001 showed an increase in oil reserves of 26% over the 2000 estimate to 259.1 Mtoe of oil. For most of the 1990s, oil reserves were estimated at around 170 Mtoe, remaining fairly constant. In 1999, reserve estimates were increased by 22% over the 1998 level. The 2001 assessment is the highest estimate for Danish oil resources to date, as well as the highest upward adjustment of Danish reserves.

The increase is attributable mainly to a write-up of reserves in the new Halfdan field. More precisely, it is largely due to the discovery of a new type of accumulation where hydrocarbons extend over large areas between existing fields, whereas previous discoveries had been accumulated in "bulges" in the subsoil. Exploration for such accumulations is expected to intensify in light of their great potential. In March 2001, Mærsk submitted a plan for a major further development of the Halfdan oil field, one of the new types of accumulation. The reserves of several other fields have also been reassessed. Gas reserves were estimated to be 135.6 Mtoe in 2000 and 137.5 Mtoe in 2001.

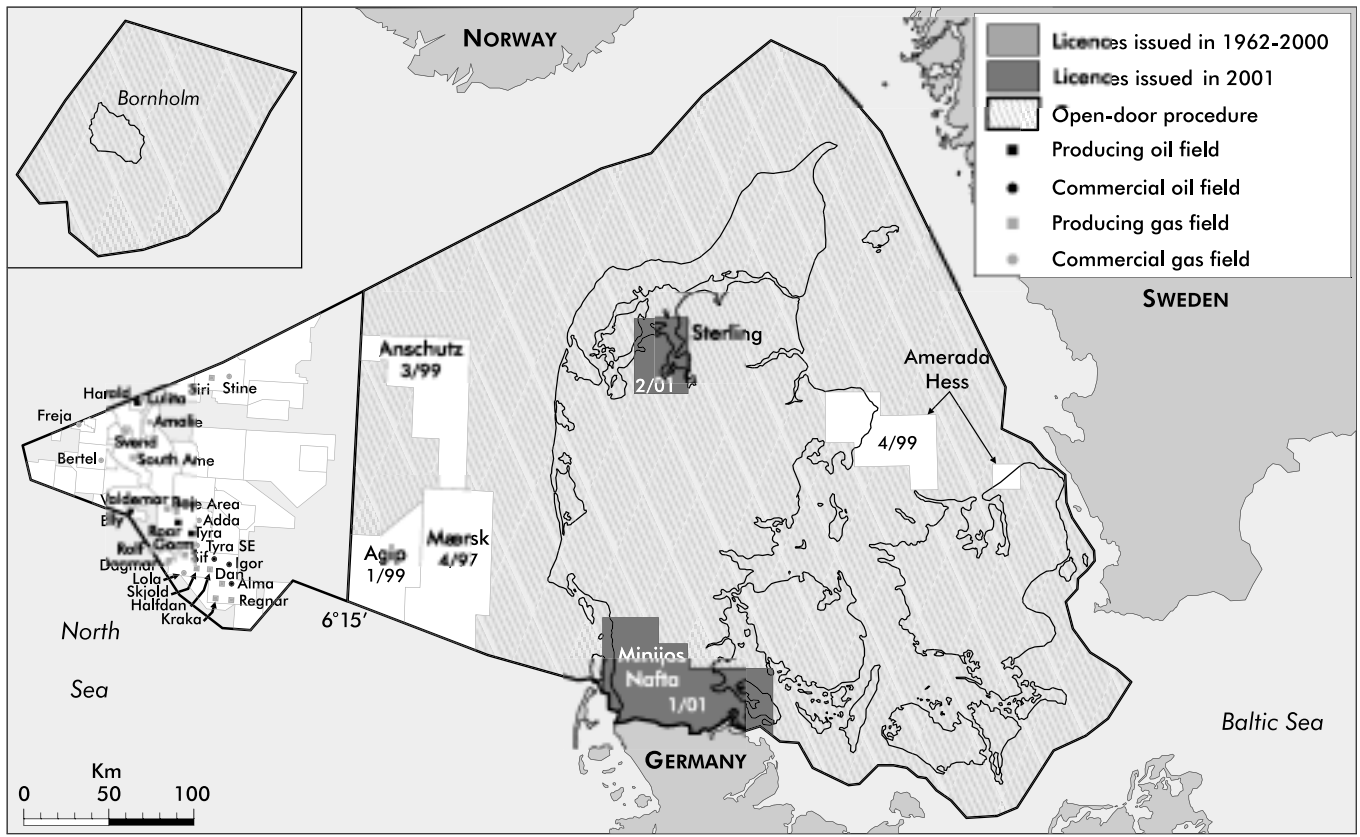
The outlook for the years to come is optimistic in a number of areas, including hydrocarbon exploration. The oil potential in the Danish part of the North Sea, the production potential in structures as yet unexplored and the potential in using new technology represent an additional resource potential over the above reserve estimates of 87 to 130 Mtoe of oil for the next ten-year period.

The Minister of Environment and Energy grants licences for exploration and production of hydrocarbons in licensing rounds, the first of which was held in 1984. The most recent fifth licensing round was announced on 19 September 1997 with a deadline for applications of 27 January 1998. As in the fourth licensing round in 1994/95, the area offered for licensing comprised all unlicensed areas in the Central Graben with adjoining areas in the Danish part of the North Sea. The Danish Energy Agency received 19 applications from 17 companies. In comparison, the number of applications submitted in the fourth licensing round was 12. Seventeen licences for exploration and production of oil and gas were granted on 15 June 1998. No date has been set for the next licensing round, but it is not expected before 2003.

The high oil price level during 2000 strongly affected oil and gas activities. The oil companies' earnings increased significantly, and so did the incentive to invest in further exploration and production. Exploration activity was high in 2000 owing to drilling operations initiated by the licensees from the fifth licensing round. Two of the seven exploration wells drilled during the year encountered new oil deposits outside the Central Graben. The Danish Energy Agency expects drilling activities to continue at the same high level in 2001. Another consequence of the high oil price level is record-high revenue for the State in the form of taxes and fees from the oil-producing companies. If this trend in the oil and gas sector is sustained, Denmark expects to be self-sufficient in oil and gas for many years to come.

Figure 14

Danish Hydrocarbons Licence Area and Production Facilities



Source: Danish Energy Agency.

Since 1997, the Danish government has had a special "open door" procedure in place to facilitate exploration (east of 6°15' East, see Figure 14). Under sections 5 and 13 of the Subsoil Act, companies can file applications for exploration and production licences for this area every year, and the licences are awarded successively. Under this procedure, licences are generally granted for an exploration term of six years, with a right to a 30-year extension for fields where production is initiated. The "open door" procedure has attracted much interest. In September 2000, two new applications were submitted, by the Minijos Nafta group and the Sterling group, respectively. On 5 March 2001, the then Minister for Environment and Energy granted each of the two applicants a licence for exploration and production.

Mærsk Olie og Gas A/S, Amerada Hess ApS and Statoil Efterforskning og Produktion A/S are operators responsible for the actual production of oil and gas from the North Sea fields. In addition to these operator companies, a number of other companies participate in the individual licences. Each company controls a share of the oil and gas produced that corresponds to its percentage share in the licence concerned.

Danish oil production increased throughout the last years. As a result of a sustained high level of development activities in the North Sea, the year 2000 set another record for oil and gas production with 18.3 Mtoe taken together, corresponding to an average production rate of about 364 000 barrels of oil per day. This is 22% above 1999 levels. Natural gas production amounted to 7.4 Mtoe in 2000; 6.7 Mtoe of this were supplied to DONG.

Despite this rise, the increased estimate of oil reserves means that the resources-to-production ratio (R/P ratio) remains at 14, i.e. oil production is calculated to be sustainable at the 2000 level for the next 14 years. The R/P ratio has dropped from 28 to 14 since 1990. The declining R/P ratio is mainly attributable to sharply increasing production which tripled during this period. If the reserves had not been reassessed since 1990, the depletion caused by production would have reduced reserves in 2001 to a mere 37.3 Mtoe. The R/P ratio for these reserves would have meant that production at the 2000 level could be sustained for only two years.

Over the past ten years, expected recovery has increased on average at the same rate as production. The increased recovery is attributable to a large degree to improved recovery methods such as horizontal drilling, gas re-injection, dry gas recycling and water injection.

In autumn 2000 a well-head platform was installed in the Halfdan field, followed by the start-up of production. The Halfdan platform is the 42nd platform installed in the Danish part of the North Sea. At the beginning of 2001, oil and/or gas were produced from a total of 16 Danish fields. In 2000, 17 wells were drilled in the producing fields. Fourteen of these were production wells.

The estimated value of total Danish oil and gas production rose to about DKK 32.9 billion in 2000, DKK 28.5 billion for oil, and DKK 4.4 billion for gas. This represents a 96% increase over 1999. The increase is chiefly due to oil

prices and the dollar exchange rate, which were much higher than in 1999, but also to the higher production rates. In 1999, the value of oil production had been DKK 14.3 billion, while the value of gas production was estimated at DKK 2.5 billion.

Trade and Transportation

DONG A/S owns all well-to-shore gathering pipelines for oil and gas in Denmark. There are also pipelines running between fields, and these are owned by other companies. Since 1984 DONG A/S has participated in exploration, and since 1998 it has been an oil and gas producer. Through several subsidiaries, it engages in oil and gas transportation, trading and sales in Germany and Sweden. Established originally in 1972, DONG's corporate structure today is as follows (April 2000):

- DONG A/S is the group holding responsible for overall group management.
- DONG Naturgas A/S (formerly DANGAS) is a 100% owned subsidiary responsible for transportation of and trade in natural gas.
- DONG Efterforskning og Produktion A/S (DONG E&P) is a full subsidiary, whose main task is exploration and production of oil and gas[14].
- DONG Olierør A/S, another full subsidiary, carries out pipeline transportation of crude oil and condensates.
- DONG Grønland A/S (100%) and Nunaoil (50%) are responsible for exploration in Greenland.
- DANGAS GmbH, 100% owned by DONG A/S, transports natural gas to and from Germany.
- Vattenfall Naturgas A. B. trades and transports natural gas in Sweden. DONG A/S holds a 10% stake.

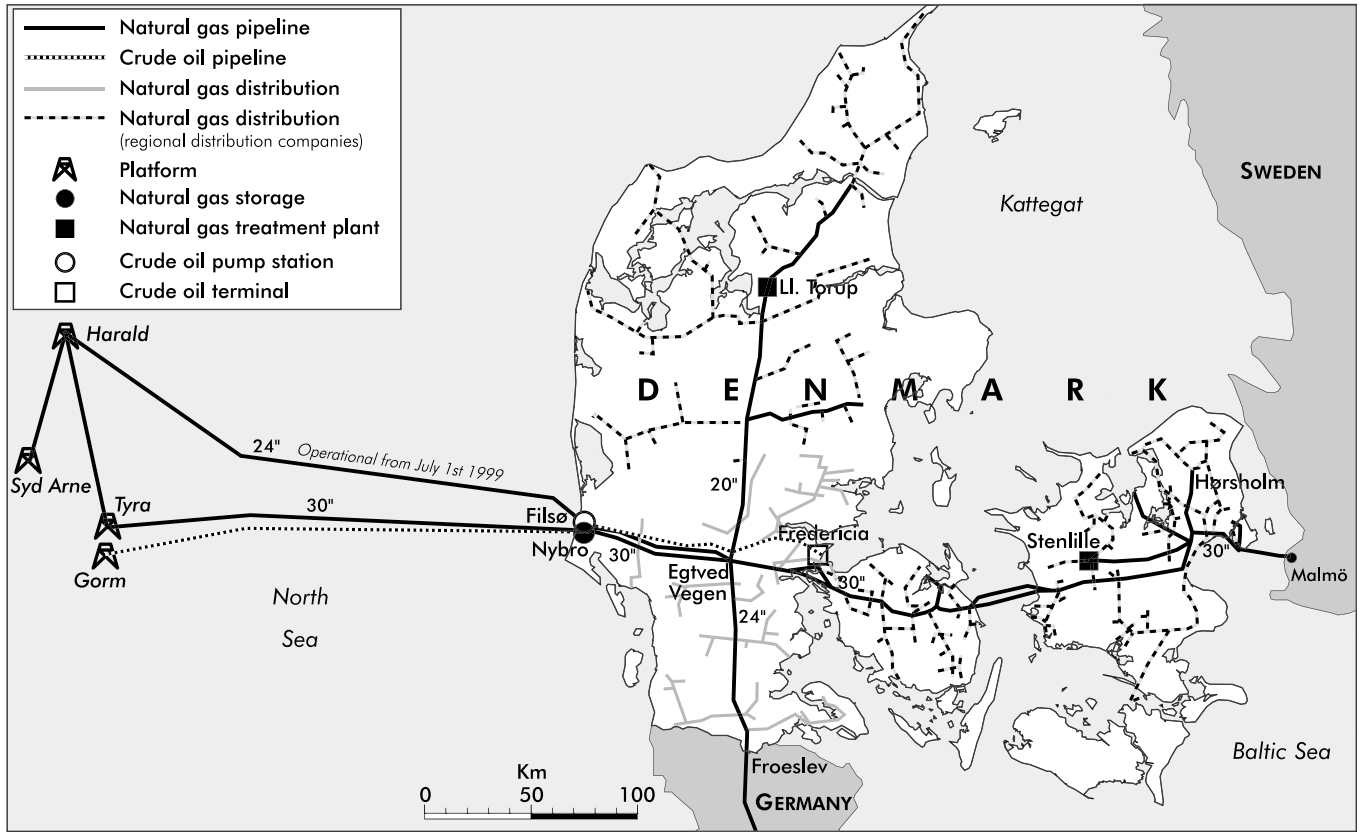
DONG Olierør owns and operates the crude oil pipeline running from the offshore Gorm field to the crude oil pump station in Filsø, where the oil is landed, and on to the crude oil terminal in Fredericia. When the oil transport system went into operation in 1984, its capacity was 60 000 barrels per day. This had increased to 330 000 barrels per day in 2000. The oil from the new fields in the North Sea, Siri and Syd Arne (South Arne), is not transported via the pipeline but by tanker directly from the production platform.

DONG Naturgas gathers the North Sea gas at the Gorm, Syd Arne and Harald fields and transports it via two offshore pipelines to the natural gas treatment plant in Nybro. The northern pipeline connecting the Syd Arne and Harald fields with

14. The functions of DONG's former operating subsidiary Dansk Operatørselskab I/S (DANOP) and of its former exploration, production and engineering subsidiary Dansk Olie og Gasproduktion A/S (DOPAS) have been fully integrated into DONG E&P.

Figure 15

Oil and Gas Pipelines in Denmark, 2000



Source: DONG.

Nybro – called the Syd Arne pipeline – was completed only recently. It was initiated in 1997 and began operating in 1999. Under normal circumstances, this pipeline only carries gas from Syd Arne. But as it is linked with the Harald field, that in turn is linked to the Tyra field, gas from the Tyra platform can be brought to shore even if the Tyra pipeline is interrupted. From Nybro, high-pressure pipelines run to Zealand and on to Malmö in Sweden, and to the north of Jutland and Germany. DONG Naturgas had a statutory monopoly on gas imports until this was repealed in 1994 as a first step to prepare for competition.

DONG Naturgas has two natural gas storage facilities, one at Lille Torup near Viborg in Jutland, and one at Stenlille in Zealand. The Lille Torup and Stenlille storage facilities provide an extraction capacity of 410 million cubic metres and 400 mcm, respectively. A modification of the Stenlille facility has improved DONG Naturgas's ability to meet its short-term objective of supplying customers with gas in case of failing gas supplies from the North Sea on very cold winter days. The company has also adopted a long-term gas supply policy that makes allowance for accidents that may interrupt the gas supplies carried ashore through the pipeline from the Tyra field for up to 30 days. With a total extraction volume of 810 mcm from storage and its long-term gas purchase agreements concluded with DUC, DONG Naturgas believes it is able to meet its long-term objective. To increase security of supply for fixed customers, DONG has also concluded interruptible gas sales contracts with large customers, in particular power plants and large industrial companies. In return for holding stocks of coal or oil that they can switch to, these companies get their natural gas at a discount.

Since gas sales began in 1984, Danish natural gas has been supplied under gas sales contracts between DUC and DONG Naturgas. DONG Naturgas has three long-term gas purchase agreements with DUC. The first contract was concluded in 1979 for total deliveries of 55 bcm between 1984 and 2009. A second contract for 38 bcm runs from 1989 to 2012. The first two contracts were take-or-pay agreements on fixed volumes. The third is a variable open-ended agreement concluded in 1993. These three contracts taken together result in annual deliveries from DUC to DONG of 7.5 bcm. Since other companies began producing oil and gas in the North Sea in 1998, DONG Naturgas started buying gas from the Statoil's Lulita field and, as of 1999, from the Amerada Hess group's Syd Arne field. DONG Naturgas takes up all gas available in the Danish section of the North Sea.

In 2000, DONG sold 4.07 bcm of gas in Denmark and exported 3.04 bcm. Since 1984, DONG has exported gas to Ruhrgas and BEB in Germany. The quantities are around 2 bcm to 2.5 bcm; occasionally, Ruhrgas purchases extra supplies at short term. About 0.8 bcm to 1 bcm is sold in Sweden via Vattenfall Naturgas.

DONG has plans to expand exports in future. A supply contract with Poland was concluded in July 2001. Under this contract, DONG will sell 2 bcm per year between 2004 and 2012 to the Polish state-owned oil and gas company POGC. These supplies require the construction of a dedicated pipeline (BalticPipe) to run through the Baltic Sea from Rødvig in Zealand to Niechorze in Poland. DONG and

POGC also signed an agreement establishing a joint consortium to construct this pipeline. DONG will hold two-thirds of its shares. The sale of natural gas to Poland is conditional on a new contract for additional volumes between DONG and DUC.

As of 2008, Norway is to supply an additional 5 bcm of gas per year to Poland through the same pipeline. This requires linking up the Danish and the Norwegian systems. Two routes are under discussion: a link-up with the existing Europipe that runs from Kårstø in Norway to Emden in Germany, or a dedicated pipeline to run through the Kattegat and Skagerrak straits.

DONG also contemplates construction of a pipeline to the UK, running from the Syd Arne platform either to the Murdoch or Trent platforms or to the Rough platform. The gas would be landed in Theddlethorpe, Bacton or Easington, respectively. DONG sees the UK link-up as the only realistic option to sell its gas if a significant share of its home market should break away owing to competition.

Government Intervention in the Upstream Market

Government intervention in the upstream hydrocarbons market takes the form of mandatory participation of DONG in exploration, field development and production, mandatory payment for DONG's offshore oil pipeline (even if it is not used), and taxation and royalties.

Mandatory participation of DONG in exploration, field development and production. DONG Exploration and Production A/S (previously named DOPAS) is automatically granted a share in all licences for hydrocarbons exploration and production awarded to oil companies. The share is generally 20%. DONG's mandatory participation has been a standard requirement since the fourth licensing round held in 1995, as well as under the open-door procedure. The obligatory participation applies for all exploration and production concessions except licences granted before 1986.

DONG participates on the same terms as the other companies in each joint venture. The company must pay its share of expenses in its licences on the same terms as the other licensees, receives the corresponding share of the profits and pays taxes and fees to the State at the current rates. No royalty is due. The main objective of state participation in the licences is to secure the State a share in the proceeds from oil and gas recovery.

The Danish government believes that this form of state participation does not influence the profitability of a given project, but only the size of the financial result, since the companies' exploration, investment and operating costs are reduced by the same share as their income. In some cases, DONG has supplemented this share on commercial terms by purchasing additional licence shares. DONG participates in the production from the new fields not under DUC's control, i.e. the Siri field, the Syd Arne field and the Lulita field.

Mandatory payment for the offshore oil pipeline. According to Denmark's Oil Pipeline Act, all Danish oil producers in the North Sea had to use DONG's oil pipeline from the Gorm field to Fredericia. For this, all users were required to pay a fee to DONG Olierør. This fee includes a profit element of 5% of the value of the crude oil transported. DONG transfers 95% of the revenue from that profit element to the government. The Oil Pipeline Act was amended in June 1997 to take into account that new operators were going to be allowed to produce oil in Denmark, and that they might not wish to use the pipeline. The amendment granted an exemption from the obligation to connect to and use the pipeline. As noted in the preceding section, the companies producing oil from the new Siri and Syd Arne fields have indeed chosen to ship their oil by tanker directly from the production platform. However, the amendment stipulated that those parties are still required to pay a fee to the State amounting to 5% of the value of their crude oil and condensate. This fee is paid on the production from the Syd Arne and Siri fields. Hence, whereas the requirement to use, and pay for, DONG's crude oil pipeline may have originally been a measure to ensure the economic viability of this heavy investment (compared to the small Danish market), it is now merely a tax on oil revenue, and acknowledged as such by the government.

Taxation and royalties. Taxation of oil and gas production consists of the following elements: corporate tax, hydrocarbon tax, and royalties.

- Oil and gas producers pay corporate tax like all other Danish companies. However, the government has put a "one-way ring-fence" around hydrocarbon activities to ensure that losses from other activities cannot undermine the tax base. On 1 January 2001, Danish corporate tax was lowered from 32% to 30%.

- The hydrocarbon tax was introduced through a Parliamentary Act in 1982 with the aim of taxing windfall profits, for example as a result of high oil prices. In the case of new investment, an uplift of 25% per year is deductible from the hydrocarbon tax base for a maximum of ten years. The Danish government believes that this provides a strong incentive to reinvest in further exploration and development when prices are high, but reduces exploration during low-price periods, and thus ensures increased and better use of the hydrocarbon resource. The hydrocarbon tax only became payable for a few years during the first half of the 1980s, with total revenue amounting to approximately DKK 870 million in 2000 prices. Motivated by the fact that the recent high oil prices have not resulted in hydrocarbon tax payment, a committee headed by the Ministry of Taxation reviewed the current hydrocarbon tax in 2000 and concluded that the present form of taxation may distort the oil companies' incentive to invest. Subsequently, the ministry appointed a committee that is to lay the groundwork for introducing a new hydrocarbon tax system for future licences. The committee was to have completed its work by October 2001.

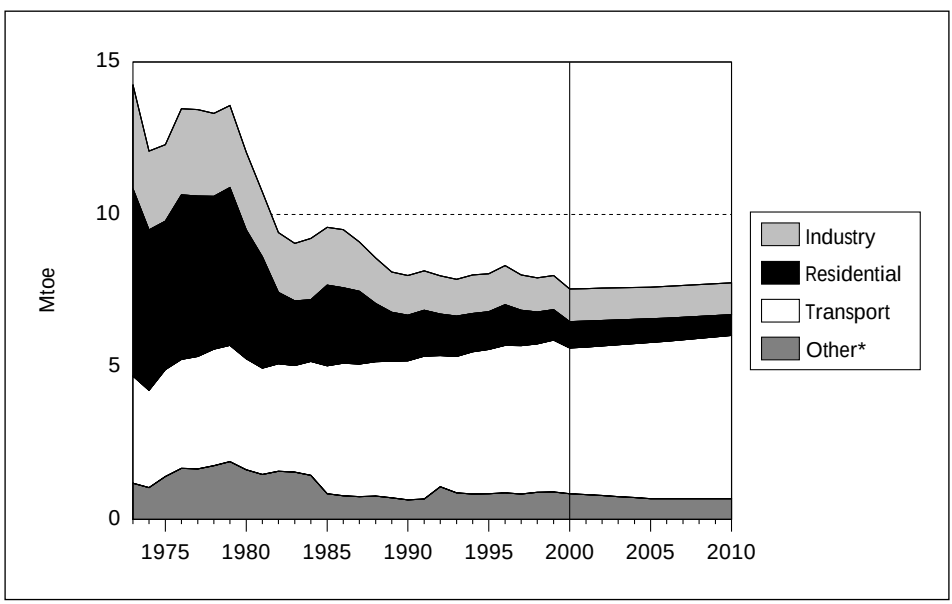
- The conditions for royalty payments vary depending on the licensing round. Under the terms of A. P. Møller's Sole Concession of 1962, royalty is payable

on the basis of production. The royalty is 8.5% of the value of oil and gas produced, after deducting the cost of transporting the oil to land (including the oil pipeline tariff). In licences attributed during the second licensing round of 1986, the royalty is levied on a sliding scale, depending on the level of production. In addition, the Statoil group is to pay royalty based on the size of the production attributable to its share of the Lulita field. No royalty is payable for licences awarded in the third and subsequent licensing rounds.

DOWNSTREAM OIL

There are two refineries in Denmark. Both are owned by foreign companies, one by Shell and one by Statoil. Refining and marketing of oil products are competitive activities. Until 1985, Denmark regulated oil prices. Since then, government surveillance has been reduced to the requirement to communicate price changes to the Competition Council. Most oil companies' prices differ little and mirror the Rotterdam quotations. A few small companies, covering about 10% of the total retail market, offer lower prices.

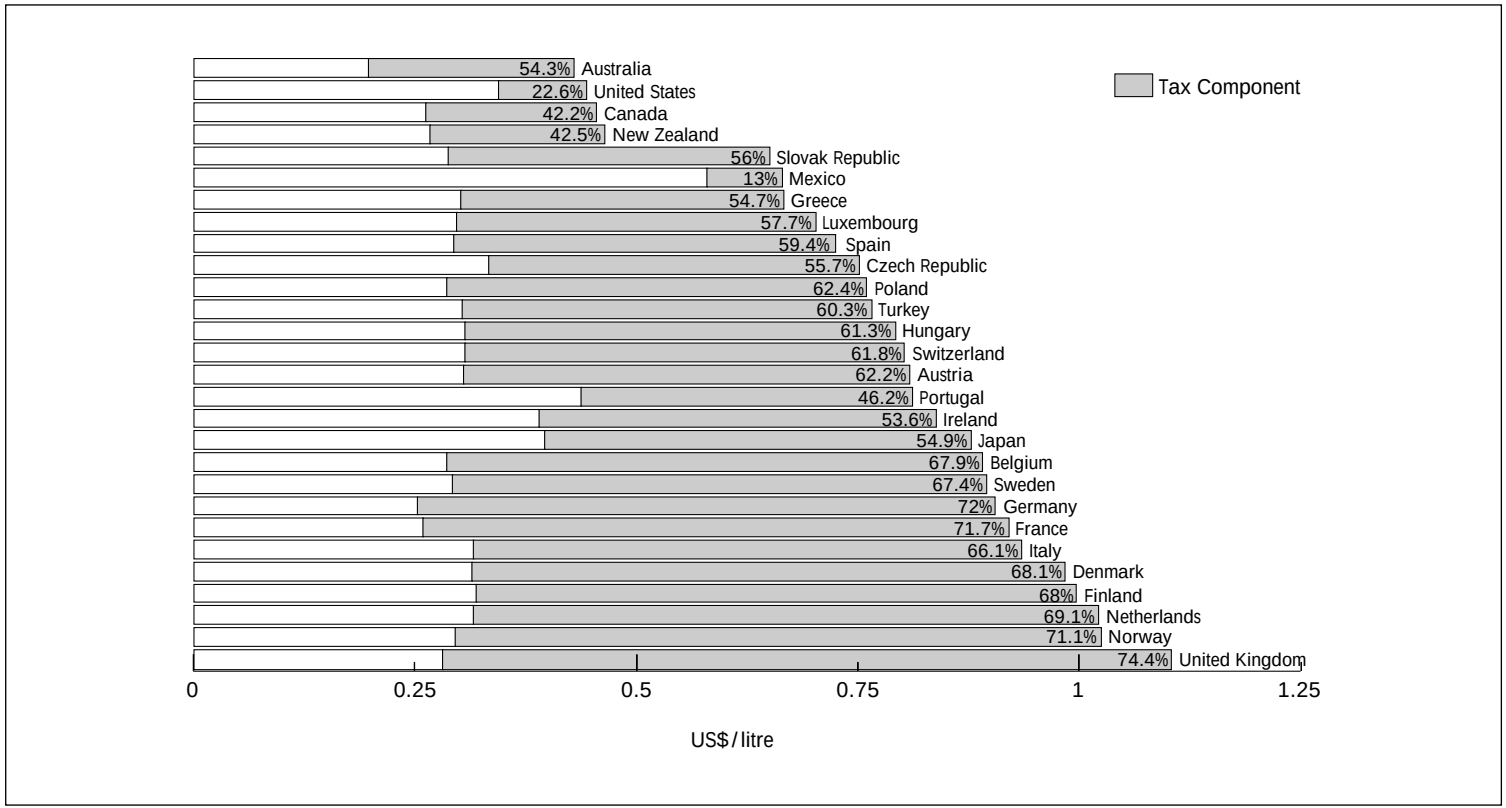
Figure 16
Final Consumption of Oil by Sector, 1973 to 2010



* Includes commercial, public service and agricultural sectors.
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001, and country submission.

Figure 17

OECD Gasoline Prices and Taxes, 1st Quarter 2001

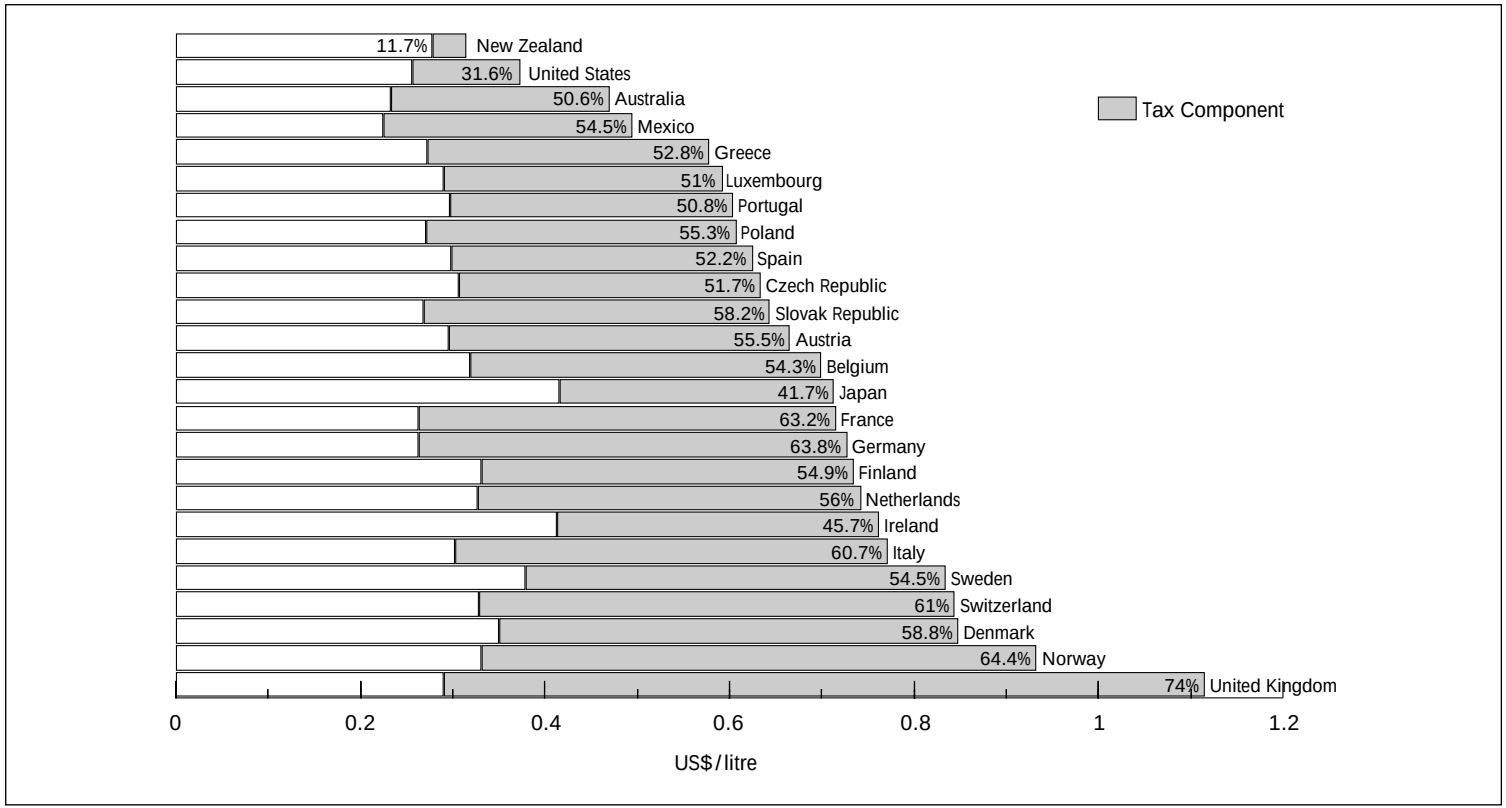


Note: Data not available for Korea.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2001.

Figure 18

OECD Automotive Diesel Prices and Taxes, 1st Quarter 2001



Note: Data not available for Canada, Hungary, Korea and Turkey.
Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2001.

EMERGENCY PREPAREDNESS

Denmark has the following wide-ranging statutory powers for implementation of emergency response measures:

- *The Supply Measures Act 1986*, which authorises the Minister for Economic and Business Affairs to stipulate provisions about the use, distribution, price equalisation and location of Denmark's stocks of energy commodities in case of a supply disruption. Such measures presuppose that they are endorsed by the Parliament's Standing Committee on Energy.

- *The Act on Reporting and Selling Obligations 1975*, which authorises the Minister for Economic and Business Affairs to stipulate provisions ordering companies producing or importing hydrocarbons to sell such hydrocarbons in order to fulfil Denmark's international sharing obligations.

- *The Act on Compulsory Stocks of Mineral Oil and Mineral Oil Products 2000*, which authorises the Minister for Economic and Business Affairs to stipulate provisions about compulsory stock obligations and reporting obligations for companies producing or importing hydrocarbons.

- *The Act on Civil Emergency Preparedness 1992*, which contains general provisions about civil emergency preparedness matters.

The Danish National Energy Emergency Sharing Organisation (NESO) consists of staff from the Danish Energy Authority in the Ministry of Economic and Business Affairs. Although there are no specific staffing plans, the NESO can be flexibly and quickly expanded in co-operation with experts from the oil industry.

Denmark maintains a high level of emergency oil stocks, the majority of which is held by the FDO (the Association of Danish Oil Reserve Stocks) on behalf of the oil companies. Thus, the FDO is the cornerstone of the Danish stockholding system. The FDO is an association of almost all oil companies in Denmark and is owned by these companies. The Danish Energy Authority has a member on the Board of Directors of the FDO, but it is not in a controlling position as to its operations.

Apart from crude oil stocks and some other stocks held for flexibility, the composition of FDO stocks reflects the market product mix. In addition, some commercial stocks would be available in case of a supply disruption. The stock obligation for oil companies was lowered from 90 days to 81 days of consumption as of 1 July 1999, in accordance with EU Directive 98/93/EC.

Emergency oil stocks held in excess of international obligations can be released by a specific decision by the Danish government lowering the oil companies' compulsory stock obligations, thereby making these quantities available to the market. In this way, Denmark would be able to participate in a co-ordinated stockdraw in a flexible manner under conditions where the IEA's Co-ordinated Emergency Response Measures apply or in situations triggered under the International Energy Program.

The Supply Measures Act 1986 is regarded as the basis for implementing, if necessary, demand restraint measures tailored to the specific supply disruption situation. Such demand restraint measures could be decided by the Minister for Economic and Business Affairs and will presuppose that they are endorsed by the Parliament's Standing Committee on Energy.

NATURAL GAS

Distribution and Retailing

Denmark has five regional distribution companies that carry out local supply tasks within delimited geographical areas. These gas distributors are Naturgas Syd (NGS) in southern Jutland and North Schleswig, Naturgas Sjælland (NGSJ) in western and southern Zealand, Naturgas Fyn (NGF) in Funen, Hovedstadsregionens Naturgas (HNG) in the area surrounding Copenhagen, and Naturgas Midt-Nord (NGMN) in the central and northern parts of Jutland. The city of Copenhagen and the municipality of Frederiksberg also have gas networks. From the beginning of gas supply in Denmark in 1984, the five distributors bought gas from DONG and sold it to end-users. DONG Naturgas supplied large-scale CHP plants and natural gas customers in Copenhagen and Frederiksberg directly.

The regional gas distribution companies are non-profit organisations owned by the municipalities they supply. Denmark has a long-standing tradition of organising regional and local infrastructure industries as consumer co-operatives or communal undertakings that do not have the right to retain profits for future investments. Prices can only reflect "justified" costs, as determined by the Price Commission. If profits are made, they have to be paid back to the consumers in the following year. This makes it impossible to form capital in the company or to raise equity.

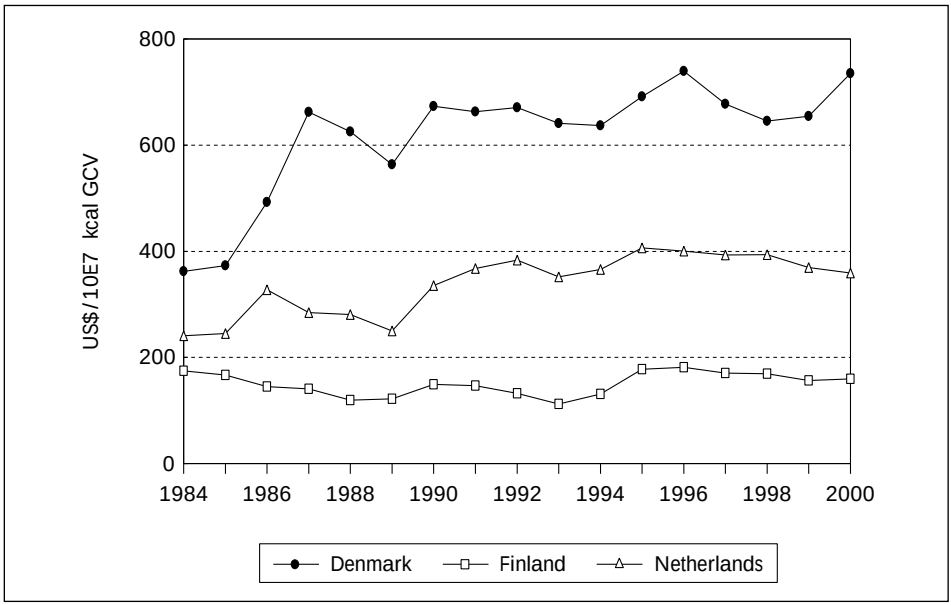
Based on pre-existing distribution grids for city gas, the Danish government encouraged the construction of the gas distribution infrastructure under this model over a short period in the early 1980s, driven by considerations of security of supply after the oil crises. But the restrictions on the commercial operation of the companies meant that the capital for the development of the gas system had to be raised by loans. These loans were guaranteed by their community owners. Consequently, the gas distribution companies are heavily indebted. The government financed reimbursement of the debts through regulated gas prices for ultimate consumers and preferential tax treatment for natural gas in relation to oil, effectively amounting to a large subsidy.

The relationship between DONG Naturgas and the regional gas companies was regulated by a contract that became known as the "4 June Agreement" after its conclusion on 4 June 1987. Under this agreement, DONG Naturgas had an obligation to supply the companies with gas up to 2.6 bcm. In 1998, DONG Naturgas signed an agreement with the five distributors to supply them with additional quantities of gas beyond the "4 June Agreement".

To prepare the introduction of competition required under the EU Gas Directive and address the debt problem, negotiations took place in 1999 between the government, the regional gas distribution companies and DONG Naturgas about the future structure of the gas sector and future state aid.

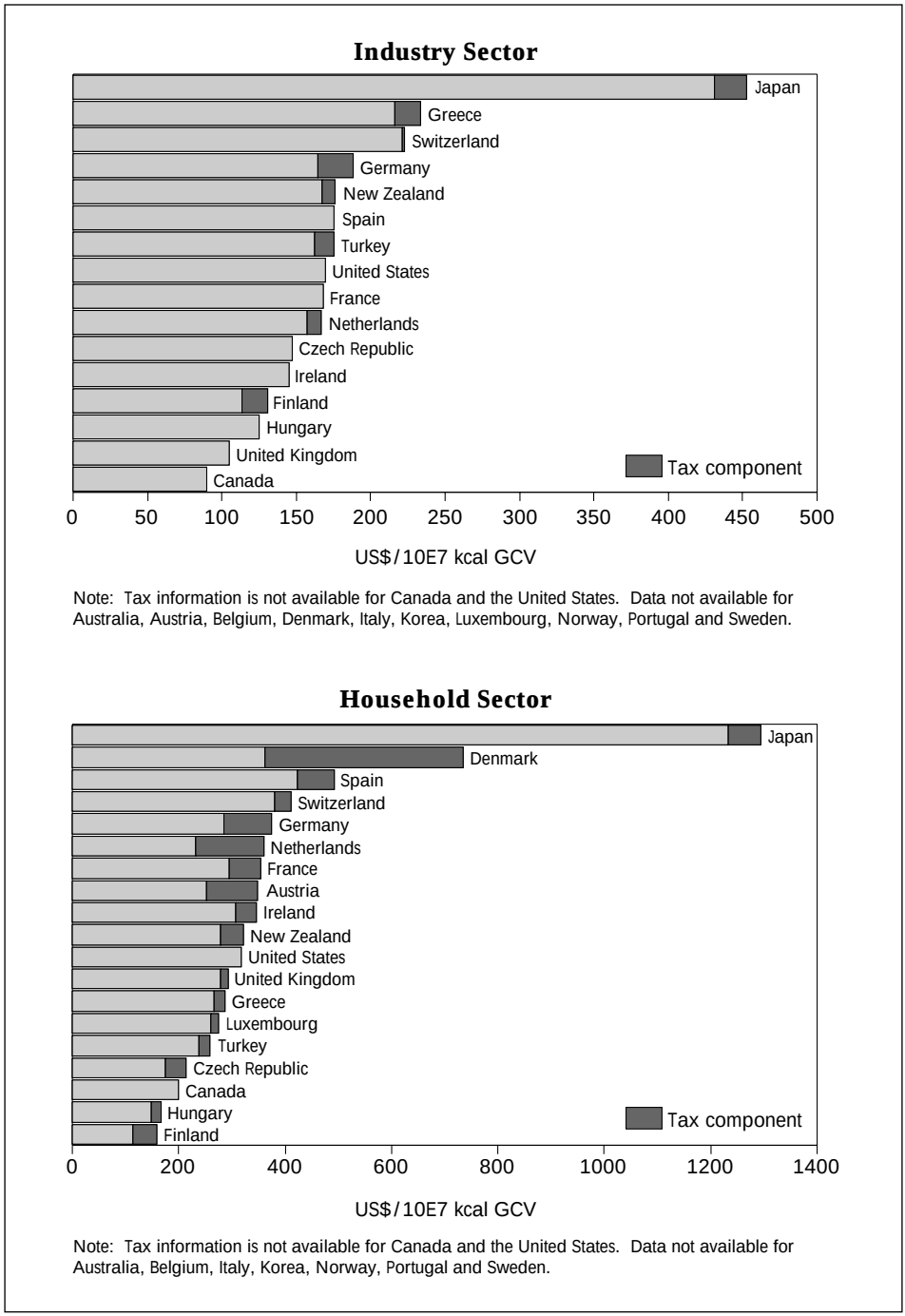
On 23 June 1999, the government concluded an agreement with Naturgas Midt-Nord (NGMN) and Hovedstadsregionens Naturgas (HNG), the two largest regional gas distribution companies in Denmark. The agreement provided that the two regional companies form a closely co-operating entity. This co-operation is expected to lead to joint reduction of the companies' debts, allowing the companies to pay back their debts at the same rate and become free of debt at the same time. The agreement will also constitute the framework for closer operational co-operation to minimise costs. As a consequence of this agreement, DONG Naturgas, HNG and NGMN signed a new contract on the delivery and transportation of natural gas, which came into force on 1 July 2000. Under this contract, DONG Naturgas acquired the right to sell to larger industrial consumers and small-scale CHP plants in HNG's and NGMN's geographical areas directly. The "4 June Agreement" no longer applies to the two regional companies. On 1 July 1999, DONG acquired the regional distributor Naturgas Syd and thus gained direct access to 58 000 customers in southern Jutland. As DONG has the financial power to redeem the distributor's debt, the take-over and the new agreements effectively solved the most serious part of the debt problem in the Danish gas sector.

Figure 19
Natural Gas Prices in Denmark and in Other Selected IEA Countries, 1984 to 2000
Household Sector



Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2001.

Figure 20
Natural Gas Prices in IEA Countries, 2000



Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2001.

The agreement of 23 June 1999 expressly invited two remaining (the smallest) regional gas distribution companies Naturgas Fyn (NGF) and Naturgas Sjælland (NGSJ) to join the agreement on the same terms as HNG and NGMN. But NGF expressed no wish to join the agreement and the gas supply contract. However, DONG Naturgas informed NGF that the "4 June Agreement" and the old supply agreement built on it were to lapse as from 1 July 2000. Parliament decided to increase the energy tax on natural gas to the same level as oil products (based on their respective carbon content) as from that date, thereby effectively ending the tax subsidies for gas. On 1 July 2000, the new Natural Gas Supply Act also became effective (see next section on Gas Market Reform), introducing partial opening to competition into the gas industry. NGF does not acknowledge the lapse of the June 4 Agreement. The agreement is a private law issue, and steps have been taken to resolve the dispute between the parties definitively.

On 31 January 2000, DONG acquired the former municipally-owned distributor Naturgas Sjælland. The two acquisitions burden DONG with a debt portfolio of DKK 7.2 billion, but DONG can amortise the debt. The government believes that HNG, NGMN and NGF will be able to repay their debt by 2014. As a consequence of the two take-overs, DONG now supplies 75% of the Danish gas market directly, and the remainder through the three municipally-owned distribution companies HNG, NGMN and NGF. HNG and NGMN each account for 10% of the Danish market. As DONG has acquired the right to supply the largest customers in their supply areas through the agreements of 23 June 1999 and 1 July 2000, it has acquired a strong dominating position in the Danish gas market. NGF with 5% market share is the only supply company that is independent of DONG to date. The Danish Competition Authority has taken note of DONG's dominating position.

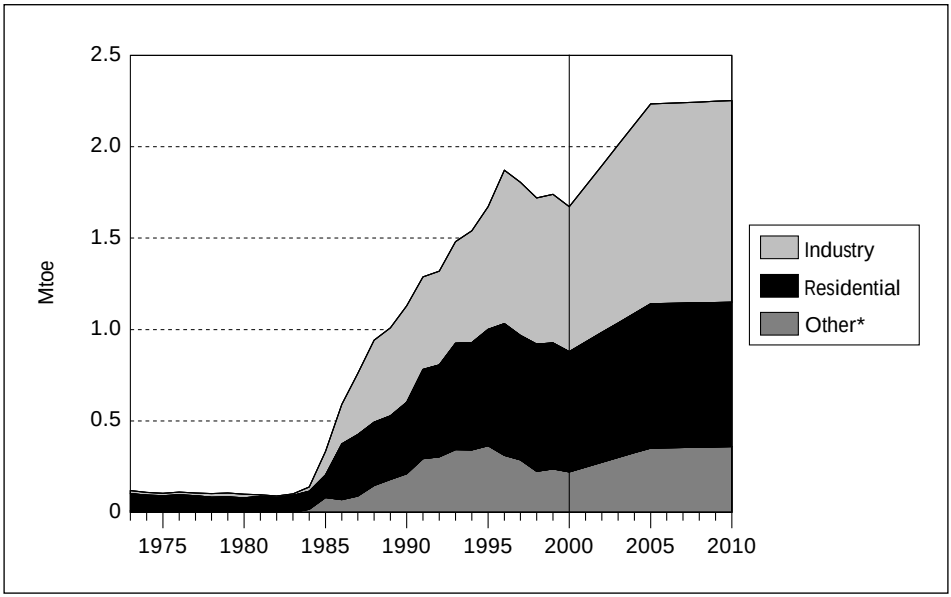
Natural Gas Demand

Natural gas sales in the Danish domestic market were 4.07 bcm in 2000, down just under 2% compared to 1999. Residential and commercial consumers took 0.9 bcm, industrial consumers 1.1 bcm, CHP and district heating plants 1.3 bcm and power generators 0.7 bcm in 2000. The Danish gas market is very small compared to that of other European countries, amounting to 4% of the UK market and 5% of the German market.

The development of gas demand has been subject to mixed incentives over the past years. On the one hand, natural gas as a domestic and environmentally relatively advantageous energy resource had been favoured in power generation and especially in CHP for a long time, and had been subject to relatively low taxation. On the other hand, the heat market was tightly regulated through the national Heat Plan, thereby restricting the market for gas to predefined geographical areas.

The outlook for gas demand is mixed and will depend in particular on gas sales to large-scale CHP plants. This in turn depends on the development of the competitive gas and electricity market. Including anticipated exports to Germany, Sweden and Poland, sales of Danish natural gas are expected to grow to 8 bcm to 10 bcm per year to 2004.

Figure 21
Natural Gas Consumption, 1973 to 2010



* Includes commercial, public service and agricultural sectors.
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001, and country submission.

Gas Market Reform

Gas market reform in Denmark was initiated through the EU Gas Directive (98/30/EC), adopted on 22 June 1998 and in force since 10 August 1998. European Union member states had to transpose the directive, i.e. adapt their laws, regulations and administrative provisions to the new rules, two years after the entry into force of the directive, i.e. on 10 August 2000. The Danish government presented draft legislation to Parliament on 29 March 2000. The Natural Gas Supply Act was adopted on 31 May 2000 and entered into force on 1 July 2000.

According to the Gas Directive, at least all gas-fired power generators, irrespective of their annual consumption, and other final customers consuming more than 25 million cubic metres (mcm) per year had to be made eligible for competition as from August 2000. The eligibility threshold must gradually be lowered to 15 and 5 mcm by 2003 and 2008, respectively. The minimum share of competition in the market required by the directive was 20% as from 10 August 2000, increasing to 33% by 2008.

However, the Gas Directive allows member states to introduce ceilings on market opening. This is possible in exceptional circumstances, for example in case of safety or security of supply risks. In order to "safeguard the balance" of the electricity market, member states may introduce a threshold for the eligibility of combined heat and power (CHP) producers. As power generators, CHP plants of all

sizes would normally be eligible for competition. Under this provision, a size limit can be introduced for combined heat and power producers at the general level of eligibility. This derogation was originally laid down by the EU Council of Ministers in accordance with Denmark's wishes and following submission to the Danish Parliament (*Folketing*). Finally, more restrictive thresholds can also be used if the consumption-based levels result in a market opening exceeding 30% in the first phase, 38% in the second phase and 43% in the third phase. Member states may then limit market opening "in a balanced manner" to this ceiling level.

Denmark intends to make use of these more restrictive provisions. Therefore, the Natural Gas Supply Act provides for market opening of 30% on 10 August 2000, increasing to 38% in 2003 and 43% by 2008. This means that currently, consumers using a minimum of 35 million cubic metres (instead of 25 mcm) per year are free to choose their suppliers. The 35 mcm threshold also applies for CHP plants. All electricity generating plants and the largest of the small-scale CHP plants and industrial enterprises have or will gain market access. Regional and local gas distribution companies will not be granted market access[15], as this would mean that publicly-owned companies would enter into direct competition with each other. The Danish government believes that this is inappropriate because of the large public investments and the considerable state subsidies that the sector has received.

There is a further derogation in the Gas Directive that allows denial of grid access under certain circumstances. The introduction of competition in gas can lead to the loss of market share for incumbent suppliers. But gas supply companies have often purchased large volumes of gas under "take-or-pay" contracts – i.e. long-term contracts under which buyers guarantee to pay for a large proportion of the contract volume even if they cannot sell the gas. Since competition is expected to lead to falling gas prices, this could give rise to serious financial difficulties for gas companies having entered into take-or-pay obligations at higher prices.

If a natural gas company encounters serious economic and financial difficulties because of its take-or-pay commitments, the Gas Directive permits access to the network be refused temporarily as a last resort, thereby protecting the market of a supplier. The gas company in question must send an application containing all relevant information to the government or the regulatory agency, which must notify the European Commission. The commission can amend or withdraw the temporary restriction of access. The Danish government believes that the "balanced" market opening will suffice to resolve the problem of the long-term take-or-pay agreements that the state-owned company DONG has vis-à-vis DUC and others, but reserves the right to use this instrument and is developing detailed procedures for this case.

Under the Natural Gas Supply Act of July 2000, a licensing system was introduced. This system introduces licences for four different activities in the gas business: transportation,

15. The Gas Directive provides that member countries can decide themselves whether gas distribution companies are among the eligible consumers or not. If they are not made eligible, they still have to be allowed to shop for gas in the competitive market to the extent that they themselves have eligible customers that they might lose.

distribution, storage and supply to ultimate consumers without access to competition (captive consumers). All other activities are free. DONG and the regional companies will be granted licences for the grid services and supply that they provide at present.

The law provided for negotiated access to the transmission network, including upstream pipelines, and regulated access to the distribution network. Access to the high-pressure transportation grid was to occur under published commercial conditions set by the pipeline owner on the basis of objective and non-discriminatory criteria. A regulatory agency (Energy Regulatory Authority, *Energitilsynet*)[16] was established to monitor access to the transportation grid, sanction abuses and settle disputes. The regulator's task is to supervise and regulate the parts of the natural gas industry not exposed to competition, ensure fair and non-discriminatory conditions for consumers, and prevent cross-subsidisation between companies. Eligible consumers have the possibility to appeal to the Energy Regulatory Authority if they are denied access, or if they find that the prices and conditions for access discriminate against them.

The regulator is an autonomous body within the Danish Competition Authority, appointed by the Minister of Environment and Energy and assisted by the Danish Energy Agency. In cases of disagreement, its decisions can be referred to an Energy Complaints Board (*Energiklagenævnet*). The Minister for Environment and Energy will lay down rules to ensure that disputes can be settled quickly.

Negotiated access to storage was required where such access is technically necessary for efficient access to the system. The principal commercial conditions for access to storage must be published. Access to gas distribution was to occur on the basis of regulated uniform ("postage stamp") pipeline tariffs. These distribution tariffs and end-user prices to captive customers were subject to price cap regulation by the regulator.

The trading and network functions of integrated gas companies had to be separated by "Chinese Walls". Internal accounts were to be unbundled and a documented system of administrative procedures put in place to ensure that commercially sensitive information was not abused.

The Natural Gas Supply Act contained a number of "public service" obligations. The most important ones provided that the transmission companies were responsible for security of supply, and that distributors must connect consumers to the gas grid and offer them consultancy services on energy conservation.

The adoption and entry into force of the Natural Gas Supply Act were preceded and followed by a number of agreements between political parties and between gas companies. As a result of several of these agreements, an amendment to the Natural Gas Supply Act was adopted by the Danish Parliament on 1 June 2001. According to this amendment, the regulated cap on retail prices is to be revoked, and the access conditions to the transmission pipelines are to be changed to regulated access to introduce greater transparency. Regulated access became effective as of 1 October 2001.

16. See also the section on Electricity Market Reform in Chapter 7.

Gas companies will now be obliged to form separate subsidiaries for network and trade activities from 1 January 2003. Consequently, DONG will have to create separate companies for the operation of the transmission network and storage of gas, the operation of the distribution network, and the supply of gas to the captive customers. The same will apply for the regional companies with regard to operation of the distribution network and supply of captive customers. The amended law now also contains a provision that allows simple insertion of further market opening if decided at the EU level.

The law contains no provisions for privatisation, and the various agreements among parties showed broad consensus that the gas infrastructure should remain in public ownership. Public ownership of the gas infrastructure was seen as a guarantee that security of supply, the environment and consumer protection will continue to be taken into account. However, the new government that took office in November 2001 decided that the Danish gas market will be opened to full retail competition by 2004, and that DONG will be privatised at some stage in the future.

Denmark has 14 gas users that consume more than 35 mcm and that have been eligible for competition since July 2001. These are listed in Table 7. All of them are DONG's customers. Numbers 1 to 6, all of them power generators, had long-term take-or-pay contracts with DONG that were to expire in 2020, but they have not been bound by them since the onset of competition. So far, none of them has switched suppliers.

Table 7
Natural Gas Customers Eligible for Competition, 1 August 2001

No.	*Company*	*Consumption (mcm)*
1	Fynsværket	223
2	Skærbækværket	174
3	Svanemølleværket	173
4	Avedøreværket	135
5	H. C. Ørstedværket	108
6	Herningværket	87
7	Hillerød K/V	87
8	Silkeborg K/V	83
9	Dansk Salt	58
10	Viborg K/V	58
11	Helsongør K/V	53
12	Cheminova Agro	46
13	Hjørring K/V	38
14	Hartmann Emballage	36
Total		**1 356**

Source: DONG.

Upstream Hydrocarbons

Denmark has the good fortune to have discovered its own oil and gas in the North Sea, and this has been very beneficial for the Danish economy. Since the mid-1980s, oil and gas production has gradually eroded the pre-existing deficit in the country's trade balance, which became a DKK 293 million surplus in 1995 and a DKK 5.3 billion surplus in 2000. The government's revenues have also benefited greatly from oil and gas taxation. It should be noted, though, that Denmark's resources are much too small to have any major effect on security of supply in the surrounding countries: Denmark's entire known gas reserves would only be sufficient to supply the UK gas market for little more than one year. But Denmark is a small country and its resources are large enough to make the country self-sufficient. In the light of these positive effects, the government's main objective for oil and gas exploration is to locate as many new reserves as possible and to ensure an extension of the current situation.

In recent years, there have been many successes in this area. Intense exploration and development activities have led to new discoveries, increased resource estimates, the coming on stream of new fields and high levels of production. The main factor behind these successes is certainly the high oil price, as this provides the necessary incentive to look for and produce oil and gas from the technically relatively difficult formations in the North Sea. The "open door" procedure of attributing hydrocarbons concessions is a flexible instrument which has certainly contributed to the success of Danish government policies regarding exploration.

On the other hand, upstream taxation appears somewhat piecemeal. The previous Danish government introduced the hydrocarbons tax with the objective of taxing away "windfall" profits and contributing to the generation of stable, predictable government revenues from upstream activities. "Windfall" taxation of this kind would not receive unanimous support in many countries. But even measured against its own objective, it does not appear to perform well. It was only paid in the early 1980s[17]. To reach its goal of ensuring a stable take, the government sought other means, such as the crude oil "pipeline fee". This "fee" is due even if the pipeline is not used – it is simply another upstream tax. Another way of generating government oil revenue is DONG's participation in all licences. The hydrocarbons tax may have skewed investment, probably towards excessive investment. The government is aware of this and work has begun to review the tax. This work should be continued. Its ultimate objective should be to establish a resource taxation system that is both simple and effective.

17. This may be due to the fact that the tax was designed on the basis of assumptions that did not materialise. When the tax was introduced in 1982, the interest rate was close to 20%, the inflation rate nearly 10% and significant further oil price increases were expected. Instead, the oil price fell and interest and inflation rates have been significantly lower.

Natural Gas

The Danish gas industry has had to go through major change to adapt to the new requirements of openness and competition. The industry was not built up according to market principles, but rather induced by the government's desire to replace coal and oil (hence the name "natural gas project"). Owing to the rush as much as to Danish traditions, this led to the establishment of deeply indebted non-profit distribution companies and large tax subsidies to enable the gas companies to pay back their loans. Under usual commercial conditions, capital for such a major project would have been raised by a combination of equity and loans. The initial investor would have been able to sell all or part of his stake in the gas companies. None of this was possible in Denmark. Had the development of a European market not occurred, the distribution companies would eventually have repaid the loans, supported by tax subsidies, although this would have taken a very long time. They might have been able to continue operating as non-profit companies in a restricted market afterwards.

But in a competitive regime, the companies would be regarded as insolvent in conventional commercial terms, and unable to compete or take advantage of changing market circumstances, because of their restricted capital base. The last IEA in-depth review predicted that these asset-rich but low-equity companies would be targets for take-overs. It suggested industry restructuring and ownership changes to allow the gas distributors to trade their way out of debt. In the event, both happened. The largest part of the problem was solved through the acquisition of NGS and NGSJ by DONG, and the agreement by which DONG obtained access to the largest customers of HGN and NGMN in return for taking over some of their debt. Even under these improved circumstances, HGN, NGMN and NGF will take until 2014 to pay off their heavy initial investment. In principle, these developments represent the first (major) steps towards a solution of the debt problem over time.

But this solution comes at a high cost. By acquiring the two distributors and the largest clients of two others, DONG has attained a degree of dominance in gas retailing that could be called a quasi-monopoly. To be sure, all statutory monopoly rights have been abolished. DONG no longer has any monopoly rights in gas transportation or trading and third party access to upstream pipelines is even permitted. But DONG is still the only player in those areas. It participates in all new upstream licences. Long-term contractual arrangements remain in place between the various players. With the situation so heavily skewed in favour of DONG, it is not surprising that so far no competitive entry into the Danish gas market has occurred.

Denmark has opted for the minimum amount of market opening allowed under EU legislation, but the recent amendments to the Natural Gas Supply Act show that the need to move to greater market opening is clearly understood and accepted. However, the government considered it a priority to bring the debt problem closer to a solution by letting DONG take care of a large part of it. It is understandable that the government had a large incentive to solve the problem this way, especially as it had few options. But the last remaining independent parts of the market should be encouraged to remain independent. DONG should be closely monitored by the

Competition Authority to prevent it from becoming a monopoly supplier along the entire gas chain. The government should ensure that the policy and regulatory environment does not deter new entrants. Rather, the government might find it useful to reflect on how the regulatory system could create incentives for such entry. The decision of the new government to introduce full retail competition and to privatise DONG will help promote competition and is therefore commended.

RECOMMENDATIONS

The Government of Denmark should:

- ☐ Review the hydrocarbon tax to eliminate distortions in upstream investment and to establish a clear and simple upstream taxation system.
- ☐ Facilitate effective competition in the Danish gas market by preventing DONG from becoming a monopoly supplier along the entire gas chain. The Competition Authority should monitor DONG's behaviour closely.
- ☐ Create incentives for new suppliers to enter the Danish market.

7

ELECTRICITY AND HEAT

INDUSTRY OVERVIEW

The Danish power industry was not developed on the basis of private, profit-oriented companies but in the form of municipal non-profit organisations (in towns) and consumer co-operatives (in the countryside). A process of concentration followed, especially in generation, but up to the early 1990s, there were still 12 power-generating companies owning 18 power plants and 119 local power distributors. Among the distributors, 53 were municipal enterprises, 54 were consumer co-operatives, ten were private foundations and only two were private-law commercial companies. As in the gas industry, the local electricity distributors are non-profit enterprises. Any cost reduction or profit they might achieve must be passed on to their owners in the form of reduced prices.

Both producers and distributors had clearly delimited supply areas, but the producers co-operated in two larger organisations, the association Elsam I/S (Det jysk-fynske elsamarbejde I/S) and the co-operative Elkraft A.m.b.A. Elsam was responsible for Denmark's western regions Jutland and Funen; Elkraft covered the parts east of the Great Belt including Zealand, the island Lolland and the smaller western islands. In general, the distribution companies within a region are owners of the regional power company. Elsam and Elkraft were owned by the regional power companies, as well as directly by some municipalities and power distributors. The transmission grid (> 30 kV) was owned by 28 power companies, including all 12 generators.

Elsam and Elkraft were responsible for planning, load dispatching, operation of the transmission grid and international connections. Denmark does not have a uniform, nationwide transmission grid. Elsam operated the transmission grid in Jutland and Funen, which is synchronously interconnected with the UCTE transmission grid system[18] via Germany and linked to Sweden and Norway via direct current (DC) sea cables. Elkraft covered Zealand and its nearby islands in the east, and is synchronously interconnected across the Sound (Øresund) with Sweden. Both Elsam and Elkraft were members of Nordel, the organisation for the interconnected Nordic countries comprising Denmark, Finland, Norway and Sweden[19]. The Danish

18. The Union for the Co-ordination of Transmission of Electricity (UCTE) co-ordinates the interests of transmission system operators in 20 European countries.Their common objective is to guarantee the security of operation of the interconnected power system.

19. Nordel is in charge of the operation of the Nordic grid. Its primary aim is the establishment of the necessary framework for an efficient and harmonised Nordic electricity market.

island of Bornholm is connected with Elkraft's system only via Sweden. There is no direct interconnection between the areas of Elsam and Elkraft. A possible future connection of the two areas across the Great Belt (*Store Bælt*) via a direct current (DC) sea cable has been under discussion since a parliamentary resolution passed in 1992, but no progress has been made to date.

Government oversight of the economic aspects of electricity supply was long seen as unnecessary. Public ownership and organisation as consumer co-operatives were assumed to guarantee efficient operation of the sector. For this reason, legislation relating to the power industry was adopted only in 1976. The Electricity Supply Act (Act No. 54 of 25 February 1976) gave the Minister of Economic Affairs and later the Energy and Environment Minister the power to license all operators of more than 25 MW of generating capacity and 100 kV grid capacity.

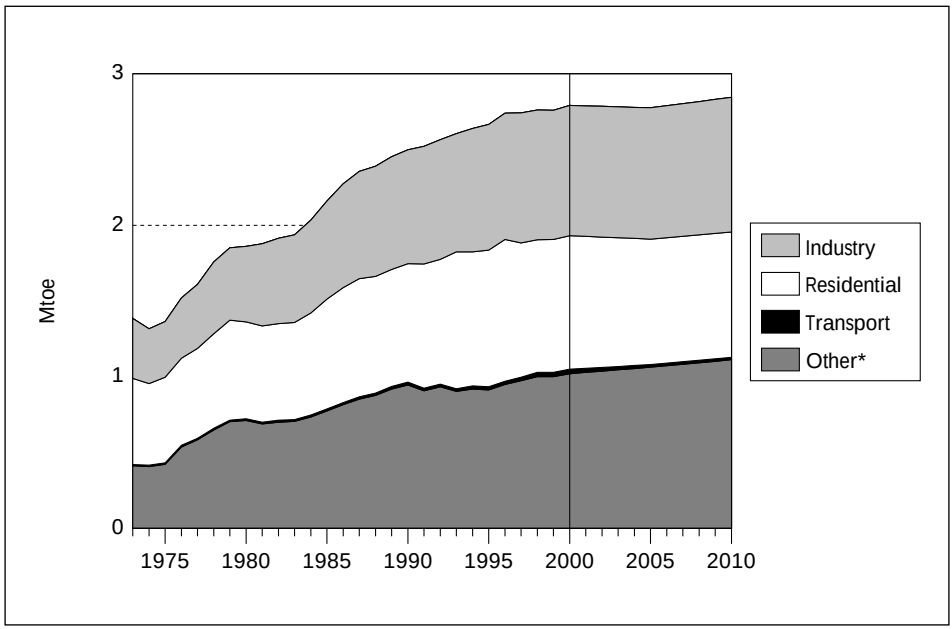
Vast powers to intervene in the power industry and the energy market at large were given to the minister and local governments under the Heat Supply Act (Act no. 258 of 8 June 1978). Under this law, the minister designed a national heat plan, which determined the priority energy to be used for space heating for individual parts of the country. The objective was to create and extend the market for heat from combined heat and power generation (CHP) in order to save primary energy. Since the early 1980s, all new power plants have been CHP plants; no electricity-only plant has been granted a licence. The municipalities participated in the elaboration of the heat plan and had far-reaching rights to enforce it. They could, for example, mandate the connection of new and existing buildings to the district heating network and collect monies for the construction of new heating plants. They could also prohibit the use of certain types of energy for heating purposes, e.g. electric heating. A ban against electric heating was effectively put in place in 1995.

The transition towards competition began in 1996 with amendments to the Electricity Supply Act of 1976. The definitive move towards competition was taken in 1999 with the adoption of the new Electricity Supply Act (Act No. 375 of 2 June 1999), as well as a number of amendments, political agreements and secondary legislation built upon this act. The 12 "centralised" power-generating companies that still existed in the early 1990s had merged to form eight companies by 1997. Following further mergers, only two large power-generating companies were left in 2001, Elsam A/S in western Denmark and Energi E2 in the east. The transmission grid in Jutland and Funen is owned and operated by the new transmission company Eltra. In Zealand and the interconnected islands, Elkraft System and Elkraft Transmission are responsible for system operation, and ownership and maintenance of the transmission grid, respectively. Regrouping and mergers have also reduced the number of distributors. At the end of 1999, there were 88 local distribution companies, of which 38 were municipal companies, 36 were co-operatives, 11 were private foundations, one was a partnership and one was a joint-stock company.

ELECTRICITY DEMAND

Figure 22 shows electricity demand in Denmark by sector. Electricity demand is expected to remain stable until 2005 and then begin rising again, although very slowly. The largest share of electricity is consumed by households (30%) and industry (30%), followed by the services sector (18%), public services (12%), agriculture (8%), traction (1%) and street lighting (1%).

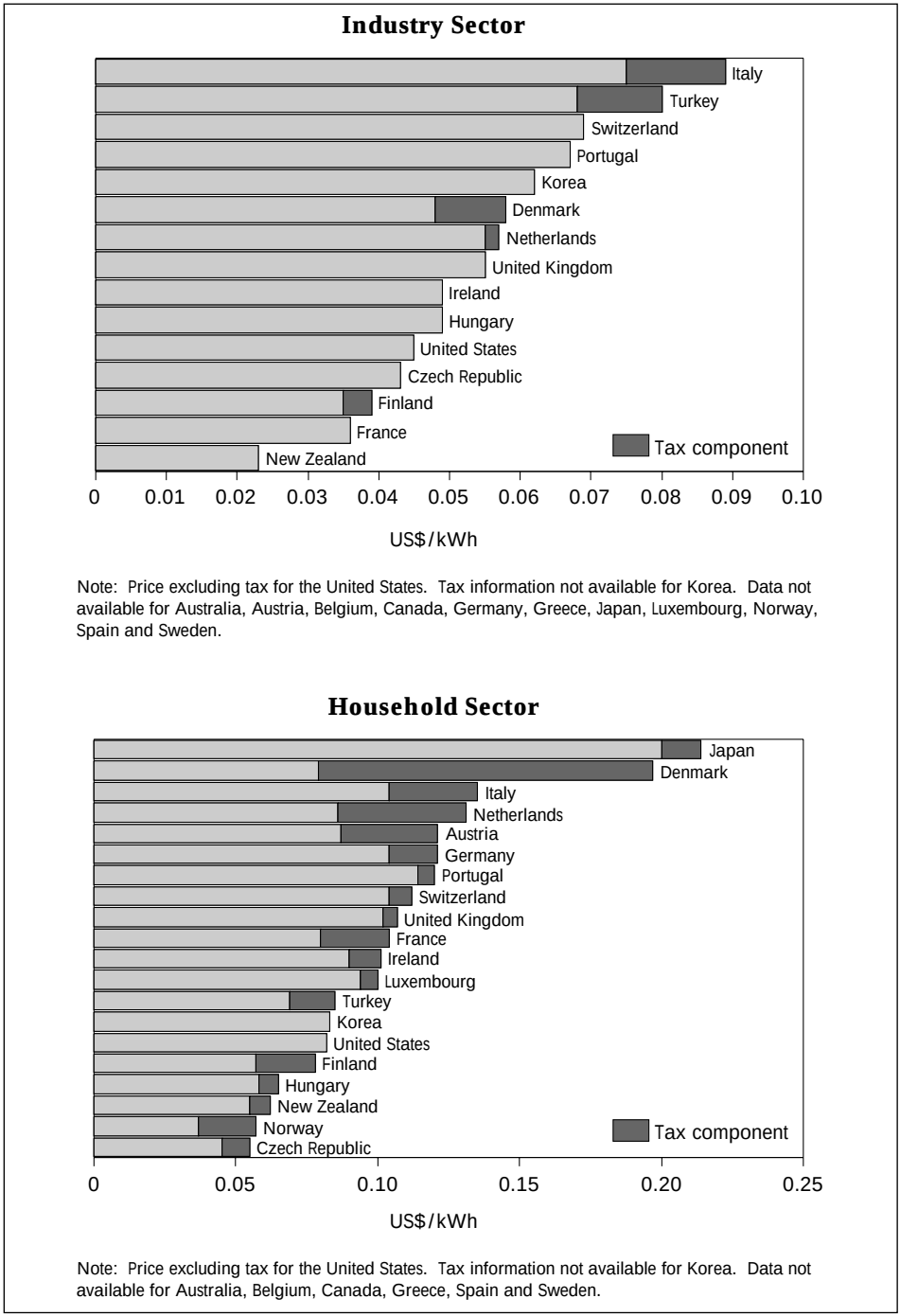
Figure 22
Electricity Consumption by Sector, 1973 to 2010



* Includes commercial, public service and agricultural sectors.
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2001, and country submission.

As can be seen from Figure 23, comparing Denmark and other IEA countries that submit price data, Danish electricity prices are mid-range for industry – although they would be towards the bottom end of the scale, were it not for the relatively significant tax component. However, residential energy prices are by far the highest among the selection, owing to taxation in excess of 60% of end-user prices.

Figure 23
Electricity Prices in IEA Countries, 2000



Note: Price excluding tax for the United States. Tax information not available for Korea. Data not available for Australia, Austria, Belgium, Canada, Germany, Greece, Japan, Luxembourg, Norway, Spain and Sweden.

Note: Price excluding tax for the United States. Tax information not available for Korea. Data not available for Australia, Belgium, Canada, Greece, Spain and Sweden.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2001.

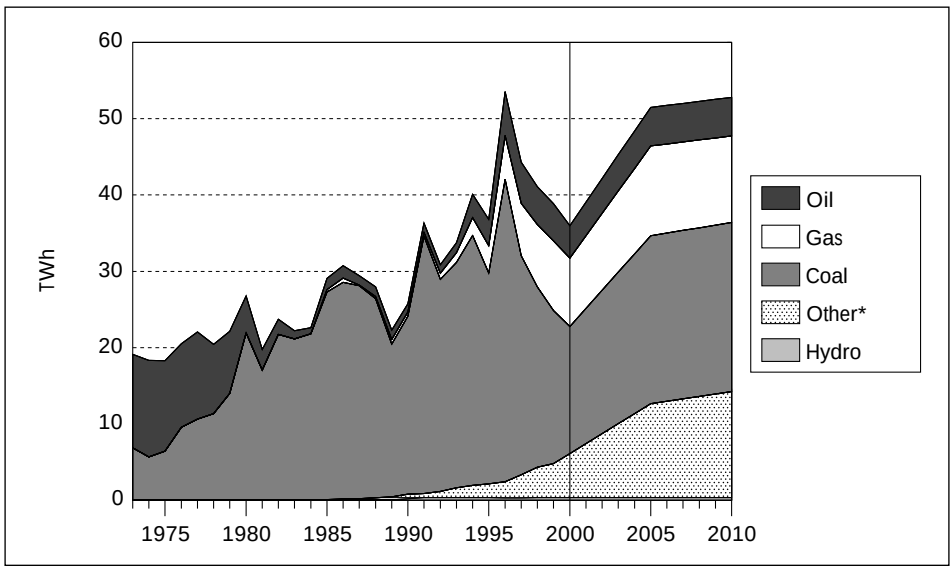
ELECTRICITY PRODUCTION

Overview

Denmark's electricity supply industry has gone through several drastic changes in its fuel choice in the last three decades. In 1973, the power industry was heavily dependent upon oil, which accounted for 64% of its output. By 1980, the high oil prices and the government's efforts had already led to substantial replacement of oil by coal and in 1990, Denmark had one of the highest coal shares in power generation in the IEA, with just over 90%. Coal has since been substituted by natural gas, again assisted by government policies under the "natural gas project". In 2000, total gross electricity production was 3.09 Mtoe or 35.97 TWh. Coal still had the lion's share with 46.3%, followed by natural gas (24.9%), oil (11.8%), wind (11.7%), and combustible renewables. The share of wind energy in the Danish system is the highest in the world, and, again, the result of strong support by the government. In accordance with a parliamentary decision adopted in 1985, Denmark has no nuclear power plant and does not intend to develop nuclear power.

As can be seen from Figure 24, Danish power generation is hugely variable in contrast to the country's relatively smooth demand growth. The reason for this is Denmark's close trade relationship with the Nordic countries. Denmark acts as "hydro-firming" system for the Nordic system: Nordel is strongly hydro-based and exports large amounts of electricity in wet years, but purchases fossil-generated electricity from Denmark during dry years.

Figure 24
Electricity Generation by Source, 1973 to 2010



* *Other* includes solar, tide, wave and ambient heat used in heat pumps.
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2000, and country submission.

According to Danish statistics, electricity production from the country's 19 "central" power stations amounted to 21.2 TWh or 62% of the total in 2000. Hundreds of local CHP plants contributed 8.5 TWh or 25%, wind 4.4 TWh or 13%, and hydropower the very small remainder of 0.029 TWh. Total installed capacity was 8 257 MW of "central" power plant capacity, 2 372 MW of local CHP, 2 418 MW of wind turbines and 10 MW of hydro.

District Heating and CHP

District heat is supplied by some 400 district heating companies, and today accounts for approximately 50% of Denmark's heat demand, compared to 30% in 1980. Most of the companies produce and supply the heat, but some purchase heat from one of the "central" power plants. The average connection rate in district heating areas is 82% and is still increasing. The district heating network supplies heat not only to large consumers, apartment blocks and institutions but also to a large extent to modern single family houses. Danish district heating companies are owned either by the municipalities, particularly in the major cities, or by local consumer co-operatives or foundations. In 1996 average distribution losses were 20%.

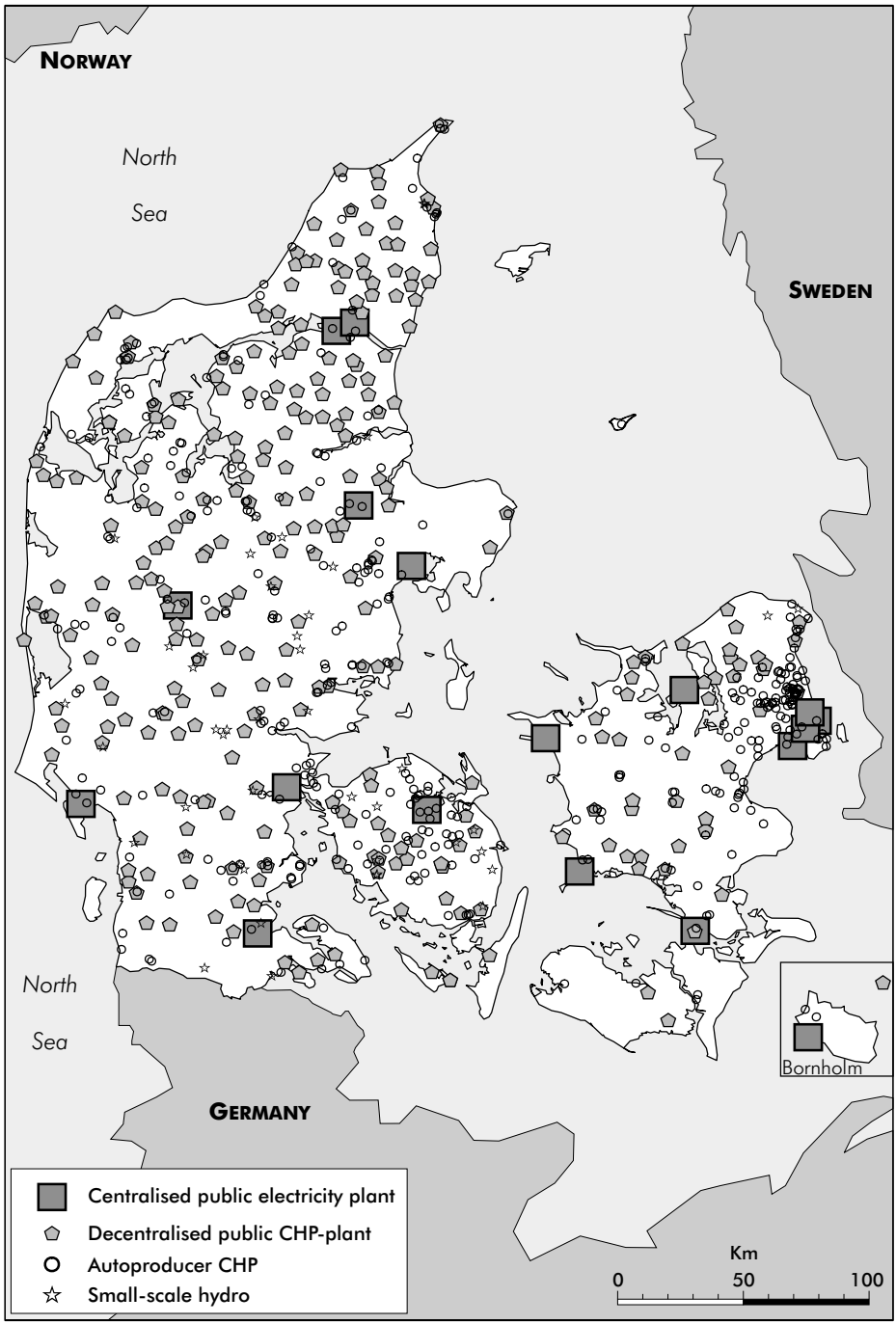
In 1980, 68% of district heat production was from oil, 18% was from coal and 14% was from renewables. Natural gas was phased in from the beginning of domestic gas production in 1984, and coal began to substitute for oil. In 1999, 35% of district heat production was from renewables, 28% from gas, 30% from coal and 7% from oil.

In 1999, almost 80% of all district heat was produced from CHP plants, up from just under 40% in 1980. Almost 50% of electricity generation was from CHP in 1999, compared to just under 20% in 1980. Twelve of the 14 largest power stations in Denmark deliver all or part of their surplus heat to a district heating network. Nearly all large-scale power plants are located close to major cities. This and the fact that 80% of the population lives in urban areas allowed the combined development of district heating and CHP. The conditions for industrial CHP were less favourable as Danish industry is dominated by small and medium-sized companies with relatively low energy demand.

The first steps in the development of CHP were taken in Copenhagen at the beginning of the twentieth century. In 1904 the first CHP plant was commissioned, supplying heat and electricity to a hospital. By the mid-1930s the Copenhagen district heating network was well established, even though heating was to a large extent still provided by coal-fired boilers or small individual coal-fired burners. The first plant specifically designed for CHP was commissioned in 1934. The heat planning process, initiated in 1979, aimed to increase the share of co-generation in the district heating supply system and to promote natural gas. Through the heat plan, the cities were divided into areas suitable for district heating and areas more suited for individual supply of natural gas. The heat plan shielded district heating from inter-fuel competition from natural gas and electric heating.

Figure 25

CHP Plants, District Heating Plants and Industrial Autoproducers in Denmark, 2000



Source: Danish Energy Agency.

Today, ten major cities have city-wide district heating systems where almost all of the heat (95 to 98%) is produced in large coal-fired or gas-fired CHP plants and waste incineration plants, with a number of small oil-fired or gas-fired heat-only units for peak-load and emergency. Since the early 1980s, no new power plants have been commissioned unless provided with the ability to perform CHP and to supply heat to the district heating networks. This was motivated by environmental concerns and the wish to encourage energy efficiency. Construction of new electricity-generating capacity must be justified by the need for new heat production capacity.

In addition to the large-scale CHP and district heating units, a large number of small-scale CHP plants exist. In Denmark, "small-scale" CHP designates CHP plants outside the centrally supplied areas, i.e. the larger agglomerations. The largest small-scale CHP plant has an installed electric capacity of 99 MW. However, most of the plants range between capacities of 0.5 to 10 MW and supply heat to small communities and institutional buildings. Often the plants consist of more than one CHP unit. Small-scale CHP plants not connected to a district heating network rarely exceed an electric-capacity of 1 MW. Small-scale CHP plants are laid out to cover at least 90% of the local heat demand. The electricity generated is sold to the public grid. Power utilities are obliged to purchase the electricity from these plants. The main fuels used in small-scale CHP are natural gas and waste, and, to a lesser extent, biogas and other biomass.

Small-scale CHP received government support through a 1986 parliamentary decision, adopted by the power utilities, to establish 450 MW_e of small-scale CHP using indigenous fuels (natural gas, waste, biogas or biomass). The first phase of the programme covered 80 to 100 MW of demonstration plants; these were to experiment with a wide range of technologies and plant configurations. In connection with the presentation of the *Energy 2000* plan in 1990, a more ambitious programme for small-scale CHP was put forward. To accelerate the establishment of small-scale CHP, a state subsidy was introduced in 1992 for power production from waste incineration, natural gas and renewables used in small CHP plants. The subsidy originally amounted to 10 øre per kWh but has been reduced to 7 øre per kWh, except for plants smaller than 3 MW.

The development of small-scale CHP peaked in 1994-1995. About 80% of the installed capacity (< 25 MW) is based on natural gas boilers, 16.5% are gas turbines and 3.5% are biogas-fired boilers. Most of the installed gas boilers have an electric capacity in the range of 0.5 to 4 MW_e whereas gas turbine units typically range in capacity from 4 to 25 MW_e. There are more than 60 biogas-fuelled CHP plants, supplying heat to either the local district heating network or supplying a single farm. The electricity is fed into the national grid. The total installed electric capacity is now approximately 20 MW with only a few facilities larger than 1 MW.

The feed-in tariffs for local CHP equal the purchasing utility's own long-term marginal cost (avoided cost). Danish electricity feed-in tariffs are based on a three-tier tariff system, with tariffs reflecting electricity demand patterns (low, medium

and high tariff periods). The resulting heat price from small-scale CHP is very sensitive to variations in the gas price, but less sensitive to changes in interest rates and investment costs. As a result of the support measures, the capacity of local CHP was 3.4 times as high in 2000 as it was in 1993, whereas "central" power capacity remained stable[20].

Industrial CHP is used in industries with high demand for process heat, especially the petrochemical, wood and paper industries. The food industry and greenhouses can also use low-pressure steam or hot water from CHP. In 1990, Denmark had about 20 industrial CHP plants, mainly coal or oil-based boiler or steam turbine units. However, the penetration of industrial CHP in Denmark remained low before 1992, largely owing to the low energy intensity of the Danish industrial sector compared to industry in neighbouring countries.

In 1992, an industrial CHP programme was launched. Its objective was to realise the potential for industrial CHP, which was estimated at an additional 400 MW. Under the programme, investment subsidies were introduced for industrial energy efficiency measures, as was a bonus system for electricity production from gas and biomass in combined heat and power production.

Following the introduction of the first "green" tax package in 1991, industrial companies could obtain state grants of up to 30% of investment costs in energy efficiency, including CHP. This provision is still in force. In special cases, small and medium-sized enterprises can obtain 40% coverage of the investment of industrial CHP plants from the government. However, a time limit of six years has now been set for the subsidy to industrial plants.

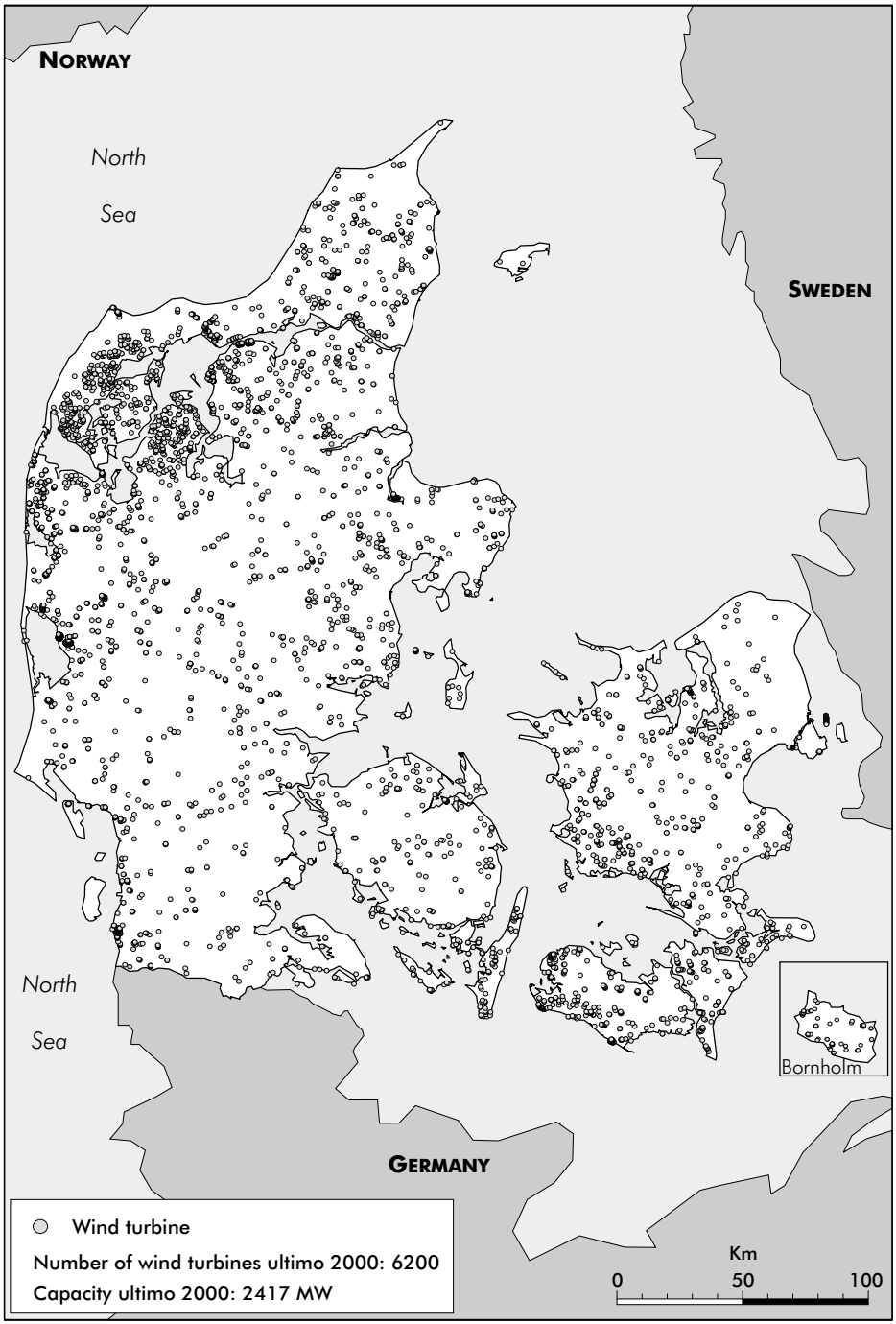
As a consequence of the support measures, the number of industrial auto-producers rose to more than 100 by 1997. The total potential for industrial CHP was reassessed in 1995 to be 750 MW. In 2000, installed capacity was more than 300 MW and electricity production from industrial CHP was about 8% of total power generation. Industrial CHP is almost exclusively based on natural gas, but a few biomass-fuelled plants have been commissioned.

The government plans to develop CHP further in future. The *Energy 21* programme of 1996 set a number of CHP-related targets for the long run (to 2030), which are still in force:

- The bulk of future heat and electricity consumption is to be covered by CHP.
- Individual gas-based heating systems are to be converted to CHP-based district heating.

20. Taking into account retirement of old plants and the start-up of approximately 1 340 MW of new capacity to replace them between 1997 and 2001, including the 540 MW Avedøre-2 plant in 2001.

Figure 26
Wind Turbines in Denmark, 2000



Source: Danish Energy Agency.

- Industrial CHP and mini-CHP are to be developed to a total capacity of 1 400 MW or approximately 10% of total public electricity-generating capacity in 2000.

- Coal use in power plants is to be phased out.

- Electricity from renewable energy sources, excluding large hydro and electricity from waste, is to account for 20% of power generation by 2003 and 79% by 2030.

Wind Power

Denmark has about 5 700 individual wind turbines installed on its territory. With 12.6% of total gross power generation, Denmark has the highest wind share of any country. Denmark alone accounts for half the world's wind power generation, and Danish wind energy technology is exported to some 40 countries, including Germany, Spain, the United States, Italy and Sweden.

Unlike in other countries, e.g. in California, Danish wind turbines are not in large clusters or wind farms, but are often scattered individually across the landscape. More than 80% of the turbines are owned by individual farmers or wind energy co-operatives. Some 150 000 Danish families own wind turbines or shares in wind co-operatives. The development of wind capacity was particularly rapid between 1993 and 2000, when installed wind turbine capacity quintupled to 2 417 MW. This development is the result of vigorous government support. Figure 26 shows the location of wind turbines in Denmark. The government's objectives and support measures are discussed in detail in Chapter 5.

ELECTRCITY MARKET REFORM

As energy market operation and environmental objectives are very closely intertwined, electricity market reform in Denmark necessarily relates to both areas. In fact, the complete set of legislative changes comprises five new acts, adopted by the Danish Parliament on 28 May 1999. The most important provisions of these acts will be discussed in the three following sections. The five acts are:

- The Electricity Supply Act (Act No. 375).

- The Act on CO_2 Quotas for Electricity Production (Act No. 376).

- The Act to Amend the Act on Subsidies for Electricity Production (Act No. 377).

- The Act to Amend the Act on the Utilisation of Renewable Energy Sources (Act No. 378).

- The Bill to Amend the Heat Supply Act (Bill No. 379).

Reform Process

Reform of the Electricity Supply Act

In Denmark, the transition towards a more market-based approach was first initiated by the adoption of an amendment to the former Electricity Supply Act by the Parliament in May 1996. The purpose of the amendment was to introduce competition in Denmark while ensuring that the electricity industry would fulfil the obligations of the Danish government, in particular those relating to protection of the environment. The amendment entered into force on 1 January 1998. The main parts of the EU Electricity Directive were included in the Electricity Supply Act through this change. On 11 February 1999, the Ministry of Environment and Energy issued a decree to ensure that all electricity-generating companies could negotiate network access to purchase or sell electricity. This decree entered into force on 19 February 1999, and with these two actions, the Danish power market was governed by legislation technically compatible with the EU directive.

However, the electricity supply companies and the government saw a need to further adapt the Danish power industry, and therefore a new Electricity Supply Act was adopted (Act No. 375 of 2 June 1999) that entered into force on 30 December 1999. This act reflects an agreement reached on 3 March 1999 between the Danish government and the large majority of the political parties represented in the Danish Parliament concerning the future regulation of the electricity sector. An addendum to this agreement on the conditions for introducing competition in the electricity sector was concluded between the political parties on 17 November 1999. The Electricity Supply Act was amended accordingly by Parliament on 17 December 1999 (Act No. 1100 of 29 December 1999). Most of this legislation has been approved by the EU Commission; approval of the final elements was to be given in spring 2002.

Under these various pieces of legislation and agreements, distribution companies and final consumers with a site-specific annual electricity consumption above 100 GWh per consumption site have been eligible for competition since 1 January 1998. The market share of the final 100 GWh consumers equalled about 5% of the total electricity consumption in Denmark at the time. By including distributors with annual sales above 100 GWh, about 90% of the market was opened to competition, although not at retail level. The eligibility thresholds are being reduced gradually. Since 1 April 2000, final customers consuming 10 GWh or more per year have been eligible. On 1 January 2001 the threshold was lowered to 1 GWh. On 1 January 2003, all final consumers will become eligible. Hence, the market opening in Denmark goes beyond the requirements of the EU directive.

The Electricity Supply Act provides that electricity generation, ownership of the transmission grid, operation of the transmission grid, distribution and supply must all be organised in separate legal entities. Activities not related to electricity may only be carried out via independent companies organised as limited liability companies, and are thus unbundled. Municipal supply companies need not create separate companies for power generation through waste incineration, nor for grid activities. But if all activities are undertaken in one company, it must have unbundled accounts.

The Electricity Supply Act allows the minister responsible for energy to derogate from the obligation to install separate legal entities. The minister can:

- Allow joint ownership and operation of the transmission grid. Unbundling of the company's accounts is still required.

- Allow joint ownership of the transmission grid and the distribution network, provided the company in question is not involved in the operation of the transmission grid. Unbundling of the company's accounts is required.

The amendment to the Electricity Supply Act (Act No. 1100 of 29 December 1999) entitles the minister, before unbundling is undertaken, to permit appreciation of the value of the electricity grid compared to the present book value. The reason for this is that the market value is considered to be much higher than the book value. The low book value is due to the provisions in the former Electricity Supply Act, which allowed for advance depreciation of up to 75% of the grid investment. The appreciation allows the grid companies to raise loans with security in the grid, and then inject the capital in the generating companies in order to give them a financially sound start. This capital injection was considered necessary due to the weak economic performance of the production companies. The ultimate cause of this weak performance was the non-profit obligation of the former Electricity Supply Act. The Agreement of 17 November 1999 between the government and the parties made this option conditional on merger of Denmark's eight generating companies into two companies, one in the western part of Denmark and one in the eastern part.

An independent regulator, the Energy Regulatory Authority (*Energitilsynet*) was established to replace the former Electricity Price Committee (*Elprisudvalget*). The authority regulates network tariffs, as well as end-user prices in the non-competitive segment of the market. The Energy Regulatory Authority is appointed by the minister responsible for energy. The members must be independent of the energy sector and must represent expertise in the fields of law, economics, technology, environment, business and consumer interests. The Danish Competition Authority and the Danish Energy Agency give secretarial support to the Energy Regulatory Authority. Market participants can appeal against the regulatory authority's decisions to the Energy Complaints Board, which is also the instance of appeal for decisions taken by the minister.

The Energy Regulatory Authority has seven members, all appointed by the minister responsible for energy. The natural gas and heat supply acts provide the legal bases for the regulator. The regulator can initiate investigations, as can consumers, companies and public authorities. Its decisions can be taken to the courts, including the Danish High Court.

The main regulatory instruments of the Energy Regulatory Authority are benchmarking of the individual companies against each other, demands to reduce cost, and rate-of-return regulation. The regulator controls certain cost components of the network companies according to efficiency requirements and an allowed rate of return on capital is applied. Taken together with an estimate of the company's transmission volumes, this yields a maximum allowable income for the regulated

companies. This revenue cap is published at the beginning of the year during which it applies. In 2000, Denmark's transmission companies had a revenue cap of DKK 1 405 million, using a 7% rate of return. The distribution companies were allowed to earn DKK 3 900 million, also with a 7% rate of return.

Reform of the Heat Supply Act

The government also intends to amend the Heat Supply Act. Competition will not be introduced to the heat supply sector, but the goal of the amendment is to ensure the continued development of an economic, efficient and environmentally sustainable heat sector with a high degree of quality and security of supply

Competition is excluded from the heat market because the infrastructure in the public heat supply plants does not constitute a physically connected grid. Also, local authorities in Denmark have already planned and invested in specific supply systems on the basis of overall environmental and economic considerations. Thus the present non-profit principle is retained, while allowing public heat supply plants to include necessary costs in their prices.

The new element is that the district heating sector will be regulated using benchmarking as in the electricity and natural gas sectors. Through this procedure, a revenue cap will be set for each heat plant. If a plant can keep its costs below the cap, it will make a profit. The profit may be set aside or paid back to consumers. An individual price ceiling for heat supplies will be established for waste-fired district heating and CHP plants to avoid transferral of the costs of waste disposal to heat consumers. To retain the non-commercial ownership of the district heating grid, consumers will have a pre-emptive right to purchase the district heating grid if it is not already consumer-owned. Similarly, the local authorities will receive a pre-emptive purchase right to the consumer-owned grid.

The district heating networks that are not locally owned by the consumers or local authorities are to be unbundled into separate companies. Moreover, the consumers and/or the local authorities are to have a controlling interest in the heat network company. If a supply plant owned by a local authority is sold, any profit is to be reimbursed back to the consumers or deducted from the general state subsidy to the local authority.

Reform of Government Intervention

As the more competitive operation of the electricity supply industry will gradually eliminate the scope for command-and-control intervention, the Danish government has adapted its environmental legislation concerning the power industry. Following are the most important government interventions in the liberalised power industry.

CO_2 quota system. CO_2 emissions from electricity generation are regulated through a CO_2 quota system (tradable emission permits)[21]. Existing electricity producers

21. For more detail, see Chapter 4.

receive permits in proportion to their historical emissions, but new entrants will obtain permits at no cost. The CO_2 Quota Act came into force on 1 January 2001 and will be in force provisionally until 2003. The political parties have begun negotiations on the quotas to apply after 2003. The new government has announced its intention to extend the CO_2 quota system beyond 2003. The act was approved by the EU Commission in April 2000. No trading in Danish quotas has yet taken place, although enquiries have been made.

CHP, district heating and renewables. The Electricity Supply Act itself contains obligations concerning combined heat and power/district heating and renewables. These obligations have been approved by the European Commission. They are:

- An obligation for electricity enterprises to purchase the electricity from small-scale combined heat and power plants and renewable-generated electricity at fixed prices. The final consumers are subsequently obliged to purchase their proportional part of this electricity, thus covering the costs for the electricity companies.

- An obligation to purchase electricity from other CHP plants supplying district heat, to the extent that the electricity cannot be sold at cost-covering prices. As above, final consumers are subsequently obliged to purchase their proportional part of this electricity.

- An obligation for all consumers to buy renewable ("green") energy certificates[22] as a way of giving financial support to producers of electricity from renewable energy sources. It has been decided to postpone this system until 2002. Until then, the current system continues, as set out in the first obligation above.

Biomass. On the basis of an agreement dating back to 22 March 2000, biomass is to be used as input fuel at several large power plants. This includes supplementary firing with straw at the Studstrup plant, pure straw-firing at the Amager plant and firing with wood chips at the Avedøre and Herning plants. In addition to this, a final decision is to be taken before the end of 2004 on burning a further 150 000 tonnes of straw annually. The government has decided that biomass should also fall under the new system of "green" certificates.

Market Outcomes Following the Reforms

Generation

The introduction of competition has had a strong impact on the generating side of the Danish power industry. Whereas in 1998, Denmark had eight major power generators, only two were left in 2001, Elsam A/S in the western part of Denmark and Energi E2 east of the Great Belt.

22. See Chapter 5 for a discussion of the certificates system for renewables.

Among the various agreements that formed part of the deregulation process in Denmark, two agreements had particular importance for the industry's structure. These two were the agreement of 28 October 1999 between the government and the power utilities and the agreement adopted on 17 November 1999 by the political parties as an amendment to the new Electricity Supply Act. Both agreements were concluded with the intention of allowing power utilities to restructure to the extent necessary and prepare for competition. On the basis of these agreements, the six power utilities in the western part of Denmark commenced negotiations to form one company. The new, merged company Elsam A/S was formed on 22 June 2000 with retrospective application as from 1 January 2000. All values and obligations of the merged firms were transferred to the new company on that occasion. The agreement between the government and the power utilities runs for four years until the end of 2003 when Elsam A/S will operate under ordinary market conditions. The share capital of Elsam A/S is DKK 2.0 billion. Elsam's shares were distributed among the electricity distributors that owned Elsam's predecessor companies in proportion to the value of the firms before the merger.

Elsam is currently undergoing a restructuring process, and is reviewing its position on the Danish power market. As part of this process, Elsam has decided to discontinue its business of selling electricity to final customers in the western part of Denmark. Elsam's end-customer contracts were transferred to Helia A/S, at that point owned by Elsam and the Swedish company Öresundskraft AB. Elsam has meanwhile sold its stake in Helia. The company is now concentrating its efforts on expanding its trade in electricity on the wholesale market. Elsam's new customers are trading companies or other players in the market selling to end customers.

Elsam owns and operates 3 491 MW of "central" power plant capacity and has 166 MW of wind capacity and 267 MW of local units in addition. Once established, Elsam found that it had excess generation. This is brought about by the continued expansion of renewable energy facilities. It results in an elevated need to export electricity, in particular during winter nights, when CHP plants run to capacity owing to the high heat demand, but when electricity demand is comparatively low. According to Elsam's estimates, the excess totals about 2.5 TWh per year. This non-controllable overproduction is sold on the wholesale power market at a price far below the price Elsam pays for production. Elsam is trying to identify solutions to the problem so that the electricity can find a domestic use, for instance to produce heat.

The other newly formed electricity-generating company is Energi E2. Energi E2 was formed from a merger of the two pre-existing power utilities in Zealand and Lolland in 1999. The company owns and operates 4 100 MW of capacity in Denmark and owns 200 MW of hydropower in Sweden. Like Elsam, Energi E2 is owned by the municipalities and distribution companies that owned its predecessors.

Transmission and Trade

Denmark has 166 750 km of high-voltage lines, of which 6 050 km are 400 to 132 kV. As noted above, the Danish transmission system is operated by two separate grid companies, Eltra and Elkraft Transmission. They were formed as a consequence

of the Electricity Supply Act (Act No. 486) of 1 January 1998 and the EU Electricity Directive. Both Eltra and Elkraft benefit from a natural monopoly position as owners and operators of public infrastructure facilities, and have been granted long-term concessions issued by the Danish Minister for Environment and Energy under the Danish Electricity Supply Act of 31 May 1999. Their systems are not directly interconnected. But since both are connected to the Nordic market, indirect power exchanges are possible. A cable connecting both Danish systems has been under discussion for a long time, but no firm plans exist to construct it.

Eltra is the owner and operator of the high-voltage transmission grid and the transmission system operator in the western Danish electricity system. Eltra is jointly owned by 48 western Danish grid companies which, in turn, are owned by local authorities or consumer co-operatives in Jutland and on Funen. The company was founded on 13 November 1997. On 1 January 1998, Eltra took over I/S Elsam's transmission networks and its activities and responsibilities regarding the network. On 1 January 2000, Eltra became a limited liability co-operative with the previous partners as members.

Eltra plans, engineers, constructs and maintains the primary (400 kV) high-voltage network that forms the backbone of the system. Eltra is also responsible for the overall security of supply in Jutland and on Funen. Eltra bears the responsibility for developing environmentally benign electricity generation and incorporating it into the system. Eltra is currently undertaking an effort to reconstruct and restructure the Jutland-Funen transmission network as a whole. One reason for this is that there is an internal transmission bottleneck in Jutland. This bottleneck has existed for years but must be removed owing to the greater amount of power trade from competition.

The ever-increasing local electricity production from wind turbines and local combined heat and power units also places special requirements on the strength of the network. The CHP plants are not subject to central load dispatching and are run according to their heat load, not electricity requirements. In winter, this means that all CHP plants must be dispatched first, regardless of their location on the grid – or their price that is fixed at above-market rates. Wind is an intermittent resource but also enjoys this "priority"[23] dispatch. End-users are obliged to buy "priority" production from their local grid company. Eltra has only one generator on its grid that is not prioritised and can be dispatched according to its price bids. The portion of "priority" electricity generation in Jutland amounts to 40%. Therefore, it is often necessary to transport large amounts of electricity over long distances.

As a consequence, Eltra has had to reinforce the 400 kV network in the middle and eastern parts of Jutland and on Funen. Major progress was made in 2000, when the construction of a new 400 kV connection between the power station Vendsysselværket (Aalborg) and Trige (Aarhus) was approved, but some further lines must still be constructed before the Eltra service area is sufficiently secured.

23. The priority system requires that renewables and CHP must be dispatched first, regardless of their price. In other words, when the wind blows and the wind turbines generate electricity, the network utility has to purchase this electricity even if it has to take cheaper fossil-fired power plants off the grid as a consequence.

The oldest part of the network must be also be renovated and upgraded to maintain and/or increase transmission capacity.

Eltra operates the synchronous interconnection of the Danish system with Germany (1 200 MW maximum capacity) and the DC sea cables to Sweden (Konti-Skan, 600 MW) and Norway (Skagerrak cable, 1 000 MW). When the market was first opened for competition, the Skagerrak cable to Norway and the interconnection to Germany were largely tied up by old supply contracts and not available for competitive spot trading. Imports from NordPool were limited by grid congestion.

Meanwhile, the entire transmission capacity to Sweden and Norway was made available for spot trading with NordPool. As noted above, power exchanges with the Nordic system depend to a large degree upon the relative prices of hydro-based generation versus fossil generation that are, in turn, heavily influenced by rainfall in Norway and Sweden. Therefore, the trade volumes are highly variable. In 2000, the Eltra region imported 4.488 TWh (net) from Norway and 0.365 TWh from Sweden, and exported 5.152 TWh (net) to Germany. The transmission capacity across the Danish-German border is administered in co-operation with the German grid company E.ON Netz in annual, monthly and daily auctions of capacity. Registered market players can make reservations for trade across the border.

Elkraft Transmission is the owner and operator of the high-voltage (400 kV) transmission grid in the eastern part of Denmark, including the island of Bornholm. It owns and operates the interconnections of that area with Germany and Sweden. Elkraft System is the system operator. Both companies were created on 1 January 2000 out of Elkraft A.m.b.A. Elkraft Transmission and Elkraft System are owned by ten eastern Danish grid companies, which, in turn, are also majority-owned by local authorities or consumer co-operatives. The owners are Nesanet A/S, the grid subsidiary of Denmark's largest distribution and supply company, Copenhagen Energy; SEAS Transmission A/S; NVE Net A/S; Frederiksberg Elnet A/S; Hillerød Elforsyning; Helsingør Elforsyning; Roskilde Netvirksomhed; Nykøbing Sjællands El-Net and SKE-Net A/S. In principle, Elkraft System functions independently from commercial interests, including its owners and Elkraft Transmission. But its organisation is shared with Elkraft Transmission.

Elkraft System is responsible for both short-term and long-term security of supply in the main electricity supply system and for system development within the framework set by the government. Elkraft also has a significant share of "priority" production from wind turbines and other renewables, as well as small-scale CHP plants. For the winter season 2001/02, a share of 35% to 37% "priority" production was expected on Elkraft System's grid.

Elkraft's interconnection with Sweden is located in Helsingør and consists of four AC links – two 400 kV cable connections (established in 1973 and 1985 respectively) and two 132 kV cable connections (established during the period 1951 to 1964) with a total capacity of some 1 900 MW. The link with Sweden also serves as a connection with the Nordic grid. Bornholm is linked to southern Sweden by a 60 kV cable with a transmission capacity of 60 MW. The link with Germany, Kontek,

is a 400 kV DC interconnection with a transmission capacity of 600 MW. The connection was established in 1995 in co-operation with VEAG of Germany. Elkraft Transmission owns the Danish AC/DC converter station at Køge and the DC cable from Denmark to the German coast. The Elkraft System area imported 1.382 TWh (net) from Sweden in 2000, and exported 0.444 TWh to Germany.

Thus, Denmark is relatively strongly interconnected with its neighbouring countries, with combined interconnector capacity about level with peak-load. However, trade is less than this favourable situation may suggest, largely because of bottlenecks inside Denmark (especially in Jutland) and in southern Sweden. Also, Sweden levies a border tariff of 2 øre per kWh. This is regarded as a real impediment to electricity trade with NordPool by Danish utilities, who have demanded its abolition. For this reason, most of the trade between the Eltra area and the Nordic market occurs through the Skagerrak line linking the western part of Denmark and Norway.

Distribution and Supply

The number of local distribution and supply companies in Denmark has been in slow decline for more than a decade. At the end of 1999, there were 88 distributors left. The concentration process, which is encouraged by the government because it increases the economic efficiency of the companies, is set to accelerate in the coming years.

NESA is the largest power distribution company in Denmark and also the only one organised as a joint stock company – although the majority stock is owned by the municipality of Gentofte. Other shareholders include the County of Copenhagen and Vattenfall AB. NESA's supply area includes northern Zealand, the municipalities in the Roskilde area and most of the municipalities of Greater Copenhagen. NESA's electricity grid supplies a total of around 533 000 connections, of which about 469 000 are residential units. The rest are business enterprises, shops, schools, etc.

Restructuring is taking place in electricity retailing. In 2000, 13 local distributors formed separate companies for electricity trading and supply, another 62 established seven joint supply companies, and only 13 did neither. NESA has announced an aggressive strategy to acquire smaller vendors throughout Denmark in an effort to become a national rather than a regional supplier. The ultimate objective for NESA is to have no fewer than one million customers, or twice the current number. At the same time, major suppliers in the neighbouring counties are preparing to gain market access. The Swedish utility Vattenfall, which is among the five largest power companies in Europe, has declared its intention to acquire 20% of the Danish market.

Demand

Table 8 shows the number of consumers who have or will become eligible for competition. Of those who were eligible in 2000, 86% actually changed their power supplier. This share is very high in comparison with most other IEA countries, where in the first years following the introduction of competition only a small minority switched.

Table 8
Eligible Electricity Consumers in Denmark

Date	*Eltra Supply Area*	*Elkraft Supply Area*	*Total*
1 January 1998	2	4	6
1 April 2000	130	76	206
1 January 2001	1 482	762	2 244
1 January 2003	1 600 000	1 400 000	3 000 000

Source: Dansk Energi.

CRITIQUE

The Danish power industry as it exists today has been shaped by relatively heavy government intervention for decades. Much of this intervention occurred with the aim of saving primary energy, promoting energy efficiency, enhancing security of supply and, above all, protecting the environment from emissions of a heavily fossil fuels-based power industry. Achieving the high degrees of energy conservation and environmental protection desired in Denmark required very significant alteration of market results, and very far-reaching intervention. Such intervention cannot occur without significant cost.

Altering market results, even at high cost, is perfectly legitimate if it is desired by the electorate of a democratic country, and if that electorate is well informed about the choices involved. It should also be free of adverse effects on international trade, or at least not put trading partners at a disadvantage. These conditions are met in Denmark.

Liberalisation of the Danish power industry was initiated by the European Union, but Denmark embraced the principles of liberalisation rapidly, and has gone beyond EU requirements in terms of market opening. This meant that a large adaptation effort had to be made. First, liberalisation required revision of some of the more command-and-control type measures that had so far been used. With the introduction of the CO_2 quota system and the planned move towards a renewables certificate system, the Danish government has accomplished a significant part of that work. The remaining dirigiste measures certainly affect the attractiveness of the Danish power industry to investors but do not constitute trade barriers *per se*.

Nevertheless, liberalisation has starkly exposed the cost of the past and present environmental policies. There is excess production of electricity. The excess production is from "priority" power plants that cannot be dispatched according to power market prices. The part of the market that is governed by price signals is 60% in western Denmark and about 63% to 65% in eastern Denmark. The excess production is either wind energy, which is intermittent, or it is combined heat and power, which is driven by the heat load, not the electricity spot market. Generators have a certain leverage to shift the production of their plants towards electricity, or

towards heat. But generally speaking, if the plant runs at full regime, it will produce much electricity and much heat simultaneously. Cold, windy winter nights, when wind generation and heat production are high but power demand is relatively low, lead to vast excess generation. The utilities must sell this generation at a very low price. In fact, in a market functioning in such situations, the price might have to become negative – the generator might have to pay somebody to get rid of the excess electricity. But Danish utilities have to buy this generation at the long-term marginal cost of a new power plant, with the corresponding effect on their profitability.

"Priority" production also results in a considerable amount of uncertainty for electricity producers, traders and consumers because of the complexity of the "priority" system. In fact, very large amounts of intermittent or non-dispatchable generation cause external costs, and these have to be factored into energy prices in the same manner as environmental externalities.

The current situation is not sustainable in the long run, and the government will have to find solutions to this problem. Greater trade in the Nordic market and with Germany might help, but it will not entirely solve the issue, particularly as further expansion of the wind and CHP capacity is planned. Technical solutions, such as turning the excess electricity into heat, are under consideration. The government might even have to consider giving up its ban on electrical heating. The government has set up a working group to propose sensible uses for this over-production. Rapid and effective solutions are needed if the planned environmental policies are to be implemented, while protecting Danish generators from bankruptcy. Also, the benefit that ultimate consumers will gain from power deregulation – notably lower prices – will be limited, as electricity prices are higher than they could be owing to the need to finance renewables and CHP, and taxes will have to remain high so as to limit electricity demand.

Like the Danish gas industry, the electricity supply industry bears the marks of its early organisation in the form of consumer co-operatives and small municipal utilities. These organisational forms may have been appropriate when electricity was new. But at the beginning of the third millennium, the power industry has become very large, and operates under a more or less competitive regime in most IEA countries – and in virtually all countries surrounding Denmark. Today, power companies must be able to draw on all options open to commercial companies, or risk collapse. The current ownership structure and the restrictive regulations appear to limit power companies' ability to make use of the business opportunities provided by liberalisation. These include asset sales and equity injections and the possibility to set aside profits for further investment. The ownership structure of electricity distribution and supply should be adapted to the new market environment. The amendment to the Electricity Supply Act shows that the government and the majority of the parties and market participants are aware of these issues. A gradual process of restructuring that will eventually eliminate part of the problem has been set in motion. Whether this is sufficient or whether bolder government action is needed remains to be seen.

Apart from reconciling electricity deregulation and a very high degree of environmental protection, the Danish electricity market has made significant progress. By opting for

legal unbundling rather than accounting unbundling in most cases, Denmark has gone beyond the requirements of the EU Electricity Directive. The existing interconnections with the surrounding countries are gradually being opened up for competitive trade, and wholesale power prices in Denmark show comparatively little variation from NordPool spot prices, except during needle peaks. The number of power generators, suppliers and transmission companies has decreased through mergers. Considering the large number of companies in a very small market, this probably entailed large cost savings. Most companies were far below their optimal size, especially in distribution and supply.

That said, it is important not to let this development go too far. There is a large degree of vertical integration through ownership ties going from municipalities to distributors to generators and the transmission companies, and there are now only two large generators left. While this was necessary to put the Danish power industry on a commercial footing, competition from abroad is vitally important. The government should work towards further opening of the interconnections and removal of the Swedish border tariff for electricity. The wholesale market needs continuing monitoring and evaluation by the authorities and the reduction of infrastructure bottlenecks within Denmark. According to the most recent information, the two transmission companies are already undertaking such work. There also should be a co-ordinated approach to the removal of bottlenecks in the Nordic transmission system.

RECOMMENDATIONS

The Government of Denmark should:

☐ Strive to increase competition by:
- Working towards further opening of Denmark's interconnection with other countries for competitive power trade, especially spot purchases.
- Encouraging the removal of internal bottlenecks in the transmission system and striving for a similar approach in Nordel.
- Encouraging more market-oriented behaviour among power companies, and especially among small distribution and supply companies.
- Encouraging the transformation of consumer co-operatives into commercial companies, and facilitating the privatisation of municipal utilities.

☐ Through the Competition Authority, monitor the electricity market and deal with abuses rapidly.

☐ Continue to adapt the environmental policies aimed at the power industry to the realities of competition.

8

ENERGY RESEARCH AND DEVELOPMENT

PRIORITIES, INSTITUTIONS AND FUNDING

The overall objective of the Danish Energy Research Programme (ERP) is to contribute to the realisation of Danish energy policy goals. These goals are laid down in the 1996 *Energy 21* programme and follow from Denmark's commitment to reduce its emissions of greenhouse gases. Priority areas of energy R&D were also laid down in the *Energy 21* programme. They still apply and include as major points:

- *Renewable energy technologies.* Special emphasis is given to wind energy and biomass, and in particular to the new areas of offshore wind turbines and combined heat and power production based on biomass.

- *Energy conservation and increased energy efficiency.* This includes both energy-efficient technologies and research on the interaction between behaviour, lifestyles and energy consumption.

- *Integrated technologies and systems.* The focus of this programme is to optimise energy systems with complex consumption and supply structures by using control technologies, methods of process optimisation, etc.

The priorities of publicly-funded R&D are decided by the Danish Energy Agency on the basis of advice from the Advisory Council of Energy Research (ACER). For each priority area, an advisory subcommittee is appointed to provide detailed input to DEA and ACER. These subcommittees take an active part in the evaluation of project proposals and make recommendations concerning their support to the DEA. Members of the subcommittees are persons from companies, research institutions and universities.

Funding for energy research activities is provided mainly by the ERP and the Danish Development Programme on Renewable Energy (DPRE). Publicly-funded research is carried out at the Risø National Laboratory, at the technical universities and technological institutes, and by private companies. Following liberalisation of the electricity market in 1999-2000, development of technology for electricity production and distribution is now financed in part by a fee on electricity sales under the Public Service Obligation (PSO) arrangement, in place of direct funding by the utilities. Although the funding of the ERP has remained static and is forecast to decline in 2002 to DKK 100 million, other project funding mechanisms are now available, including the Public Service Obligation (DKK 100 million), the electricity end use R&D requirement (DKK 20 million) and specific initiatives to support short-term projects in hydrogen, wave energy, photovoltaics and electrical insulation materials.

The various funding possibilities are evaluated on a regular basis. To mention one, the effects of ERP have been assessed in an evaluation of the overall programme.

Furthermore, questionnaires have been sent to ERP project leaders finalising projects in the years 1999 and 2000 to assess the utilisation of results. In some cases, evaluations of specific priority areas are carried out. An evaluation for oil and gas was carried out recently. An evaluation of the development programme for renewable energy was also completed recently, as was an evaluation of the hydrogen programme.

The budget for the hydrogen programme in 1997-2000 was DKK 20 million. An additional DKK 41.5 million has so far been allocated for 2001-2004. The programme has been dedicated to practically-oriented R&D and technology demonstration projects with some emphasis on the transportation sector. The programme focuses exclusively on hydrogen produced from renewable energy sources and on the integration of hydrogen technology in renewable energy systems. The evaluation of the hydrogen programme for the period 1997-2000 yielded the following results:

- The programme was found to be unique in its approach compared to other international hydrogen programmes because of its practical approach and its exclusive orientation towards utilisation of renewables.

- Nevertheless, practical results were found lacking for some projects owing to problems with delivery of the appropriate "practically-oriented" equipment.

- The programme stimulated Danish enterprises to get involved in the development of different components for hydrogen systems.

- More comprehensive information regarding the results of the programme and scenarios for possible future large-scale renewable energy systems/hydrogen energy systems were recommended to improve private-sector involvement in hydrogen technology.

- Full-scale demonstration projects were still expected to be expensive. The Danish programme was considered valuable in stimulating international technology co-operation in the development of hydrogen systems.

- The assessment of the development project part of the DPRE with focus on the period 1996-2000 identified a range of projects where good results had been achieved and found that the total DPRE budget was sufficient to ensure support for a large number of qualified projects. But it also stated a need to strengthen the co-ordination with other (including new) R&D programmes – i.e. the ERP and PSO programmes. According to the assessment, full integration of the ERP and the DPRE should maintain the unique characteristics of the DPRE.

The Energy Research Programme (ERP) finances R&D in energy priority areas. At present there are six priority areas: oil and gas; environment-friendly production of power and heat; wind energy; energy efficiency in buildings; energy efficiency in industrial processes; and social science projects.

Projects outside these priority areas may be funded if they are found to be of special importance. DPRE typically finances smaller development and demonstration projects concerning renewable energy. Priority areas are biomass, wind energy, solar heating, photovoltaics and heat pumps.

Additional funding has been channelled to specific priority areas in recent years. These include development and demonstration of hydrogen technology, integration of photovoltaics in buildings, wave energy, etc. Subsidies available for energy conservation initiatives in industry can also be used to fund development and demonstration projects in industry (called UD projects).

A small Public Service Obligation fee levied on electricity production is used to finance R&D in biomass and wind energy. Fuel cells, wave energy, and the integration of photovoltaics in buildings are also supported under the PSO scheme. These activities are R&D projects initiated and carried out by the transmission system operators responsible for the operation of the power transmission grid. The projects must involve technologies that aim at environmentally benign power production. To discourage free riding, the technology must not be commercially viable without such support. The companies are allowed to finance their costs by levying a fee on electricity consumption.

Private companies carry out R&D in a number of areas (e.g. oil and gas, fuel cells, superconductors, and wind energy) and also take an active part in the ERP. All research programmes and projects except those initiated by private companies and by transmission system operators are administrated and co-ordinated by the Danish Energy Agency. The transmission companies Eltra and Elkraft System administer the PSO-financed programmes. However, their priorities and actual project funding have to be approved by the DEA.

DETAILED ENERGY R&D ACTIVITIES

Energy Efficiency and Fuel Use

R&D in this category is supported by the ERP in the priority areas of energy efficiency in buildings, energy efficiency in industrial processes and "energy and society". Development and demonstration are supported under the scheme for subsidies to energy conservation initiatives in industry (UD projects). R&D is carried out at the public research institute for buildings (SBI), at the technological institutes and by private companies.

Fossil Fuels

R&D in this category is supported by the ERP under the priority area oil and gas. Furthermore, R&D is carried out by the Danish geological research institute GEUS and private oil companies. There is no research on coal, as Denmark has decided that for environmental reasons there will be no new coal-fired power plants.

Renewable Energy

R&D in this category is supported by the ERP under the priority areas of environmentally benign production of power and heat, and wind energy. These efforts are co-ordinated with the funding of activities under DPRE. This type of project is also subsidised by the PSO fee. In addition, DPRE supports demonstration of heat pumps. Further initiatives involve demonstration of wave energy, hydrogen projects and the integration of photovoltaics in buildings.

Nuclear Fission and Fusion

Various parliamentary decisions and pieces of legislation have established that nuclear fission will not be used for power production in Denmark. The government has recently decided to shut down the nuclear fission research facilities at Risø National Laboratory. However, Risø National Laboratory continues to participate in international collaboration on nuclear fusion in the context of the EU.

Other

R&D in fuel cells is subsidised under the ERP and PSO programmes whereas R&D in superconductors is subsidised only under the ERP. In future, research on electricity system technologies, distribution and grid interconnection may be subsidised under the ERP.

CRITIQUE

The ERP was reviewed in 1997 in the course of the IEA's last in-depth review, and again in 1998 by an international team brought together by the IEA. There has since been evident progress in implementing the findings and recommendations, in particular of the 1998 IEA review. The structure of the ERP has been revised. A more limited number of programme areas have been selected for future government support: six priority areas matching the key goals of Danish energy policy now receive funding. Administration of the ERP and DPRE programmes has been merged into a division for renewable energy and energy research within the Danish Energy Agency.

There is a well-defined co-ordination and allocation structure linking the Public Research Council of the Ministry of Environment and Energy with the Advisory Council of Energy Research (ACER) and six committees of professionals overseeing project review and funding. Membership from government, industry and research communities is balanced, and guidelines are in place to address conflicts of interest. Collaboration with industry has been strengthened with a view to concentrating on long-term development. A long-term strategy for future activities is under preparation. Despite this very positive development, further attention could be paid to:

- Completing a comprehensive energy research policy and strategy to focus research on priority areas and take full advantage of domestic and international programming.

- Road-mapping in areas of strategic energy importance and industrial development potential.

- Inter-agency co-ordination, co-financing and communication.

- Fully integrating the ERP and the Development Programme on Renewable Energy (DPRE).

- Enhancing the commercialisation of resulting technology, which should include more active engagement of the Ministry of Economic and Business Affairs.

- Applying more rigorous stage-gating (go/no go project tracking process) to individual projects.

- Implementing a results-based management system which measures and monitors outputs, outcomes and impacts of project investments.

- Avoiding duplication of commercial activities, notably in the wind industry.

Denmark has long had world-class technology in wind turbines, coal and biomass combustion, especially in CHP plants, and in district heating. Although the ERP funding is secured in principle, there are signs that the country's ability to maintain this position may decline in future as a result of changes in the energy market and in energy policy. For example, Denmark has decided not to build any new coal-fired power plants and hence not to spend money on coal R&D. As a consequence, Denmark's leading role in this area is likely to erode, and there will be no domestic technical capacity to re-power or retrofit coal plants as a contingency option.

In response, the Ministry of Information Technology and Research has launched an initiative to develop and finance centres of excellence linking education, research, industry and facilities and equipment renewal. This is to be encouraged, and direct representation of that ministry on ACER could develop positive synergies.

The oil and gas industries have well-funded in-house and collaborative programmes that are adequate to meet the needs for technological advances that are already built into forecasts of reserves and production. Government funding in the ERP and the Geological Survey (GEUS) could focus on developing independent information for policy and regulatory purposes. The Danish Natural Gas Technology Centre is well structured to address technology for end use of natural gas.

With electricity restructuring, there has been a decline in R&D investment by electricity producers, who now focus on near-term commercial and operational issues. The funds raised through the PSO can be used to carry out research on electricity production issues, such as the production of heat and electricity from

municipal wastes and biomass. Roles, responsibilities, identification of priorities, co-ordination and communication should be clarified and improved between the electricity system operators administering the PSO and the Danish Energy Agency. This applies similarly to the electricity end-use R&D requirement. Given the expected importance of biomass in Denmark's energy future, ACER could consider focusing on biomass gasification as a potentially cleaner, more flexible and efficient option for CHP.

Denmark's industrial sector is dominated by small and medium-sized enterprises with insufficient resources to develop energy-efficient, low-CO_2 technology while remaining competitive. The strengthened requirement for cost-sharing by industry and the ERP is already enhancing the probability of commercialisation. Nevertheless, a strategy to address this problem more comprehensively would be beneficial. Targeted consortia of companies, banks, universities, and government agencies may be one approach, focused initially on enabling technologies such as process integration with short-term paybacks to develop confidence and a positive track record.

Denmark is encouraged to continue its successful record of taking full advantage of international research programmes in the EU and collaboration through the IEA. The development of a co-ordinated national climate change research programme with strong linkages to the ERP and other Danish energy R&D funding mechanisms is also encouraged.

RECOMMENDATIONS

The Government of Denmark should:

- ☐ Complete a comprehensive energy research strategy covering the full spectrum of innovation, and domestic and international programming.

- ☐ Clarify responsibilities and improve the co-ordination between the Danish Energy Agency and the electricity system operators that administer the Public Service Obligation. This also applies to the electricity end-use R&D requirement.

A

ANNEX

ENERGY BALANCES AND KEY STATISTICAL DATA

Unit: Mtoe

SUPPLY

		1973	1990	1998	1999	2005	2010	2020
TOTAL PRODUCTION		**0.40**	**9.68**	**20.19**	**23.64**	**22.93**	**12.22**	**..**
Coal		–	–	–	–	–	–	..
Oil		0.07	5.81	11.66	14.86	11.70	5.49	..
Gas		–	2.74	6.76	6.94	8.58	3.80	..
Comb. Renewables & Wastes[1]		0.33	1.08	1.51	1.58	2.07	2.15	..
Nuclear		–	–	–	–	–	–	..
Hydro		0.00	0.00	0.00	0.00	–	–	..
Geothermal		–	0.00	0.00	0.00	–	0.00	..
Solar / Wind / Other[2]		–	0.06	0.25	0.27	0.59	0.77	..
TOTAL NET IMPORTS[3]		**19.85**	**8.01**	**0.18**	**–4.62**	**–1.99**	**9.54**	**..**
Coal	Exports	0.04	0.03	0.10	0.12	..	..	..
	Imports	1.91	6.23	4.87	4.30	4.50	5.46	..
	Net Imports	1.87	6.20	4.77	4.18	4.50	5.46	..
Oil	Exports	2.89	5.37	11.69	15.32	0.96	5.52	..
	Imports	21.58	8.46	11.35	10.55	..	..	..
	Bunkers	0.69	0.96	1.40	1.31	1.51	1.51	..
	Net Imports	18.00	2.13	–1.74	–6.08	–2.47	4.00	..
Gas	Exports	–	0.93	2.51	2.55	3.14	1.55	..
	Imports	–	–	–	–	–	–	..
	Net Imports	–	–0.93	–2.51	–2.55	–3.14	1.55	..
Electricity	Exports	0.11	0.42	0.65	0.65	0.88	1.48	..
	Imports	0.09	1.03	0.28	0.45	..	..	..
	Net Imports	–0.02	0.61	–0.37	–0.20	–0.88	–1.48	..
TOTAL STOCK CHANGES		**–0.44**	**0.17**	**0.49**	**1.05**	**–**	**–**	**..**
TOTAL SUPPLY (TPES)		**19.81**	**17.85**	**20.86**	**20.07**	**20.95**	**21.76**	**..**
Coal		1.93	6.07	5.67	4.64	4.50	5.46	..
Oil		17.57	8.26	9.55	9.33	9.23	9.50	..
Gas		–	1.79	4.22	4.42	5.44	5.35	..
Comb. Renewables & Wastes[1]		0.33	1.08	1.53	1.60	2.07	2.15	..
Nuclear		–	–	–	–	–	–	..
Hydro		0.00	0.00	0.00	0.00	–	–	..
Geothermal		–	0.00	0.00	0.00	–	0.00	..
Solar / Wind / Other[2]		–	0.06	0.26	0.27	0.59	0.78	..
Electricity Trade[4]		–0.02	0.61	–0.37	–0.20	–0.88	–1.48	..
Shares (%)								
Coal		*9.7*	*34.0*	*27.2*	*23.1*	*21.5*	*25.1*	..
Oil		*88.7*	*46.2*	*45.8*	*46.5*	*44.1*	*43.6*	..
Gas		*–*	*10.0*	*20.2*	*22.0*	*26.0*	*24.6*	..
Comb. Renewables & Wastes		*1.7*	*6.0*	*7.3*	*8.0*	*9.9*	*9.9*	..
Nuclear		*–*	*–*	*–*	*–*	*–*	*–*	..
Hydro		*–*	*–*	*–*	*–*	*–*	*–*	..
Geothermal		*–*	*–*	*–*	*–*	*–*	*–*	..
Solar / Wind / Other		*–*	*0.3*	*1.2*	*1.4*	*2.8*	*3.6*	..
Electricity Trade		*–0.1*	*3.4*	*–1.8*	*–1.0*	*–4.2*	*–6.8*	..

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

Please note: TPES for a given year strongly depends on the amount of net import of electricity, which may vary substantially from year to year.

Forecast data for 2005 and 2010 are based on the 1999 submission.

Unit: Mtoe

DEMAND

FINAL CONSUMPTION BY SECTOR

	1973	1990	1998	1999	2005	2010	2020
TFC	**16.15**	**14.06**	**15.67**	**15.64**	**15.83**	**16.24**	**..**
Coal	0.34	0.39	0.34	0.30	0.34	0.34	..
Oil	14.26	8.00	7.92	8.00	7.66	7.88	..
Gas	0.12	1.13	1.72	1.74	2.09	2.12	..
Comb. Renewables & Wastes[1]	0.05	0.20	0.51	0.51	0.57	0.57	..
Geothermal	–	–	–	–	–	–	..
Solar / Wind / Other	–	0.00	0.01	0.01	0.01	0.01	..
Electricity	1.39	2.50	2.76	2.76	2.77	2.88	..
Heat	–	1.84	2.41	2.32	2.41	2.45	..
Shares (%)							
Coal	*2.1*	*2.8*	*2.2*	*1.9*	*2.1*	*2.1*	..
Oil	*88.3*	*56.9*	*50.6*	*51.1*	*48.4*	*48.5*	..
Gas	*0.7*	*8.0*	*11.0*	*11.1*	*13.2*	*13.0*	..
Comb. Renewables & Wastes	*0.3*	*1.4*	*3.3*	*3.3*	*3.6*	*3.5*	..
Geothermal	–	–	–	–	–	–	..
Solar / Wind / Other	–	–	–	–	–	–	..
Electricity	*8.6*	*17.8*	*17.6*	*17.6*	*17.5*	*17.7*	..
Heat	–	*13.1*	*15.4*	*14.8*	*15.2*	*15.1*	..
TOTAL INDUSTRY[5]	**4.04**	**2.99**	**3.34**	**3.30**	**3.54**	**3.64**	**..**
Coal	0.21	0.31	0.31	0.28	0.31	0.31	..
Oil	3.41	1.30	1.12	1.12	1.05	1.07	..
Gas	0.02	0.53	0.80	0.81	0.99	1.00	..
Comb. Renewables & Wastes[1]	–	0.02	0.12	0.10	0.11	0.12	..
Geothermal	–	–	–	–	–	–	..
Solar / Wind / Other	–	–	–	–	–	–	..
Electricity	0.40	0.75	0.86	0.85	0.91	0.98	..
Heat	–	0.07	0.14	0.14	0.17	0.17	..
Shares (%)							
Coal	*5.2*	*10.4*	*9.4*	*8.6*	*8.6*	*8.5*	..
Oil	*84.5*	*43.7*	*33.5*	*34.0*	*29.7*	*29.2*	..
Gas	*0.4*	*17.7*	*23.9*	*24.6*	*27.8*	*27.5*	..
Comb. Renewables & Wastes	–	*0.6*	*3.4*	*2.9*	*3.2*	*3.2*	..
Geothermal	–	–	–	–	–	–	..
Solar / Wind / Other	–	–	–	–	–	–	..
Electricity	*9.8*	*25.2*	*25.6*	*25.8*	*25.8*	*26.8*	..
Heat	–	*2.5*	*4.1*	*4.1*	*4.8*	*4.7*	..
TRANSPORT[6]	**3.52**	**4.58**	**4.89**	**5.01**	**5.27**	**5.57**	**..**
TOTAL OTHER SECTORS[7]	**8.59**	**6.50**	**7.44**	**7.33**	**7.03**	**7.03**	**..**
Coal	0.13	0.08	0.03	0.02	0.03	0.03	..
Oil	7.34	2.14	1.94	1.90	1.41	1.31	..
Gas	0.10	0.60	0.92	0.93	1.10	1.12	..
Comb. Renewables & Wastes[1]	0.05	0.18	0.40	0.42	0.45	0.46	..
Geothermal	–	–	–	–	–	–	..
Solar / Wind / Other	–	0.00	0.01	0.01	0.01	0.01	..
Electricity	0.98	1.73	1.88	1.88	1.79	1.84	..
Heat	–	1.76	2.27	2.18	2.24	2.28	..
Shares (%)							
Coal	*1.5*	*1.2*	*0.3*	*0.3*	*0.4*	*0.4*	..
Oil	*85.4*	*33.0*	*26.1*	*25.9*	*20.1*	*18.7*	..
Gas	*1.2*	*9.3*	*12.4*	*12.6*	*15.7*	*15.9*	..
Comb. Renewables & Wastes	*0.6*	*2.8*	*5.4*	*5.7*	*6.5*	*6.5*	..
Geothermal	–	–	–	–	–	–	..
Solar / Wind / Other	–	–	*0.1*	*0.1*	*0.1*	*0.1*	..
Electricity	*11.4*	*26.6*	*25.2*	*25.6*	*25.5*	*26.1*	..
Heat	–	*27.2*	*30.6*	*29.8*	*31.8*	*32.4*	..

Unit: Mtoe

DEMAND

ENERGY TRANSFORMATION AND LOSSES

	1973	1990	1998	1999	2005	2010	2020
ELECTRICITY GENERATION[8]							
INPUT (Mtoe)	**4.69**	**7.36**	**9.70**	**9.01**	**9.97**	**11.35**	**..**
OUTPUT (Mtoe)	**1.64**	**2.21**	**3.53**	**3.34**	**3.89**	**4.61**	**..**
(TWh gross)	19.12	25.74	41.10	38.87	45.28	53.58	..
Output Shares (%)							
Coal	*35.8*	*90.6*	*57.5*	*51.6*	*40.1*	*42.3*	..
Oil	*64.1*	*4.1*	*12.1*	*12.5*	*10.0*	*8.8*	..
Gas	*–*	*2.2*	*19.9*	*23.5*	*28.6*	*26.2*	..
Comb. Renewables & Wastes	*–*	*0.6*	*3.6*	*4.5*	*8.3*	*7.7*	..
Nuclear	*–*	*–*	*–*	*–*	*–*	*–*	..
Hydro	*0.1*	*0.1*	*0.1*	*0.1*	*–*	*–*	..
Geothermal	*–*	*–*	*–*	*–*	*–*	*–*	..
Solar/Wind/Other	*–*	*2.4*	*6.9*	*7.8*	*13.0*	*14.9*	..
TOTAL LOSSES	**3.74**	**3.77**	**4.87**	**4.54**	**5.12**	**5.52**	**..**
of which:							
Electricity and Heat Generation[9]	3.04	2.85	3.11	2.74	3.16	3.78	..
Other Transformation	0.44	–0.43	–0.12	–0.08	0.00	0.00	..
Own Use and Losses[10]	0.26	1.34	1.88	1.87	1.96	1.74	..
Statistical Differences	**–0.08**	**0.03**	**0.32**	**–0.11**	**–**	**–**	**..**

INDICATORS

	1973	1990	1999	2000	2005	2010	2020
GDP (billion 1995 US$)	128.44	163.49	195.50	199.67	223.54	246.81	..
Population (millions)	5.02	5.14	5.30	5.32	5.40	5.44	..
TPES/GDP[11]	0.15	0.11	0.11	0.10	0.09	0.09	..
Energy Production/TPES	0.02	0.54	0.97	1.18	1.09	0.56	..
Per Capita TPES[12]	3.94	3.47	3.93	3.77	3.88	4.00	..
Oil Supply/GDP[11]	0.14	0.05	0.05	0.05	0.04	0.04	..
TFC/GDP[11]	0.13	0.09	0.08	0.08	0.07	0.07	..
Per Capita TFC[12]	3.22	2.74	2.96	2.94	2.93	2.99	..
Energy–related CO_2 Emissions (Mt CO_2)[13]	57.1	49.7	57.7	53.3	54.5	58.8	..
CO_2 Emissions from Bunkers (Mt CO_2)	4.5	5.0	6.7	6.4	7.1	7.1	..

GROWTH RATES (% per year)

	73–79	79–90	90–99	99–00	00–05	05–10	10–20
TPES	1.2	–1.6	2.0	–3.8	0.7	0.8	..
Coal	14.4	3.1	–0.9	–18.2	–0.5	3.9	..
Oil	–1.4	–5.9	1.8	–2.3	–0.2	0.6	..
Gas	–	–	11.4	4.7	3.5	–0.3	..
Comb. Renewables & Wastes	6.5	7.6	4.5	4.6	4.3	0.8	..
Nuclear	–	–	–	–	–	–	..
Hydro	–	–	–	50.0	–	–	..
Geothermal	–	–	–	–	–	–	..
Solar/Wind/Other	–	44.0	20.8	7.2	11.4	6.3	..
TFC	0.6	–1.6	1.4	–0.2	0.2	0.5	..
Electricity Consumption	4.9	2.8	1.3	–0.1	0.1	0.8	..
Energy Production	15.0	23.8	9.6	17.1	–0.5	–11.8	..
Net Oil Imports	–2.6	–16.4	–	250.3	–13.9	–	..
GDP	1.5	1.4	2.3	2.1	1.9	2.0	..
Growth in the TPES/GDP Ratio	–0.4	–2.9	–0.3	–5.8	–1.2	–1.2	..
Growth in the TFC/GDP Ratio	–0.9	–2.9	–0.9	–2.3	–1.7	–1.5	..

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

Footnotes to Energy Balances and Key Statistical Data

1. Comprises solid biomass, biogas, industrial waste and municipal waste. Data are often based on partial surveys and may not be comparable between countries.
2. Other includes ambient heat used in heat pumps.
3. Total net imports include combustible renewables and waste.
4. Total supply of electricity represents net trade. A negative number indicates that exports are greater than imports.
5. Includes non-energy use.
6. Includes less than 1% non-oil fuels.
7. Includes residential, commercial, public service and agricultural sectors.
8. Inputs to electricity generation include inputs to electricity, CHP and heat plants. Output refers only to electricity generation.
9. 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 efficiency of 100% for hydro.
10. 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.
11. Toe per thousand US dollars at 1995 prices and exchange rates.
12. Toe per person.
13. "Energy-related CO_2 emissions" specifically means CO_2 from the combustion of the fossil fuel components of TPES (i.e. coal and coal products, peat, crude oil and derived products and natural gas), while CO_2 emissions from the remaining components of TPES (i.e. electricity from hydro, other renewables and nuclear) are zero. Emissions from the combustion of biomass-derived fuels are not included, in accordance with the IPCC greenhouse gas inventory methodology. Also 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 1999 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.

B

ANNEX

INTERNATIONAL ENERGY AGENCY
"SHARED GOALS"

The Member countries* of the International Energy Agency (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

* 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.

IEA Members wish to retain and improve the nuclear 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.)

C

ANNEX

GLOSSARY AND LIST OF ABBREVIATIONS

In this report, abbreviations are substituted for a number of terms used within the International Energy Agency. While these terms generally have been written out on first mention and abbreviated subsequently, this glossary provides a quick and central reference for many of the abbreviations used.

AC	alternating current.
BP	British Petroleum.
bcm	billion cubic metres.
b/d	barrels per day.
cal	calorie.
CCGT	combined-cycle gas turbine.
CDM	Clean Development Mechanism (Kyoto Protocol).
CERT	Committee on Energy Research and Technology of the IEA.
CFCs	chlorofluorocarbons.
CHP	combined production of heat and power; sometimes, when referring to industrial CHP, the term "co-generation" is used.
CNG	compressed natural gas.
CO	carbon monoxide.
CO_2	carbon dioxide.
cm	cubic metre.
DC	direct current.
DH	district heating.
DSO	distribution system operator.
EFTA	European Free Trade Association: Iceland, Norway, Switzerland and Liechtenstein.
EIA	environmental impact assessment.
ETSO	European Transmission System Operators Group.
EU	The European Union, whose members are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom.

Euro	European currency (€).
FCCC	Framework Convention on Climate Change.
FSU	Former Soviet Union.
GDP	gross domestic product.
GNP	gross national product.
GEF	Global Environmental Facility.
GJ	gigajoule, or one joule × 10^9.
GW	gigawatt, or one watt × 10^9.
GWh	gigawatt × one hour, or one watt × one hour × 10^9.
IAEA	International Atomic Energy Agency.
IEA	International Energy Agency whose Members are 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.
IEP	International Energy Program, one of the founding documents of the IEA.
IGCC	integrated coal gasification combined cycle plant.
IPCC	International Panel on Climate Change.
ISO	independent system operator.
J	joule; a joule is the work done when the point of application of a force of one newton is displaced through a distance of one metre in the direction of the force (a newton is defined as the force needed to accelerate a kilogram by one metre per second). In electrical units, it is the energy dissipated by one watt in a second.
JI	Joint Implementation (Kyoto Protocol).
kV	kilovolt, or one volt × 10^3.
kWh	kilowatt-hour, or one kilowatt × one hour, or one watt × one hour × 10^3.
LDC	local distribution company.
LNG	liquefied natural gas.
LPG	liquefied petroleum gas; refers to propane, butane and their isomers, which are gases at atmospheric pressure and normal temperature.

mcm	million cubic metres.
Mt	million tonnes.
Mtoe	million tonnes of oil equivalent; see toe.
MW	megawatt, measure for energetic capacity (for example, one MW of electricity equals one watt $\times 10^6$).
MW_e	megawatt of electricity, often used to distinguish the electrical capacity from the heat-generation capacity in combined heat and power plants.
MWh	megawatt-hour = one megawatt $\times$ one hour, or one watt $\times$ one hour $\times 10^6$.
NATO	North Atlantic Treaty Organisation.
NEA	Nuclear Energy Agency of the OECD.
negTPA	negotiated third party access.
NGO	non-governmental organisation.
NO_x	nitrogen oxides.
OECD	Organisation for Economic Co-operation and Development.
PJ	petajoule, or one joule $\times 10^{15}$.
ppm	parts per million.
PPP	purchasing power parity: the rate of currency conversion that equalises the purchasing power of different currencies, i.e. estimates the differences in price levels between different countries.
regTPA	regulated third party access.
R&D	research and development, especially in energy technology; may include the demonstration and dissemination phases as well.
SB	single buyer.
SLT	Standing Group on Long-Term Co-operation of the IEA.
SO_2	sulphur dioxide.
TFC	total final consumption of energy; the difference between TPES and TFC consists of net energy losses in the production of electricity and synthetic gas, refinery use and other energy sector uses and losses.

TJ	terajoule, or one joule × 10^{12}.
toe	tonne of oil equivalent, defined as 107 kcal.
TOP	take-or-pay contract.
TPA	third party access.
TPES	total primary energy supply.
TSO	transmission system operator.
TW	terawatt, or one watt × 10^{12}.
TWh	terawatt × one hour, or one watt × one hour × 10^{12}.
UGS	underground storage (of natural gas).
UN	the United Nations Organisation.
UNECE	United Nations Economic Commission for Europe.
VAT	value-added tax.
VOCs	volatile organic compounds.
WANO	World Association of Nuclear Operators.

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