INTERNATIONAL ENERGY AGENCY

Energy Policies of IEA Countries

DENMARK

2006 Review

OECD

INTERNATIONAL ENERGY AGENCY

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.

The IEA member countries 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. The European Commission takes part in the work of the IEA.

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The OECD is a unique forum where the governments of thirty democracies work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

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

TABLE OF CONTENTS

Tables and Figures

TABLES

FIGURES

ORGANISATION OF THE REVIEW

REVIEW TEAM

The 2006 IEA in-depth review of the energy policies of Denmark was undertaken by a team of energy specialists drawn from IEA member countries and the IEA Secretariat. The team was in Denmark from 13 to 18 November 2005. Meetings were held with government officials, energy suppliers, energy consumers and public interest groups. This report was drafted on the basis of those meetings and the government's official response to the IEA's policy questionnaire. The team greatly appreciates the openness and co-operation shown by everyone it met.

The members of the team were:

Hugo Brouwer
(team leader)
Ministry of Economic Affairs
The Netherlands

Uwe Schroeder-Selbach
Federal Ministry of Economics
and Labour
Germany

Jean-Claude Hulot
Ministry of Economy,
Finance and Industry
France

Demus King
Department of Industry,
Tourism and Resources, Australia

Cristobal Burgos
Directorate-General for Energy
and Transport European Commission

Jun Arima
Head, Country Studies Division
IEA

Jonathan Coony
Country Studies Division
IEA

Jonathan Coony managed the review and drafted the report with the exception of the electricity chapter, for which the IEA wishes to acknowledge the invaluable contribution of Demus King from the Department of Industry, Tourism and Resources in Australia. Monica Petit and Bertrand Sadin prepared the figures, and Sandra Martin provided editorial assistance.

The team held discussions with the following groups:

- Danish Energy Authority (DEA)
- Energinet.dk
- The Danish Energy Regulatory Authority (DERA)
- The Danish National Competition Authority

- The Confederation of Danish Industries
- The Danish Consumer Council
- The Federation of Large Energy Consumers (FSE)
- ENERGI E2
- Association of Danish Energy Companies
- Danish District Heating Association
- DONG
- Vattenfall
- Greenpeace
- World Wildlife Fund (WWF)
- OVE
- The Ecological Council
- Elsam
- Danish Wind Turbine Owners Association
- Danish Wind Industry Association
- The Electricity Savings Trust
- Association of Danish Electricity Distribution Companies (ELFOR)
- Rockwool Denmark
- The Danish Construction Association
- Risø National Laboratory
- Danish Building Research Institute (SBI)
- Technical University of Denmark (DTU)
- Institute of Local Government Studies (AKF)
- The Danish Economic Council

REVIEW CRITERIA

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

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

Denmark's energy sector is a microcosm of many of the major energy issues facing IEA countries today. These include very proactive government policies in renewable energy and energy efficiency, advanced market reform of the electricity and gas sectors, market power's effect on competition, fossil fuel production and issues related to reserve depletion, and a very challenging greenhouse gas (GHG) reduction target. However, it is Denmark's pioneering role in renewable energy and energy efficiency that allows it to provide particularly valuable lessons for other countries. For this reason, the 2006 *In-depth Review of Danish Energy Policies* has placed particular emphasis on these two issues.

Denmark's emergence as a leader in the renewable energy sector represents a remarkable transformation. Despite lacking almost entirely in hydroelectric resources and without the strong biomass tradition of its Scandinavian neighbours, the government has used policies to build up one of the biggest renewable energy sectors in the world. Renewable energy supply more than doubled from 1992 to 2003 when it accounted for 13.4% of total primary energy supply (TPES).[1] The figures for electricity generation are even more pronounced. In 1991, renewable energy accounted for only 3.1% of domestic electricity generation but in the 12 years to 2003, that share grew more than sixfold to 19.0%. The preliminary figures show substantial further growth in 2004 when renewables' share rose to 25% of total electricity generation.

Renewable energy brings numerous benefits to Denmark. Renewables are generally emission-free, resulting in substantially lower GHG emissions. In 2004, renewables reduced carbon dioxide (CO_2) emissions by 6.5 million tonnes of CO_2 ($MtCO_2$), or about 10% of that year's emissions. Such reductions are particularly important for Denmark, which faces a very challenging Kyoto target. Renewables also contribute to security of supply since they are a domestic resource that represents supply diversity. While this is not an immediate concern in Denmark given its oil and gas reserves, it will become increasingly so as those reserves are depleted. In addition, the Danish renewables industry, benefiting substantially from government policy, is now the world leader in wind turbine manufacturing, creating substantial employment and export revenue.

1. 2004 figures, while still preliminary, show an additional 8.5% increase in renewable energy supply to account for 15% of TPES.

At the same time, the government's renewable support policies did not come without a cost. The above-market payments for electricity generated from renewable sources are recovered from electricity customers as a component of the Public Service Obligation (PSO), a levy placed on every kilowatt-hour (kWh) of electricity sold in Denmark. In 2005, the renewable component of the PSO was approximately 5.4 øre[2] per kWh on every kWh of electricity sold in Denmark. This surcharge was equal to approximately 3% of the household consumer's final bill when all taxes and grid charges are included, and approximately 9% of the electricity bill for businesses.[3] Danish customers directly paid a total of DKK 2 088 billion in 2004 to support renewable energy. This is equal to around 0.2% of the country's gross domestic product (GDP) or DKK 390 per person. As a percentage of the total wholesale price payment, it is substantial, equalling approximately 20% of the payment for the purchase of wholesale electricity to meet Danish demand.

Apart from the direct subsidy payments from customers, there are additional costs resulting from the government support for renewables. These mainly involve interference with the competitive dynamics of the electricity market. Any type of government influence, which favours certain technologies over others, will decrease market efficiency. Mandated must-run plants of a certain technology, size and timing make the electricity system less efficient and thus more costly to run. One cost resulting from wind power is the stress on the transmission system, which can result in economic inefficiency. Such costs are the inherent consequence of added renewable capacity and need to be compared with the benefit of renewables in the light of other energy policy objectives.

Taking a narrow view of renewables policy by considering just the most easily measured benefit (GHG reduction) and the most easily measured cost (direct subsidies from consumers), costs of supporting renewable energy, to date, are not justified. Estimates from the Danish Economic Council and the Danish Energy Agency, as well as independent analysis by the IEA, show that the cost of reducing each tonne of CO_2 emissions has historically been substantially higher through renewables than could have been achieved through other domestic programmes, such as energy efficiency, or through international mechanisms. The estimates conclude that the historical cost of reducing each tonne of CO_2 emissions through renewables policies of the 1990s was roughly between EUR 35 and EUR 50 per tonne. This is well above the current (and forward) price of emissions in the EU Emissions Trading Scheme (EU-ETS) and well above the assumptions on the cost of emissions reductions assumed

2. On average in 2005, one Danish krone (DKK) = USD 0.1668. (1 DKK = 100 øre.) This rate will be used for any conversions performed in this report. The krone is closely tied to the euro.
3. The figure is higher for businesses because their electricity prices are lower owing to lower taxes and lower grid charges than households.

when formulating the country's climate change strategy. Nevertheless, trends in the relative cost favour renewables. Improving technology and greater operational experience will continue to lower their costs while competing energy prices are likely to rise.

Other factors should also be considered beyond this narrowly defined analysis. Perhaps the most relevant is the decreasing cost of renewables over time. The Danish Energy Authority (DEA) has calculated that all-in costs of onshore wind turbines fell from around 10 eurocents per kWh in the 1980s to 7.5 eurocents per kWh in the early 1990s to 4.9 eurocents per kWh in 2004 and will drop to 3.7 eurocents by 2020. Such advances not only make any future renewable supports more attractive but also vindicate previous support policies to a degree since they clearly had a role in accelerating the cost reductions. In addition, as market prices for electricity rise, comparative prices for renewables, paid through either feed-in tariffs or a capped premium, are less costly for Danish consumers. In addition, the price for CO_2 reduction allowances in the EU-ETS, as well as for oil and gas, could rise thereby making renewables more attractive.

While renewables can enhance energy security given their domestic nature, they can also diminish security, at least in the case of wind, which has a highly intermittent generation profile compared to fossil fuel plants. While Denmark has been successfully dealing with wind intermittency and integrating greater shares of wind power into the system, it relies heavily on its hydro-rich neighbours and its strong connections with the continent to do so.

While such a debate on renewables is instructive and can inform future decisions, given the current rate of renewable penetration, the existing capacity in operation and the well-established renewable (wind) industries, there is no going back on Danish renewables policy. Nevertheless, it is crucial for current policy-makers to shape future policies based on cost-effective analysis of past and ongoing policies to get the most from renewable energy while minimising its disadvantages.

The current government is very attentive to cost-effectiveness and inclined to market-based approaches in promoting renewable energy. The new premium system combined with market prices is a positive step to incorporate market elements into the support framework. The current support level is lower than in other countries guaranteeing prices. However, the transitional arrangement offered by the government through the previous feed-in tariff may, in certain cases, create over-subsidisation. To reduce this problem, the government has moved to the capped premium and its gradual reduction depending on the year of installation. The most recent premium applied to the plants from 2005 is 12.3 øre per kWh without any cap. While this will make the possibility of over-subsidisation less likely, depending on the pace of cost reduction of wind turbines, carbon prices and oil/gas prices, there could be a situation where the wholesale market prices are sufficient for cost recovery without any such premium. This possibility suggests how difficult it is to ensure an appropriate support level through administratively determined prices (or premiums).

Green certificates, which are priced according to the difference between the market price and production cost could theoretically solve the problem of over-subsidisation. Green certificate systems are relatively new and the experiences in other countries are mixed. Transitional challenges would arise changing from the current mix of support schemes. However, certificate schemes would in theory induce long-term cost reductions through direct competition of renewable facilities of all technologies. Denmark could learn from other countries' experiences, including Sweden, the United Kingdom and Australia.

The new offshore wind is supported by the tendering system. By incorporating competitive elements, this system offers a more market-oriented approach than the past feed-in tariff scheme. On the other hand, consistency between the tender approach, whereby the government mandates a large quantity of a particular technology and the liberalised Nordic market's, as well as the government's basic position to let the market pick up new capacity, needs to be observed.

The other area where Denmark plays a pioneering role is in energy efficiency. Denmark's energy intensity is the lowest in the European Union (EU). Although it is 35% below the IEA average, the government continues to seek improvement through an ambitious new efficiency programme. This impressive record on efficiency has come from a concerted effort by the government and not from any inherent characteristic of Denmark itself. Among other measures, the government has put in place stringent building and appliance codes, public service campaigns on energy use, a public sector that sets an efficiency example, an extensive combined heat and power (CHP)/district heating (DH) network, high taxes on energy and negotiated agreements with industry. Furthermore, these and other efficiency measures have in no way detracted from the country's quality of life or economic performance; Denmark has both a higher GDP per capita and lower unemployment than the EU-15 countries on average. While countries have different demand profiles (influenced largely by the presence of energy-intensive industry), Denmark provides a good example of the benefits of government-induced energy efficiency.

Many of the benefits of greater efficiency are the same as the benefits of renewable energy, notably GHG emissions reduction and enhanced energy security. In addition, both renewable energy and energy efficiency can and should, at least to a certain degree, benefit from government programmes that support them more than a purely free market would. While there is no basis to treat renewables and energy efficiency as mutually exclusive goals, it is worth noting their relative cost-effectiveness in meeting essentially the same goals.

On the basis of the available evidence from Denmark, energy efficiency programmes have been significantly more cost-effective so far than renewable energy programmes in reducing GHG emissions and enhancing energy security. Evaluations of the Electricity Savings Trust, an efficiency group funded by a special surcharge, indicate that the cost of reducing CO_2 through its efficiency programmes is around DKK 55 (EUR 7.38) per tonne. The Association of Danish Electricity Distribution Companies, which also carries out efficiency work, reports that its efficiency efforts in 2003 resulted in CO_2 emissions reductions at a cost of DKK 40 (EUR 5.37) per tonne, while in 2004 its efforts were entirely cost-effective based on the value of suppressed demand and thus correspond to a GHG emissions reduction at no cost.

These results favour efficiency but come with two caveats. One, they represent just a snapshot of the costs and benefits of these programmes. Both technology and energy prices can change significantly over time, thus altering the relative attractiveness of efficiency and renewables. The second caveat concerns the methods of assessing efficiency programmes. The figures cited above from the Electricity Savings Trust and the electricity distribution companies are derived from the groups themselves and thus might be subject to a degree of bias. In addition, there is understandable uncertainty as to how different efficiency measures should be valued. Nevertheless, given the apparent cost-effectiveness of the efficiency measures and the renewed government push in this sector, it would be extremely beneficial if the government developed an objective methodology for assessing the costs and benefits of its efficiency programmes.

The current government efficiency programmes are more market-oriented than previous schemes. One of the major avenues for demand reduction will be through the electricity distribution companies. Each company is allocated a certain amount of demand reduction that they must achieve but will be free to do this in whatever way they wish. The money they receive to realise this demand reduction is fixed and thus they have incentives to reduce costs rather than propose expensive new programmes. The companies can even buy and sell demand reductions among themselves as a means of concentrating efforts in the most efficient locations. These more market-based measures are commendable and likely to increase the cost-effectiveness of these efforts. The biggest possible obstacle will be the complexity of the system and determining standard ways to measure savings realised by each efficiency programme. The government should ensure that such a methodology is in place as soon as possible, striving for simplicity whenever possible, and consulting the experiences of other countries with similar programmes, notably the UK.

One area conspicuously absent from government efficiency programmes is transport. The political agreement initiating the new efficiency push explicitly excludes transport from its purview. This is unfortunate since transport represents 33% of final consumption and is showing the fastest energy growth in Denmark. While curbing energy demand in transport is a challenge for all IEA countries, a number of measures could be introduced in Denmark. For one, the currently high registration tax (easily surpassing 150% of the ex-tax price) could be graduated according to the efficiency of the vehicle, as yearly registration fees already are. In addition, the high registration tax and normal petrol tax (by EU standards) penalises car ownership rather than actual use. A reconsideration of these incentives may lead to ways to reduce demand without altering the total combined taxation on cars and fuel. Denmark could also consider expanding the scope of voluntary agreements to freight industries. Both Finland and Japan have introduced innovative agreements with freight and other road transport groups.

The district heating sector also offers untapped opportunities to improve efficiency. The sector is currently regulated with cost-plus tariff methodology, which has a poor record in inducing cost reductions or efficiency. Some form of benchmarking should be introduced to set standards for costs so that outliers can be identified. In addition, a number of larger cities, notably Copenhagen, have or will have two or more heat suppliers feeding the heat pipeline system and therefore some measure of managed competition could be introduced there. Another area for improving the heating system is the mandatory participation of all consumers with access to district heating. Such controlling behaviour can stymie new products and/or other forms of innovation.

Denmark has been progressive in reforming its gas and electricity markets. As a member of Nordpool, it belongs to one of the most competitive and transparent electricity markets in the world. For the gas sector, it offered right of supplier choice to all customers in January 2004, three years before the requirement in the EU directive. The legal and regulatory parameters of the competitive market are sound. However, the merger between Danish Oil and Natural Gas (DONG) and the country's two major electricity generators and distributors raises market power issues that could impede competition and raise prices for consumers. The new company would have a dominant position in electricity generation in both east and west Denmark; own most of the electricity and natural gas distributors; and have partial operational control of gas storage.[4] Moreover, this consolidation is taking place at a time when there are already reports of increased electricity prices, which cannot be explained by standard market competition.

Some of the motivation for the DONG merger is a fear that the unmerged companies would be too small to fend off unwanted takeovers from larger foreign companies. While some countries have responded to this threat with

4. The European Commission, in its 16 March 2006 conditional approval of the merger, required that DONG sell the larger of its two storage facilities, Lille Torup in Jutland.

the type of consolidation taking place in Denmark, such as Austria, others have been largely indifferent to the nationality of their utility owners, such as the UK and the Netherlands. Proponents of the merger also argue that Denmark's extensive international connections make discussion of market power on a national basis irrelevant and that any measure of market concentration should take place on a European level where the merged DONG company would remain a modest player. In addition, Denmark has instituted full legal and partial ownership unbundling. Nevertheless, the new DONG will have such a degree of horizontal and vertical integration across the entire energy sector that it is very likely to be able to exert market power in a non-competitive fashion at certain times throughout the year. This is especially true in light of plans to partially privatise DONG in the coming years, thus ceding some control to a company or individual shareholders whose sole objective is profit maximisation. The government and the regulator are encouraged to thoroughly explore all means by which the new DONG could profitably raise prices and vigilantly investigate any instances where this might have been done.

RECOMMENDATIONS

The government of Denmark should:

General Energy Policy

- *Review energy and environmental taxation as a whole to establish more targeted and efficient price signals to achieve energy policy objectives, such as security of supply, environmental protection and the economic production and consumption of energy.*

- *Monitor the energy market carefully in order to take concrete steps to minimise the implications that the horizontal, vertical and cross-fuel integration in the electricity and gas markets resulting from the merger activity, particularly the foreseen DONG merger, will have on competition in the Danish energy markets.*

Energy and Climate Change

- *Take further account of the compliance risk of an insufficient supply of Joint Implementation (JI) and Clean Development Mechanism (CDM) credits being available within the envisaged price range as well as the availability and price of allowances under the EU-ETS.*

- *Address the competitive implications of the emissions reduction obligations of sectors included under the EU-ETS.*

- *Investigate further domestic cost-effective measures to reduce emissions in sectors not covered by the EU-ETS.*

- *Further investigate solutions to the possible double-burdening of CO_2 emissions by EU-ETS and Danish CO_2 and energy taxes.*

- *Address the windfall profit issue for covered installations that are benefiting from free receipt of European Union Allowances (EUAs) through the EU-ETS.*

Energy Efficiency

- *Continue implementation of the ambitious energy efficiency targets which can bring greater energy security, reduced CO_2 emissions and greater national competitiveness.*

- *Continue to perform further cost-benefit analyses as part of this implementation to assess the efficacy of individual efficiency measures.*

- *Clarify the concept and details of the "market-oriented" system imposed on distribution companies to achieve energy savings; consider the examples of countries implementing or planning "white certificate" or energy efficiency obligation programmes, such as Italy, France, the Netherlands and the UK, and the administrative costs involved as the system becomes more complicated.*

- *Clarify the measurement parameters of the efficiency programmes engaged in by the distribution companies, the Electricity Savings Trust and other groups to be able to better assess the efficacy and progress of such programmes; be aware that the planned review of these programmes in 2008 provides only a modest time to judge and thus requires clearly defined parameters.*

- *Implement a control and follow-up enforcement of the new energy regulations for buildings by all levels of government to ensure that the energy efficiency requirements are really achieved.*

- *Introduce measures to improve transport energy efficiency by addressing the following issues, among others:* i) *the current registration tax to ensure it differentiates on efficiency and does not keep older, inefficient cars in the fleet,* ii) *a tax system that penalises vehicle use rather than ownership, and* iii) *use of voluntary energy savings agreements.*

- *Investigate whether load-shifting measures can be introduced together with efficiency measures to shave demand from costly peak times and/or to make the demand profile more consistent with the Danish supply profile.*

- *Explore opportunities to induce greater efficiency in the district heating (DH) sector through performance benchmarking, incentive-based rate-making or some form of competition*

- *Ensure that DH regulations regarding obligatory participation and tariff structures with high fixed components do not impede efficiencies such as introduction of new appliances and new technologies, greater insulation and behaviour modification.*

- *Investigate the prospects of energy efficiency coming from private-sector energy service companies (ESCOs).*

Renewable Energy

- *Make greater use of cost-benefit analyses to assess the worth of various government support schemes for renewables.*

- *Continue the development of market-based approaches for any increased use of renewable energy, ensuring that caps and other measures limit the possibility of over-subsidisation.*

- *Closely monitor the impact of the tendering system for offshore plants on the functioning of the liberalised electricity market.*

- *Continue to take initiatives and co-operate with local authorities to overcome siting difficulties of wind turbines, including test facilities.*

- *Analyse the green certificate systems in other countries.*

- *Ensure that all power plants, particularly wind, pay their share of transmission upgrades needed to serve their new generating additions.*

Electricity

- *Continue the work to improve the market framework for the use of demand-side response in day-to-day energy trading as a way to enhance market efficiency and as an alternative mechanism to reserve margin management.*

- *Review the arrangements applying to the use of electricity in district heating to improve commercial market incentives to use electricity at times of high production and low price.*

- *Ensure that objective cost-benefit analyses drive investment decisions for the network.*

- *Provide a more stable operational and investment planning framework for the removal of transmission bottlenecks through market linked regulatory incentives on the transmission system operator.*

- *Work towards the harmonisation of regulatory instruments across countries participating in the Nordic market and Germany.*

Fossil Fuels

- *Maintain a policy supporting an open and competitive investment climate in the exploration and production sector.*

- *Maintain a tax policy in the exploration and production sector favourable to investments in new technologies and new recovery methods to prolong the life of the existing fields and produce new discoveries.*

- *Consider the effects of gas reservoir depletions on security of supply as well as possible medium-term responses such as enhanced connections with other North Sea gas infrastructures, the possibility of connecting to the Russian fields (through the North European Gas Pipeline project) and liquified natural gas facilities.*

- *Ensure that objective cost-benefit analyses drive investment decisions for the gas transport network.*

- *Ensure that all companies, whether incumbents or new entrants, are given true equal access to storage facilities and that this in no way becomes a barrier to competition.*

- *Evaluate whether a gas release programme for domestically produced gas might induce new suppliers into the market and thus facilitate more competition.*

Energy Research, Development and Demonstration

- *Continue the recent trend of increased government spending in energy RD&D activities.*

- *Ensure that energy RD&D continues to be consistent with domestic energy policy to support Danish industries in order to extend their success in the international market.*

- *Continue to ensure that transformations in the energy sector, most notably the creation of Energinet.dk from existing electricity and gas transmission companies, and the DONG acquisition of Elsam A/S and ENERGI E2, do not result in decreased or disrupted RD&D activity in the relevant sectors.*

GENERAL ENERGY POLICY

COUNTRY OVERVIEW

The Kingdom of Denmark is situated in northern Europe. It has a population of 5.4 million people, with an annual population growth of 0.3%. While its population density of approximately 125 persons per square kilometre is average by European standards, it has by far the highest population density among the Nordic countries. Approximately 85% of Danish citizens live in cities, the biggest of which is the capital, Copenhagen, which, including the environs, holds approximately 1.8 million people.

Denmark has a land mass of 43 098 km^2 and an extensive coastline of 7 314 km that runs along both the Baltic and North Seas. While Denmark is in the middle of northern Europe, it has a land boundary with only one other country, Germany to the south. Norway lies to the north across the Skagerrak and Sweden is connected by bridge to the north-east. Copenhagen was recently connected to the Swedish city of Malmö by a bridge. The Danish terrain is flat with rolling hills and the country's highest point is only 173 m above sea level. The climate is temperate with mild windy winters and cool summers.

The Danish economy is market-oriented and features high-tech agriculture, comprehensive government welfare measures, comfortable living standards, a stable currency and dependence on foreign trade. Denmark is a net exporter of food and energy and enjoys a comfortable balance of payments surplus. In addition to petroleum and natural gas resources, the country also has fish, salt, limestone, chalk and gravel. Although Denmark is one of the previous 15 member countries of the European Union (EU), it has decided not to join the 12 other EU countries in adopting the euro as its currency and has maintained the Danish krone (DKK).

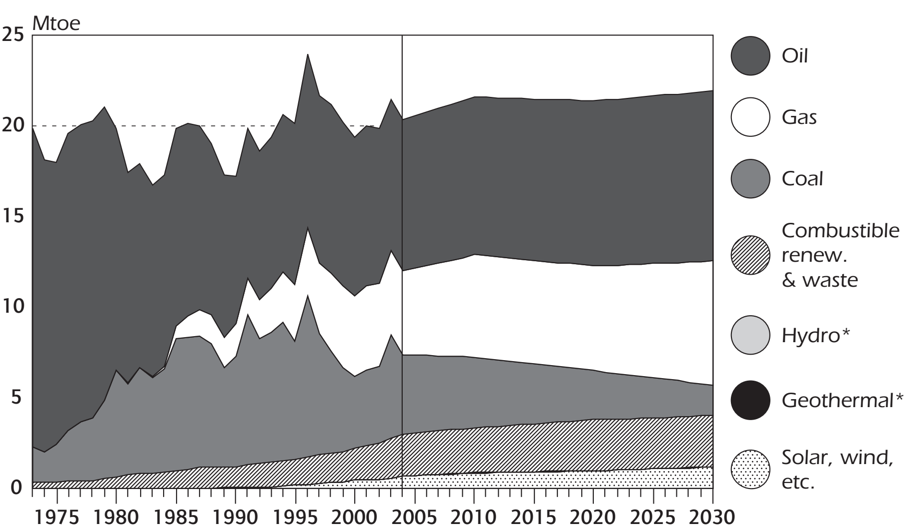
Denmark is made up of 14 counties and two boroughs; however, a recently decided reform will reduce this to six regions by 2007. It has a Parliament (or Folketinget) of 179 seats. Members are elected by popular vote to serve four-year terms. The last election was in February 2005 in which the coalition of the Liberal Party and the Conservative People's Party maintained control of the government. Following a dip in economic activity in 2003 when GDP growth was 0.6%, the Danish economy has recovered slightly to 2.1% annual growth in 2004 and an estimated 3.0% in 2005. Inflation remains below 2.0% and unemployment has fallen to 4.9% for 2005.

ENERGY SUPPLY

In 2003, Danish total primary energy supply (TPES) was 20.8 million tonnes of oil equivalent (Mtoe). This represents an increase of 5.3% from 2002, which is primarily due to increased electricity exports from domestic coal generation. Because coal is only about 40% efficient, while electricity is considered to be 100% efficient, coal imports to generate exported electricity result in a net increase in a country's TPES. From 1999 to 2003, annual TPES growth averaged 0.01% although it varied substantially over that time from a low of –3.8% in 1999 to a high of 5.3% in 2002. The fluctuation is largely explained by changes in electricity exports, which are linked to changes in the domestic electricity production of both Norway and Sweden owing to rainfall in any given year. From 1973 to 2003, TPES increased by 0.3% annually. By way of comparison, the average annual TPES growth for all OECD countries from 1971 to 2002 was 1.5%.

Figure 1

Total Primary Energy Supply, 1973 to 2030



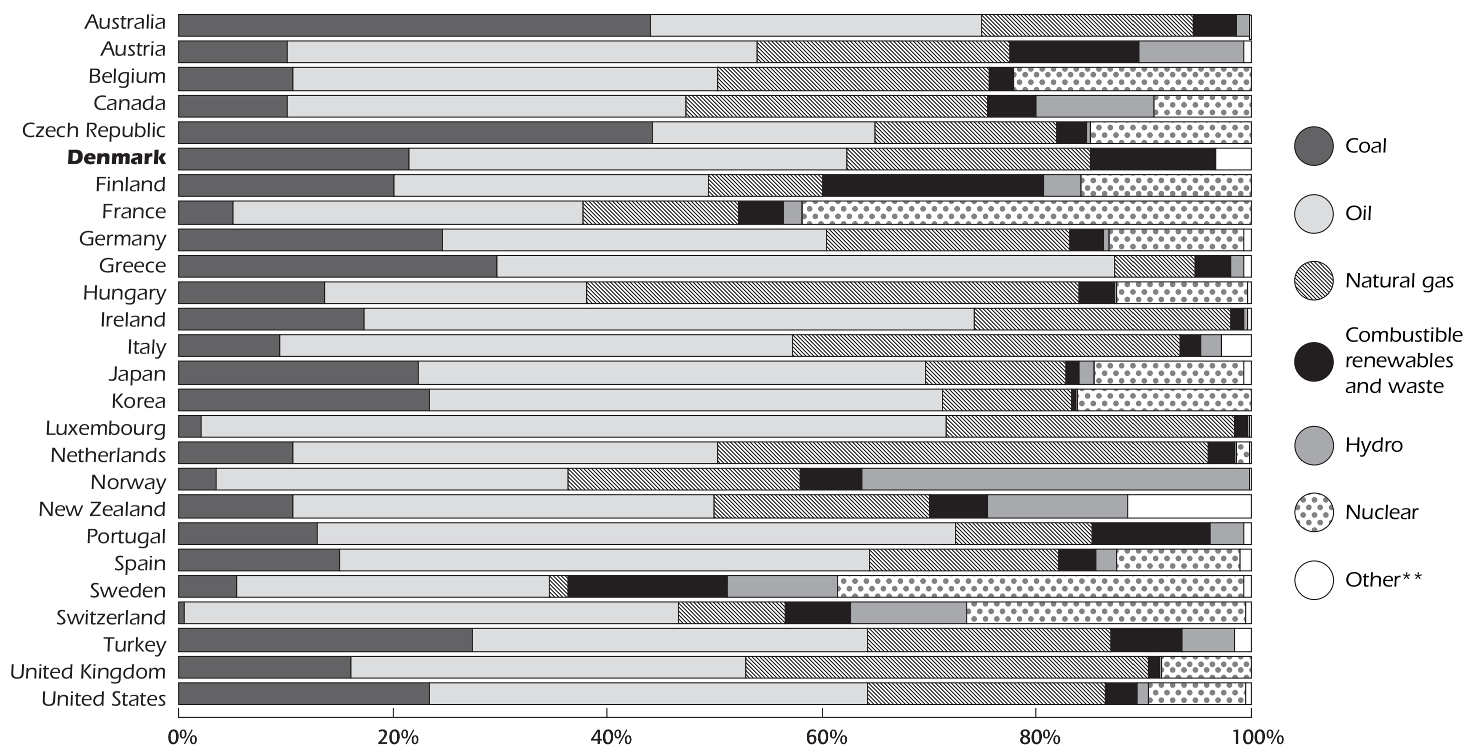
* negligible.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2005 and country submission.

Oil is Denmark's dominant primary fuel, accounting in 2003 for 40.3% of the total. This percentage share represents a dramatic decrease from 1973 when oil accounted for 88.6% of total primary energy. Oil's place has been taken by coal, which in 2003 accounted for 27.3% of TPES, natural gas

Figure 2

Total Primary Energy Supply in IEA Countries, 2004*



* preliminary data.

** includes geothermal, solar, wind, and ambient heat production.

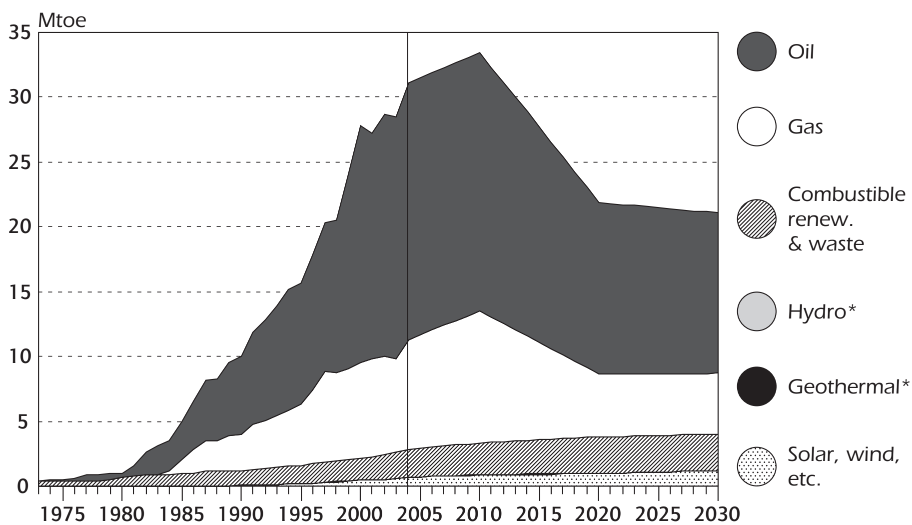
Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2005.

(22.4%), biomass (10.7%) and wind power (2.7%). These percentage shares add up to 103.5% of TPES, but are offset by electricity exports of 3.5%. The government forecasts that oil's share of TPES will remain stable but that coal's share will decrease as supply from gas, biomass and wind increase. In 2020, the government projects that oil will have a 42.7% share of TPES, followed by gas (27.0%), biomass (13.2%), coal (12.7%) and wind (4.5%).

In 2003, Denmark produced 18.6 Mtoe of oil and 7.2 Mtoe of natural gas. In addition, the country produced 2.1 Mtoe of biomass and 0.6 Mtoe of wind power. In 2003, Denmark had net exports of 7.9 Mtoe. Of this amount, 10.3 Mtoe was oil, 2.6 Mtoe was gas and 0.7 Mtoe was electricity. These net exports were equal to 38% of the country's TPES. This represents a dramatic change from previous years when Denmark was highly dependent on imports. From 1973 to 1975, Denmark averaged net imports equal to 104% of TPES.[5] Net imports stayed above 50% of TPES until 1990 and Denmark only became a net energy exporter for the first time in 1998.

Figure 3

Energy Production by Source, 1973 to 2030



* negligible.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2005 and country submission.

5. This figure is greater than 100% owing to rises in oil stocks at marine bunkers during those years.

ENERGY DEMAND

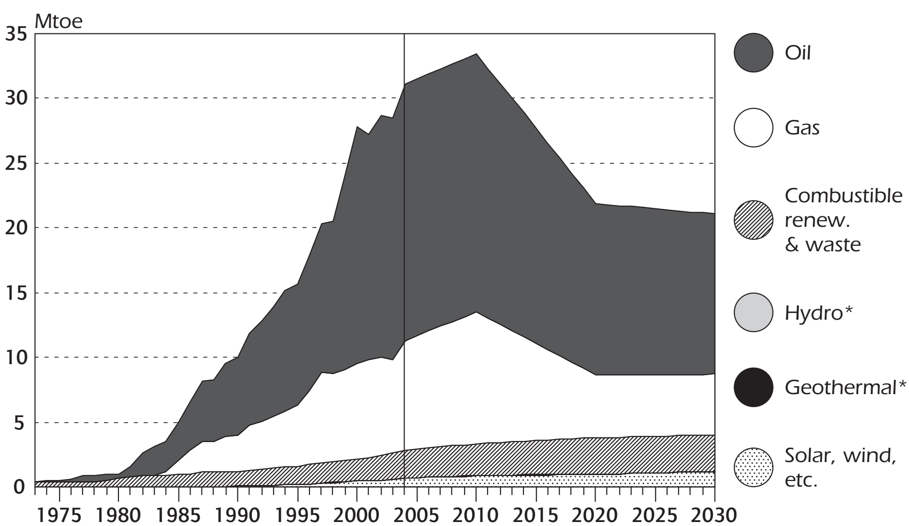
In 2003, Danish total final consumption (TFC) of energy was 15.3 Mtoe. From 1999 to 2003, TFC shrank by an average annual rate of 0.2% and from 1973 to 2003, TFC stayed nearly constant, decreasing by a total amount of 6% over 30 years, or at an average annual rate of –0.1%. By way of comparison, TFC for the IEA as a whole rose by 0.9% annually from 1973 to 2003.

In 2003, oil was by far the most important energy source for final consumption, accounting for 48.5% of TFC. This was followed by electricity (18.2%), heat (16.1%), natural gas (11.2%), biomass (4.7%), coal (1.4%) and solar and wind combined (0.1%). This fuel consumption profile is comparable to the IEA as a whole, where in 2002, oil accounted for 52.8% of TFC, followed by gas (20.1%), electricity (19.9%), biomass (3.0%), coal (3.0%) and others (3.3%). The one outstanding feature of the Danish TFC profile is the predominance of heat, which comes as a result of their extensive district heating systems.

The transport sector is the largest final energy user in Denmark, accounting for 32.8% of TFC in 2003; 25.9% of which was used for road transport. The residential sector was the next largest user of energy with 27.9% of the total, followed by industry (18.9%), other sectors (mostly commercial and public sector, 18.8%) and non-energy use (1.7%).

Figure 4

Total Final Consumption by Source, 1973 to 2030

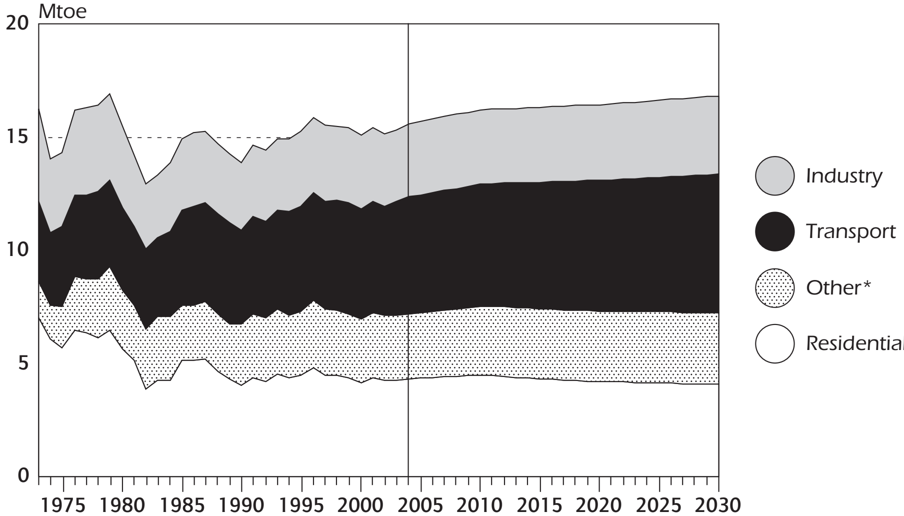


* negligible.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2005 and country submission.

Figure 5

Total Final Consumption by Sector, 1973 to 2030



* includes commercial, public service and agricultural sectors.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2005 and country submission.

GENERAL ENERGY POLICY

ENERGY POLICY OBJECTIVES

The goal of Danish energy policy is to create well-functioning energy markets within frameworks that secure cost-effectiveness, security of supply, environmental concerns and efficient use of energy. The markets are intended to be transparent with efficient competition in order to ensure the lowest possible energy prices for energy consumers.

Three recent political agreements and statements have established the framework that Danish energy policy will be using to move forward.

- Agreements of 29 March 2004.
- Energy Strategy 2025.
- 10 June 2005 Agreement on energy-saving initiatives.

AGREEMENTS OF 29 MARCH 2004

In March 2004, two important agreements were reached by the majority of the Danish Parliament (Folketinget). The first agreement, the Agreement of 29 March 2004 to ensure a reliable energy infrastructure for the future, concerns the establishment of a single entity to own and operate Denmark's entire high-voltage electricity transmission system. The two transmission systems at the time (Elkraft for eastern Denmark and Eltra for western Denmark) were completely separated and each was communally owned by the respective region's low-voltage distribution companies. These distribution companies – operating largely through their industry association, ELFOR – agreed to transfer ownership of the high-voltage transmission assets to the State on 1 January 2005 at no cost. As part of this agreement, the distinction between free and tied-up capital, which limited the use of equity within the distribution companies, was abolished. The government was then to place the transmission assets into the new entity, Energinet.dk, which it would own 100%.

During the formulation of laws to create Energinet.dk, it was decided that the natural gas transport assets would also be included in the new entity. These assets had been legally separated from DONG, the Danish oil and natural gas group, and placed into a company called Gastra. Gastra was 100% owned by the Danish federal government. Although domestic pipelines were transferred to Gastra and ultimately to Energinet.dk, DONG has maintained ownership and operational control of both the domestic gas storage and gas interconnections with Sweden and Germany.

The second agreement, the Agreement of 29 March 2004 on wind energy, decentralised power and heat, etc. (follow-up to the agreement of 19 June 2002), concerned expanded and upgraded wind farms as well as new regulations governing the subsidy structure to support existing wind, CHP and biogas facilities. The agreement established the framework to support two new offshore wind farms, each with 200 MW total capacity at Horns Rev and Omø Stålgrunde. It was later decided to build one of the wind farms at Rødsand instead of at Omø Stålgrunde. The projects will result from a tender process whereby competing firms submit proposals with the parameters for the plant they would build, including the required supplement to market price for each kWh of power generated. After several rounds of bidding, negotiations were to be held with the qualified bidders that delivered the lowest price for the generation. This agreement also establishes a re-powering programme whereby owners of new wind turbines receive an additional subsidy for the production covered by a certificate from decommissioned older small turbines.

ENERGY STRATEGY 2025

On 17 June 2005, the government released "Energy Strategy 2025". The strategy completes a work that started more than a year before and is the first comprehensive energy strategy since "Energy 21" that was published in 1996. Major messages from the strategy are as follows:

A good point of departure

Denmark is well placed to meet future energy challenges. The Danish energy system is robust, flexible and oriented towards competitive international markets. Denmark has a multi-faceted energy supply based on a variety of energy sources, a well-constructed energy infrastructure, a high degree of efficiency in energy consumption and significant autoproduction of oil and natural gas. Furthermore, the government's policy will lead to improved use of market mechanisms and to more cost-effective initiatives.

Long-term challenges

It is necessary to think in the long term when setting energy policies. In the long term, there are the following three major challenges:

- *Supply security:* Rising world energy consumption puts greater pressure on global resources. The Danish economy must maintain a high level of robustness vis-à-vis high and unstable energy prices.
- *Global climate change:* Implementation of the Kyoto Protocol and future fulfilment of the United Nations Framework Convention on Climate Change's (UNFCCC) goal to achieve major global reductions in GHG emissions, particularly the emission of CO_2.
- *Growth and economic development:* Globalisation leads to increased international competition and new commercial opportunities. Danish enterprises must have competitive framework conditions and research must be transformed into exports and jobs.

Initiatives to meet the energy challenges

The government will meet these challenges with initiatives in the following areas.

Government initiatives for energy saving and renewable energy

- Ensure intensified energy-saving efforts.
- Increase focus on the transport sector's energy consumption and oil dependence.
- Increase renewable energy by means of continued effective framework conditions.

Government initiatives against global climate change

- Ensure that the emission of GHGs in Denmark is regulated in a cost-effective way, with a cross-sector balance.
- Support the development of new energy technologies to fulfil future climate obligations.

- Continue to take local and regional environmental factors into consideration when establishing energy-policy priorities.
- Encourage the European Union (EU) to seek an ambitious agreement on the reduction of GHGs before the first phase of the Kyoto Protocol expires in 2012.
- Work actively during international climate negotiations in order to achieve a tenable framework for international climate policy.

Initiatives for well-functioning energy markets

For the electricity sector, the government will:

- Carry out an expansion of the overall electricity infrastructure, particularly an electricity connection between eastern and western Denmark and consider the possibilities of strengthening electricity connections to Norway and Germany.
- Set clear requirements for necessary supply security in the local electricity grid.
- Continue work on establishing an action programme for more flexible electricity consumption.
- Investigate the possibilities for removing tax-related obstacles to socio-economically and environmentally viable use of electricity in the district heating systems.

For the gas sector, the government will:

- Work on the European level to further integrate the Danish gas market with other European gas markets by establishing unified and transparent framework conditions.
- Ensure a socio-economically viable expansion of the gas infrastructure in step with long-term development of Danish gas consumption and production.
- Ensure consumers the lowest possible heat prices by continuing to increase the efficiency of district heating supply.

Government initiatives for technological development

- Promote development of new technologies and the use of industrial potentials by: *i)* increasing research efforts, *ii)* intensifying development and demonstration of new, energy-efficient technologies and renewable energy, *iii)* co-ordinating efforts across the various public research and development programmes, and *iv)* focusing efforts in the energy field towards the realisation of particular Danish industrial potentials and energy policy priorities.

AGREEMENT ON ENERGY-SAVING INITIATIVES (10 JUNE 2005)

On 10 June 2005, all major political parties in Denmark agreed on future energy-saving targets and initiatives. The parties stated that the country should achieve specific documentable energy savings corresponding to an annual average of 7.5 petajoules (PJ) during the period 2006-2013. These savings shall be achieved exclusive of the transport sector and represent approximately three times the current annual savings. They will represent an average annual improvement in national energy intensity of 1.7%.

While the specific measures to achieve these savings were still to be formulated, the political agreement laid out some guidelines for the measures to be used, identifying three key areas. The first part of the savings are to be achieved by network and distribution companies in the electricity, natural gas, district heating (DH) and oil sectors. The second set of measures is to be introduced in the building sector through tightened energy standards and a more expansive labelling programme. The third area for energy savings is to be in the public sector at both the federal and municipal government levels. The Danish Energy Authority (DEA, described below) produced a draft paper in September 2005 with a more detailed explanation of the measures introduced in these three areas. Negotiation between the related parties continued as of early 2006, with decisions leading to more precise initiatives expected shortly.

ENERGY POLICY INSTITUTIONS

On 18 February 2005, responsibility for energy was transferred from the Ministry of Economic and Business Affairs to an enlarged Ministry of Transport and Energy. The Energy Office of the secretariat handles assignments within the energy field and the contact between the minister and the various government energy units described below.

THE DANISH ENERGY AUTHORITY (DEA)

The Danish Energy Authority (DEA) was established in 1976, and is currently under the authority of the Ministry of Transport and Energy. The DEA carries out tasks, nationally and internationally, in relation to the production, supply and consumption of energy. It is the task of the DEA to ensure security of supply and the responsible development of energy in Denmark from the perspectives of the economy, the environment and security.

Exploration and production of oil and gas

The DEA deals with oil and gas production, geothermal energy and storage. It also supervises the Subsoil Act, the Offshore Installations Act, the Pipelines Act and the Continental Shelf Act. In addition, the DEA prepares the resource and financial forecasts for oil and gas production and is responsible for preparing and implementing licensing rounds and issuing licences.

Energy supply

The DEA is responsible for the three main acts in the field of energy supply, namely *i)* the Electricity Supply Act, *ii)* the Natural Gas Supply Act, and *iii)* the Heat Supply Act. It also administers the legislation concerning CO_2 quotas for electricity production and subsidies for environment-friendly electricity production. In recent years, the major task has been the extensive reform of energy structure from monopoly to competition.

Energy consumption and savings

The DEA works to ensure efficient energy use. The objective of this work is to establish the basis for the political decisions concerning energy saving policy and work for the implementation of energy savings in households, public and private services, and trade and industry. There are also tasks involving energy consumption in the transport sector.

Energy research and development

The DEA administers the Energy Research Programme (ERP), which grants subsidies to R&D in the area of cleaner and more energy-efficient technologies. The scheme also finances Denmark's participation in international energy research co-operation (such as the IEA) and Nordic co-operation in the area.

International co-operation

The DEA takes care of Danish energy policy interests through its international, multilateral and bilateral co-operation on energy and environment policy. These activities take place in a number of different forums, including the EU, the European Energy Charter, the OECD, the IEA, the United Nations (UN) and the Nordic Council of Ministers, and with various bilateral co-operation partners.

THE DANISH ENERGY REGULATORY AUTHORITY

The Danish Energy Regulatory Authority (DERA) is an independent authority engaged in the supervision of the monopoly companies – electricity, natural gas and district heating – in the Danish energy sector. DERA works to secure efficient and transparent energy markets in Denmark, and, in so doing, contributes to securing Danish households, enterprises and others the energy they require, at fair and transparent prices, and with fair conditions. To do this, DERA regulates the prices and terms of supply fixed by the monopoly companies, such as the terms applying to access to transmission and distribution networks. The Authority also supports structural development and improvements in efficiency within the energy sector and its secretariat plays an active part in Nordic and European co-operation among regulatory authorities.

The members of DERA are appointed by the Danish Minister of Transport and Energy for a period of four years and cannot be dismissed except on the grounds of gross incompetence. The Authority was established on 1 January 2000, replacing the former Electricity Price Committee and the Gas & Heating Price Committee. The four-year term of theddddd present members of the Authority expires at the end of 2007.

THE ENERGY BOARD OF APPEAL

The Energy Board of Appeal is the final administrative appeal body for decisions by public authorities under various laws governing the energy sector. The decisions that are subject to appeal will in most cases have been handed down by the DERA, the DEA or one of Denmark's 275 municipalities.

The board consists of a chairman and deputy chairman as well as a number of experts in all aspects of energy-related issues. At present, the board has 20 members. It hears appeals from individual decisions made by public authorities under energy-related laws such as the Electricity Supply Act, the Heat Supply Act, the Natural Gas Supply Act and the Act to Promote Energy Conservation. The decisions of the Energy Board of Appeal are final, *i.e.* they cannot be appealed to other administrative authorities. Parties not satisfied with a decision reached by the Board of Appeal, can institute legal proceedings against the board in the courts.

ENERGY SUPPLIES COMPLAINT BOARD

The Energy Supplies Complaint Board was established through co-operation between the Consumer Council, the Association of Danish Energy Companies, DONG (Danish Oil and Natural Gas), Greater Copenhagen Natural Gas/Natural Gas Middle-North, Natural Gas Funen and the Danish District Heating Association. The board has a mandate to handle disputes from the contractual relationship between energy consumers and electricity, gas or district heating suppliers.

THE ELECTRICITY SAVINGS TRUST

The objective of the Trust is to promote electricity savings in dwellings and public institutions in accordance with socio-economic and environmental considerations. The Trust receives a total annual income of around DKK 95 million derived from the proceeds of the special electricity savings surcharge of DKK 0.006 per kWh, which is collected on all the electricity sold to households and the public sector. The major part (approximately DKK 65 million) of the Trust's funds is used for investment grants while a smaller part (DKK 30 million) is used for other activities, which primarily consist of. campaigns, consultancy and information activities, subsidy administration and quality control, web sites, project management and other activities. The Trust was established in 1996 and is headed by a board consisting of a chairman and eight other members appointed by the Danish Ministry of Transport and Energy.

SUPPLY INDUSTRY CONSOLIDATION

Denmark is undergoing a major consolidation of its electricity and natural gas supply industries in both the generation/production and the transmission/transportation sectors. On the generation/production side, DONG, the state-owned Danish oil and natural gas group, is in the process of merging with the major Danish electricity incumbents, Elsam A/S and ENERGI E2. The new company will also own a number of electricity distribution companies, notably NESA (the electricity distribution company in northern Zealand with 550 000 customers), Københavns Energi (350 000 customers) and Frederiksberg Forsyning (60 000 customers).

A portion of the new company's generating assets (27% by net capacity) will be divested to the Swedish state-owned electricity company, Vattenfall. These divested assets consist of 33.3% of the assets in western Denmark and 12.8% of the assets in eastern Denmark. For the entire country, Vattenfall will acquire 23.7% of the total generating assets to be transferred from Elsam A/S and ENERGI E2 to DONG. A breakdown of old and proposed ownership of the major generating stations is shown in Table 1.

The merger was referred to the EU Competition Authority on 13 September 2005. On 18 October 2005, the European Commission decided to initiate proceedings pursuant to Article 6(1)(c) of the Merger Control Regulation – the so-called Phase ii – in order to conduct an in-depth investigation of the merger. On 23 December 2005 the commission approved the proposed divestment to Vattenfall of the specified generating assets. On 16 March 2006, the commission conditionally approved the merger subject to two requirements (in addition to the previously agreed divestitures to Vattenfall). One, DONG

Table 1

Existing and Proposed Thermal Generation Ownership

Plant (sites)	*Current Ownership*	*Future Ownership*	*Capacity (2004) MW*	*Primary Fuel (2004)*
ENSTED	ELSAM	DONG	670	Coal
ESBJERG	ELSAM	DONG	408	Coal
FYNS	ELSAM	Vattenfall	625	Coal
HERNING	ELSAM	DONG	89	Bio
NORDJYLLAND	ELSAM	Vattenfall	691	Coal
NORDKRAFT	ELSAM	DONG	285	Coal/Mothballed
SKÆRBÆK	ELSAM	DONG	419	Gas
STUDSTRUP	ELSAM	DONG	760	Coal
AVEDØRE	E2	DONG	606	Gas
H.C. ØRSTED	E2	DONG	197	Gas
SVANEMØLLEN	E2	DONG	131	Gas
HILLERØD	E2	Vattenfall	77	Gas
HELSINGØR	E2	Vattenfall	60	Gas
DTU	E2	DONG	39	Gas
RINGSTED	E2	DONG	11	Gas
AMAGER	E2	Vattenfall	341	Coal
ASNÆS	E2	DONG	1 057	Coal
KYNDBY	E2	DONG	734	Oil
MASNEDØ	E2	DONG	9	Bio
STIGNÆS	E2	DONG	409	Coal
HASLEV	E2	DONG	5	Bio
KØGE	E2	DONG	26	Bio
MARIBO	E2	DONG	11	Bio
SLAGELSE	E2	DONG	12	Bio
		Market Share Breakdown		*Mkt Share of Thermal Capacity* [1]
DONG share			5 878	58%
Vattenfall share			1 794	18%
Non-aligned share			2 528	25%
Total combustible capacity		10 200		
		Effect of Import Capacity on Market Shares [2]		
Import capacity			4 980	33%
DONG share			5 878	39%
Vattenfall share			1 794	12%
Non-aligned share			2 528	17%
Total			15 180	

1. The market share figures consider only thermal power plants since wind power plants cannot have the same effect in bidding and determining market price. In addition to the capacity listed in this table, there is around 2 528 GW of more, mostly decentralised CHP plants with different ownership.

2. This section of the table looks at the effect of import capacity on market share, and considers that all potential imports can act as domestic generation and are thus in direct competition to plants sited in Denmark. This likely overstates the dilutive effect on market concentration from imports and the threat of import since a significant portion would be controlled by Vattenfall.

Source: Dansk Energi/ELFOR.

must sell the larger of its two gas storage facilities, Lille Torup in Jutland, and two, DONG must begin a gas release programme whereby it auctions 400 million cubic metres of gas – about 10% of Danish demand – each year for the next six years.

The government has announced plans to privatise the merged company through an initial public offering with the State maintaining a majority of the shares. Danish law states that the gas network and storage facilities should always be controlled by the government. If the government were to further divest DONG shares (not currently planned) thereby losing operational control of the company, the gas network and storage facilities would have to be sold to the State so that it could maintain control of these assets.

The issue of market power for both the existing and proposed supply industry paradigms has been addressed by Danish authorities. In the summer of 2005, the Danish National Competition Authority stated that Elsam had charged unwarranted high prices in its territory. High wholesale electricity prices in November 2005[6] prompted Energinet.dk, the transmission system operator (TSO), to issue a statement. On 23 November 2005, Energinet.dk stated that in western Denmark, the recent prices "must be seen as the result of insufficient capacity being placed at the disposal of the market. However, the causes for the limited production capacity in western Demark are not of a physical nature, and the price formation in this area must therefore be the result of the players' bids."

Furthermore, the Danish Economic Council, a government-supported independent economic think-tank, recently addressed the forthcoming DONG merger. It stated in its autumn 2005 report that "the merger is a disadvantage to society and should be avoided" and that "the Competition Authorities should accept the merger only if electricity production, gas production and electricity distribution are separated into different companies."

Regarding consolidation of the electric transmission and gas transport networks, the aforementioned "Agreement of 29 March 2004 to ensure a reliable energy infrastructure for the future" established the regulatory framework to create Energinet.dk. This new entity, entirely owned by the Danish State, owns and operates the high-voltage transmission lines[7] and high-pressure gas transport pipelines.

6. Prices reached DKK 3 000 per MWh in eastern Denmark and DKK 1 000 per MWh in western Denmark.
7. A small but significant share of the high-voltage lines are still owned by municipalities although the entire network is operated by Energinet.dk, regardless of ownership.

DANISH ENERGY TECHNOLOGY EXPORTS

One important aspect of Danish energy policy is its effect on energy technology exports. Domestic energy policies have acted in a way that supports certain segments of Danish industry, which in turn is intended to boost Danish enterprises, create employment and generate export revenue.

The best example of this is the wind industry. The support given to the construction of domestic wind plants, primarily through feed-in tariffs, strongly supported the Danish wind industry. This has made Danish wind producers, primarily Vestas, and related suppliers leading global players in this field. (A full description of the Vestas position is found in Chapter 6.)

In 2004, export of energy-related equipment accounted for 7.4% of total exports. The comparable figure from the EU-15 countries in 2004 was 5.3%. An increase in energy technology exports can be traced to the mid-1990s. At that time, energy technology represented lesser amounts of total exports, around 5.5%. Since 1996, however, energy technology exports doubled, growing by 9.0% annually compared to 5.4% annual growth for Danish exports as a whole. Table 2 shows the top 20 energy technology export categories and their export value in 2004.

Table 2

Top 20 Energy Technology Export Categories and Amounts, 2004

Energy Technology	*Exports (million DKK)*
Wind driven electricity generators (except for use in civil aircraft)	5 313
Components mainly used for electrical engines and electricity generators	2 932
Axel rings, non-magnetic, for electrical engines or electricity generators	2 252
Components for fluid pumps	1 638
Fibreglass products (except electrical insulation)	1 495
Valves for oil hydraulic transmissions	1 245
Circulating pumps without axel packing, for central heat and hot water systems	948
Static inverted rectifiers with effect <=7.5 kVA (except for use in civil aircrafts)	624
Radial fluid pumps	582
Static inverted rectifiers with effect >7.5 kVA (except for use in civil aircrafts)	541
Steel valves	538
Underwater pumps, several stages	536
Components for taps, valves, etc. for pipelines, boilers	512
Control boards, numeric, with automatic data processing included	448
Gear transmissions (except for use in civil aircraft)	421
Boards, consoles, etc. for instruments	406
Ovens, boilers with heat supply, etc. for domestic use	385
Turbo compressors, one stage	373
Control boards, consoles, etc. for electric system control	373
Components for steam boilers and boilers with superheaters	368

Source: Energy Industry branch of Danish Industry.

SECURITY OF ENERGY SUPPLY

In general, Denmark has very sound security of supply. The extensive oil and gas resources promise to make the country self-sufficient in these two fuels through the medium term. In addition, a great deal of the electricity (54.7% in 2003) and total supply (27.3%) comes from coal, which is obtained through a stable international market that is subject to considerably less price volatility than natural gas or oil. Although the Danish electricity system did experience a blackout in 2003 stemming from transmission failures in Sweden (see box below), it has existing domestic generating overcapacity and major interconnections with neighbours to provide it with security. The substantial wind power generation both adds to the security since it is a domestic source and detracts from security as wind is inherently intermittent.[8]

Danish energy security is enhanced by its low energy intensity. Not only does lower energy consumption per unit of GDP decrease the chances of actual physical shortages, but it also protects the Danish economy from the macroeconomic effects of price increases. Rapid run-ups in fuel prices, primarily oil, have led to recessions in IEA countries in the 1970s and 1980s. At present, this effect is clearly lessened but not eliminated through improved energy intensity in the IEA. Countries, such as Denmark, that have achieved lower-than-average intensities would be further protected from almost entirely uncontrollable price volatility in international fuel markets.

ELECTRICITY

According to the IEA data,[9] Denmark has substantial generating overcapacity. As of year-end 2003, there was 13.3 GW of domestic capacity against 6.4 GW of peak demand. Of this capacity, wind accounted for 3.1 GW, or 23%. Information from Dansk Energi, the Association of Danish Energy Companies,[10] indicates that in 2004, Denmark had 7 284 MW of central power stations, 1 689 MW of small, local CHP plants, 3 119 MW of wind, 547 MW located inside-the-fence at manufacturing facilities and 11 MW of hydropower, for a total capacity of 12 650 MW. In addition to the volume of capacity in the Danish system, the plants' flexibility also contributes to security. More than 6 GW of thermal power is multifuel and thus can burn some combination of coal, oil, gas, biofuels or municipal waste.

8. Denmark's system proved its resiliency in the face of fluctuations in wind power generation when, owing to a storm, it lost about 90% of its wind generation (more than 1.5 GW) in approximately six hours. Thanks largely to imports from Norway and Sweden, the system had no major problems in maintaining system integrity. This occurrence is explored more fully in Chapter 6.
9. "Electricity Information," 2005.
10. "Danish Electricity Supply, Statistical Survey 2004", Table 14, p. 45.

There is substantial international interconnection with import capacity from Norway (950 MW), Sweden (580 MW and 1 900 MW lines) and Germany (600 MW and 950 MW lines) for total import capacity of 4 980 MW, or nearly 80% of the peak demand through 2004. Internal transmission capacity also appears adequate. Even though the country is divided into two, roughly equal, non-synchronous halves, there has been very little reason to believe that the separation between the two control areas has led to a substantially greater risk of blackouts and shortages. A 600-MW direct current (DC) line is being built to connect east and west Denmark.

Despite the strong capacity and transmission situation in Denmark, the country did experience a blackout in 2003 (see box for description). The blackout was the result of a series of transformer accidents in Sweden and does not reflect any weaknesses in Danish electricity security.

The September 2003 Blackout

In September 2003, an electricity blackout cut power to both Sweden and Denmark. The cause of the blackout originated in Sweden and then spread to Denmark.

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

At 00h30 on 23 September 2003, Unit 3 of the Oskarshamn Nuclear Power Plant shut down automatically in response to internal valve problems in the feedwater circuits, reducing generating capacity by 1 175 MW. This loss was within the contingency standard established by the Nordic TSOs.

At 00h35, a unique event led to the failure of a double bus bar in a 400-kV substation on the west coast of Sweden. As a result, circuit breakers for the transmission lines linking two 900-MW units at Ringhals immediately tripped, effectively reducing generation by a further 1 750 MW and severing the transmission path along the west coast.

The south-east and south-west sections of the Swedish transmission network became heavily overloaded, with no major generation available in these regions to maintain reactive power. Voltage levels began to drop, reaching critical levels as demand in the region began to recover from the initial generation outages. Voltage collapsed in a section of the 400-kV transmission network south-west of Stockholm, which triggered automatic circuit breakers leading to a cascading failure of the entire southern portion of the transmission network. The interconnector between Sweden and Denmark (Zealand) also tripped. The total loss was around 3 000 MW in Sweden and 1 850 MW in Denmark.

Following emergency restoration procedures, lines and substations were energised to rebuild the network from north to south. The 400-kV grid was re-energised throughout the southern region and to Denmark within an hour. Regional and local networks were subsequently restored. By 19h00 almost all supplies in Sweden and Denmark had been restored.

FOSSIL FUELS

In 2003, fossil fuels accounted collectively for 90% of Danish TPES. Denmark is self-sufficient in oil (40% of TPES) from production in its North Sea fields. Government forecasts project that domestic production, augmented by new technology and further exploration, will continue to exceed demand until 2025 and beyond. For gas, which accounts for 22% of TPES, domestic production, augmented by new technology and further exploration, will fall below domestic demand shortly before 2020. Coal accounts for slightly more than 27% of TPES. Coal is imported from various sources, primarily from Russia, South Africa and Colombia.

Given Denmark's self-sufficiency in oil production, it has no oil stockholding obligation to the IEA which requires that member countries have stocks equal to 90 days of their net imports. However, Denmark does have a stockholding obligation to the EU. Denmark has successfully maintained stocks of crude and oil products corresponding to 81 days of consumption, which is well above the stockholding obligation of 67.5 days of consumption set by the EU, and has also put release of stocks as a high priority in the Danish emergency response plan. The Danish emergency policy is quite consistent with all commitments requested by IEA emergency collective action plans. (More information on stocks and emergency response is available in Chapter 8.)

ENERGY FORECASTS

METHODOLOGY AND ASSUMPTIONS

A government projection of Denmark's energy consumption and energy supply until 2025 was published in June 2005. It is important to note that the projection was completed before the political agreement on increased efforts in energy conservation of 10 June 2005. The initiatives in this agreement are included neither in the baseline nor in the alternative scenarios and therefore these forecasts may likely project greater demand than will be the case if and when the new measures resulting from this agreement are introduced.

The alternative scenarios differ from the baseline scenario with regard to assumptions on both fuel prices and the prices of CO_2 carbon allowances. The table below shows the final prices of fuels and carbon allowances in 2025 at 2002 currency levels.

Table 3

Forecast Assumptions for Prices in 2025

	Low	*Baseline*	*High*
Crude oil, USD/bbl	20	28	50
Coal, USD/tonne	38	45	62
Natural gas, Europe, USD/1 000 Nm^3	113	159	283
CO_2 quota, EUR/tonne	7	20	40

Note that all prices are at 2002 levels.

Source: DEA.

RESULTS

The forecast predicts that under the baseline scenario, final energy demand will grow at 0.8% annually until 2025. The table below shows the final demand levels in 2025 under the baseline scenario and four alternative scenarios.

Table 4

Final Energy Demand in 2025

All demand figures given in PJ	*Energy Supply excl. Transport*			*Transport*	*Total*
	Electricity	*Other Energy*	*Subtotal*		
Baseline	156	351	507	243	750
High oil, high CO_2 allowance price	150	334	484	229	712
High oil, low CO_2 allowance price	151	336	488	229	716
Low oil, high CO_2 allowance price	156	354	510	249	759
Low oil, low CO_2 allowance price	159	359	517	249	766

Source: Danish Energy Authority.

ENERGY TAXATION

UPSTREAM TAXATION FOR OIL AND GAS PRODUCTION

Denmark has considerable oil and gas production in the North Sea. The upstream taxation on this production is described in Table 5.

Table 5

Upstream Oil Gas Taxation

	Sole Concession on 1 January 2004	*Licences Granted before 1 January 2004*	*Licences Granted after 1 January 2004*
Corporate income tax	30% Deductible from the hydrocarbon tax base	30% Deductible from the hydrocarbon tax base	30% Deductible from the hydrocarbon tax base
Hydrocarbon tax	52% Allowance of 5% over 6 years (a total of 30%) for investments	70% Allowance of 25% over 10 years (a total of 250%) for investments	52% Allowance of 5% over 6 years (a total of 30%) for investments
Royalty	None	2nd round licences pay as follows: 0 – 5k bbl/day: 2% 5k – 20k bbl/day: 8% 20k bbl/day - : 16% Deductible from income and hydrocarbon bases	None
Oil pipeline tariff/ compensatory fee	5% until 8 July 2012 then none	5%	5% until 8 July 2012 and then none
State participation	20% from 9 July 2012	20%	20%
Profit-sharing	From 1 January 2004 to 8 January 2012, 20% of profit before tax and before net interest payments	None	None

Source: "Oil and Gas Production in Denmark 2004," Danish Energy Authority.

DOWNSTREAM TAXATION

The current Danish tax policy on downstream energy products is a result of the country's Green Tax Shift. A Green Tax Package was introduced in 1996 with two objectives, namely *i)* taxes had to be high enough to have an effect on reduction of the CO_2 emissions, and *ii)* taxes must not affect the competitiveness of Danish companies and industry. A balance of the two conflicting objectives was reached by:

- Redirecting the additional tax revenue from the green taxes to trade and industry.
- Increasing the tax rates gradually, thus giving companies time to improve energy efficiency, switch to fuels with lower emissions, etc.
- Applying differential tax rates depending on the use of energy, thus lowering rates for energy-intensive production methods.

The Green Tax Package for trade and industry comprises three different taxes, namely a CO_2 tax, a SO_2 tax and an energy tax. The taxes for CO_2 and SO_2 were indirectly reintroduced to the Danish economy through: *i)* reduction of labour taxes, *ii)* subsidies to energy efficiency measures, and *iii)* special subsidies for small companies. In 2000, the last year for which figures were made available, these two taxes produced EUR 319 million for the government and EUR 367 million was given back to the economy in the three aforementioned ways. This resulted in a net loss of government coffers of EUR 48 million but does not include the energy taxes, which are substantially higher than the other two taxes and thus led to a substantial increase in government revenues coming from the entirety of the green tax shift.

Energy-related taxes in Denmark are generally more complicated than in other IEA countries. The government intends to modernise and simplify the tax system now that the CO_2 allowances have been introduced at the European Community level as of 1 January 2005. The government will propose that future energy- and CO_2 taxes be changed and has set up a committee to study the question.

CRITIQUE

Danish energy policy, and in particular the recent Energy Strategy 2025, is fully consistent with the IEA focus on the three E's of successful energy policy: Energy security, Economic growth and Environmental protection. Regarding energy security, the country's domestic oil and gas resources substantially boost the Danish position. These resources should continue to provide self-sufficiency in the near and medium term and Denmark's use of coal poses no problem from a security point of view given the stability of the international market. The electricity blackout of September 2003 originated in Sweden, not in Denmark, and, in any event, resulted from an extremely coincidental set of accidents rather than systematic weaknesses in the system. While care should be taken that outages in neighbouring countries do not penetrate the Danish system, Nordpool has proven itself to be highly resilient and this, combined with existing Danish generation oversupply and extensive international connections, contributes to a strong electricity security. The relatively high use of wind for electricity generation enhances security given that it is a domestic resource, but also poses intermittency challenges which, while being adeptly addressed, will never fully disappear (*i.e.* sometimes the wind does not blow). Biomass for heating and electricity generation is a significant contributor to security and is at levels substantially above the EU average.

The Danish policy objective of economic growth as it relates to the energy sector is twofold. In the first instance, the system for supplying energy to domestic consumers must be efficient. As a founding member of Nordpool,

Table 6

Energy, CO_2, and SO_2 Taxes on Various Energy Products (DKK/GJ)

Use	Energy Type	CO_2 2005	Energy 2002	Energy 2003	Energy 2005	Sulphur 2005	Total 2005
Transport	Diesel oil	6.77	76.95	76.95	77.70	0	84.48
	Light diesel oil	6.77	74.16	74.16	74.91	0	81.69
	Ultra light diesel oil	6.77	66.63	66.63	66.63	0	73.41
	Low sulphur diesel oil[4]	6.77	69.14	69.14	69.90	0	76.67
	Naptha	6.98	79.31	79.31	80.09	0	87.07
	Natural gas	4.95	70.52	70.52	71.46	0	76.67
	LPG (for cars)	5.80	69.65	69.65	70.29	0	76.09
	LPG	5.87	69.13	69.13	69.78	0	75.65
	Leaded petrol	6.70	137.60	137.60	136.99	0	143.68
	Unleaded petrol[1]	6.70	117.81	117.81	117.20	0	123.90
Other purposes	Gas oil 0.2% S	6.77	51.02	51.02	51.77	0.95	59.50
	Heavy fuel oil 1% S	7.08	50.68	50.68	51.46	4.92	63.47
	Heating tar 1% S	6.92	51.10	51.10	51.87	5.49	64.29
	Naphtha	6.98	52.59	52.59	53.36	0.00	60.34
	LPG	6.52	51.09	51.09	51.72	0.00	58.24
	Refinery gas	5.02	45.19	45.19	45.75	0.00	50.77
	Orimulsion[2]	0.07	51.00	52.00	51.00	1.95	53.06
	Hard coal, coke	0.08	53.77	53.77	54.69	6.11	61.88
	Petroleum coke	0.10	57.17	57.17	58.27	8.87	67.24
	Brown coal	0.09	56.28	56.28	57.21	8.85	67.65
	Natural gas	4.95	50.51	50.51	51.35	0	56.32
	Town gas	11.73	50.51	50.51	51.35	0	62.61
	Electricity (space heating)	25.00	139.17	139.17	141.94	n.a.	166.94
	Other electricity	25.00	157.22	157.22	160.00	n.a.	185.00
	Waste incinerated at CHP plants (waste tax)[3]	0	26.67	26.67	26.67	0.86	27.52
	Waste incinerated at heat CHP plants (waste tax)[3]	0	31.43	31.43	31.43	0.86	32.29
	Waste for deposition	0	0.00	0.00	0.00	0.00	0.00
	Heat supply from waste plants	0	12.90	12.90	12.90	0.00	12.90
	Straw	0	0.00	0.00	0.00	1.38	1.38
	Wood pellets (w. sulphur)	0	0.00	0.00	0.00	2.29	2.29
	Other wood pellets	0	0.00	0.00	0.00	0.57	0.57
	Wood	0	0.00	0.00	0.00	0.75	0.75

1. Less than 0.013 g lead per litre petrol.
2. More than 27% water. 90% sulphur cleaning assumed.
3. More than 10% of the production must be electricity.
4. Sulphur content max. 0.005%.

Source: Danish Energy Authority.

one of the most competitive and transparent electricity systems in the world, Denmark benefits from the competitive pressures that drive down the wholesale pool prices. It also benefits from being placed between the massive hydro-driven generation of Norway and Sweden, and the more baseload-focused continental system, which is primarily German. In this position, it can easily tap power from whichever of the two systems has the cheapest power or, alternatively, sell into either region if it is experiencing very high prices.

The second aspect of Danish economic growth as it relates to energy policy is the support and fostering of Danish industry. The wind industry benefited from government feed-in tariffs and other schemes to boost domestic wind power demand as well as from extensive research and development (R&D) funding in this area. Vestas, although currently undergoing some growing pains, is well positioned in a global wind power industry that now eclipses wind product demand in Denmark. Many Danish industries have had success in the international market, primarily wind power but also energy efficiency technologies. Such success creates jobs, taxes for government and national export revenues. At the same time, the rise of Danish energy technology has required government support, the cost of which is ultimately borne by the consumer. The costs and benefits of the schemes supporting renewables and energy efficiency technologies are explored more in the respective chapters. In addition, an Economic Council report (discussed at length in Chapter 6) cautions against using the success of a government-supported industry as justification for the underlying policy, given the costs involved and the possibility that the industry would have developed just as well without this support.

While market forces can and will improve Danish economic efficiency, and domestic energy policy can increase the international competitiveness of Danish energy companies, the taxes and other surcharges used in achieving government ends constitute a drain on economic growth. As a result of government-mandated taxes and surcharges, Danish consumers face some of the highest power prices in the IEA. Taxation is used to guide more environment-conscious demand behaviour (through higher prices), as a government revenue source and as a means to gather funds to support renewable energy and, to a lesser extent, energy efficiency operations favoured by the government. The specific advantages and disadvantages of this tax system are discussed below, but it is noted here that high taxes and surcharges undermine to a degree the benefits realised through an efficient energy system and greater technology exports.

Denmark is also strong in the third "E" of sound energy policy, environmental protection. In the Danish context, the focus is heavily on climate change. The large increase in renewable energies' share of TPES over the last decade has decreased emissions and created the framework for further emissions reductions in the future. The currently low energy intensity also reduces emissions and the government's plans to increase savings from 2006 to 2013 will further help in this regard. (The topic of climate change and emissions along with Denmark's challenging Kyoto target will be addressed further in Chapter 4.)

The last in-depth review observed that environmental protection affected most aspects of Danish energy policy and came close to being an overriding objective throughout the 1990s. For this reason, the previous government provided generous support for energy conservation and substitution of renewables for fossil energy sources. Moreover, largely to serve as an example to other countries, the previous government put particular emphasis on domestic environmental measures even though they were probably more costly than international alternatives. However, as laid out in the Energy Strategy 2025, the government has put more emphasis on market forces as a primary driver in order to achieve its energy policy goals as cost-effectively as possible. With this in mind, the government has been reducing subsidies for promoting energy efficiency and renewables. The change of renewable promotion policies from fixed feed-in tariff to premium added on market price is one example. The absence of any fixed targets on shares of energy sources in the future is another example of the government's determination to rely on market forces. The government's position to fully utilise Kyoto's flexible mechanisms as long as their costs are lower than domestic policies and measures also reflects its attentiveness to cost-effectiveness. This is a commendable development in line with the recommendation of the last in-depth review suggesting the review of the existing policy measures with a view to developing more cost-effective policies and more priority on market-oriented approaches. While the level of environmental protection as it relates to energy is ultimately decided by the Danish voters, the shift towards more market-oriented and international policies will allow the country to achieve such goals at lower cost.

The consolidation of the Danish energy supply industry in the form of the merger between DONG, Elsam and ENERGI E2 raises questions of excessive market power. The new company will have the following:

- A dominant position in electricity generation where it will hold 58% of net combustible domestic capacity, although counting import capacity as competing suppliers, this figure falls to 39%.
- Ownership of major electricity distribution assets.
- A minor share of oil and gas production from the Danish North Sea.
- Ownership and operational control of gas storage.
- Ownership and operational control of most of the offshore gas pipeline network.
- Ownership of gas distribution facilities.

There are three elements of these mergers that could give rise to market power and thus warrant the attention of the government and the regulator. The first is horizontal market power in the form of excessive market share or control of too many price-setting generators. While DONG will have a majority of Danish generation, Vattenfall's acquisition of 24% of the Elsam and ENERGI E2's generating assets and the substantial interconnections with Norway, Sweden and Germany will provide some check on any attempts to raise the wholesale price of power above competitive levels. The type of uncompetitive pricing that the Competition Authority noted about Elsam could be less likely under the proposed industry paradigm given *i)* the presence of another generator, such as Vattenfall, in the two Danish systems, and *ii)* the planned 600-MW East-West interconnector. Nevertheless, even with the assets divested to Vattenfall and the import capacity, DONG will still have 39% of the generation market share in Denmark and this share will be markedly higher in eastern Denmark where it has a larger presence. Such market shares are still sufficient to exert market power on the wholesale prices for a significant portion of the time.

The second element of DONG's market power concerns its vertical integration, principally its ownership of many of the major electricity distribution companies and the effects this could have on new entry. While the right of customers to switch supplier is firmly established and the merger will in no way undermine this right, new entry by suppliers could nevertheless be deterred. If a new electricity supplier were to enter the market and try to sell electricity to Danish consumers, it would have to both compete against DONG as a generation company and be required to use DONG distribution assets under equal access laws. There are numerous ways for a distribution company to show favouritism to certain suppliers, especially incumbents, that are difficult for the regulator to detect or to stop. In addition, the Danish State now owns both DONG and the high-voltage transmission company Energinet.dk. However, collusive behaviour by Energinet.dk that favours DONG is unlikely, owing to the governing arrangements that keep Eneginet.dk separate from state interests. For example, Energinet.dk's capital is kept separately from the State and it is not allowed to distribute profits or equity through dividend to the State. Nevertheless, the regulator should continue to ensure that Energinet.dk operations, including decisions on network additions, treat all competing suppliers equally.

The third way in which the merger gives DONG market power is through cross-fuel integration with strong operations in oil, gas and electricity. One of the primary competitive options for new entrant electricity, through greenfield plants or acquisitions, is via gas-fired generation. While supplier choice and equal access rules for all transport and distribution pipelines should theoretically place all competitors on a level playing field, even the suggestion of favouritism would deter new entrants and thus stifle competition. The European Commission's requirement that DONG institute a gas release programme and sell the larger of its two gas storage facilities are important steps to mitigate this threat of market power.

With its horizontal, vertical and cross-fuel integration, DONG will be a substantial competitor for the large multinational energy companies. Certainly, a desire to make the merged company a sustainable competitor for the large continental players is one motivation for the merger. Another may be the government's plan to offer shares in DONG through an initial public offering (IPO) in the coming years. While the government will maintain a majority position in DONG, up to 49% of the company will be offered as shares on the market. A company with leading positions in all facets of the country's electricity and gas sectors will likely be more attractive, and thus raise more money through the IPO, than would the combined value of a number of smaller, more disparate companies that compete with one another. Simultaneously, the merger will dilute the government's share through the ownership participation of Elsam and ENERGI E2 shareholders with whom they will have to share any IPO revenues. The Danish Economic Council has advised that the merger be "avoided" on competitiveness grounds although it seems that the merger will nevertheless proceed. All steps should be taken to ensure that the depth and breadth of the new company does not impede competition in the electricity and gas markets. The European Commission's conditions for merger approval (*i.e.* a gas release programme and divesture of the larger gas storage facility) should be met as soon as possible.

Denmark has been active in green tax reform, shifting away from income and corporate taxes to taxes on energy, resource use and polluting activities. The resulting targeted taxation is one of the reasons why Danish energy demand remains well below that of comparable IEA countries. However, the review team is not fully convinced that the current complicated tax system is always effective in meeting the energy goals in the longer term. There are several areas of inconsistency that undermine the effective attainment of policy goals. First, energy taxes on electricity are substantially higher than those on fossil fuels or district heating. This discrepancy is not justified by the relative socio-economic costs of each energy source and thus leads to an inefficient allocation of resources. The second inconsistency involves household energy taxes that are considerably higher than those on industry and a good portion of the commercial sector. While such differentials are common in IEA member countries given international competitiveness concerns, they appear more pronounced in Denmark. In addition, a number of commercial service industries that do not face international competition nevertheless still enjoy lower tax rates. High taxes on electricity prices for households will also likely reduce responsiveness to market signals of changing energy prices potentially leading to uneconomic allocation and use of energy. Another problematic area is the simultaneous use of both a CO_2 tax borne by end-users and the EU-ETS system where producers/emitters pass through the (opportunity) cost of allowances. Thus, there is a double price signal for reduction of CO_2. Finally, the tax regulations discourage the use of electricity for district heating, which may be an attractive option when many of the must-run renewable energy plants are generating, which results in electricity prices decreasing substantially or approaching zero.

With the introduction of the EU-ETS, the government has set up a committee for modernising and simplifying the energy and CO_2 tax system. This is a commendable development. Taking this opportunity, the government should also broadly explore how energy and environmental taxation could be better targeted in order to allow stronger price signals to achieve energy policy goals.

RECOMMENDATIONS

The government of Denmark should:

- *Review energy and environmental taxation as a whole to establish more targeted and efficient price signals to achieve energy policy objectives, such as security of supply, environmental protection and the economic production and consumption of energy.*
- *Monitor the energy market carefully in order to take concrete steps to minimise the implications that the horizontal, vertical and cross-fuel integration in the electricity and gas markets resulting from the merger activity, particularly the foreseen DONG merger, will have on competition in the Danish energy markets.*

DOMESTIC GHG EMISSIONS PROFILE

In 2003, Denmark emitted 56.2 million tonnes of CO_2 ($MtCO_2$) from fuel combustion.[11] This represented a 9.8% increase from 2002 and an 11.0% increase from 1990. CO_2 emissions from fuel combustion are highly variable in Denmark owing to substantial changes in imports and exports of electricity from year to year. The level of electricity exports/imports is largely influenced by the rainfall in Norway and Sweden. Substantial rainfall in these countries fills their hydroelectric dams, allowing them to export power to Denmark very cheaply, while lower-than--average rainfall requires them to import electricity from Denmark where coal-based power plants generate the needed electricity. Consequently, Danish CO_2 emissions from fuel combustion have changed several times by more than 20% a year, as in 1996 when they rose to 22.6%.

In 2003, oil and coal were the dominant emission-producing fuels. Oil accounted for 39.8% of all emissions from fuel combustion while coal accounted for 39.3%. Natural gas accounted for 19.3% and other fuels for 1.6%. Since 1990, natural gas's share of total emissions has increased substantially, going from 8.2% to a high of 21.0% in 2002. The variability of emissions owing to large changes in the export/import of electricity is reflected in coal emissions, which increased by 37% in 1996 and decreased by 26% in 1997.

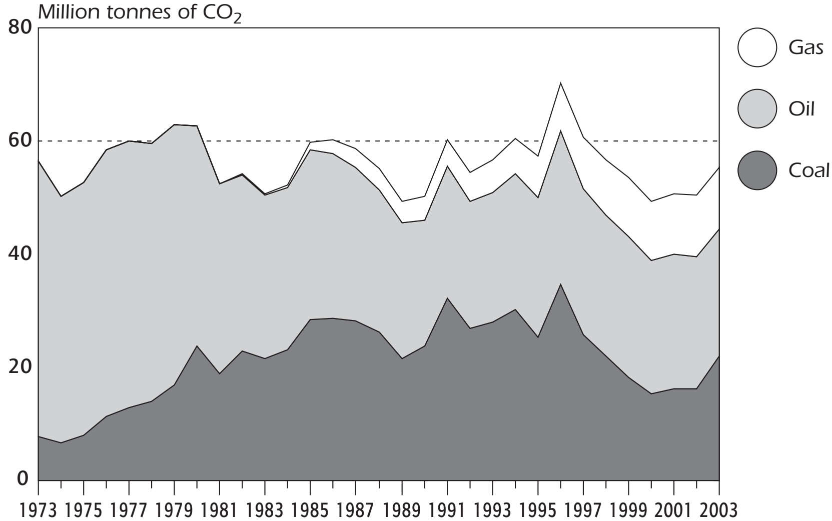
On a sectoral basis, electricity and heat production[12] accounts for the largest share of CO_2 emissions, in 2003 equal to 56% of the total. Transport was the second most important sector with 23% of the total, followed by industry with 9%, residential with 7% and other (including commercial, public buildings and agriculture) with 5%.

In 2003, Denmark emitted 10.43 tCO_2 per capita compared to an average in the OECD countries of 11.08 tCO_2 per capita. Danish emissions of CO_2 per USD (2000 purchasing power parity) was 0.36, or 20% lower than the figure for the OECD in total.

11. All figures come from IEA statistics unless otherwise noted. The slightly differing Danish government figures are featured in the following section.
12. Includes other energy industries, such as oil and gas production which is a small share of the total.

Figure 6

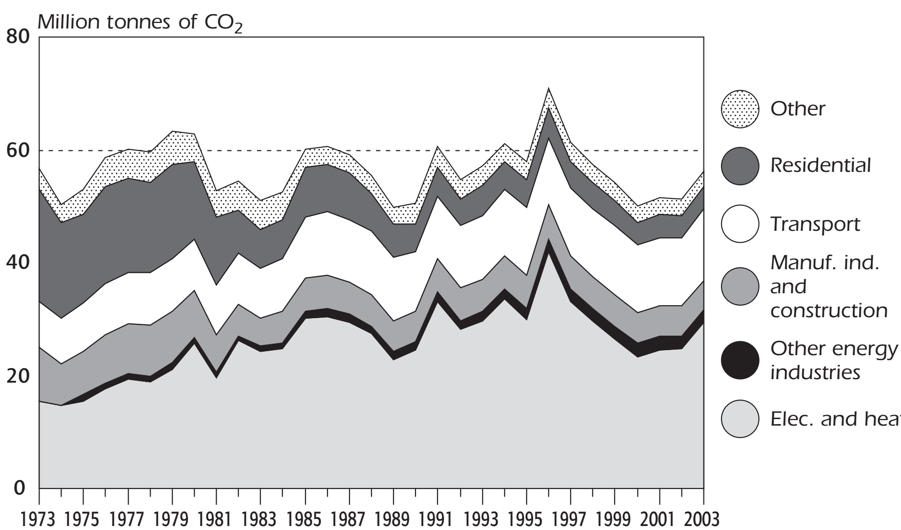
CO_2 Emissions by Fuel*, 1973 to 2003



* estimated using the IPCC Sectoral Approach.
Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2005.

Figure 7

CO^2 Emissions by Sector*, 1973 to 2003



* estimated using the IPCC Sectoral Approach.
Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2005.

DANISH GOVERNMENT DATA AND PROJECTIONS

In November 2003, the Danish Environmental Protection Agency of the Ministry of Environment published "Denmark's Greenhouse Gas Inventories 1990-2001 and Projections 2002-2017". This report provides historic data for all six greenhouse gases (GHG) and projection through 2017, including the crucial Kyoto window of 2008-2012. According to this projection, the Danish emissions would be some 25.5 $MtCO_2$-equivalent above target annually during the Kyoto commitment period.

Table 7

Historical and Projected GHG Emissions ($MtCO_2$)

Sector/Gas	*1990*	*2001*	*Change from 1990*	*2008-2012*	*Change from 1990*	*2013-2017*	*Change from 1990*
Energy	26.8	27.8	3.7%	36.9	37.7%	34.9	30.2%
CO_2	*26.4*	*27.0*	*2.3%*	*36.0*	*36.4%*	*34.0*	*28.8%*
Other GHG	*0.4*	*0.8*	*100.0%*	*1.0*	*150.0%*	*0.8*	*100.0%*
Transport	10.7	12.6	17.8%	14.6	36.4%	15.1	41.1%
CO_2	*10.5*	*12.2*	*16.2%*	*13.9*	*32.4%*	*14.4*	*37.1%*
Other GHG	*0.2*	*0.5*	*150.0%*	*0.7*	*250.0%*	*0.7*	*250.0%*
Agriculture	16.8	14.1	−16.1%	13.1	−22.0%	13.0	−22.6%
CO_2	*2.4*	*2.5*	*4.2%*	*2.3*	*-4.2%*	*2.2*	*−8.3%*
Other GHG	*14.4*	*11.7*	*−18.8%*	*10.8*	*−25.0%*	*10.8*	*−25.0%*
Industry	8.6	9.1	5.8%	10.4	20.9%	10.8	25.6%
CO_2	*8.1*	*8.3*	*2.5%*	*9.6*	*18.5%*	*10.1*	*24.7%*
Other GHG	*0.5*	*0.9*	*80.0%*	*0.8*	*60.0%*	*0.7*	*40.0%*
Households	5.2	4.4	−15.4%	4.0	−23.1%	3.9	−25.0%
CO_2	*5.1*	*4.3*	*−15.7%*	*3.8*	*−25.5%*	*3.7*	*−27.5%*
Other GHG	*0.1*	*0.2*	*100.0%*	*0.2*	*100.0%*	*0.2*	*100.0%*
Waste	1.3	1.2	−7.7%	0.9	−30.8%	0.7	−46.2%
Methane	*1.3*	*1.2*	*−7.7%*	*0.9*	*−30.8%*	*0.7*	*−46.2%*
All Sectors	69.5	69.3	−0.3%	80.1	15.3%	78.3	12.7%
CO_2	*52.7*	*54.3*	*3.0%*	*65.6*	*24.5%*	*64.4*	*22.2%*
Other GHG	*16.8*	*15.0*	*−10.7%*	*14.4*	*−14.3%*	*13.9*	*−17.3%*
Kyoto Obligation				***54.9***	***−21.1%***		

1. Sums may not add up exactly owing to rounding.

Source: "Denmark's Greenhouse Gas Inventories 1990-2001 and Projections 2002-2017." From the Danish Environmental Protection Agency (November 2003).

BASE YEAR QUESTION

Denmark's Kyoto commitment under the EU Burden-Sharing Agreement is a 21% reduction in GHG emissions from 1990 levels by the years 2008-2012.

However, there has been considerable debate over the appropriate figure to use for the base year. Emissions vary considerably year-to-year in Denmark depending on hydroelectric production in Norway and Sweden. Denmark imported large amounts of electricity in 1990 and consequently domestic generators ran less than normal and actual CO_2 emissions were less than in an average year. The government estimates that the 1990 emissions were approximately 70 $MtCO_2$-eq while the emissions adjusted for imports of electricity would have been approximately 76 $MtCO_2$-eq. In relation to Denmark's reduction commitment of 21%, the government argues that this 6 Mt difference in the 1990 base year would mean a difference of approximately 5 Mt per year for the period 2008-2012.

Denmark has raised this base year issue with the European Commission (EC), which has been reluctant to grant the country any decrease in its reduction commitment. However, at the EU Council meeting in connection with the ratification of the Kyoto Protocol on 4 March 2002, Denmark did achieve agreement on a political declaration. According to the declaration, Denmark's claim for adjusted electricity imports for the 1990 base year will be considered when individual member state reductions in tonnes are finally determined in 2006. If the EC does finally agree to the Danish request on the base year issue, Denmark's expected reduction would decrease from 25 $MtCO_2$-eq to 20 $MtCO_2$-eq. When preparing its first National Allocation Plan (NAP) for the first phase of the EU-ETS, the government assumed that the EC would accept its interpretation of the base year question.

NATIONAL CLIMATE POLICY

EMISSIONS REDUCTION OPTIONS

In February 2003, the government released its "Proposal for a Climate Strategy for Denmark". The document looks at reduction possibilities through both domestic and international actions. The available domestic options outlined by the report are shown in Table 8.

In addition to the domestic options included in the climate strategy, the document also considers international mechanisms. Based on preliminary estimates, it states that the price of quotas and project credits from Joint Implementation (JI) and Clean Development Mechanism (CDM) projects is unlikely to exceed DKK 100 per tCO_2 (EUR 13.42) for the period 2008-2012. The strategy expected the most likely price level to be between DKK 40 and DKK 60 (EUR 5.37 and EUR 8.05) per tCO_2 although this forecast is described as being considerably uncertain. Initially, the government earmarked DKK 130 million in the 2003 Finance Act to establish emissions reduction projects in Central and Eastern Europe. Investment in CDM projects in developing countries also provides a possibility for reduction credits.

Table 8

Domestic Initiatives for Emission Reduction, 2008-2012

(in order of ascending cost)

(All reduction potentials are approximate)	*Annual Reduction Potential, $MtCO_2$*	*Cumulative Reduction, $MtCO_2$*	*Socio-economic Cost, DKK/tCO_2[2]*
Window standards	0.2	0.2	–550
Oil and gas boiler standards	0.1	0.3	–500
Flare gas recovery	0.3	0.6	–330
Heat pumps - replace decentralised combined heat and power	1.5	2.1	–60
Heat pumps - replace oil-fired district heating	0.8	2.9	10
Reduction of electricity production	5.0	7.9	20-60
Establishment of biogas central plants	0.5	8.4	40
Conversion from coal to natural gas	3.0	11.4	150
Additional methane collection from landfills	0.1	11.5	180
Storage in the underground on land or in oilfields	–[1]	–[1]	160-310
Heat pumps - replace centralised combined heat and power	5.0	16.5	250
Offshore wind parks	2.0	18.5	270
Further conversions from coal to natural gas	5.0	23.5	280
Conversion to biomass plants	2.5	26	290
Changed feeding of dairy stock	0.4	26.4	590
Use of biofuels	0.5	26.9	740
Tax per km on cars	0.5	27.4	1 140
Increased fuel taxes	0.6	28	1 430

1. Could cover all of Denmark's reduction commitment.

2. Calculations of unit costs reflect the costs incurred in achieving reduction levels that are less than the potential reduction listed for each initiative. It is possible that achieving the full potential would result in higher per unit costs.

Source: "Proposal for a Climate Strategy for Denmark," Danish government, February 2003.

LEAST-COST REDUCTION STRATEGY

The climate strategy recognises that the most cost-effective strategy would include all domestic measures that have lesser costs than the price of credits on the international flexible mechanism market. The strategy estimates that if this approach is used, the costs to Denmark of meeting its Kyoto commitment would be between DKK 1 billion and DKK 2 billion per year for each of the five years during the 2008-2012 commitment period. This assumes the most likely price of reduction credits is within a range of DKK 40-60 per tCO_2 while being highly unlikely to exceed DKK 100 per tCO_2. It also assumes that the government will prevail in its base year argument with the EC and only have required emissions reductions of 20 $MtCO_2$ and not 25 $MtCO_2$. The accumulated annual emissions reduction of all identified domestic options with an implied socio-economic cost of less than DKK 60 per tonne would be around 8.5 $MtCO_2$. Thus, if the country needs only 20 Mt of reduction, 60% of these would come from international mechanisms. If the country needs 25 Mt, two-thirds would come from international mechanisms.

Alternatively, the document estimates that if only domestic measures are used without any flexible mechanisms, the cost would be on the order of DKK 4 billion per year from 2008 to 2012 if the emissions target was 20 $MtCO_2$. If the emissions target was 25 $MtCO_2$, costs for Kyoto compliance would be closer to DKK 5 billion per year.

In discussing the point at which domestic measures would give way to international flexible mechanisms, the strategy states that "in order to ensure cohesion in reduction initiatives across sectors, the government has set an indicator of DKK 120 per tCO_2 to be used as a basis for implementing domestic initiatives outside the area covered by the EU quota system." In other words, domestic measures are considered cost-effective and worthwhile if their cost does not exceed EUR 16 per tCO_2.

EU EMISSIONS TRADING SCHEME

The European Union has launched an emissions trading scheme (EU-ETS) whereby participating installations can trade emissions allowances among themselves at a price determined by the market. The EU allowances (EUAs) give the holder the right to emit 1 tCO_2. Power plants, industrial facilities and others covered by the scheme are first subject to a three-year commitment period (2005-2007), while the second phase will coincide with the five years of the Kyoto Protocol's commitment period, 2008-2012. Member States are responsible for drawing up their own National Allocation Plans (NAPs), which must specify the amount and method of the EUA allocation. The NAPs are submitted to the EC, which can either accept them or request changes. Denmark submitted its first NAP in March 2004 for the first phase and is expected to submit its second NAP for the 2008-2012 window in 2006. The first NAP was accepted by the EC without comments or requests for changes, one of the few receiving this treatment. The key figures of the NAP for the first period are included in Table 9.

Table 9

Key Figures for the Danish NAP, 2005-2007

	Number of Installations	*2003 Emissions, $MtCo_2$*	*Projected Emissions, $MtCO_2$*	*Allowance Allocation, $MtCO_2$*	*Change form Projection*
ETS-covered sector, total	357	36.6	39.3	33.5	14.8%
Electricity and heat production	*234*	*28.1*	*29.4*	*21.7*	*26.2%*
Other ETS-covered industries	*123*	*8.5*	*9.9*	*9.2*	*7.1%*
Auction				1.7	
New entrants				1.0	
Non-ETS sectors		37.8	39.0	39.0	0.0%
Entire country		74.4	78.3	72.5	7.4%
Kyoto target[1], $MtCO_2$			54.9		

1. Assumes Denmark is not allowed to alter its base year emissions to compensate for extraordinary electricity imports for that year.
Source: Danish National Allocation Plan from the Ministry of Environment (March 2004).

The NAP also includes a table similar to the one in the climate strategy, which lists all the domestic options for reduction of emissions. The accompanying analysis concludes that no major, inexpensive reduction potentials have been identified in the sectors and areas that have already been subjected to high taxes or have received significant subsidies. These areas correspond to those not covered by the EU-ETS. On the other hand, a number of relatively inexpensive emissions reductions were identified in the electricity production and offshore sectors, such as flaring, which are covered by the EU-ETS. The NAP concludes that significant emissions reductions can be found in the areas covered by the EU-ETS, justifying the relatively stringent reductions from projections, as shown in Table 9. The NAP also reiterates the climate strategy's principle that all domestic measures expected to have an effective socio-economic cost of less than DKK 120 per tCO_2-eq should be implemented.

USE OF FLEXIBLE MECHANISMS

A total of DKK 335 million has been allocated by the government to purchase JI and CDM credits. An additional allocation of DKK 200 million per year is budgeted for the years 2005, 2006 and 2007 for a total allocation of DKK 935 million during the 2003-2007 period. With an estimated average price of DKK 50 (EUR 6.71) per tCO_2, this allocation corresponds to a total purchase of 18.7 Mt for the 2008-2012 period or 3.7 Mt annually during this period. In 2003, contracts were entered into with a value of approximately DKK 38 million.

CRITIQUE

Denmark's record on the environmental aspects of energy production and use has been very good. In addition to being a leader in renewable energy and energy efficiency (see respective chapters), its CO_2 emissions per unit of GDP are 20% below the average for all OECD countries. This is particularly impressive for a country with no nuclear power and only very limited hydroelectric generation.

The country faces a very challenging emissions target to meet its Kyoto commitment through the EU burden-sharing system. Denmark's initial reduction target is one of the most aggressive and there are no extenuating circumstances that would help it meet its target, as is the case in Germany with its re-unification and the UK with its "dash for gas". Of all the Annex I countries, only Luxembourg has a more stringent target (minus 28%). In addition, Denmark has already implemented many emissions reduction measures, such as renewable energy and energy taxes, which are now helping it fulfil its Kyoto commitments. Thus, with many of the low-hanging fruit already claimed, the additional cuts might be more difficult and expensive to achieve.

The unusually high level of electricity imports during the base year of 1990 further disadvantages Denmark. The extent of fluctuations in Danish electricity imports/exports must be one of the highest in Europe and, as a result, any climate change programme carries a high degree of uncertainty. Denmark's efforts in the EU Commission to alter its 1990 base year figure have not yet been successful. While the country may receive some relief from the EC, it seems likely that the final emissions base will be closer to actual 1990 emissions than to the modified emissions base of 5 $MtCO_2$ higher. If so, the target for the years 2008-2012 will be around 55 $MtCO_2$ and meeting this target will require a more than 30% reduction in emissions from the projected emissions level of around 80 $MtCO_2$.

Given Denmark's challenging reduction target and the degree of emissions reduction measures already introduced, it was prudent to employ such a high degree of international mechanisms in the climate change strategy. The use of flexible mechanisms to deliver up to two-thirds of the country's needed reduction represents one of the highest figures in the EU. This reflects the current government's focus on cost-effectiveness and shows a clear contrast with the previous in-depth review where the IEA recommended further consideration of the Kyoto mechanisms. The problem is that this strategy is vulnerable to changes in the international price of carbon. The current price of carbon in the EU-ETS has been substantially higher than was foreseen in the climate change strategy or the NAP and is very volatile. While the proposed climate strategy states that the most likely price range will be between DKK 40 to DKK 60 (EUR 5.37 to EUR 8.05) per tCO_2 and unlikely to exceed 100 DKK (EUR 13.42), the actual price has been well above that. In late January 2006, the price for EU allowances was more than EUR 26 (DKK 194). It is not certain that such price levels will be observed in JI and CDM credit markets, let alone in quota trading among Kyoto Parties, but they do represent a jump from earlier expectations. Uncertainty also comes from the carbon market's ability to deliver the needed JI and CDM credits during the Protocol's first commitment period – and whether reliance on other countries' quota surpluses will be politically acceptable as a fall-back strategy.

These problems with both the price and availability of international emissions reduction credits are prompting the government to adjust its strategy. Under current conditions, the most cost-effective mix of domestic and international reductions will now include more domestic measures than was deemed best when the strategy was originally envisioned in 2003. Denmark's second NAP will reflect this shift and will almost certainly increase the cost estimate of meeting the Kyoto Protocol. If the cost goes to the upper end of estimates, say DKK 4 billion per year, this will imply that the annual cost is DKK 755 (EUR 101) per person, or approximately 0.3% of GDP.

In addition to a shift towards more domestic measures to reduce emissions, the climate policy should also reflect the price risk inherent in the international carbon market, the variability of which is greater than that of domestic measures. While international mechanisms can and should play a role in meeting emissions targets, Denmark has already learned that assumptions about future international emissions markets can be well off the mark. The government must look at the trade-off between safer and perhaps more expensive domestic emission-cutting measures and the possibly lower cost, but higher risk, of international emissions reduction credits. The government is advised to consider the benefits of domestic measures for the period beyond the Kyoto window. Purchasing allowances or credits for the Kyoto window may be less costly in certain cases but their benefits expire in the year they are used. Domestic measures will likely continue to give emissions reduction benefits after the end of the target window.

In addition, the climate policy must be clear on exactly which measures are to be implemented. The previous strategy had an excellent list of options to reduce emissions, along with the crucial data of reduction potential and cost per tonne of CO_2. However, it never clearly stated which of the domestic measures were to be used and what percentage of required emissions reduction would come from international sources. There was also confusion over which price of international credits would be used in calculating whether to proceed with domestic programmes. A range of "likely" prices was given (DKK 40 to DKK 60 per tCO_2) along with an upper limit of DKK 100 per tCO_2 as well as a figure of DKK 120 per tCO_2 intended to be used in calculating the relative worth of domestic measures. There are less than two years to the start of the Kyoto commitment and Denmark cannot afford any uncertainty. Domestic measures that may contribute to meeting the Kyoto target must be implemented as a matter of urgency.

The EU-ETS has the potential to provide an excellent means for Denmark to reduce emissions at the lowest cost. The government rightly submitted a NAP that included a substantial reduction in emissions (15%, compared to business-as-usual) within the covered areas in the 2005-2007 window. In order not to hamper the competitiveness of Danish industry, a substantially greater percentage reduction was placed on electricity and heat production, which the government considers largely insulated from international competition, rather than on other sectors, which face substantial international competition. The planned privatisation of DONG (with the recently acquired electricity assets) could influence the allocation. Clearly, if the DONG assets are allocated more allowances, their value in the sale would rise and the Danish Treasury would receive more money. This must be avoided because more allocations to DONG plants will mean greater reduction to be achieved elsewhere, perhaps at higher cost.

Both the electricity sector and the oil and gas sector have seen healthy profits in the last few years. The electricity companies have benefited from the rising electricity prices, against the backdrop of increasing consolidation, accusations of market power and the pass-through of the price of free CO_2 allowances to the wholesale electricity price, and substantial payments they continue to receive under the name of "security of supply" and funded by the consumers through the Public Service Obligations. Oil and gas companies have benefited from the historic rise in the price of these commodities. Both are in a position to cut emissions from their operations and would currently have the financial resources to bear their share of the burden.

While the EU-ETS does provide an efficient means of lowering emissions, it should not be the sole vehicle for meeting the Kyoto target. In the first NAP, installations covered by the EU-ETS accounted for about 50% of the projected emissions. While they were asked to reduce emissions by 15%, sectors not covered by the EU-ETS were not expected to make any reductions from projected emissions levels. While the reasoning included in the NAP – that reductions from these sectors are more costly than the covered sectors – needs to be taken into account, it is unlikely that no potential for cost-effective emissions reduction exists in a full 50% of the emission sources. A more balanced allocation of the burden between covered and non-covered sectors will likely lower the overall cost of meeting the Kyoto target.

The EU-ETS can overlap with numerous existing energy-related measures. For example, the Danish CO_2 tax has much the same effect as the EU-ETS scheme. Care should be taken that emitting installations are not burdened by both systems or that the two systems conflict with each other. At the same time, certain industries are largely shielded from the energy taxes and therefore the EU-ETS would not represent a double burden. The EU-ETS has provided a financial boon for some of the covered installations, especially in the electricity sector. Given that allowances are allocated for free but are included in the product price because they represent an opportunity price, certain industries have experienced rising prices for their products with no corresponding increase in costs. These so-called "windfall profits" are seen most prominently in the electricity industry. In addition to ensuring that covered installations are not burdened with both the EU-ETS and domestic taxation, the government should also ensure that these emitters do not benefit from the EU-ETS at the expense of consumers.

RECOMMENDATIONS

The government of Denmark should:

- *Take further account of the compliance risk of an insufficient supply of JI and CDM credits being available within the envisaged price range as well as the availability and price of allowances under the EU-ETS.*
- *Address the competitive implications of the emissions reduction obligations of sectors included under the EU-ETS.*
- *Investigate further domestic cost-effective measures to reduce emissions in sectors not covered by the EU-ETS.*
- *Further investigate solutions to the possible double-burdening of CO_2 emissions by EU-ETS and Danish CO_2 and energy taxes.*
- *Address the windfall profit issue for covered installations that are benefiting from free receipt of EUAs through the EU-ETS.*

ENERGY TRENDS AND INTENSITY MEASURES

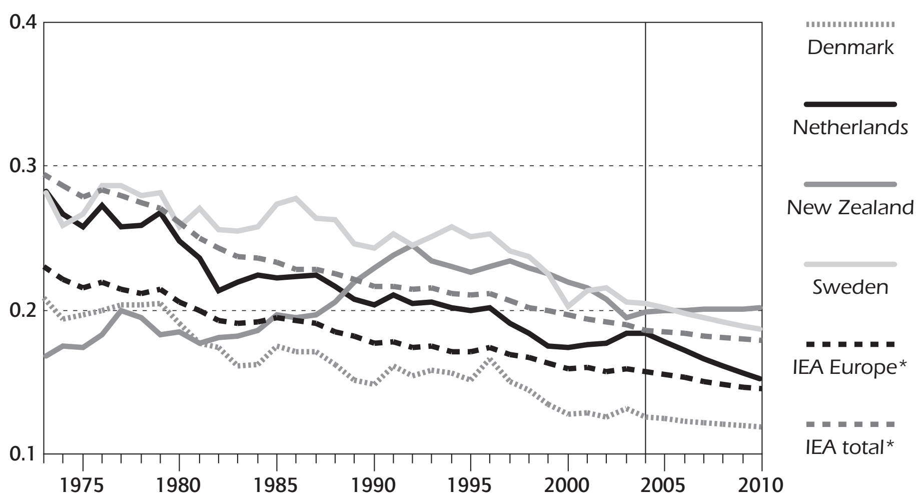
Both total primary energy supply (TPES) and total final consumption (TFC) have been stable in Denmark over the last 30 years. TPES in 2003 is only 4.6% higher than in 1973, even though the (simple) average of TPES growth for all OECD countries over the same period is 97.5%. TFC in Denmark has actually fallen by 6% from 1973 to 2003 while TFC has grown by more than 32% in the OECD as a whole. Denmark's GDP grew over the same period by 67%.

In 2003, Danish aggregate energy intensity, as measured by a ratio of the country's TPES in tonnes of oil equivalent (toe) over its national gross domestic product (in thousands of 2000 USD), was 0.127 toe per USD 1 000. This was the third-lowest efficiency level in the IEA (behind Japan and Switzerland) and 35% below the IEA average. It is the lowest level among all EU countries. Figure 8 compares Danish national energy intensity to the IEA average as well as to selected countries.

Figure 8

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

(toe per thousand USD at 2000 prices and purchasing power parities)



* excluding Luxembourg and Norway throughout the series, as forecast data are not available for these countries.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2005; *National Accounts of OECD Countries*, OECD Paris, 2005 and country submissions.

Such snapshot aggregate measures of energy intensity, however, can lack statistical integrity. For example, the results depend to a great extent on the choice of a base year for the GDP figures and the means chosen to get national GDPs portrayed in the same units for all countries. In addition, the numbers are heavily influenced by economic structure and geography. A sounder and more revealing analysis can be gained from observing the progression of these figures over time. From 1973 to 2003, Danish TPES per unit of GDP fell by 37%. Over the same period, this intensity ratio fell by 19% for the OECD as a whole. Shorter-term measures also show Denmark's reductions to be more pronounced than the OECD as a whole. Table 10 looks at the fall in energy intensity over a range of time periods for Denmark, the OECD as a whole and three other countries with similar profiles.

Table 10

Decrease in Energy Intensity Measured as TPES/GDP

(toe per thousand 2000 USD)

Country	*1973 to 2003*	*1983 to 2003*	*1993 to 2003*
Denmark	*36.6%*	*18.0%*	*16.4%*
France	23.2%	5.3%	8.2%
Sweden	26.8%	19.0%	17.7%
Netherlands	35.0%	16.1%	10.9%
OECD total[1]	19.0%	13.1%	12.3%

1. Simple average of percentage improvements of all countries.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2005.

NEW ENERGY EFFICIENCY TARGETS

POLITICAL AGREEMENT

Despite an already good record for national energy intensity, the government has made improved energy efficiency a major part of its new energy strategy. On 10 June 2005, Denmark's principal political parties agreed on future energy-saving initiatives, stating that there is a need for ambitious and dynamic energy-saving efforts. The agreement is therefore a central element in an energy strategy which takes the long-term challenge very seriously. Politically, there is a broad consensus on that matter. The parties agreed that overall energy consumption, exclusive of transport, must be reduced. Increased efforts will be made to achieve specific documentable energy savings corresponding to an annual average of 7.5 PJ per year (equal to 1,7 % of final energy consumption excluding transport) from the baseline scenario during the 2006-2013 period. The savings objective set with the agreement is approximately three times higher than the current actual savings. This political statement follows a draft action plan published by the government in December 2004. In this plan, the government explained measures that could be used to achieve an average annual energy saving of 1.0%, considerably less than was finally decided upon politically. If the macroeconomic assumptions for the energy consumption forecasts prove to be valid, the result would be a total energy consumption (exclusive of transport) of 430 PJ in 2013 compared to 435 PJ in 2003.

The theoretical foundations for this energy efficiency push come from the following three areas:

- *Growth and competitiveness:* The government believes that greater energy efficiency in both Danish industry and society in general will bring increased international competitiveness and more growth.
- *Security of supply:* Lower demand is the surest way to increase security of supply, especially as domestic and European resources become scarcer.
- *Environmental protection and CO_2 reduction:* Energy efficiency offers a cost-effective domestic means of reducing CO_2 emissions and helping Denmark meet its challenging Kyoto target.

The basic principles to be used in determining which tools will be used to reach the stated target are as follows:

- Cost-efficiency.
- Market-based approaches with no subsidy schemes.
- Focus on realisation of profitable savings.

PLAN OF ACTION

In September 2005, the government published the final "Action Plan for Renewed Energy Conservation Efforts" intended as a blue-print of measures which could achieve the 1.7% annual energy savings target specified by the political agreement. This was essentially an amendment of the Action Plan from the previous December. Like the political agreement, the Action Plan excludes treatment of energy use in the transport sector.

The Action Plan calls for energy savings in the following three main areas:

Savings through distribution companies

A significant part of the increased energy savings will be achieved through savings in the electricity, natural gas, district heating (DH) and oil network and distribution companies. This must occur within current economic frameworks, meaning that tariffs will not be increased to cover the costs of new energy efficiency measures. Monitoring will be introduced and companies will have a large degree of choice when it comes to the methods adopted. They will be able to work in any industry, field or jurisdiction they wish. They will also be able to trade obligations among themselves and buy savings from other actors.

Savings through new building codes and enforcement

Energy conservation efforts will increasingly be made regarding energy consumption in buildings. The main initiatives include strengthened energy requirements in the Building Regulations, a new and improved energy-labelling scheme, enhanced inspection of boilers and ventilation systems, and increased efforts in the public sector.

Savings in the public sector

Energy savings in the public sector is another focal area. The public sector must procure energy-efficient products and implement profitable savings. A circular has been issued on improving the energy efficiency in government institutions. As a result of the political agreement, identical requirements as those applied to government institutions, regarding energy-efficient procurement and achievement of energy savings, with up to five years' payback time, will be applied to municipalities and regions.

Many of the details concerning the measures to be implemented in these three categories are still being worked out. In early January 2006, the government and the distribution companies finalised a draft agreement on

Table 11

Existing and Draft Savings by Sector

Savings excl. Transport Annual Savings, PJ	*Actual*	*Draft Action Plan*	*Draft Agreement*
Electricity Savings Trust	0.39	0.49	0.6
Electricity grid companies	0.78	0.97	1.4
Natural gas companies	0.08	0.10	0.5
District heating companies	0.16	0.20	0.9
Oil companies	0.0	0.0	0.15
New buildings	0.00	0.70	0.7
Existing buildings	0.60	1.82	1.85
Public sector	0.00	0.25	0.4
Appliances	0.30	0.30	0.5
Industry	0.40	0.50	0.4
Total	**2.71**	**5.33**	**7.5**

Source: DEA.

the distribution companies' activities, including the amount of energy savings they would be required to contribute to the 7.5 PJ target. This draft agreement is under approval in the companies. Table 11 shows the savings that were realised under the existing system, the savings allocation based on the December 2004 draft Action Plan, which targeted 1.0% annual energy savings and the draft savings obligations by sector to reach the 1.7% target of 7.5 PJ of annual savings.

ENERGY SAVINGS POTENTIAL

The final Action Plan of September 2005 estimates the total potential energy savings available in the Danish economy. Although significant energy savings have been achieved for several years, the document claims that there are still major, profitable potential savings, with new savings potentials resulting from technological development.

The document concludes that using low-cost measures, the profitable, cost-effective savings potential with today's technology currently represents at least 10% of energy consumption. If savings are realised when equipment, processes and buildings are being improved, maintained or replaced, it will be possible to achieve attractive cost-effective savings amounting to nearly 25% over the next ten years, assuming that increased research and development bring about technological developments.

Energy savings potentials are tabulated according to both private economy and socio-economic criteria. For energy savings potential corresponding to the private economy criteria, all energy efficiency measures and investments that make long-term economic sense to the individual energy user are included and the effect of their savings added together. The criteria include only the initial cost of the efficiency investment and the discounted savings over the lifetime of this investment. The socio-economic criteria are a more complex model intended to assess all the effects on society of any given action, in this case increased efficiency. The costs include the investments required as well as the loss of tax revenue through reduced energy sales. A distortionary factor of 20% is added to these lost tax revenues (as additional cost) since the assumption is they would have to be recovered in other ways, such as income tax, which have negative secondary effects on the economy. In addition, another cost of 17% is added to the investment being made because this money cannot be used elsewhere and was not used optimally because the investor/energy user was influenced by the government. The benefits in the socio-economic model include the discounted savings realised through reduced energy cost over the life of the efficiency investment. In addition, value is given to the reduced CO_2, NO_x and SO_x emissions; however, no value is given to enhanced energy security or other emissions, such as particulates.

The major difference between the calculation methods is the treatment of taxes. For the private economy potential, the decreased taxes corresponding to decreased energy consumption are only a benefit. For the socio-economic calculations, the reduction in payments is counted as a benefit for the consumer, a cost for the government and a 20% distortionary cost to the economy as a whole given that taxes must be gathered in other ways. The net cost in this model for any reduction in energy tax payments resulting from savings is 20%. Consequently, energy investments appear much more attractive under the private economy calculation methodology than under the socio-economic calculation methodology. The potential energy savings are greater using the private economy calculation than the socio-economic calculation, as shown in Table 12 below.

Table 12

Potential for Energy Savings in Various Sectors

End Use	*Final Energy Consumption*	*Socio Economic Potential up to 2015*		*Private Economy Potential (%)*	
	PJ	*%*	*PJ*	*Currently*	*Up to 2015*
Space heating	217.6	24%	51.3	18%	47%
Industrial processes	66.5	25%	16.5	13%	27%
Lighting	24.0	24%	5.7	19%	60%
Cooling/freezing	15.1	28%	4.3	10%	35%
Electric motors	12.4	15%	1.9	10%	30%
Ventilation	11.9	40%	4.8	13%	38%
Pumping	8.4	35%	2.9	14%	42%
Other	71.3	24%	17.2	11%	33%
Total	**427.2**	**24%**	**104.5**	**16%**	**42%**

Source: "Action plan for renewed energy-conservation efforts".

ELECTRICITY SAVINGS TRUST

OVERVIEW

The Electricity Savings Trust was established by an Act of Parliament in 1996 and was operational from June 1997. It is an independent organisation with its own board; its activities are within the guidelines of the law and related provisions. The Trust compiles an action plan every year based on conditions from the Danish Energy Authority. Its activities are funded through a special charge of 0.6 øre per kWh levied on all Danish electricity consumers for an annual budget of approximately DKK 90 million. There are six full-time staff and a range of secretariat services and working partners.

The fund's purpose is to promote electricity conservation in homes and the public sector in accordance with social and environmental targets. Its efforts to promote electricity savings and more efficient use can be implemented by a combination of subsidies, guideline agreements for products and services, agreements with manufacturers and distributors for marketing energy-efficient equipment, information, price and market overviews on the Internet, etc.

Among the Trust's most important tasks is the conversion of electrically-heated homes and public buildings to district heating or natural gas. It also employs a product-oriented strategy for the development of more energy-efficient apparatus, and promotes the use of such apparatus via agreements on purchasing policy.

ACTIVITIES

The Trust uses a number of different initiatives, or types of approaches, in its work to promote electricity savings. These initiatives and examples of related actions are listed below.

Cost reduction

- Direct subsidies to consumers.
- "Listing fees" to retailers.

Information campaigns

- Market through mass communication, public relations.
- Web site highlighting electricity consumption and benchmarking.
- Teaching aids and materials.

Voluntary agreements

- Agreements on phasing out less efficient electrical equipment.
- Marketing of energy-efficient products.

Market transparency

- Public relations and other marketing.
- Approved lists with prices and product comparison available on Web sites and other channels.

Concept development and market maturation

- Offers advice for free to manufacturers.
- Product endorsement via the Trust logo.

Advising and servicing large consumers, such as public sector groups, offices

- Certified testing for ventilation.
- Web sites on self-help systems, product and price overviews and other advice.

Table 13

Important Recent Activities of the Electricity Savings Trust

Activity	*Purpose/Target Group*	*Type of Initiative*
White goods campaign	Increase market share for A-labelled products such as fridges, freezers and tumble dryers	Information Price pressure and subsidies
Low-energy light bulbs	Increase the share of low-energy bulbs in private households	Information Price pressure and subsidies
The standby campaign	Encourage demand for television, video and audio equipment with lower standby consumption	Information Marketing
School campaign	Draw attention to the standby problem among school-age children	Teaching aids and materials
Conversion of electrically-heated dwellings	Influence private households to convert from electric to either DH or gas-fired heating	Subsidies Market transparency/information
Lighting	Convert larger customers to more efficient lighting systems	Subsidies Market transparency
The A-club	Electricity savings via voluntary procurement agreements for public and private institutions	Voluntary agreements Information provision
Voluntary IT agreements	Phase out inefficient products	Voluntary agreements Information campaigns

Source: "Evaluation of the Danish Electricity Savings Trust", October 2004 by Rambøll Management.

EVALUATION OF TRUST ACTIVITIES

In October 2004, Rambøll Management, a private Danish consulting firm, released a report entitled "Evaluation of the Danish Electricity Savings Trust". The report was the product of a study commissioned by the Board of the Danish Electricity Savings Trust as a means of evaluating its performance and gathering recommendations for the way forward.

The result of this study is extremely positive about the activities of the Trust. The report states that the Trust "has met [its] objectives to a very great extent." Annual electricity savings were projected to be around 1 000 GWh, or approximately 28% more than the Trust's objectives for 2004. In terms of fuel savings, the results of the Trust also exceed the defined objectives. In 2007, the activities are expected to contribute to fuel savings of 6.4 PJ, which is far above the target of 2.7 PJ. More specific conclusions of this 2004 report include the following:

The Trust has achieved very significant electricity and fuel savings

As explained above, savings objectives were surpassed.

CO_2 reduced in an environmentally and economically efficient way

In 2007, the electricity savings achieved will amount to a CO_2 reduction of approximately 777 000 tonnes. The reference point for the Trust was Energy 21.[13] In Energy 21 the efficiency requirement in relation to CO_2 reduction was a maximum CO_2 shadow price of DKK 600 per tonne. By comparison, the Trust has managed to achieve an average CO_2 shadow price at DKK 55 per tonne.

Electricity savings have been socio-economically beneficial

Study analyses show that the financial value of the savings surpasses the cost of generating the savings. On average, the value of the savings, which can be ascribed to the activities of the Trust, amounts to DKK 0.04 per kWh saved, equivalent to a total socio-economic gain of DKK 338 million.

High return on consumer electricity savings charge

The Trust can be seen as a mutual fund, in which DKK 0.006 per kWh of electricity consumption in dwellings and the public sector is invested. This electricity savings charge contributes a total budget of approximately DKK 90 million per year which, from 1997 to 2004, constituted a budget of approximately DKK 72 billion. The total lifetime user savings on current and completed projects amount to DKK 7.8 billon for a return of more than ten times the investment.

The Trust has employed cost-effective initiatives

The initiatives employed by the Trust are cost-effective. The Trust has spent DKK 90 per tonne of CO_2 reduced. The most efficient activity in terms of kroner spent has been the "Elspareskinne" (auto power saver plug bank) at a cost of DKK 0.003 per kWh saved. The standby campaign has the lowest efficiency, showing a cost of DKK 3.8 per kWh saved. The weighted average of all programmes shows a cost in initiatives and subsidies equal to DKK 0.075 per kWh saved over the lifetime of the programmes.

The Trust has influenced the market for electrically-powered appliances

The evaluation shows that the Trust has been able to influence the market. A permanent improvement in the availability of energy-efficient products such as A-labelled appliances and low-energy light bulbs has taken place.

---

13. Energy 21 is a government plan from 1996 for sustainable energy development in Denmark in an international context.

The Trust has developed new and effective initiatives

The first seven years of the Trust have been characterised by innovation. The initiatives used by the Trust constitute a wide range of traditional subsidies, clubs, procurement agreements, price overviews, Web sites, voluntary agreements, concept developments and other measures. The Trust has contributed a high level of effective innovation.

ACTIVITIES OF GRID COMPANIES

PAST ACTIVITIES

Grid companies, including electricity, DH and gas distribution companies, which provide energy directly to retail customers have also been active in energy efficiency activities. These companies receive payments each year through a component put into the tariffs they receive and use these funds to reduce the energy consumption of their customers. In 2004, electricity distribution companies received DKK 180 million, district heating companies DKK 40 million and gas distribution companies DKK 25 million. For the electricity customers, this equates to approximately 0.52 øre per kWh.

Commensurate with receiving these payments from customers, the distribution companies are obliged to offer the following services free of charge:

- General information on energy savings, such as information material, campaigns and education.
- Individual energy counselling to households.
- Outreach energy counselling to companies, institutions and public services.
- Research and development of new technologies.

The Danish Energy Authority (DEA) lays down the overall guidelines for the activities of the distribution companies. Every third year, the grid companies carry out an overall planning according to the guidelines issued by DEA with detailed planning taking place every year. The grid companies – usually through an industry association – report the success of their programmes from the previous year. DEA is also instrumental to setting and approving plans for energy efficiency activities that the distribution companies undertake.

The majority of the energy efficiency activities of the grid companies involve informing consumers of the costs they are paying for energy and what options are available to them to reduce those costs. They offer energy consulting and audits to all customers, except households who receive information by other means. The grid companies provide access to equipment to measure energy use. For example, a resident may be able to go to his or her electricity distribution company to borrow a device which can measure energy use in a refrigerator or other appliance. Seeing how much this appliance uses may inspire a new, more efficient purchase. The grid companies also set up demonstration facilities where people can come and look at and test energy-efficient technology.

Specific technology areas include the following:

- Pumps.
- Fans (ventilation).
- Motors.
- Energy Guide – small and medium-sized business.
- Informative electricity bill.
- Cooling/refrigeration (A-labelling).
- Energy-efficient light bulbs (A-labelling).
- Standby consumption.
- Education material for schoolchildren.

In addition, the grid companies organise competitions to encourage efficiency, such as the most energy-efficient company of the year and the energy-saving municipality of the year.

EVALUATION

ELFOR, the Association of Danish Electricity Distribution Companies, has analysed the effect of its members' efficiency activities. Starting in 1994, when these activities began, the collective actions of the electricity distribution companies reduced electricity consumption by slightly more than 0.3% annually compared to what consumption would have been without these actions. After ten years of activities, electricity consumption is between 3% and 3.5% less than it would have been. ELFOR concludes that its actions saved around 1 200 GWh in 2004, which is equivalent to 3.2% of total electricity consumption in that year.

ELFOR makes a projection of all electricity savings from its 2004 activities. These savings start at 160 MWh annually and then continue at that pace for four additional years. The savings taper off as the effects of the information campaigns and other efforts diminish. The lifetime savings for the efforts in any given year are 1 720 000 MWh. The cost of making those efforts is DKK 180 million and thus the cost of those savings is DKK 105 per MWh, or EUR 14 per MWh. If we discount all the additional savings at a rate of 10% to account for the time value of money of the investment made, the amount that is spent per MWh of electricity saved is approximately DKK 164, or EUR 22. These figures are substantially below what households and industry pay for electricity, even before the high taxes, and even lower than the wholesale prices for power seen in the Danish and Nordic markets. However, they only include the costs for the distribution companies and not the cost to consumers of making the investments in efficient equipment or lifestyle changes.

ELFOR has made an assessment of the energy efficiency investments and behaviour resulting from its activities. It uses the socio-economic criteria described above when showing the potential for savings in the entire Danish economy. For 2003, it estimates that its efforts and resulting efficiency activities are cost-neutral for society if each emitted tonne of CO_2 is valued at DKK 40 per tonne. A higher CO_2 value would mean that the efforts are cost-effective while the lower value of CO_2 would mean that they are not. Since the DKK 40 per tonne (or around EUR 5.40) is nearly one-quarter of the price seen on the EU-ETS market, ELFOR concludes that its actions are cost-effective and represent a positive net present value (NPV) for society as a whole. A preliminary analysis on 2004 activities shows even more positive results for the distribution companies' efficiency activities. ELFOR, using a socio-economic analysis, calculates that Danish society as a whole saw a positive NPV from these activities of DKK 178 per MWh of electricity demand reduced. This result assumes that the value of each tonne of CO_2 emissions reduced is DKK 50. In fact, this value is much lower than the currently traded allowance price for the EU-ETS. If ELFOR assumed a higher price of CO_2, the resulting benefits to Danish consumers from these programmes would also be higher.

ELFOR also calculates the attractiveness of the encouraged energy efficiency investments from the point of view of the user alone. Since the cost savings of reduced energy taxation are included in the benefits from conservation, the results are considerably more favourable than the assessment using the socio-economic criteria. ELFOR calculates that the payback period for these efficiency investments as a whole is about two years, which is a very attractive recovery window.

ACTIVITIES UNDER THE NEW STRUCTURE

Energy efficiency activities will change significantly under the proposed Action Plan resulting from the June 2005 political agreement to realise 7.5 PJ of energy savings annually. The primary change will be an increase in the collective obligation of the grid companies to save energy. Under the draft Action Plan of

December 2004, the combined annual savings asked of the electricity, district heating, natural gas and oil distribution companies was 1.27 PJ, or a 25% increase from the older, previous system. The annual savings target for these distribution companies in the draft agreement from January 2006 is 2.95 PJ. This represents an increase in savings obligations of more than 130% from the December 2004 draft plan and nearly a 200% increase from the previous system.

The other major change in the new system for efficiency efforts at the distribution level will be the greater leeway given to individual companies to achieve these savings. While all such efforts required the approval of the DEA under the old system, the new system will allow these companies to do whatever they wish to realise savings. In addition, they will no longer be restricted as to where or on which customers they will be able to spend their money. Under the previous system, money received from certain customer groups would have to be directed solely at those groups. Thus, money obtained from residential customers would have to be spent on residential customers, etc. Companies could in theory obtain most of the savings that were required of them from one customer group with no savings in the others if they believed that was the most cost-effective way, but there will be a requirement to have some activities take place within the companies' own customer bases. Activities under the previous system could only be undertaken within a given company's jurisdiction, whereas the new system allows companies to operate anywhere in Denmark.

Another change in the savings system is that the trading of obligations among distribution companies and purchasing of savings from other actors is now permitted. Thus, if one company achieves savings greater than its obligations, it is allowed to sell its excess to another company that has saved less then its obligation. The price at which these savings are traded would be determined bilaterally between the two companies. In addition, for companies that undertake a savings programme in another company's jurisdiction, thereby realising savings for another company's customers, the savings would accrue to the host company's account but a payment would be made to the company that undertook the savings activities. Thus, companies would be able to specialise in efficiency efforts for a given customer class or sub-class. One company could specialise in savings for residences, while another became expert in savings for industry. The first company would undertake efficiency efforts for the residential customers of both companies, while the second company would undertake efficiency efforts for all the industrial customers of both companies. Depending on the saving levels achieved within each customer class, the two distribution companies would arrange a payment decided bilaterally from the company that achieved less savings through its efforts to the company that achieved more savings.

The distribution companies will continue to receive payment for these efficiency efforts. However, these payments will stay at the previous levels and will not be increased in line with the greater savings obligation the companies will now have. Thus, they will have to become more cost-effective in achieving savings or will have to benefit from the trading to become more efficient in the system as a whole. If the distribution companies are able to achieve these savings at costs less than the payments they receive, they are entitled to keep the difference. Conversely, if it costs them more to achieve these savings, they would have to bear the additional financial burden.

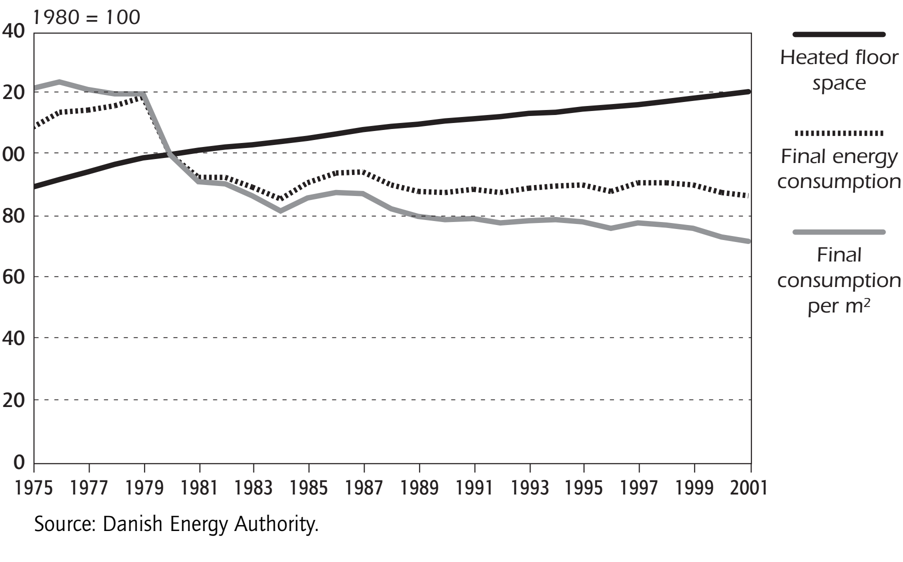
HEATING

TRENDS IN ENERGY FOR HEATING

Energy savings in buildings has been one of the major focuses of Danish efficiency policy for the last 30 years. As a result, they have achieved substantial efficiencies. From 1975 to 2001, heating floor space has increased by 34% but the primary supply needed to heat this space has decreased by more than 20%. The resulting energy supply per unit of heated space has declined by more than 40%. Figure 9 shows this progression graphically.

Figure 9

Energy Supplied for Space Heating, 1975 to 2001



Source: Danish Energy Authority.

This decrease in energy going to heating in buildings is a result of two factors. One, insulation in buildings has improved dramatically over the last 30 years. Second, the introduction of combined heat and power (CHP) and connected district heating (DH) systems improve the efficiency of the delivery system. Whereas on-site oil and gas boilers lose heat in the combustion process, CHP makes double use of the combustible energy and thus enjoys a higher efficiency.

At the same time, the net heat demand per unit of floor space has also declined over the last 20 years. This parameter measures only the usable heat delivered to a building and not the energy input either off-site with a district heating system or on-site with a boiler. Consequently, it does not capture the efficiency improvements through CHP as explained above. The reduction in net heat per unit of floor space is thus lower (24%) than the reduction in primary energy supply per unit of floor space (40%).

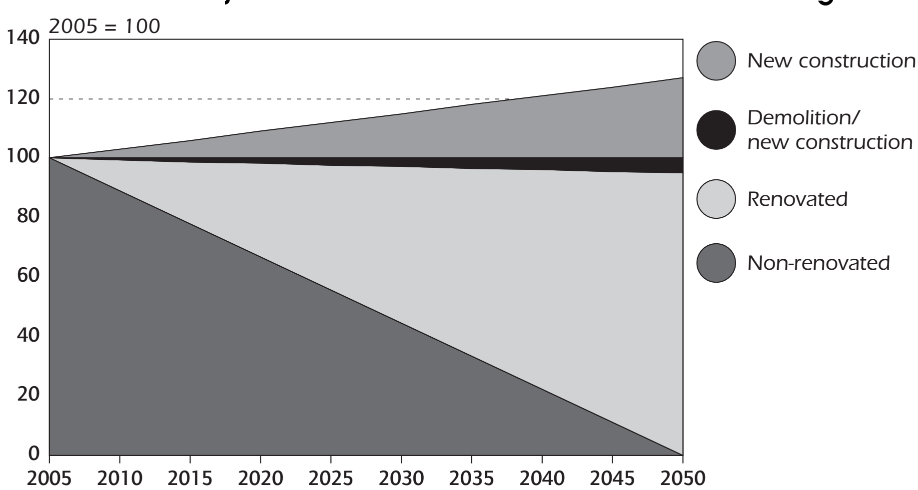
A description of heating fuels and sources is included in the CHP and DH section below.

POTENTIAL FOR ENERGY SAVINGS

Academic and other studies have indicated substantial potential exists for further energy savings in buildings. One of the difficulties in improving the efficiency of heating in buildings is the large stock of older buildings and the relatively low turnover rates. While building codes were tightened in the late 1970s resulting in greater insulation for new buildings, 75% of the building stock was built before 1979 and thus did not adhere to the tighter codes during construction. While new building construction and major renovations that require adherence to the newer tighter building codes will only occur slowly, by taking a longer-term view, the potential for energy savings in space heating becomes more obvious. The figure below shows the turnover of building stock and how, by 2050, all buildings could be either renovated or new construction.

Figure 10

Projection of Trends in Stock of Residential Buildings



Source: "Energy savings in Danish residential building stock" by H. Tommerup, S. Svendsen. Technical University of Denmark.

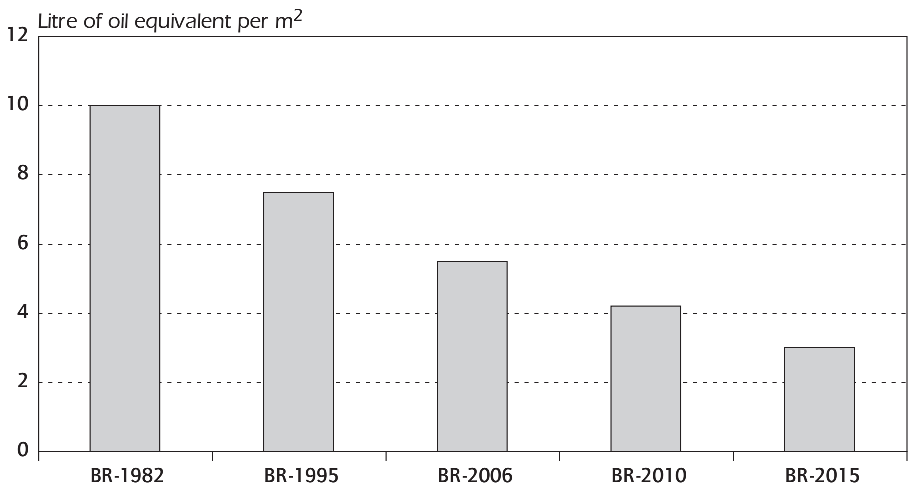
The Technical University of Denmark has estimated the potential for savings in space heating for residential buildings. They assume a real interest rate of between 0.0% and 2.5%, real energy prices between 8 and 16 euro cents per kWh and a calculation period of 30 years. The results show the possibility of lowering energy use for residential space heating from the 2005 figure of 122 PJ per year to 86 PJ per year in 2020 and 22 PJ per year in 2050. This last figure would represent an 80% reduction in energy use from current levels.

BUILDING CODES

Denmark has historically designed and implemented strong building codes to curb heating needs. These are viewed as some of the strongest and most effective energy savings tools. New building codes have just been implemented and came into force starting in 2006 which tighten the energy requirements of new buildings by 25% to 30% from the previous standards. These codes are expected to be tightened again in 2010. Figure 11 shows the historical progression of building code requirements (BR) and expectations for the future.

Figure 11

Building Code Requirements on Space Heating



Source: Danish Energy Authority.

Another important step to increasing energy savings through building codes will be the enforcement system. Previously, architects or builders had merely to bring the plans for a new or renovated structure to the appropriate government office to demonstrate on paper how they intended to meet the building codes. Actual construction that conformed to these plans was left up to the builders. There was no system for government follow-up to ensure the actual heating/insulation requirements were being met. Concurrent with the new tightened building codes which came into force in January 2006 is be the introduction of regular checks by the government of new or newly renovated buildings to ensure these constructions do meet the code's requirements.

ENERGY LABELLING FOR BUILDINGS

The energy labelling of buildings in Denmark was developed in the context of a long history of energy-saving policy initiatives. Energy labelling was and still is seen as an important way to achieve energy savings in buildings – both existing and new – since the potential for energy savings in these areas is considered quite large. Denmark has implemented the following two energy labelling schemes for buildings:

- Energy management in large buildings of more than 1 500 m^2 (the ELO Scheme).
- Energy management in small buildings, concerning one-family houses, apartments and other residential buildings of less than 1 500 m^2 (the EM Scheme).

Existing buildings pose a particular problem when trying to save heating energy. Not only do they represent a majority of the housing stock, but their energy consumption is 14.1 litres of oil per m^2, or nearly three times the requirements for the new building codes, which would only apply to an existing building in the case of a major renovation. Energy labelling is one of the most effective ways to curb energy use in existing buildings. In order to increase the efficacy of labelling in this regard, the government has taken the following steps:

- Introduce a requirement specifying that in connection with major renovations in all existing buildings and not only buildings over 1 000 m^2, energy improvements specified in the energy label must be implemented.
- Introduce specific requirements in the Building Regulations relating to replacement of roofs, windows in a façade and oil and gas boilers, and to change heat supply.
- Through legislation, implement a more efficient and user-friendly energy labelling of buildings, which are to be sold or rented.
- Set the validity of energy labels for small buildings at a maximum of five years.
- Set the frequency of regular energy labelling of buildings over 1 000 m^2 at a maximum of five years.
- Introduce regular energy labelling of all public buildings regardless of size.

- After three years, assess on the basis of the experience gained, whether regular labelling of all buildings should be introduced.
- Introduce inspection schemes for oil and gas boilers and ventilation systems.

WINDOWS

Improvement of the energy aspects of windows is an important element in Danish energy conservation measures. Major energy savings can be gained by the improvement of windows as they account for a large element of heat loss from buildings. Solar heat is also collected by windows for a large part of the year, which means they play a significant role in maintaining comfort levels within buildings. Current measures consist of the following three elements:

- The new energy provisions in Danish building codes set standards for energy properties in façade windows for both new buildings and replacement of windows in existing buildings. Large-scale replacement of windows in existing buildings will also be subject to energy requirements.
- The Danish trade organisations have entered into a voluntary energy labelling scheme for windows, and labelling schemes will be introduced for windows and internal double glazing. The schemes will categorise products into a scale from A to C.
- The DEA, the glass industry, glaziers' trade organisation and Vinduesproducenternes Samarbejds Organisation (VSO) (window manufacturers' co-operation organisation) have entered into an agreement on the phasing-out of traditional sealed units and promotion of energy-efficient window solutions.

APPLIANCES

The major thrust of the government's efforts to promote energy conservation in household appliances and light bulbs is through energy labelling. Energy Labelling Denmark is responsible for the administration in connection with random sample checks of the products, including:

- Selection of the products to be checked.
- Acquisition and review of technical documentation from the manufacturers.
- Following-up on the results of the checks with respect to the manufacturers/suppliers.

Energy Labelling Denmark is also responsible for checking the following:

- Whether the energy label is present and positioned correctly on the products in the shops.

- Whether the packaging (for light sources) and other product information is correctly formulated.

Energy Labelling Denmark also conducts inspections of the CE markings on deep-freezers, refrigerators with and without freezers and refrigerator-chillers with respect to European norms for energy efficiency. The norms stipulate that appliances that use more than a predetermined amount of energy are not permitted to be sold on the European market.

Energy Labelling Denmark maintains a section of the Danish Energy Authority's homepage, publishes a magazine about energy labelling entitled "Mærk & Spar" ("Mark and Save") for distributors/retail shops of major household appliances and publishes various information pamphlets. All information that is gathered on the efficiency of different appliances and light bulbs is disseminated through one or more of these channels.

PUBLIC SECTOR

Energy conservation in the public sector is one of the three major areas targeted in the June 2005 political agreement on savings. The government believes it must set a good example while at the same time it is encouraging others to be more efficient. A recent study reveals that in the municipal sector there are a number of barriers to energy savings, which are related to economic management and organisation, lack of knowledge, behaviour and other factors. The municipal reform can help to break down these barriers.

To reduce public sector energy demand, the government plans to:

- Strengthen its circular on energy efficiency in government institutions so that, as of 2005, the institutions will implement energy-efficient procurement and energy savings with reasonable payback times (up to five years).
- Disclose the actual electricity consumption on the Internet.
- The Minister of Transport and Energy will hold discussions with municipalities and regions on their compliance with the requirements on energy-efficient procurement and the implementation of energy savings, with up to five years' payback time, as applies to government institutions.
- Ensure that the public sector leads the way in procuring energy services. Pilot projects, a barrier study and a targeted promotion campaign will be carried out.

NEGOTIATED AGREEMENTS

Since 1996, Denmark has used voluntary agreements on energy efficiency as an important instrument to improve energy efficiency in industry. The voluntary agreement scheme is closely integrated with the Green Tax Package as companies that enter an agreement receive a rebate on their taxes related to energy. The agreement system has two main objectives. One is to encourage energy-intensive companies to improve their energy efficiency. The other is to ensure that the international competitiveness of energy-intensive companies is retained.

All agreements cover a three-year period and are based on estimates of the company's production potential and estimated investments in the agreement period. Agreements can be renegotiated during the agreement period if the original estimates change substantially. Each agreement contains the following three essential elements:

Energy management

Energy management is the cornerstone of the agreement system. The Danish Standard and Energy Management (DS 2403) was developed in May 2001. It provides a framework for individual companies to tailor their own energy management system to achieve the most cost-effective savings.

Special investigations

As part of their agreement, companies must carry out a number of special investigations (typically between two and five) that focus on specific areas of their primary production processes. The aim of the investigations is to determine the possibilities of improving efficiency of the process concerned.

Investments

The company is obliged to carry out all investments that improve its energy efficiency with a simple payback period of four years or less.

Only energy-intensive companies can enter into such agreements (and receive the related tax reductions). A company can be classified as energy-intensive if it either: *i)* carries out one or more of the processes identified as energy-intensive, such as the production of cement, paper or condensed milk, or *ii)* it has a green tax liability of more then 4% of its value added. Agreements may either be carried out by individual companies or by groups of companies.

By 2004, approximately 280 Danish companies had entered an agreement, representing more than half of the total energy consumption in the industry. By 2005, approximately 60 of these companies were to be part of the Danish allocation plan for CO_2 quotas and would therefore drop out of the voluntary agreement concerning the energy use that is under CO_2 quotas. There remains for these companies the possibility to have a voluntary agreement concerning electricity.

EFFICIENCY IN THE TRANSPORT SECTOR

Transport is the single largest sector for final energy demand in Denmark, accounting for 33% of total final consumption (TFC) in 2003. It is also the fastest growing sector. From 1973 to 2003 Danish TFC fell by nearly 6%, but over the same period transport energy demand rose by 43% and demand in the road transport sector rose by 86%. Table 14 shows demand growth in different sectors.

The Energy Strategy 2025 cites the transport sector as an important part of a successful energy future. It states that the government intends to focus more attention on this issue but that any initiatives to limit energy consumption for transport must be cost-effective. The strategy explains how many measures to curb transport energy use must take place in an EU context, such as the effort to work with manufacturers to reduce CO_2 emissions from passenger vehicles. At the domestic level, it will give greater support to R&D as a means of curbing demand. It also plans to establish a committee to explore possibilities for developing and using alternatives to petrol and diesel such as biofuels, natural gas and, as a longer-term solution, hydrogen.

The political agreement of June 2005 establishing new demand reduction targets explicitly excludes transport from its purview. The related Action Plan drawn up by the DEA to meet the reduction goals also makes no mention of transport.

Table 14

Demand Trends in Transport and Other Sectors

Sector	*1973 – 2003*	*1990 – 2003*	*1998 – 2003*
Total transport	42.6%	22.2%	3.5%
Road transport	85.7%	27.0%	6.1%
Industry	–18.9%	7.2%	–3.3%
Residential	–39.1%	6.1%	–4.4%
Total Danish TFC	–5.8%	10.4%	–0.9%

Sources: *Energy Balances of OECD Countries,* IEA/OECD Paris, 2005 and country submission.

While Danish taxes on petrol and diesel fuel are comparable to those found in other EU countries, vehicle registration taxes are much higher. These taxes vary with the price of the car – generally rising with price – and vehicle registration charges and taxes, including value-added tax (VAT), can easily reach 150% of the ex-tax value of the car. While there is no gradation of initial registration taxes to account for different engine sizes or efficiency parameters, the biannual charges to maintain the title of the vehicle over its lifetime increase with growing vehicle energy consumption.

A number of trends are combining to increase energy use in the road transport sector. One, there are more private cars on the road, each car is driven more kilometres per year and the car fleet is growing older and more inefficient. From 1993 to 2003, the total number of private cars (including taxis) rose by 17% from 1 623 734 to 1 900 370. Total private kilometres driven rose from 31 573 million in 1993 to 38 854 million in 2002, and the kilometres driven per vehicle rose by more than 5% over the same period.

At the same time, the private car fleet is becoming steadily older. Older cars are more inefficient as they degrade over time and do not have the technology advances of the newer cars. In 1995, there were 137 538 cars under one year old and 574 179 cars older than ten years. In 2005, the number of newer cars had dropped to 117 735, while the number of older cars had grown to 719 914.

COMBINED HEAT AND POWER AND DISTRICT HEATING

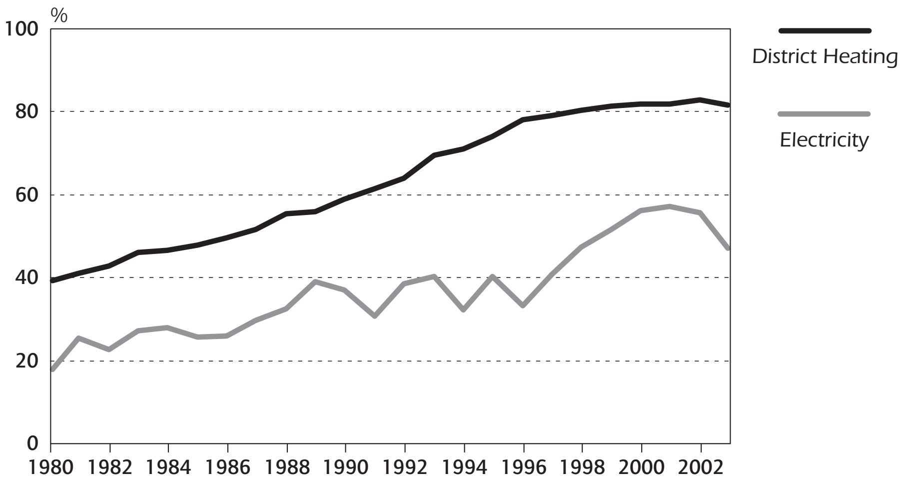
Denmark makes substantial use of combined heat and power (CHP) facilities that produce both electricity and heat. The majority of this heat is used in district heating systems that are present in most of Denmark's major population centres. There are approximately 670 CHP plants in Denmark and 230 district heating (DH) plants producing heat alone. Some of these CHP plants are considered centralised and some are decentralised. The centralised plants were originally electricity-only plants that were converted to co-generation. There are 16 such plants in Denmark, which tend to be located in large cities and owned by major energy corporations. The decentralised CHP plants began as heat-only facilities, which were then converted to CHP. There are about 290 such plants, which are located in smaller population centres and are largely owned by the local municipalities and the consumers themselves. In addition, there are approximately 380 industrial/on-site CHP plants owned by industries or institutions. They produce mainly to meet their own electricity and heat needs but then sell any surplus on the market.

CHP has a long history in Denmark and recent government programmes have seen its share of district heating and electricity production rise to new heights in the last ten years, as shown in Figure 12.

The CHP facilities are fuelled by a mix of renewable and non-renewable fuels. In 2003, renewable energy (meaning biomass and municipal solid waste)

Figure 12

CHP Production as Share of Total Electricity and District Heating Supply, 1980 to 2003



Source: Danish Energy Authority.

accounted for the greatest portion of the fuel input, at 41.9%.[14] This was followed by natural gas at 28.7%, coal at 22.8% and oil at 6.6%. Over the years, coal and oil have decreased as biomass and natural gas use have risen.

Electricity sold from CHP plants is entitled to a subsidy depending on the type of fuel they use. If they use biomass, then they can receive a price of 60 øre per kWh. If they use natural gas or waste, then they receive a payment corresponding to a three-tier tariff that accords different prices to different times of day. A more detailed description of these subsidies is included in Chapter 6 on Renewable Energy.

DH is the single biggest heat source in Denmark. In 2000, 58% of households were connected to and received heat from the local DH system. Of this amount, 94% of heat came from CHP while 6% came from heat-only facilities. Single-furnace oil supplied 18% of households, natural gas 15%, electric heat 6%, and solid fuel 3%.

Customers that have access to a DH system are obliged to connect themselves to and use the system within a certain time limit after it is introduced. Many of the meters to measure heat usage are installed at the level of the individual

14. These fuel share figures correspond more specifically to inputs for DH and would therefore include heat-only plants, but are also similar for CHP plants.

consumer rather than being at the building level with costs shared equally. This allows people to better gauge their heat use and to benefit directly from reduced consumption.

The tariffs for the provision of heat through a DH system are regulated by DERA using a cost-plus approach. Since most of these facilities also produce electricity in a co-generation process, the costs for each product must be separated out. The DEA calculates the DH tariffs offered to customers and compares them with the costs of heat from single-furnace oil and gas boilers. It calculates that DH is cheaper than the home natural gas option 92% of the time and cheaper than the home oil option 98% of the time. Customers who feel they are paying more by being forced to participate in the local DH system receive additional payments from the government as compensation.

CRITIQUE

Denmark's record on energy efficiency is very impressive. The country's TPES over the last 30 years has remained nearly constant, while that of the IEA as a whole has almost doubled. Its TFC over that time has actually fallen. Currently, its aggregate energy intensity is 35% below the IEA average and is the lowest among all EU countries. In addition, it has lowered its energy intensity at a considerably faster rate than the IEA countries as a whole and, on the basis of the new political agreement, should make even further progress in this regard.

This level of efficiency offers Denmark a number of benefits. One, it makes the country more competitive internationally and less subject to volatile fossil fuel prices. Second, it lowers emissions from fuel combustion, primarily GHGs. Denmark is facing a difficult Kyoto challenge and has used and will continue to use energy efficiency as a readily available cost-effective means of meeting this challenge. Third, a number of Danish companies are positioning themselves as world leaders in energy efficiency technologies, a field that is seeing worldwide growth. Finally, reduced energy demand is the best possible means of enhancing energy security.

Denmark's impressive energy efficiency results derive more from government efforts in this area than any national or natural characteristics. Denmark faces cold winters and does not have a particularly dense population to minimise transport energy use (although distances are small across the country). It has a high standard of living. The one factor that naturally mitigates Danish energy use is the absence of a large energy-intensive industrial base. Nevertheless, the Danish example clearly demonstrates how a concerted and long-term government effort can effectively lower a country's energy use and bring the aforementioned benefits of improved energy efficiency.

Many of the benefits of greater efficiency are the same as the benefits of renewable energy, notably GHG emissions reduction and enhanced energy security. In addition, both renewable energy and energy efficiency can and should benefit, at least to a certain degree, from government programmes that support them more than a purely free market would. While there is no basis to treat renewables and energy efficiency as mutually exclusive goals, it is worth noting their relative cost-effectiveness in meeting the same goals.

On the basis of the available evidence from Denmark, energy efficiency programmes have been significantly more cost-effective to date than renewable energy programmes in reducing GHG emissions and enhancing energy security. Evaluations of the Electricity Savings Trust, an efficiency group funded by a special surcharge, indicate that the cost of reducing CO_2 through its efficiency programmes is around DKK 55 (EUR 7.38) per tonne. The Association of Danish Electricity Distribution Companies, which also carries out efficiency work, reports that its efficiency efforts in 2003 resulted in CO_2 emissions reductions at a cost of DKK 40 (EUR 5.37) per tonne, while in 2004 their efforts were entirely cost-effective given the value of suppressed demand and therefore correspond to GHG emissions reduction at zero or negative cost. (See Renewable Energy chapter for similar figures on different types of renewable energy technologies and support systems.)

Such results which so favour efficiency come with two caveats. One is that they represent just a snapshot of the costs and benefits of these programmes. Both technology and energy prices can change significantly over time, thus altering the relative attractiveness of efficiency and renewables. The second caveat concerns the methods of assessing efficiency programmes. The figures cited above from the Electricity Savings Trust and the electricity distribution companies are derived from the groups themselves and thus might be subject to a degree of bias. In addition, there is understandable uncertainty as to how different efficiency measures should be valued. Nevertheless, given the apparent cost-effectiveness of the efficiency measures and the renewed government push in this sector, it would be extremely beneficial if the government developed an objective methodology for assessing the costs and benefits of its efficiency programmes.

One of the factors not discussed at length in this chapter is taxation (see section on Energy Taxation in Chapter 3). However, the Green Tax Package whereby taxes are raised on energy products while they are simultaneously lowered by an equal amount, at least in theory, on other taxes such as labour, deserves much of the credit for the high levels of efficiency.

The new political agreement of June 2005 seeking annual reductions in energy demand of 7.5 PJ represents a departure from previous government efficiency efforts in that the focus is on market-oriented policies that have demonstrated cost-effectiveness. This is a commendable move since it takes the government away from some of the more direct subsidies of the past. Such principles are in line with the policy to have local energy distribution companies achieve a substantial part of the savings. Granting them greater freedom on where they can achieve their savings and what customer classes they can devote their efforts to will enable them to seek the most cost-effective options. Allowing companies to trade obligations, at prices they determine, will lead to greater specialisation as well as reward companies that show greater skill in this area. This is a pronounced improvement on the previous, more limiting system.

However, shifting responsibility to non-government groups does not automatically solve the problem. While the distribution companies have had some success in the past with demand reduction, they will be asked to expand their efforts considerably while having no extra money to do so. Negotiations on commitment levels were still ongoing in December 2005 even though they were expected to take effect in January 2006. The government is working hard to determine the exact structure of the rules governing distribution companies and is encouraged to continue to work with them as they establish the institutional capacity to achieve such savings under a new framework. The government is encouraged to look at other countries, such as the UK, France and Italy, that have tried and/or are trying similar trading of demand reduction obligations (*e.g.* white certificates), and to strive for simplicity whenever possible. In particular, the UK with its Energy Efficiency Commitment (EEC) has more experience with programmes of this sort. According to the review of the UK EEC, gas and electricity suppliers have more than met their savings target (62 TWh by 2005) which will be increased substantially (130 TWh during 2005-2008). The UK experience would be very valuable in designing the detail of the Danish policy.

In addition, the government needs to continue monitoring the cost-effectiveness of its efficiency policies and incorporating the results into new measures. The socio-economic model is an interesting approach for assessing the impact of efficiency policies. While it is based on sound economic principles, some factors should nevertheless be updated or improved. For example, no monetary value is given to enhanced energy security through lower demand. The reduction in certain emissions such as particulates is not evaluated in monetary terms and the value given to each tonne of CO_2 emitted is based on an expected future value that might be too low, certainly if CO_2 prices stabilise around current levels. The value of distortionary factors applied to both efficiency investments and lost government revenue can be the subject of legitimate debate and should therefore not be accepted as absolute immutable figures. The implementation of new, innovative policies is an excellent time to learn about what does and does not work. The government is encouraged to further develop the methodology used in making cost-benefit analyses and apply it to the individual measures that are or will soon be employed. As discussed in Chapter 6, such comprehensive cost-benefit analyses should also be considered for the renewable energy promotion policies.

Such cost-benefit analyses cannot be effective if an adequate means of calculating demand reduction from the baseline scenario and thereby measuring the success of programmes is not developed. This will be particularly important when assessing the success of the distribution companies in meeting their goals but is also relevant to other groups, such as the Electricity Savings Trust. Issues to be resolved are: agreement on a baseline demand scenario; efficiency investments that would have taken place without any programmes (the free rider problem); and measuring the usefulness of information campaigns. These are not trivial issues and will be important in judging the success of the various programmes. A planned review of these programmes in 2008 does not leave much time to develop measurement criteria.

The government has taken a leading role in achieving demand reduction in buildings. Its record of decreasing primary energy supply for heat by 20% despite the increase of floor space by 34% from 1975 to 2001 is very impressive. Denmark has been taking many commendable actions. First, Denmark has been progressively tightening the building code to curb heating needs since 1977. New building codes, which will reduce energy requirements of new building by 25% to 30% compared with the previous standards, came into force in January 2006 and are expected to be tightened again in 2010. Such progressive tightening of the building codes provides predictability to housing construction companies and further reduces energy requirements whenever the turnover of the existing building stock occurs. Second, the codes will be rendered more effective through improved enforcement. The government has already announced that it plans to follow up with on-site inspections of new and renovated buildings to ensure that they do meet the codes. This will help reduce demand further in buildings. Third, the government will also address energy efficiency in existing buildings through an energy labelling scheme. It plans to introduce many steps to increase the efficacy of the labelling scheme by ensuring stronger linkages with the building codes, setting maximum validity of energy labels and introducing regular labelling of all public buildings. These are all commendable steps at a time when many IEA member countries are having difficulties in curbing energy demand in their own existing building stocks. As a whole, Denmark provides a number of good examples to other member countries in improving energy efficiency in buildings.

The performance of the Electricity Savings Trust has been highly successful. According to the evaluation report in 2004, it has surpassed the electricity saving objectives. Through cost-effectiveness analysis of various policies and measures, the report also concludes that the financial value of the savings surpasses the cost of generating them. Again, these successful performances and efforts for monitoring can be a good example in addressing energy efficiency in homes and in the public sector.

On the other hand, the review team thought that more could be done in the transport sector. The transport sector represents 33% of final energy consumption in Denmark and is showing the fastest energy growth. While the Energy Strategy 2025 recognises the particular challenge of the transport sector, the June 2005 political agreement on greater efficiency explicitly excludes the transport sector. Energy consumption in this sector has risen uninterruptedly and is almost exclusively based on oil. According to the strategy, the costs involved in reducing the transport sector energy consumption with national means are generally high and the government has therefore decided to focus on the synergy between transport and energy by giving greater support to research and development in both sectors.

While curbing energy demand in transport is a challenge for all IEA countries, a number of measures could be introduced in Denmark. The current registration tax is very high in Demark (easily surpassing 150% of the ex-tax price) but does not differentiate on efficiency of the vehicle. A tax system which had lower taxes for more efficient cars and higher taxes for less efficient cars could improve the fleet efficiency. High registration taxes in general will discourage people from buying new cars and lead to an older, less efficient car fleet. Tax rebates or simply cash payments for scrapped older cars have been tried, with varying success, in other countries, as it was in Denmark in the mid-1990s. Such ideas should be explored more in Denmark. Finally, the high registration tax and normal petrol tax (by EU standards) penalises car ownership rather than actual use. A reconsideration of these incentives may lead to ways to reduce demand without altering the total combined taxation on cars and fuel. Denmark could also consider expanding the scope of voluntary agreements to freight industries. For example, Finland includes the transport sector under its Energy Conservation Agreements, covering nearly 5 000 vehicles of 470 companies, and Japan has recently amended its Energy Conservation Law to introduce a new regulation on large-scale freight industries and cargo owners. Under the new regulations, large-scale freight industries and cargo owners are obliged to formulate energy conservation plans and report their energy consumption every year. Denmark could learn from such experiences.

While considerable attention is paid to lowering overall demand, little attention is paid to load-shifting or peak-shaving. These concepts apply primarily to electricity where the cost of the product is very time-sensitive. Such load-shifting activities would complement the general efficiency measures and could be developed concurrently. This may be particularly relevant to Denmark because its supply profile is somewhat unique with its wind and CHP plants. Load-shifting programmes that shaped the demand to better match supply could improve the efficiency of the entire system. For the larger customers, direct exposure to time-of-use rates would encourage them to adjust their demand accordingly. But the large majority of customers does not see time-of-use rates and would, in any event, have insufficient incentive to adjust their demand in the absence of government programmes.

The only area where the move to greater competition has yet to be seen is in the district heating tariffs. Cost-plus methodology has a poor track record of encouraging efficiency or performance improvements in the electricity sector and the same is true for heating. Some form of benchmarking should be introduced to set standards for costs so that outliers can be identified. A performance-based rate-making approach could also improve performance. In addition, a number of larger cities, notably Copenhagen, have or will have two or more heat suppliers feeding the heat pipeline system. Some measure of managed competition could be introduced to encourage efficiency and lower costs.

Another area for possible improvement in the heating system is the mandatory participation regulations. The motivation behind this is clear in that more users reduce the cost for everyone. It is commendable that many of the meters to measure heat usage are installed at the level of the individual customer rather than being at the building level with costs shared equally. This allows people to better gauge their heat use and to benefit directly from reduced consumption and could be a good example for other countries with high penetration of DH. At the same time, this type of controlling behaviour which requires participation in the system can easily stymie new products or other forms of innovation. In addition, the often high fixed costs paid by DH customers, and correspondingly low variable costs, discourage efforts to reduce demand by individual households. A tariff structure that was purely variable, yet still ensured recovery of the system's fixed costs, would encourage better insulation and behaviour modification.

While this report highly commends the government's efforts to curb energy demand, there is concern that private participation in the energy efficiency field might be driven out. With so many government-supported or government-mandated groups providing efficiency services, private groups have tough competition. Such private groups, notably energy service companies (ESCOs), have been active and effective in other IEA countries. They have also been instrumental in developing new technologies and new ways of financing efficiency. The government should ensure that the playing field is not too heavily tilted against such private groups in Denmark.

RECOMMENDATIONS

The government of Denmark should:

- *Continue implementation of the ambitious energy efficiency targets which can bring greater energy security, reduced CO_2 emissions and greater national competitiveness.*
- *Continue to perform further cost-benefit analyses as part of this implementation to assess the efficacy of individual efficiency measures.*

- *Clarify the concept and details of the "market-oriented" system imposed on distribution companies to achieve energy savings; consider the examples of countries implementing or planning "white certificate" or energy efficiency obligation programmes, such as Italy, France, the Netherlands and the UK, and the administrative costs involved as the system becomes more complicated.*

- *Clarify the measurement parameters of the efficiency programmes engaged in by the distribution companies, the Electricity Savings Trust and other groups to be able to better assess the efficacy and progress of such programmes; be aware that the planned review of these programmes in 2008 provides only a modest time to judge and thus requires clearly defined parameters.*

- *Implement a control and follow-up enforcement of the new energy regulations for buildings by all levels of government to ensure that the energy efficiency requirements are really achieved.*

- *Introduce measures to improve transport energy efficiency by addressing the following issues, among others:* i) *the current registration tax to ensure it differentiates on efficiency and does not keep older, inefficient cars in the fleet,* ii) *a tax system that penalises vehicle use rather than ownership, and* iii) *use of voluntary energy savings agreements.*

- *Investigate whether load-shifting measures can be introduced together with efficiency measures to shave demand from costly peak times and/or to make the demand profile more consistent with the Danish supply profile.*

- *Explore opportunities to induce greater efficiency in the district heating (DH) sector through performance benchmarking, incentive-based rate-making or some form of competition.*

- *Ensure that DH regulations regarding obligatory participation and tariff structures with high fixed components do not impede efficiencies such as introduction of new appliances and new technologies, greater insulation and behaviour modification.*

- *Investigate the prospects of energy efficiency coming from private-sector energy service companies (ESCOs).*

RENEWABLE ENERGY

CURRENT AND HISTORICAL PRODUCTION

Traditionally, renewable energy has not contributed substantially to Denmark's total primary energy supply (TPES). In 1973, renewable energy accounted for 0.35 Mtoe, or 1.8% of total Danish supply. However, in the 30 years until 2003, renewables supply grew by nearly 700% to reach 2.79 Mtoe, or 13.4% of TPES. This places it ninth on the list of 26 IEA countries ranked by percentage of TPES coming from renewables. This high ranking is particularly noteworthy given the near-complete absence of hydropower in Denmark. Denmark has the lowest absolute contribution from hydropower among all IEA countries. In 2003, the weighted average for renewables contributions from all IEA countries was 5.8% of TPES.

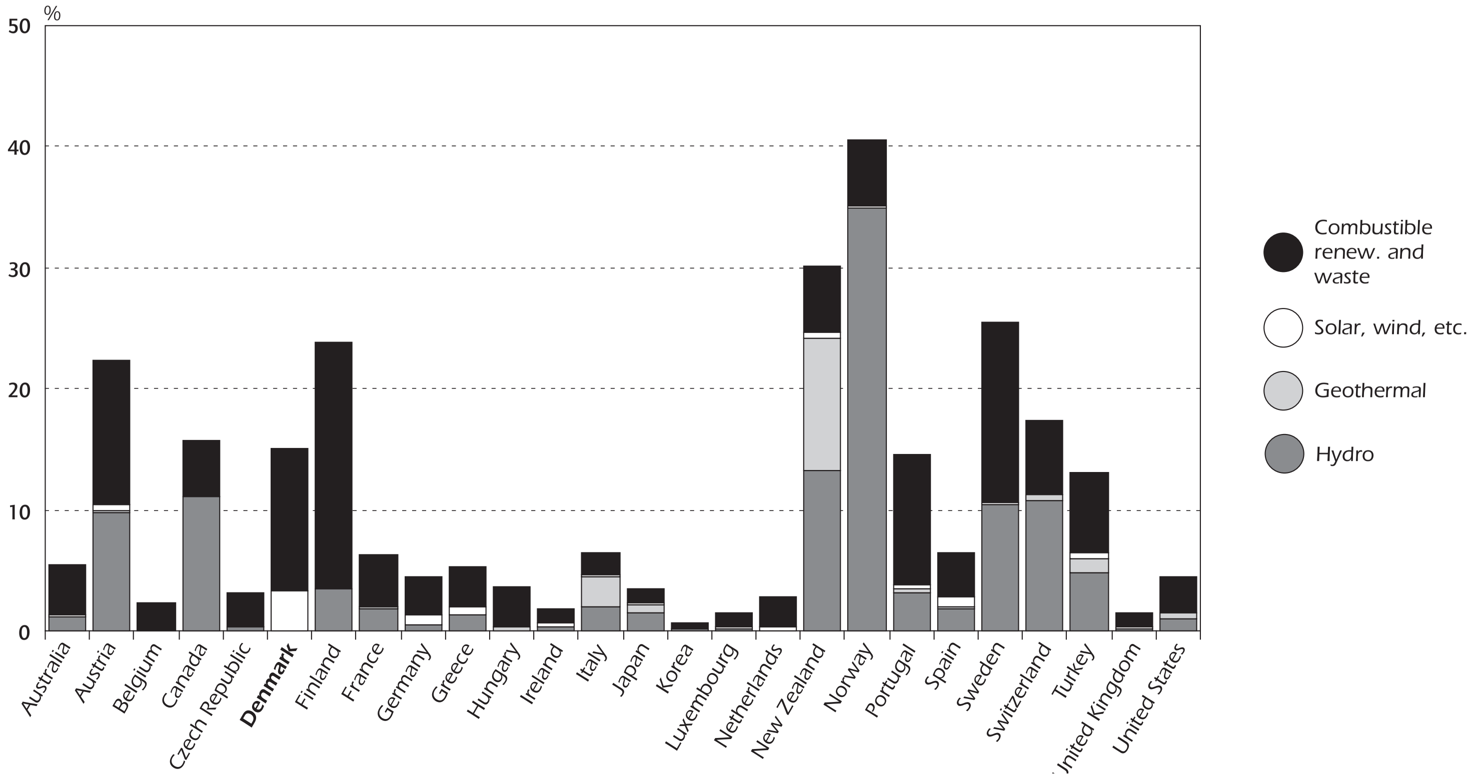
In 2003, Denmark's 2.8 Mtoe of renewable energy supply came from biomass (82% of all renewables), wind power (18% of total), solar thermal (0.3%), hydro power (0.1%) and geothermal (0.1%). In the ten years from 1993 to 2003, wind power has seen the greatest growth, expanding at an average annual rate of 18.3%. This increase has been characterised by tremendous growth spurts. For example in the two years from 1996 to 1998, wind generation grew by 130%. In 2000, wind power grew by another 40%. Growth in biomass has been strong but not quite as dramatic. In the ten years from 1993 to 2003, biomass supply grew at an annual average rate of 5.0% while in the five years from 1998 to 2003, the annual growth has accelerated to 7.0%.

Renewables play an even greater role in power generation. According to IEA statistics for 2003, electricity from renewable resources accounted for 20.0% of the total net generation in Denmark. However, given the large net exports during the year (and losses in electricity delivery), renewable electricity generation represented 26.5% of the final consumption of electricity. Table 15 shows these and other percentages for different renewable resources.

While the IEA is still in the process of calculating final energy statistics for 2004, initial indications are that renewable energy contributions to both primary supply and electricity generation rose substantially from 2003 to 2004. According to preliminary indicators, biomass supply grew by 3.3% from 2003 to 2004 and wind power by 18.0%. Biomass's share of total electricity generation grew by 28% year-on-year while wind's share grew by 34%. Statistics from the Danish Energy Authority show wind power increasing by 18.3% from 2003 to 2004 and biomass supply by 6.0%.

Figure 13

Renewable Energy as a Percentage of Total Primary Energy Supply in IEA Countries, 2004*



*estimates.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2005.

Table 15

Renewable Electricity Generation as Different Percentages, 2003 (2004)

(The figures for 2004, where available, are given in the parentheses)

	Wind Power	*Biomass*	*Waste*	*Total*
Generation, TWh	5.62 (6.58)	1.41	1.76	8.79
% of net generation[1]	12.8%	3.2%	4.0%	20.0%
% of domestic supply[2]	15.9% (18.5%)	4.0% (4.9%)	5.0% (4.1%)	24.9% (28.5%)
% of domestic consumption[3]	16.9%	4.2%	5.3%	26.5%

1. Net generation = gross generation less own use in power plants.
2. Domestic supply = net generation less net exports.
3. Domestic consumption = domestic supply – losses

Sources: IEA for 2003 figures, DEA for 2004 figures since final IEA figures not yet ready for 2004.

RENEWABLE ENERGY CAPACITIES BY TECHNOLOGY

While wind power receives the most attention in Denmark, production from biomass is actually much more extensive. Denmark also makes use of solar and geothermal energy. This section describes existing renewable energy capacities and production while the following sections outline the various current and historical government support measures for renewables.

BIOMASS

In Denmark, biomass currently accounts for approximately 80% of renewable-energy consumption, mostly in the form of straw, wood and waste for heating purposes. Consumption of biomass for energy production in Denmark nearly tripled between 1980 and 2002. A further increase is expected, rising by 15-20 PJ from approximately 85 PJ in 2002 to 100-105 PJ between 2005 and 2006. The consumption of biomass continues to rise as a source of energy for the supply of heat in DH plants and in smaller installations for households, enterprises and institutions.

A number of fuels, including garbage and waste, are categorised as "biomass". The most significant biomass fuel is solid biomass, which consists of straw and wood pellets as well as traditional firewood. This fuel accounted for 57% of Danish biomass in 2003. Renewable municipal solid waste (MSW) accounted for 30% of Danish biomass, non-renewable MSW accounted for 9% and biogas for 4%. Domestic consumption of biomass is greater than production. In 2003, 6.4 PJ wood pellets and wood chips were imported, while 1.7 PJ of biodiesel was exported.

Biomass is an important fuel used in Denmark's numerous CHP and often related DH plants. These CHP plants play an essential role in the Danish energy sector since there are very few stand-alone thermal electricity plants. Table 16 below shows the contribution from biomass fuels to production of both heat and electricity at these CHP plants.

Table 16

Use of Biomass Fuels in CHP Facilities, 2003

	Input (TJ)	*% of Total*	*Elec Gen (GWh)*	*% of Total*	*Heat (PJ)*	*% of Total*
Total CHP	398,747	*100.0%*	40,479	*100.0%*	105,874	*100.0%*
Sub-total biomass	44,735	*11.2%*	3,161	*7.8%*	24,332	*23.0%*
Solid biomass	16,273	*4.1%*	1,407	*3.5%*	7,021	*6.6%*
MSW	25,702	*6.4%*	1,479	*3.7%*	16,476	*15.6%*
Biogas	2,760	*0.7%*	275	*0.7%*	835	*0.8%*
Other non-RE fuels	354,012	*88.8%*	37,318	*92.2%*	81 542	*77.0%*

Source: "Electricity Information", IEA Paris, 2005.

WIND POWER

The total wind power capacity in Denmark reached 3 118 MW by the end of 2004, with 2 375 MW in western Denmark and 743 MW in eastern Denmark. The total number of turbines was then 5 398.

Several different groups own wind turbines in Denmark, namely private individuals, private co-operatives, private industrial enterprises, municipalities and power utilities. Wind turbines have typically been installed in clusters of three to seven machines. Such clusters are preferred in the spatial planning by local and regional planning authorities although, in a few places, larger wind farms are allowed and have been built.

Vestas

Vestas is considered a substantial success story for Danish industry. They were true pioneers in developing a wind power technology. The company benefited from the high demand for wind turbines that resulted from Danish energy policies and the fixed feed-in tariffs for electricity from wind plant. Using this domestic market as a base, the company has been able to grow rapidly and now sells the large majority of its products internationally.

Vestas is currently the world's leader in wind turbine manufacture and installation. This position has been attained through both organic growth and acquisition activity, notably through the merger with NEG Micon. In

2004, Vestas installed 2 784 MW of wind turbines, equal to 34.1% of all turbines (by power net capacity) installed around the world. To date Vestas has installed 17 538 MW, or 36.7% of the 47 912 MW. Turnover has increased steadily for the past several years. From 2000, when turnover was EUR 869 million, turnover has increased by nearly 200% to 2004 when it was EUR 2 561 million. As of year-end 2004, Vestas had 9 594 employees worldwide.

Despite Vestas's leadership position and expanding turnover, it is still experiencing some growing pains. Its share price on the Danish market fell from a high of DKK 452 in November 2000 to a low of DKK 62 in December 2004, although it had climbed back to around DKK 140 by November 2005. In August 2005, Vestas posted its first-half results for the year, which show a loss of EUR 78 million, larger than expected. The company announced planned lay-offs of 625 employees. Vestas is seeing production bottlenecks within the company owing to increased demand as well as problems with components delivered from subcontractors. In addition, competition is increasing, primarily from Spain's Gamesa, Germany's Siemens and the United States' GE.

Denmark's largest onshore wind farm in capacity is Rejsby Hede. It began in 1995 and has 39 600 kW turbines for a total capacity of 21.4-MW. The largest turbines on land are five 3.0-MW turbines and five 2.75-MW turbines installed in 2002. Currently 3.6-MW and a 4.2-MW turbines are being tested.

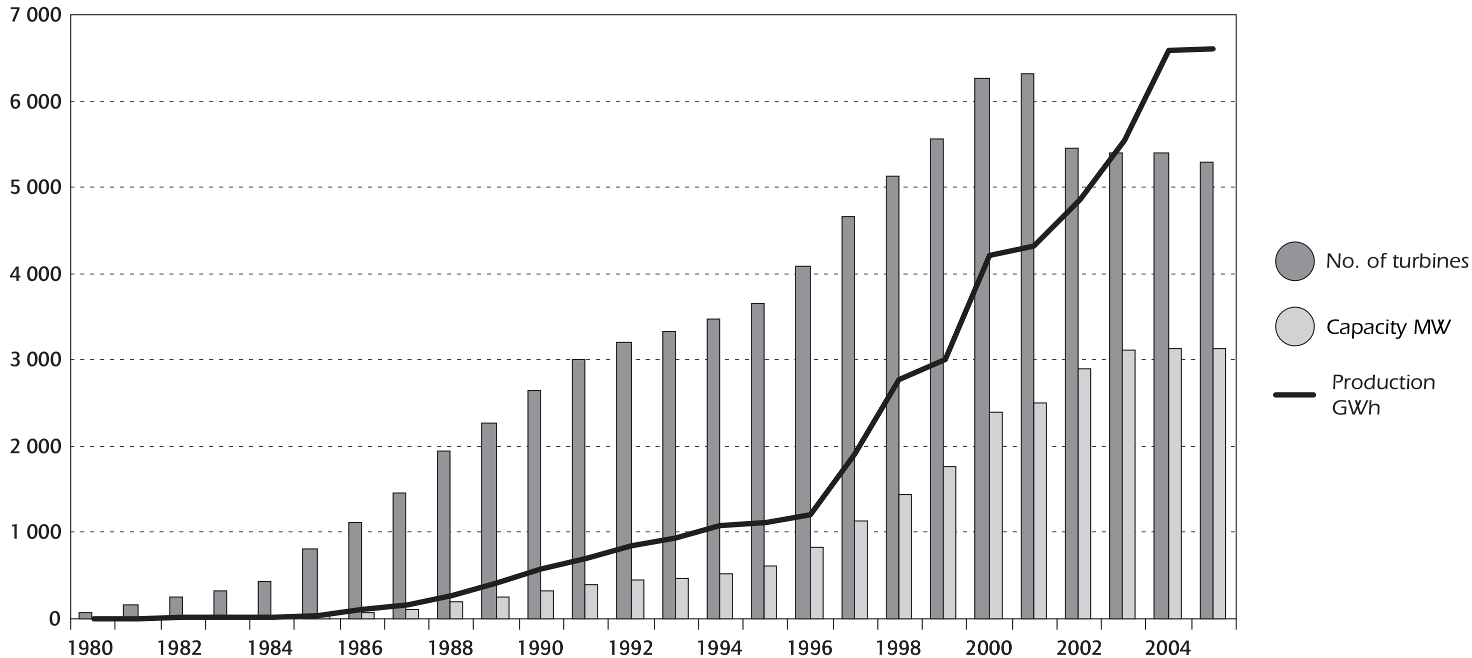
The average size of new wind turbines has grown gradually from 750 kW in 1999 to 2 MW in 2003. In 2004, the average size was smaller because no new offshore turbines were installed. Figure 14 shows the development of wind power turbines, capacity and production.

Offshore wind farms

Offshore wind farms generally have higher capital and operating costs given their location but do enjoy more consistent and generally higher wind speeds than onshore turbines. Generally, an offshore turbine will generate up to 1.5 times the electricity of a comparable onshore turbine although performance can vary considerably depending on local conditions and the height of the turbines. While offshore plants face public resistance owing to their visual effect from the shore, and to interference with bird migration and shipping, they are generally easier to site than onshore plants, especially in Denmark where many of the more attractive onshore sites have already been used. Currently, the cost of electricity produced from offshore plants is greater than that coming from onshore plants.

Figure 14

Development of Wind Power Capacity and Production, 1980 to 2004

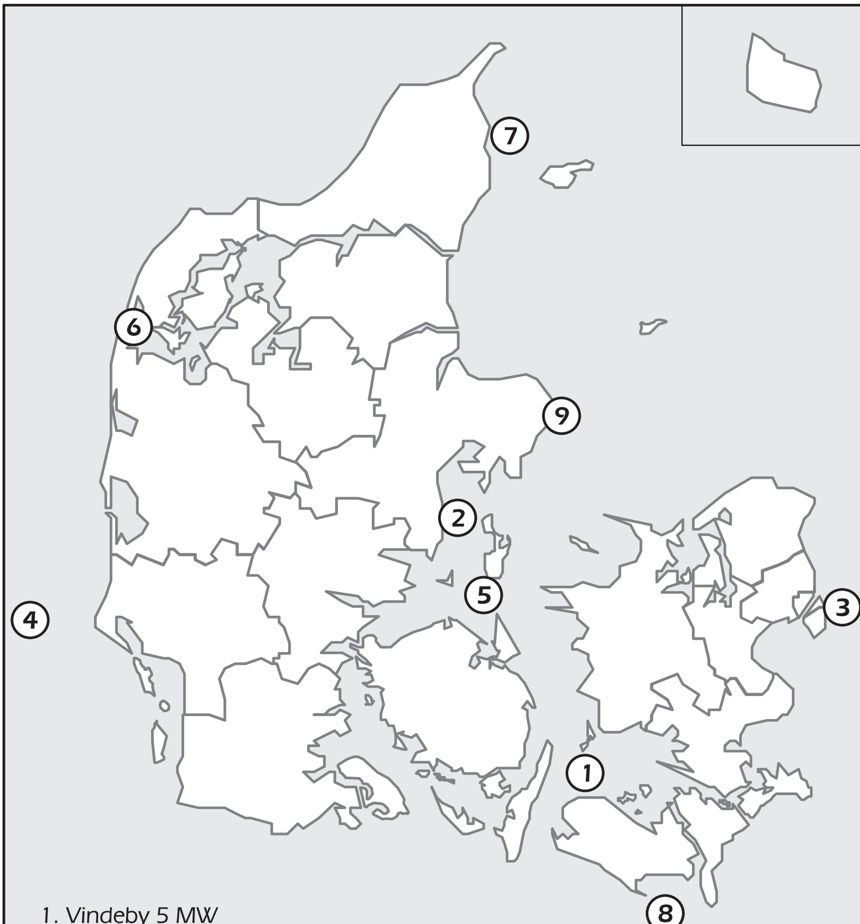


Source: IEA Wind Energy Annual Report 2004.

As of November 2005, Denmark had 425 MW of offshore wind capacity, as shown in Figure 15 below.

Figure 15

Map of Danish Offshore Wind Farms



1. Vindeby 5 MW
2. Tunø Knob 5 MW
3. Middelgrunden 40 MW
4. Horns Rev 160 MW (+ 200 MW in 2007/2008)
5. Samsø 23 MW
6. Rønland 17 MW
7. Frederikshavn 10.6 MW
8. Nysted-Rødsand 158 MW (+ 200 MW in 2007/2008)
9. Grenå 6 MW

Existing and approved offshore capacity 825 MW = 8% of elec. supply in 2009

Source: Danish Energy Authority.

The two largest offshore wind farm developments are Horns Rev and Nysted-Rødsand. Horns Rev was constructed by Elsam in the summer of 2002. The site is in the North Sea, between 14 km and 20 km off the Danish coast, west of Blåvands Huk. Nysted is located in the Baltic Sea, 10 km south of the island of Falster. Data on these two sites are shown in Table 17 below.

Table 17

Horns Rev and Nysted-Rødsand Offshore Wind Farms

Wind Farm Parameters	*Horns Rev*	*Nysted-Rødsand*
Installed capacity, MW	160.0	165,6
Number of turbines	80	72
Wind turbine type	Vestas 2-MW	Bonus 2.3-MW
Expected annual generation, GWh	600	595
Hub height	70	70
Blade length, m	40	41
Wind farm area, km^2	20	24
Water depth, m	6.5 – 13.5	6 – 9.5
Distance to shore, km	14 – 20	10
Distance between rows, m	560	850
Distance between turbines in rows, m	560	480
Internal grid voltage, kV	34	33
Transmission to shore voltage, kV	150	132

Sources: IEA Wind Energy Annual Report 2004, company information, DEA.

As part of the political Agreement of 29 March 2004, the government decided to hold tenders for expansion of turbine capacity at these two sites. It is expected that both Horns Rev and Nysted each will add 200 MW of capacity by 2009/2010. More information on the tendering process is outlined in the section on Government Policy and Support below.

SOLAR ENERGY

There are approximately 35 000 solar heating systems for hot water in Denmark. Such systems were subsidised for a number of years, but the subsidy was withdrawn on 1 January 2002. The world's largest solar heating system, which covers 9 000 m^2 is situated in Marstal. It is currently being extended to 19 000 m^2, including seasonal storage of solar heat in a soil deposit. In Denmark, 300 detached houses were supplied with photovoltaic power systems in the project SOL 300. In 2001 a new nationwide project, SOL 1000, was initiated.

GEOTHERMAL ENERGY

Denmark has subterranean geological structures that contain hot water. This water can be used for DH production, either directly or via absorption heat pumps or electric heat pumps. The first plant in Denmark was established in connection with the DH supply in Thisted in 1984. In 1996 the Danish Energy Authority set up a working group with the participation of GEUS and DONG, supplemented later by Elsam, Elkraft, SK, VEKS, CTR and KB, to study the potential for increased utilisation of geothermal energy in Denmark. In 2004, a demonstration plant supplying 1% of the total heat demand in Copenhagen was put into operation.

Samsø – The All-Renewable Energy Island

Following a competition between five island communities, in 1997 the Danish Energy Agency selected Samsø as the island that was to be converted uniquely to renewable energy supply. The aim of the project is to demonstrate that by establishing strong and broad local involvement it is possible to achieve a very high degree of self-sufficiency based on renewable energy. Samsø covers 114 km^2 and has 4 400 inhabitants as well as a large number of Danish and foreign tourists.

Already in 2000, Samsø became self-sufficient in electricity from eleven new onshore wind turbines, organised in three separate clusters with a total output of 11 MW. Wind turbine companies own two of these turbines (along with 450 island inhabitants) and individual farmers own the other nine.

Heat demand in the villages is to be covered by four or five DH systems supplied by straw, wood chips and solar heating. The first three plants have been constructed and are in operation. Outside the villages and boundaries of the DH system, residents use solar panels, biomass-fired central heating and heat pump plants. More than 15% of the residents not attached to the DH systems heat their homes entirely with renewable resources while the others use lesser amounts.

In 2003, an offshore wind farm was established at Samsø with ten turbines, each with an output of 2.3 MW. Five of the turbines are owned by the municipality of Samsø, four by large industrial companies and one by a co-operative of local investors. The production from these turbines equals the island's fossil fuel combustion in the transport sector and, in a net usage sense, makes the island self-sufficient through renewable energy use. The electricity grid on Samsø is linked to the mainland grid, which allows electricity to be transmitted back and forth depending on production from the local turbines.

In the long term, Samsø is hoping to be a leading island for utilisation of hydrogen produced from renewable resources. This hydrogen would fuel the transport sector to improve self-sufficiency.

GOVERNMENT POLICY AND SUPPORT MECHANISMS

Over the last 15 or so years, Denmark has engaged in what is probably the most ambitious support scheme for renewable energy technologies ever seen. The support has principally been feed-in tariffs that guarantee an above-market price for the sale of electricity generated by certain technologies, primarily wind. While the general trend in government support for renewables has been towards more market-oriented support, as well as an overall decrease in the level of the support, the majority of renewables plants in Denmark continue to sell their output under the older feed-in systems.

Renewable energy shares have consistently outpaced the targets established by the government. In 1990, the government released the Energy 2000 strategy, which called for 10% of Danish electricity consumption to come from renewables in 2005 and that figure has been more than doubled. In 1999, the energy policy agreement set the target of renewable generation as a share of domestic consumption at 20% for 2003. The government calculates that the actual figure was closer to 25%. The government has stated that it does not wish to set share targets for renewables (or any other forms of energy) and would rather let the market decide this within the framework of existing renewables support schemes.

OVERVIEW

Environment-friendly generation of electricity is eligible for subsidy, and includes production based on the following:

- Wind
- Biomass
- Biogas
- Waste
- Natural gas
- Solar energy
- Wave

Approximately 6 000 plants in Denmark generate electricity, of which some 5 400 are wind turbines. Eligibility and levels of subsidy depend on: *i)* fuel type, *ii)* plant technology type, *iii)* size, and *iv)* age of the plant.

Some of the subsidies are given in the form of a premium whilst others are regulated in relation to market price, so that the combination of market price and supplement ensures a fixed tariff for the producer.

ONSHORE WIND POWER SUBSIDIES FOR NEW PLANTS

Support for wind turbines began as a fixed feed-in tariff, but for newer turbines has been switched to a premium above the market price, sometimes with a price cap. The type of subsidy received is determined by the age of the plant and by when it was connected to the grid.

Turbines purchased prior to the end of 1999 are eligible for a subsidy that together with the market price ensures a tariff of 60 øre per kWh until the full load hour allowance is used up (determined by plant size), and thereafter 43 øre per kWh until the turbine is ten years old. A premium of 12.3 øre per kWh until the turbine is 20 years old is subsequently made available. This premium includes an allowance of 2.3 øre per kWh to offset costs to the generator of providing balancing power. Ten øre per kWh of this premium[15] is modified in accordance with the market price, as the total of the two must not exceed 36 øre per kWh.

Turbines connected to the grid in the period 2000-2002 are eligible for a subsidy that, together with the market price, ensures a tariff of 43 øre per kWh for 22 000 full load hours. A premium of 12.3 øre per kWh until the turbine is 20 years old is subsequently made available. This premium includes an allowance of 2.3 øre per kWh to offset costs to the generator of providing balancing power. Ten øre per kWh of this premium is modified in accordance with the market price, as the total of the two must not exceed 36 øre per kWh.

Turbines connected to the grid in the period 2003-2004 are eligible for a premium of 12.3 øre per kWh until the turbine is 20 years old, including an allowance of 2.3 øre per kWh to offset costs to the generator of providing balancing power. Ten øre per kWh of this premium is modified in accordance with the market price, as the total of the two must not exceed 36 øre per kWh.

Turbines connected to the grid from 1 January 2005 are eligible for a premium of 12.3 øre per kWh until the turbine is 20 years old, including an allowance of 2.3 øre per kWh to offset costs to the generator of providing balancing power. There is no price cap.

INCENTIVES TO REPLACE OLDER WIND TURBINES

Owners of smaller and/or older turbines that may be inefficient compared to newer technologies would be reluctant to replace or upgrade their plant since they would then lose their rights to above-market subsidies for that plant. In order to overcome this reluctance, the government has established a re-

15. The other 2.3 øre per kWh to offset the cost of balancing power can be adjusted upward to reflect increases in balancing costs and is not subject to the cap.

powering programme. This is an incentive system whereby owners of new plants receive an additional subsidy for the production covered by a certificate from a decommissioned small turbine.

For new turbines connected to the grid between 1 April 2001 and 1 January 2004, there is an extra premium of 17 øre per kWh for 12 000 full load hours for the production covered by a removing certificate from a 150 kW or less turbine decommissioned between 3 March 1999 and 31 December 2003.

For new onshore turbines connected to the grid from 1 January 2005 until 31 December 2009, there is an extra premium of up to 12 øre per kWh for 12 000 full load hours for production covered by a scrapping certificate from a 450 kW or less turbine decommissioned between 15 December 2004 and 15 December 2009. The premium is regulated in relation to the market price as the total of premiums and market price must not exceed 48 øre per kWh.

OFFSHORE WIND POWER SUBSIDIES

Wind turbines sited offshore are subject to a different, generally more generous, support scheme than the onshore facilities.

Offshore wind farms put into service between 2000 and 2004 by electricity utilities are eligible for a subsidy that, combined with the market price, comprises 45.3 øre per kWh. The subsidy is payable for 42 000 full load hours. If production is subject to a grid tariff, it is eligible for a compensation up to 0.7 øre per kWh. After all full load hours are used up, a premium of up to 10 øre/kWh is available until the turbine is 20 years old. The premium is regulated in accordance with the market price, as the total of the two must not exceed 36 øre per kWh.

Offshore plants put into service in 2005 or afterwards are eligible for a general premium of 10 øre per kWh above the market price. However, the government is now proceeding with plans for two tenders for extension of the existing offshore plants at Horns Rev and Nysted-Rødsand, each by 200 MW. These tenders resulted from a political compromise agreement. Companies interested in building and owning these wind farms submit the terms of their proposed plant to the government. Tenders submitted by the interested company must include physical specifications of the proposed plant, schedules and timelines for plant completion and the price at which the electricity from the plant would be sold. The government ultimately decides which company's proposal is allowed to proceed and thus the long-term above-market tariffs the plant can receive.

The bidding for the Horns Rev addition – the Horns Rev II – has been completed. ENERGI E2 was the winning bidder. The new wind plant, expected in operation from mid-2009, will receive a premium which, combined with the market price, will equal 51.8 øre per kWh for 50 000 full load hours, or approximately 12 years of full operation. After that, pure market conditions without any subsidy will apply.

For the extension of the Nysted-Rødsand wind farm – the Rødsand II – pre-qualification for the tender was in January 2005 and the four groups that pre-qualified are the following:

- A consortium consisting of the two Dutch companies – Ballast Nedam Infra BV and Evelop BV.
- Elsam Kraft A/S.
- Rødsand II A/S.
- A consortium of DONG Vind A/S, Sydkraft AB, now E.On Sverige and ENERGI E2 A/S.

The deadline for the submission of tenders was 13 December 2005 and negotiations with tenderers were held at the beginning of 2006. Tenderers competed on the size of the subsidy for a kWh price for 50 000 full load hours, the location of the project, the physical design and a timetable for implementation of the project. In May 2006, the government announced that a consortium of DONG Vind A/S, Sydkraft AB, now E.On Sverige and ENERGI E2 A/S won the bid. They will receive a premium which, combined with the market price, will equal 49.9 øre per kWh for 50 000 full load hours, or approximately 14 years of full operation.

SUBSIDIES FOR BIOMASS-FUELLED ELECTRICITY-ONLY PLANTS

The biomass agreement of 1993 forced central power stations to use biomass. This element of their production is eligible for a subsidy which, when combined with market price, ensures a tariff of 40 øre per kWh for a ten-year period. Electricity generated from fossil fuels in central power stations is not eligible for subsidy.

SUBSIDIES FOR ELECTRICITY GENERATED BY DECENTRALISED CHP PLANTS

Subsidies are paid to decentralised CHP plants depending on fuel type. The subsidies are paid on the electricity generation. Heat generation is usually sent to DH systems and the plants are compensated for this heat at cost-plus regulated rates.

Plants based on natural gas or waste

Existing plants with output over 10 MW (and as from 1 January 2007 over 5 MW) are eligible for an individual non-production-related subsidy corresponding to that received in the period 2001-2003. The subsidy is paid for 20 years from the date of the grid connection and for at least 15 years as from 1 January 2004.

Plants of 5 MW or less (up until 1 January 2007 under 10 MW) are eligible for a subsidy depending on when electricity production takes place. Combined with the market price, the subsidy ensures a tariff called three-tier tariff. At the start of 2005 the tariffs were approximately 22 øre per kWh at low demand, approximately 46 øre per kWh at high demand and approximately 59 øre per kWh at peak demand. Consequently, a typical mean annual tariff of 30-40 øre per kWh is achieved.

Plants using biomass

For biomass-fired plants connected to the grid before 21 April 2004, the transmission system operator (TSO) will sell the generation on the spot market, and the subsidy together with the market price will ensure a tariff of 60 øre per kWh for 20 years from the date of grid connection and for at least 15 years as from 1 January 2004.

For biogas plants connected to the grid between 22 April 2004 and 31 December 2008, the TSO will sell the generation on the spot market and the subsidy together with the market price will ensure a tariff of 60 øre per kWh for ten years and 40 øre per kWh for the following ten years. The subsidy implies that the total use of biogas does not exceed 8 PJ per year.

Biomass incinerators financed by electricity utilities

Plants financed by electricity utilities are plants built by electricity utilities as a result of an order or a special agreement. Plant owners are responsible for sale of production on the electricity market and for related costs. They are eligible for a subsidy that, combined with the market price, comprises 40 øre per kWh. The subsidy will be paid for ten years from the grid connection and for at least ten years as from 1 August 2001. A premium of up to DKK 100 per tonne of biomass fuel burnt can also be paid in the same period to a maximum of DKK 30 million per year. For the remaining period up to 20 years from the grid connection, a premium of 10 øre per kWh is paid.

Plants using renewable energy in combination with other fuels

If annual renewable energy utilisation is between 10% and 94% of the combustible value of the total fuels, then the plant is eligible for a special subsidy. For such plants, which began operation before 21 April 2004, the electricity can be sold at a premium of 26 øre per kWh for 20 years and for at least 15 years as from 1 January 2004.

SPECIAL ENERGY SOURCES AND TECHNOLOGIES

Special plants using energy sources or technologies of major importance to future exploitation of renewable energy electricity include wave power, solar energy, fuel cells using renewable energy sources, biomass gasifiers and Stirling motors or the like with biomass. Other types of plant can be approved apart from water turbines in rivers and production technologies already in use for biomass incineration. The TSO will sell the generation on the spot market and the subsidy, together with the market price, will ensure a tariff of 60 øre per kWh for ten years and 40 øre per kWh for the following ten years.

For other renewable energy plants connected to the grid after 21 April 2004, the TSO will sell the production on the spot market, and the owner will receive the market price as well as a premium of 10 øre per kWh for a 20-year period. Solar cell systems with an effect of less than 6 kW connected via consumption installations in households and that are exempt from electricity levies are not eligible for subsidy.

NET ACCOUNTS FOR PRIVATE GENERATORS

A private generator is a consumer who generates electricity or heat to cover his own requirements. Such entities are eligible upon application only to pay Public Service Obligation (PSO) in relation to the electricity they draw from the public grid. To be eligible for net subsidies, the generating plant must be entirely owned by the consumer and located at the site of consumption. A wind turbine can only be considered a private generator if it is connected to the grid via the consumer consumption installation.

TAX ADVANTAGES FOR RENEWABLES

In addition to the subsidies received for electricity from certain fuels and technologies, renewable energy sources are also treated favourably when it comes to certain types of taxation. For example, natural gas faces a combined energy, CO_2 and sulphur tax of DKK 56.01 per GJ, and coal has a combined tax of DKK 66.15 per kWh. Biomass fuels, on the other hand, face only minimal levels of taxation from the sulphur tax equalling between DKK 0.75 per GJ to 2.29 per GJ.

However, these tax advantages are muted significantly by two factors. One, the tax differential described above does not always come directly into play because all input fuels to electricity-only CHP or DH systems are tax-free; the taxes are only levied on final products. Thus, coal used to generate electricity faces the same tax as biomass used to generate electricity. Two, there is one single tax for final electricity consumption, regardless of the source of that electricity. Electricity from a wind plant is levied the same high retail taxes as electricity from a coal plant.

INTERNATIONAL COMPARISON

Table 18 provides a point of comparison between the renewable subsidy levels found in Denmark and those found in other countries. Unless otherwise specified, the figures cited refer only to feed-in tariffs or premiums that would be currently available for a new plant, not what some existing plants are getting under older subsidy schemes.

Table 18

International Comparison of Renewables Support (eurocents/kWh)

Country	*Onshore Wind*	*Primary Biomass*
Denmark (current regime)	1.7 (premium)	5.4 – 8.1
Denmark (older regime)	8.1	8.1
France	8.4	4.9 – 6.1
Germany	8.6	8.4
Spain	10.1	10.1

Source: IEA.

COSTS OF RENEWABLE ENERGY SUPPORT

PUBLIC SERVICE OBLIGATION (PSO)

The payments for the subsidies described above are recovered through the electricity bills of all Danish consumers. Prior to 2005, the portion of electricity that was generated through CHP and/or renewable energy was indicated as a separate amount on the consumers' bill. The per-kWh cost of this electricity was shown as the feed-in tariff or the premium over market price going to the renewable electricity generator.

Starting in 2005, the PSO surcharge has been put in place. Every three months, Energinet.dk calculates the total amount that will likely be required to honour the must-run subsidy obligations for renewables, the subsidies for CHP and other obligations such as research and development (R&D), maintenance of minimum capacity and balancing of renewable energy. It divides this sum by the total expected consumption in Denmark. The PSO surcharge is calculated separately for eastern and western Denmark and must be adjusted regularly because the "extra" cost of the feed-ins above the market price is directly proportional to the market price itself. At the beginning of 2005, the total PSO surcharge was approximately 15 øre per kWh applied to all electricity sales. Since market prices have risen substantially over the year, the PSO surcharge has fallen. As of 1 October 2005, Energinet.dk dropped the PSO surcharge in expectation of increased market prices of electricity in eastern and western Denmark. The PSO surcharge was reduced from 9.8 øre to 6.9 øre per kWh in western Denmark, and from 9.1 øre to 6.8 øre per kWh in eastern Denmark. Generally, approximately half of this surcharge goes to supporting renewable energy, primarily wind power.

The DEA estimates that the energy component of the average retail customer's bill in 2005 was 24.14 øre per kWh. This figure corresponds to the wholesale price in the market. Assuming that the renewable component of the PSO surcharge is 5.4 øre per kWh,[16] then this is equal to 20% of the average

16. Averaging high PSO surcharge for the year (15 øre per kWh) with the low (6.9 øre per kWh) is 10.95 øre per kWh. Half of this is used to support renewable energy.

wholesale price. So, for this example, each Danish consumer paid 20% more for the wholesale electricity than they would have in order to support renewable energy. However, customers at the retail level must also pay grid fees and taxes in addition to buying the actual wholesale electricity. These payments differ for households and businesses, with businesses generally paying substantially less grid fees and taxes than households. Table 19 summarises the estimates of PSO for renewable energy as a percentage of various components of the electricity price.

Table 19

RE Component of PSO as % of Various Electricity Prices, 2005

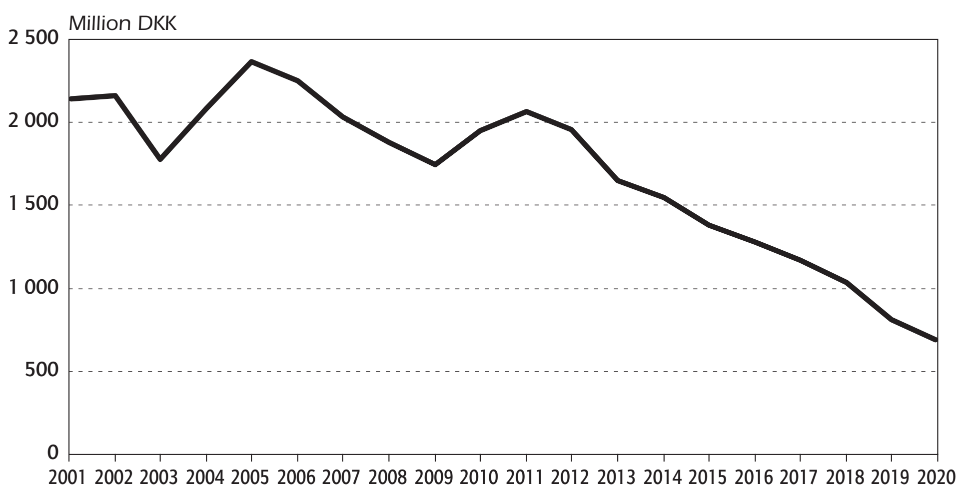
RE part of PSO as % of:	*Households*	*Businesses*
Wholesale electricity price	20%	20%
Retail price without taxes	9%	14%
Full, taxed retail price	3%	9%

RE: renewable energy.
Sources: IEA, DEA.

The total amount paid to subsidies provides another measure of the costs borne by society to support renewables. The figure below shows historical and projected costs passing through the PSO for renewable electricity generator payments above the wholesale price of electricity.

Figure 16

PSO Payments to Support Renewable Energy, 2001 to 2020



Source: Danish Energy Authority.

The jump in renewables costs from 2004 to 2005 is largely due to the move from historical to projected amounts. The projected amounts assume a market price of 22 øre per kWh while current spot and future prices are above that. Any increase in the market price of electricity will result in lower effective payments for the renewables and thus lower PSO payments.

In 2004, the expected payment on renewable is DKK 2 088 million, which is approximately 0.2% of that year's total GDP. It is also equivalent to approximately DKK 390 per person for that year.

ECONOMIC COUNCIL STUDY

In spring 2002, the Economic Council[17] published a report on the Danish economy. In addition to its assessment of the general economic conditions in Denmark, the council evaluated Danish environmental and energy policies of the 1990s. It calculated the net present value (NPV) of a range of energy and environmental policies using two different assumptions on the value of decreased CO_2 emissions. It concludes that policy support for renewables in the 1990s represented a negative investment for Danish society, even with CO_2 emissions valued at the fairly high rate of DKK 270 per tonne (approximately EUR 36 per tonne). The results from the report with two different figures assigned to the value of CO_2 emissions are shown in Table 20 below.

Table 20

Economic Council's 2002 Assessment of Renewables Policies from 1992 to 1999

Policy	*NPV (billion DKK)*	
	CO_2 Price of 47 DKK/tonne	*CO_2 Price of 270 DKK/tonne*
Support of private onshore wind farms	−13.1	−4.0
Support of utility on- and offshore wind farms	−4.5	−0.7
Support of biomass	−8.0	−4.6
Support of other renewables	−5.5	−4.8

Source: "Danish Economy, Evaluations of Danish Environmental and Energy Policy in the Nineties", Danish Economic Council, 2002.

17. The Economic Council is an economic advisory body established by the State in 1962. The Council has 29 members representing unions, employers and the government. The objective of the council is to monitor the Danish economy and analyse the long-term economic development and the interaction of the economy and the environment.

The same Economic Council report states that the net present value of all subsidies to wind plants based on policies in place from 1992 to 1999 is a negative figure of DKK –3 billion (assuming the higher of the two CO_2 prices in Table 20, DKK 270 per tonne). The subsidies and preferable taxation amount to a cost of DKK 25 billion, while the environmental benefits amount to DKK 20 billion plus DKK 2 billion because the stimulated wind production leads to the accumulation of manufacturing experience by Danish windmill makers, thus reducing their production costs.

The report cautions that a positive economic benefit to society through support of a particular industry is not sufficient to conclude that the policy has been successful. The creation of a competitive advantage for a single industry may result from chance, or because so many industries have been supported that it would be surprising if no successes occurred. A necessary condition for implementing an industrial policy directed at single industries is that the industries with the greatest potential for creating economic value to society can be identified. For these industries, government support can be expected to lead to greater growth in employment, bigger increases in consumer welfare and larger increases in the returns on capital and labour than is the case with support to other industries. Furthermore, there should be an expectation that support to the selected industries will bring more economic value to society than other policies such as those related to education or health. These requirements are demanding but are nevertheless prerequisites for directing industrial policy at single industries.

IMPACTS ON FUNCTIONING OF ELECTRICITY MARKETS

Government intervention to make renewables part of the energy mix can have impacts in the larger energy market. This is particularly apparent in the electricity sector where the introduction of renewable energy has had the following three effects on the sector.

Constrained market dynamics

As a member of Nordpool, Denmark is a pioneer of liberalised electricity market prices. As such, it benefits from the competitive forces that encourage efficiency and lower electricity costs and prices. While not perfect, both Nordpool and Denmark have been successful in maintaining an open, transparent and competitive system. (See Chapter 7 for more details.)

However, the government's influence on renewable energy may at times prevent the open electricity market from maximising its efficiency. Its influence determines to a large extent which generating technologies will be introduced, when they will be introduced and how much they will be paid for the products. While, in theory, this would be a difficulty for any electricity market, the issue is particularly acute in Denmark where about one-third of the electricity produced is either must-run renewables or must-run CHP plants.

New entrants at a disadvantage

A new entrant to an electricity (or any) market will always be at a disadvantage given the incumbent's positioning, experience and brand recognition. The new entrant's means of winning market share in the target market is through differentiation. The new company will offer either a new product or a new price that differs from the incumbent's offering in a way favoured by consumers. With the government playing such a large role in the type, timing and pricing of any new entrant, this opportunity to differentiate diminishes significantly. Entry to a market is considerably easier if the market being targeted is expanding organically. If the market stays the same size, it will be more difficult to come into a market and grab shares from the incumbents. By cordoning off a section of the market to be reserved for renewables, at terms largely defined by the government, the renewables subsidy scheme is decreasing the size of the market and thus making new entry even less attractive. The issue with existing market power of electricity incumbents and coming market power following the DONG acquisition have been well noted and are discussed in greater length in Chapter 3. The dampening effect that the renewables subsidy scheme has on new entrants will only make this situation worse. The question of new entry must always be seen in the context of Denmark's extensive interconnections with neighbouring countries, which make import/export much easier and thereby act as an impetus to new entry.

Greater potential for market power abuse

The renewables subsidy scheme can also exacerbate any potential market power abuse. Market share is the primary means by which electricity companies can raise the wholesale price of power above competitive levels. Market share in this context can be defined as the percentage of the demand that can be covered by any one company's generation. By setting a significant portion of the demand for certain types of plants (through the must-run provisions of many renewable energy and CHP plants), the demand over which companies compete effectively shrinks. This makes the market share of the incumbent companies even greater and thus enhances their ability to control the market.

TRANSMISSION REINFORCEMENT AND GRID OPERATION

All electricity generation other than autoproduction must connect to the electricity grid. There are costs inherent in that connection and in the use of the grid to transport the product to the final consumer. While this is true of both renewable energy and conventional generation technologies, renewable resources and, in particular, wind power, have some unique characteristics that may make their connection to and use of the grid system more costly. Such costs can be broken down into the following three categories.

Operational costs of managing the intermittency of wind

The amount of wind generation is proportional to wind speed, which itself is both an uncontrollable and continuously changing quantity. Thus the output from wind plants will fluctuate over days and hours and even minutes. The electricity system must be continually balanced between supply and demand, and changes (up or down) in wind generation must be matched with an inverse change (down or up) from another generator attached to the system.[18] This change in output inversely proportional to the wind plant's change is called balancing power. There is a cost involved in supplying balancing power and thus the other generator is compensated by a market-determined price.

A Test of Wind Power Intermittency

In January 2005, the transmission system's response to massive fluctuations in wind power was severely tested. A storm coming off the North Sea raised wind speeds steadily on the morning of 8 January. The overnight base level wind speeds ranged from around 10 metres per second (m/s) for north-west Zealand to around 17 m/s for north-west Jutland. As the storm entered Denmark, wind speeds across the country rose steadily. As they went over the maximum allowable limits for wind turbines throughout the morning, increasing numbers of wind turbines shut themselves down. Since the increase in wind speeds was so dramatic and spread out across the entire country, this resulted in a massive decrease in generation from wind power.

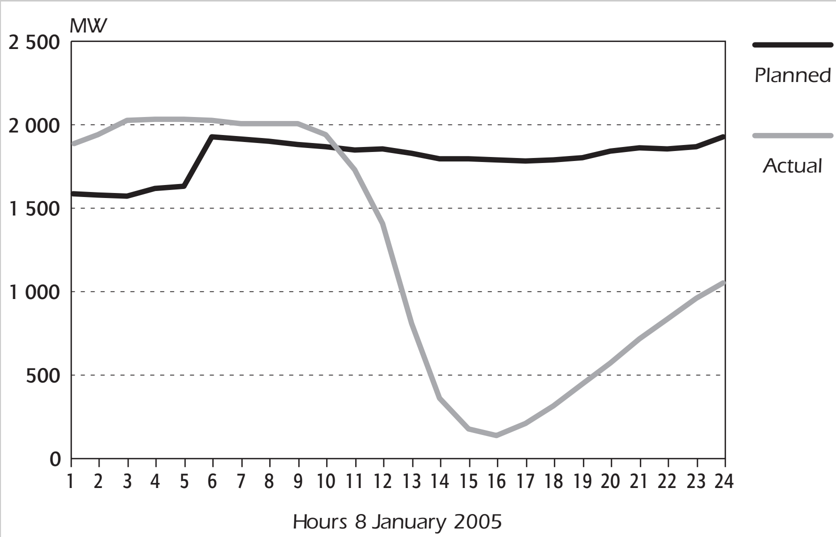
Wind generation dropped at a rate of about 500 MW per hour throughout the late morning and early afternoon. In western Denmark, which contains the majority of the country's wind turbines, generation from wind dropped to less than 10% of the predicted value and the lost generation in some hours was more than 60% of the demand at that time. This is illustrated in Figure 17.

Continued

18. This fluctuation could also be managed by a corresponding change in demand. However, demand response over short time frames is difficult to do and not highly developed in Denmark or elsewhere.

Figure 17

Wind Power Generation in Western Denmark, 8 January 2005



Source: Energinet.dk

Throughout the storm and the resultant drop in wind power, both the western and eastern portions of the transmission grid maintained system integrity. There were no blackouts, brownouts or power cuts of any kind. Almost all the lost wind power was compensated by increased imports from Norway and Sweden. At 15h00 on 8 January, the western part of Denmark had planned to export 635 MW to Norway. As a result of the loss of wind power, this flow was reversed and Denmark imported 823 MW from Norway. In the last 12 hours of 8 January, the western part of Denmark had planned to export 6 658 MWh of power to Norway, whereas it actually imported 4 934 MWh, a swing of 11 592 MWh. This represented more than 40% of the consumption for the western part of Denmark. At one point in that afternoon, the amount of ramped up, unexpected regulating power coming into the system was 1 707 MW, or nearly 70% of the domestic demand at that time. Throughout this period, exports from Denmark to Germany were maintained at near to planned levels.

The loss of wind power on that day was a massive phenomenon by any measure and the continual system integrity speaks to the resiliency of the system, especially the importance of access to the hydro resources of Norway and Sweden.

The essential dynamics of balancing power are no different for a wind plant as they would be for a coal plant or a photovoltaic (PV) facility. The difference in overall balancing costs for each technology is based on the extent to which their generation will be involuntarily changed over relatively short periods of time. In this case, wind has substantial disadvantages compared to fossil fuels and therefore faces greater balancing payments. One study commissioned by the UK Department of Trade and Industry and performed by ILEX Energy Consulting[19] assessed the costs of handling the intermittency of wind power by comparing modelled costs in the current electricity system with costs in a system with different quantities and dispersions of wind power. The model results for the balancing costs are EUR 3-4 per MWh of wind power at penetration rates of 20-30%. These costs include some costs for keeping operational reserves.

Eltra, the TSO in western Denmark, reports that for the 3 368 GWh of wind power that it handled in 2003, the total balancing costs were DKK 65 million. This corresponds to EUR 2.6 per MWh of wind power. Currently Eltra makes wind power forecasts with a 13-37 hour time horizon that has an average error of 30-35 %. The 13-37 hour time horizon is the relevant time frame in the current Nordic market. This implies that for every 100 MWh of wind power, alternative resources must adjust their operation by some 30-35 MWh on average.

In Denmark, wind power plants are treated the same in terms of balancing power as their conventional counterparts. Wind plants bid their expected production into the market. Their failure to meet that bid, or generation above that level, results in the TSO buying balancing power from the market and passing along the price of this balancing power to the wind power plants that failed to meet its generation targets. In this way, the need for additional balancing power required given wind's inherent intermittency is fully transparent and is included in the subsidy payment the wind plant receives and is therefore not a hidden cost. The 2.3 øre per kWh balance that certain wind plants receive on top of their 10 øre per kWh premium is intended to compensate for the additional balancing costs that wind incurs.

Hydropower plants are able to ramp up and ramp down production quickly and with little additional wear and tear in the equipment or losses in efficiency. Consequently, they are an excellent technology to provide balancing power. In this way, Denmark's connection to Norway and, to a lesser extent, Sweden, is fortuitous and almost certainly decreases the cost of balancing power compared to a less hydro-intensive electricity system.

19. ILEX Energy Consulting & Goran Strbac, Manchester Centre of Electrical Energy, "Quantifying the System Costs of Additional Renewables in 2020", A report to the Department of Trade and Industry, October 2002.

Costs of keeping additional reserve generation as backup

While balancing costs to maintain system integrity in response to short-term fluctuations in generation are priced by the market and covered by the generators themselves, the longer-term security of supply aspects of wind power are not so explicitly stated. Since Nordpool has no capacity component to its pricing scheme, explicit value is not given to generator capacity. However, the system operator (TSO) is obliged to ensure security of electricity supply. Within the mix of generating technologies that the TSO has to ensure this security, some are more valuable than others. This value is a function of a technology's reliability and, to a lesser extent, the degree to which its generation profile matches the demand profile. No technology is completely reliable, so an evaluation of the capacity cost of wind power must be relative to the reliability of alternative resources. In general, wind's reliability and generation profile make a substantially lesser contribution to system security than other generation options such as thermal plants (fossil fuel or biomass-fired). The presence of wind power within the system brings with it an inherent security of supply cost. Unlike the additional balancing power costs, these are not explicitly stated and therefore are not covered by the wind plants themselves.

Two studies have estimated the cost of wind's poor value as a system capacity provider. The aforementioned ILEX study calculated that with a share of wind power representing 20% of the consumption, the additional capacity costs in Great Britain are EUR 6.7 per MWh of wind power generated. A report commissioned by the European Commission,[20] assesses the capacity cost of wind power in several EU countries and concludes it to be EUR 3-4 per MWh of wind power at shares of approximately 20% of consumption.

Costs in reinforcing and maintaining system control

All power generators selling into the grid must be connected to the central high-voltage transmission system, which places an additional burden on the security of the system. A number of characteristics of wind power make its connection to the grid and integration of its output into the system particularly expensive and/or operationally difficult. Individual onshore wind turbines and small onshore wind farms are usually connected to the local low-voltage grid. Large wind farms are often located in remote areas with little electricity demand and are connected to the grid at a higher voltage level. Offshore wind farms require the extension of the electricity system to new territories where there is no load. This will in many cases necessitate reinforcements of the grid. In addition, the relatively low capacity factors of wind plants means that the cost of any capacity upgrade to serve wind generation must be spread out over a smaller number of MWhs.

20. Hans Auer, Michael Stadler, Gustav Resch, Claus Huber, Thomas Schuster, Hans Taus, Lars Henrik Nielsen, John Tidwell and Derk Jan Swider, "Cost and Technical Constraints of RES-E Grid Integration", a report in the GreenNet study, February 2004.

Numerous wind power-related effects on electricity grids have been identified in systems with large shares of wind power. The most important effects are the following:

- Connection of production capacity closer to the load than traditional power stations will reduce grid losses.
- Large wind farms far away from the load will increase the need for electricity transport. There will be a need to reinforce the transmission and distribution grids.
- Traditionally, generation has been concentrated in a few large plants that are connected with the load through transmission lines in a hierarchical structure. The systems to monitor and control the grid have been developed for that. With large shares of wind power in the lowest level of the "hierarchy" close to the load, the control systems must be changed accordingly.

Many of the costs that will be incurred in meeting these challenges are not necessarily driven by the increase of wind power, but by the fact that the grid was developed to meet one set of needs, and now these needs are changing. The most obvious cost factor that is directly derived by an increasing share of wind is the need for transport of wind power from the wind resources to the load centres.

The effect wind power has on the transmission and distribution grid is highly system-specific. In the ILEX study, the grid costs of extending the share of wind power in the UK from 10% to 30% is assessed to be EUR 5.2 per MWh of additional wind power. The costs of extending the share from 10% to 20% are EUR 4 per MWh of additional wind power. These assessments are based on a scenario where most of the wind power is concentrated around the good wind resources in the north. In the GreenNet study, the assessment of the costs of reinforcing transmission and distribution grids is EUR 2.5-3 per MWh of wind power at penetration levels of approximately 20% of the consumption.

COSTS OF EMISSIONS REDUCTIONS FROM RENEWABLE ENERGY

One of the primary advantages of renewable energy over fossil fuels is the lack of emissions, primarily greenhouse gas (GHG) emissions that contribute to global climate change. This section performs some basic estimates of how much such emissions are decreased as a result of renewable energy and how that compares to the subsidy cost of supporting them.

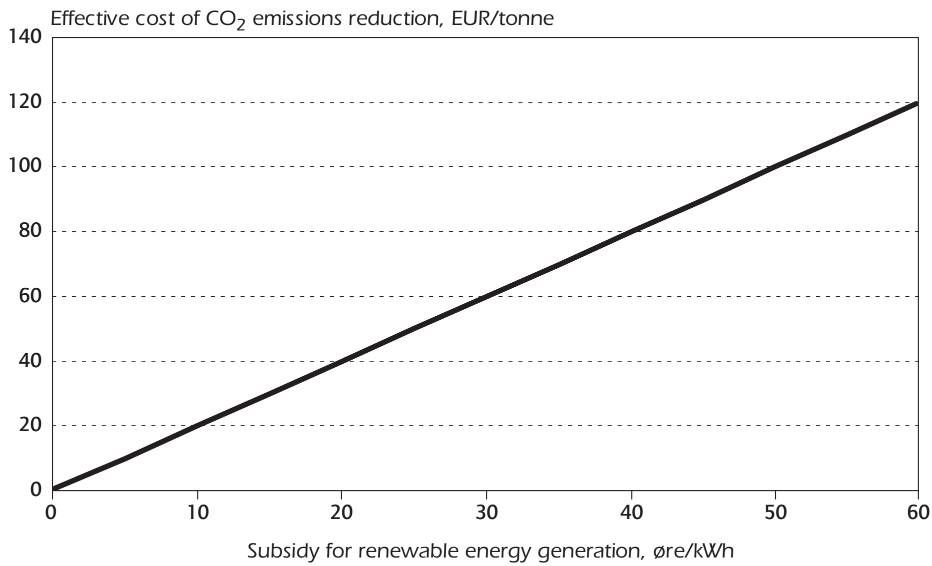
Given that approximately every zero-emission MWh of electricity generated from renewable energy in Denmark reduces CO_2 emissions by 0.67 tonne,[21]

21. Assumptions and methodologies behind this figure are found in the notes to Tables 21 and 23.

every øre per kWh of premium, or above-market rate, given to zero-emission renewable energy equals a cost of EUR 2 per tonne of CO_2 reduced. For example, if a wind plant received a tariff that is 20 øre per kWh above the market price, the effective cost of emissions reduction through use of that wind plant is EUR 40 per tonne of CO_2 (see Figure 18).

Figure 18

Effective Cost of CO_2 Emissions Reduction per Unit of Renewable Subsidy



Source: "Environmental Report 2005." Energinet.dk.

COST OF EMISSIONS REDUCTIONS BASED ON PREMIUMS FOR ELECTRICITY RENEWABLES

Tables 21 to 23 show the actual cost of supporting renewable energy per unit of CO_2 it reduces through displacing generation from fossil fuels. Results range from a low of EUR 24.63 per tonne of CO_2 displaced to EUR 79.77. The low figure corresponds to the wind premium of 10 øre per kWh plus 2.3 øre per kWh as compensation for balancing power. This figure is deemed too low to support new wind plants and thus far less than 40 MW have been installed under the subsidy scheme.

Table 21

Estimate of Effective Cost of GHG Reduction through Renewables Support

Data for first set of figures below relate to historical electricity prices while the second set relates to forward prices

Technology	*Feed-in Tariff øre/kWh*	*Assumed Mkt Price[1] øre/kWh*	*Actual or Effective Premium[5] øre/kWh*	*Actual or Effective Premium[4] EUR/MWh*	*Offset of CO_2 tonne of CO_2/MWh[3]*	*Effective GHG Offset Price EUR/tonne of CO_2*
Offshore wind						
Existing	45.30	20.16	25.14	33.74	0.67	50.34
Onshore wind						
< 1999, full load	60.00	20.16	39.84	53.46	0.67	79.77
< 1999, > full load	43.00	20.16	22.84	30.65	0.67	45.73
2000 – 2002	43.00	20.16	22.84	30.65	0.67	45.73
> 2003	n/a	n/a	12.30	16.51	0.67	24.63
CHP biomass plants[6]	60.00	20.16	39.84	53.46	0.67	79.77
Price to estimate EU-ETS market price	n/a	n/a	9.99	13.40	0.67	20.00

Data below relate to forward prices of electricity

Technology	*Feed-in Tariff øre/kWh*	*Assumed Mkt Price[2] øre/kWh*	*Actual or Effective Premium[5] øre/kWh*	*Actual or Effective Premium[4] EUR/MWh*	*Offset of CO_2 tonne of CO_2/MWh[3]*	*Effective GHG Offset Price EUR/tonne of CO_2*
Offshore wind						
Existing	45.30	26.04	19.26	25.85	0.67	38.57
Horns Rev II	51.30	26.04	25.26	33.90	0.67	50.58
Onshore wind						
< 1999, full load	60.00	26.04	33.96	45.57	0.67	68.00
< 1999, > full load	43.00	26.04	16.96	22.76	0.67	33.96
2000 – 2002	43.00	26.04	16.96	22.76	0.67	33.96
> 2003	n/a	n/a	12.30	16.51	0.67	24.63
CHP biomass plants[6]	60.00	26.04	33.96	45.57	0.67	68.00
Price to estimate EU-ETS market price	n/a	n/a	9.99	13.40	0.67	20.00

1. This is the average wholesale electricity price in western Denmark, weighted by wind generation, for every hour from 1 January 2001 to 16 November 2005; **2.** This price is the straight average of the yearly forward prices for wholesale electricity on the Nordpool financial market. The forwards for 2006, 2007 and 2008 were EUR 35.70/MWh, EUR 34.55/MWh and EUR 34.6/MWh; **3.** This figure is derived from Energinet's "Environmental Report 2005". In 2004, the average tonne of CO_2 emitted/MWh generated was about 0.5. Since we are only interested in the fossil fuels that would be displaced by renewable energy, we calculate that the emissions for fossil fuels are 0.67 tCO_2/MWh based on about 25% of the generation coming from renewables; **4.** 1 EUR = 7.45 DKK; **5.** This does not take into account the caps on various subsidy schemes; **6.** The final figure for CHP biomass is misleadingly high because parts of the subsidy payment is intended to compensate the plant for the efficiency benefits inherent in CHP, not just the carbon-neutral consumption of biomass.

Sources: Nordpool, "Environmental Report 2005." Energinet.dk, and IEA.

COST OF EMISSIONS REDUCTIONS BASED ON TOTAL PSO TO RENEWABLES

In 2004, Energinet.dk stated that Danish onshore and offshore wind plants, combined with hydropower and solar cells, produced 6 588 GWh. As calculated above, each non-renewable kWh of electricity generated in Denmark results in approximately 0.67 tonne of CO_2 being emitted. In 2004, electricity generation from wind, solar and hydro reduced Danish emissions by 4.4 Mt. Biomass also contributed to decreased emissions. In 2004, 25 776 TJ of biomass was used in CHP facilities. In its absence, additional fossil fuel combustion would have occurred. The ratio of fossil fuel combustion in 2004 for CHP plants was: coal (59%), natural gas (35%) and oil (6%). The weighted average carbon content of such a mix is 82.2 tonnes of CO_2 per TJ of energy. The emissions from such a mixture to replace the subsidised biomass would have been 2.12 Mt of CO_2.[22] This makes a combined CO_2 emissions offset from subsidised renewable energy equal to 6.53 Mt of CO_2.

The cost-effectiveness of these offsets can also be estimated. The total PSO payment in 2004 was DKK 4 170 million. The DEA estimates that about half of this, or DKK 2 085 million, is used to subsidise renewables. This is equivalent to around DKK 280/tonne of CO_2, or EUR 37.58 per tonne. This analysis can be even more specific. On the basis of DEA's forward-looking analysis, which calculates the expected final PSO payments, about 77% of PSO payments related to renewables will go to wind while 23% will go to biomass. Using those same ratios for the 2004 analysis, one can calculate that subsidised wind power provides CO_2 offsets at around EUR 49 per tonne of CO_2 and biomass around EUR 30 per tonne of CO_2.

COST OF EMISSIONS REDUCTIONS BASED ON DEA ANALYSIS

In 2005, the DEA released a report that included an analysis of the cost of reducing CO_2 emissions through historical support schemes for each of the subsidised renewable energy technologies. The related calculations assumed renewables had no other benefits and thus all excess payments for renewable electricity versus other options were allocated to emissions reductions. The results are shown in Table 22.

22. Although biomass is used in sectors other than CHP, this is the only one receiving explicit support in the form of a subsidy.

Table 22

DEA Figures on Cost of Emissions Reduction through Historical Support Schemes for Renewables

Technology	*CO_2 Reduction Cost (DKK/tonne)*	*CO_2 Reduction Cost (EUR/tonne)[1]*	*Avg. Emissions Reduction (tonnes CO_2), 2008-12*
Private onshore wind	275	36.9	3.4
Utility-owned wind	250	33.6	0.9
Decentralised CHP	100	13.4	2.1
Biomass	325	43.6	1.1

1. 1 EUR = 7.45 DKK.

Source: DEA.

SUMMARY

Table 23 below provides a summary of the costs of displacing CO_2 emissions through subsidised renewables use. Four different methodologies or sources are given: *i)* the Economic Council 2002 report, *ii)* the DEA report from 2005, *iii)* IEA bottom-up calculations, and *iv)* IEA top-down calculations.

Table 23

Summary of Estimates on Cost of Emissions Reduction through Historical Support Schemes for Renewables (EUR/tonne of CO_2[1])

	Economic Council	*DEA*	*IEA Premium-based Calculations*	*IEA PSO-based Calculations*
Existing offshore wind	n/a	n./a	50.3	49.0
Horns Rev II[4]	n/a	n/a	62.3	
Private onshore wind	49.4	36.9	24.6 – 79.8[2]	
Utility-owned wind	41.8	33.6		
Decentralised CHP	n/a	13.4	n/a	n/a
Biomass[3]	76.7	43.6	79.8	30.0

1. All figures look at data from 2003 and 2004. As electricity market prices rise (predicted by Nordpool forward prices) the cost of supporting renewables and the costs of reducing emissions through renewables will drop; **2.** Depends on when turbine is put into service. See Table 21 for more details; **3.** Biomass figures are difficult to compare because their support is difficult to separate from the support to greater efficiency of CHP plants where biomass is often fired; **4.** Since Horns Rev II will not be operational until 2010, it uses market forward prices from 2006 to 2008 to estimate how much above market the tariff will be. As market electricity prices rise – if only at inflation – the implicit cost of each tonne of CO_2 suppressed will go down and will likely be less than the EUR 50.58/tonne shown in Table 21.

Sources: "Danish Economy, Evaluations of Danish Environmental and Energy Policy in the Nineties", Danish Economic Council, 2002; DEA and IEA.

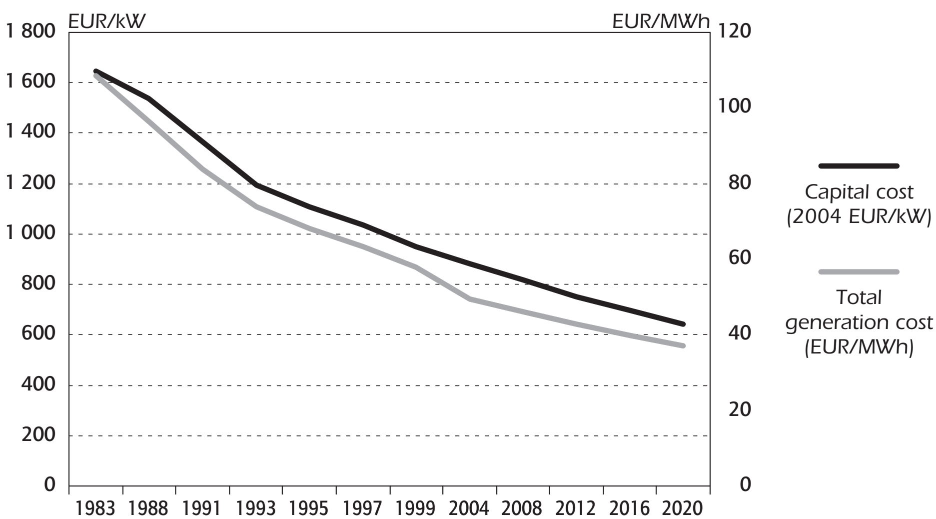
DEA ESTIMATES OF WIND POWER COSTS

The DEA has performed a range of analyses on the capital, operating and full production costs of wind plants operating in Denmark. While each plant's costs will be different owing to siting and construction issues, financing costs, wind resources and state of technology, DEA has assembled a guide to the historical and projected costs for wind generation.

The progression of these costs has clearly been downward and this trend is expected to continue. DEA estimates that the average cost for wind power in 1983 (in 2004 prices) was 10.8 eurocents per kWh whereas it had fallen to 4.9 eurocents by 2004. By 2020, the cost will be down to 3.7 eurocents per kWh. The main reason for this fall in prices has been the fall in capacity costs, which itself results partly from the increasing size of the turbines and related economies of scale: from the 1983 capacity cost of more than EUR 1 600 per kW installed (2004 prices) to a 2004 level of EUR 881 per kW and to a projection of EUR 642 per kW by 2020. The figures below show DEA's assessment of full and capital costs both historically and as a projection.

Figure 19

Capital and Full Generation Costs for Onshore Wind Turbines, 1983 to 2020



Source: Danish Energy Authority.

IEA/NEA GENERATING COST STUDY

In 2005, the IEA and the Nuclear Energy Agency (NEA) jointly produced a survey of the costs of generating electricity from different technologies, among them renewable energy plants. The study gathered capital and operation and maintenance (O&M) costs from industry participants and turned them into per kWh costs through a levelised methodology.

For wind plants, information from three different onshore turbines was gathered with levelised costs ranging from 2003 USD 44.2 per MWh to USD 54.8 per MWh. The costs for Danish plants tended to be somewhat lower than the costs for turbines sited in other countries. The full range of wind costs for two different sets of financing assumptions is shown in Figure 20.

Fewer data points were collected for other renewable energy sources. For example, no data were collected on biomass use in CHP plants although there were two stand-alone electricity plants fired by biomass. One in the Czech Republic reported a full cost of between 2003 USD 85.2 per MWh and USD 100.5 per MWh (depending on financing), while one in the United States reported a much lower range of costs between USD 37.3 per MWh and USD 50.3 per MWh. For solar photovoltaic electricity, one plant in Denmark reported a full production cost of 2003 USD 484 per MWh.

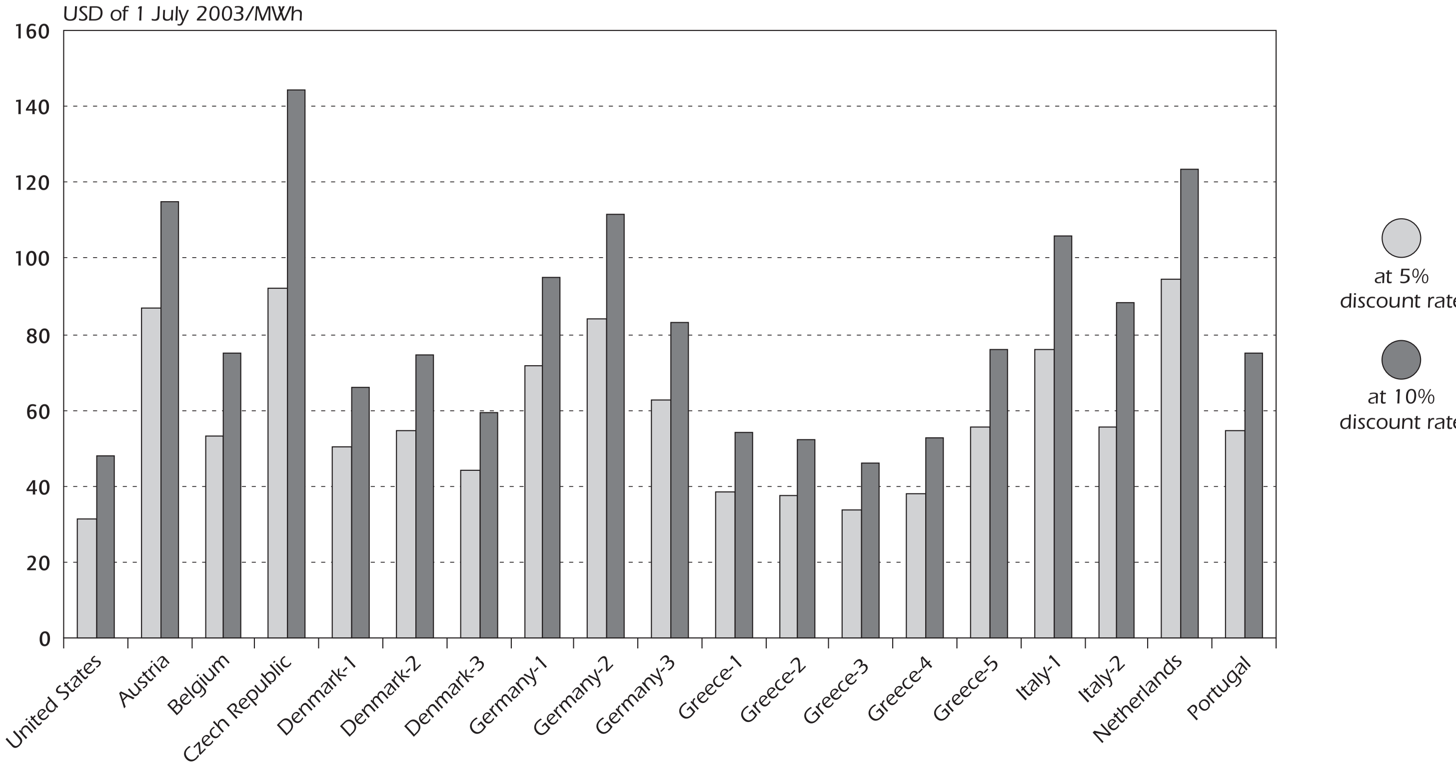
CRITIQUE

Denmark has been a pioneer in the advancement of renewable energy. The country has been a leader in the technology of wind power, subsidy schemes to promote renewable energy use and integration of these technologies into the larger electricity market. As a result, the country now has one of the greatest shares of non-hydro renewable energy among all OECD countries and the greatest percentage of electricity produced from wind. Unlike many countries that have high renewable energy use resulting from historical exploitation of cheap hydropower (and to a lesser extent biomass), Denmark's large renewables share is a direct result of policy action. Danish industry, and the country as a whole, has also benefited from government support of renewables. The wind industry creates jobs and brings export revenues to the country. The R&D spent on renewables and the effective demonstration of high renewables penetration provide an excellent source of experience for other countries that may wish to pursue similar paths.

While Danish efforts have undoubtedly been successful in achieving and even surpassing goals on renewable energy shares, the success of these efforts from the point of view of overall national interest requires further analysis. For example, the Economic Council's 2002 report concluded that the present value of the policies in place from 1992 to 1999 to support privately-owned onshore windmills was negative (DKK –3 billion, using a CO_2 value of DKK 270 per tonne). Taking a very cautious approach about directing industrial

Figure 20

Full Production Costs for Onshore Wind Turbines



Note: Data refer to different plants.

Source: *Projected Costs of Generating Electricity, 2005 Update*, NEA-IEA/OECD Paris, 2005.

policy at specific industries, the report also argued that the economic benefit from the support of a particular industry is not a sufficient benchmark for judging the success of such policies.

Given the current rate of renewables penetration, the existing capacity in operation and the well-established renewables (particularly wind) industries, there is no going back on Danish renewable energy policy. The question for current policy-makers is how to shape future policies that are informed by past experience and thus get the most from renewable energy while minimising its disadvantages. While the aforementioned report by the Economic Council is a retrospective analysis of Danish policies in the 1990s, such cost-effective analyses should also be conducted periodically on ongoing policies. This is particularly relevant for the current government, which is very attentive to the issue of cost-effectiveness.

Promoting renewable energy by intervening in the market entails various costs. In 2004, the payment to encourage renewables equalled slightly more than DKK 2 000 million, or around 0.2% of the national GDP. When looking at the renewables component as a percentage of the total retail electricity price, the amount is quite modest given the grid charges and high taxes. However, as a percentage of the total wholesale price payments, it is substantial, equalling about 20% of payments made in 2004 for the purchase of wholesale electricity to meet Danish demand.

Government-mandated support (of any technology) can prevent the electricity market from reaching maximum efficiency. The freedom granted to suppliers and consumers, which is the basis of a successful competitive market, is antithetical to the government's promotion of renewable energy. Mandated must-run plants of a certain technology, size and timing will make the electricity system less efficient and therefore more costly to run. One cost resulting from wind power is the stress it puts on the transmission system. The reasons for this and the costs involved are discussed above. In addition, the construction of substantial renewables capacity came at a time when generation margins were already adequate, thus leading to a government-inspired overcapacity in the electricity sector. The related costs to economic efficiency are an inherent consequence of added renewable energy capacity, particularly wind.

These direct and indirect costs need to be compared with the benefit of renewables in the light of other energy policy objectives, namely, energy security and environmental protection (climate change).

Perhaps the primary benefit from Danish renewable energy resources is the reduction of greenhouse gases (GHGs). It is estimated above that renewable energy use resulting from state-mandated subsidies reduced CO_2 emissions in 2004 by 6.5 Mt. This is equivalent to more than 10% of that year's total Danish emissions. This reduction is extremely helpful to Denmark in meeting its challenging CO_2 target.

Despite this clear benefit, it appears that the costs of supporting renewable energy have not been justified if only considering CO_2 offsets. The analyses described above suggest that the costs of reducing each tonne of CO_2 has been substantially higher through renewables than could be achieved through other domestic programmes, such as greater energy efficiency, or through international mechanisms. While the policy environment has changed substantially and support levels are considerably below those from the 1990s and early 2000s, the effect of earlier policies nevertheless continues with payments to renewable energy plants installed under the old support regimes. For the PSO, this study revealed that the cost in 2004 of reducing each tonne of CO_2 of emissions through renewables was EUR 42.84 per tonne, or more than twice the current (December 2005) price of emission allowances traded through the EU-ETS. Other calculations performed by the IEA as well as the DEA and the Danish Economic Council also support the conclusion that solely from the perspective of reduced emissions, renewable energy has thus far not been cost-effective. It should also be noted that the above costs only refer to those included in PSO and do not include other indirect costs, such as grid reinforcing, which further increase the effective costs of emissions reduction from renewables.

The cost-effectiveness of renewable energy needs to be assessed with a mid-to long-term perspective. A number of factors, including the fact that the price of renewables will fall, will work in favour of renewables in the coming years to make their use as an emissions-cutting tool more cost-effective. DEA's analysis clearly shows such a trend for the last 20 years and, while it may decelerate, there is no reason to believe it will stop. We can infer from the current lack of new projects taking advantage of the existing 12.3 øre per kWh premium that the existing technology is still some distance from commercial competitiveness. The second factor favouring renewables involves the declining real value of the subsidies paid. Much of the subsidies paid to renewable energy plants are paid via either a feed-in tariff or a capped premium to the market price. These payments are fixed in nominal terms, which means that they will decrease in real terms. Assuming a 2% annual inflation rate, these payments will fall by more than 10% in real terms every five years. The third factor relates to the likely trend of the wholesale electricity market. Since the payments are either inherently compared to market prices or inversely proportional to them in the case of capped premiums, any rise in the wholesale electricity market price will reduce the effective payments to renewables. There are strong indications that this will occur as Denmark works through its overcapacity and the rest of Nordpool looks to add new plants. The introduction of the EU-ETS as well as high oil and gas prices will also work themselves through to the power market.

The fourth factor relating to the value of renewables concerns the unpredictability of carbon credit pricing. The country's climate change plan called for substantial purchases of allowances through both the EU-ETS market and joint implementation (JI)/clean development mechanism (CDM) projects. However, such credits are either more expensive or less readily available than originally envisioned and the government is therefore now looking increasingly at domestic options. The domestic renewables system limits exposure to the volatile international GHG market. In addition, the price of heat or electricity from renewables is considerably more stable than that coming from fossil fuels, especially given recent activity in the oil and gas markets. One should, however, note that this advantage vis-à-vis international carbon credits is applicable not only to renewables but also to other domestic measures including energy efficiency.

Renewable energy can both enhance and diminish national energy security. On the one hand, it is a domestic resource, while on the other its supply is often intermittent, as is the case for wind and solar power. Denmark had been able to deal with wind's intermittency and has integrated a greater share of wind power into the system than was originally thought possible. The successful response to the almost complete loss of wind power over a short period of time in January 2005 demonstrates this success. Nevertheless, it would be imprudent to extrapolate Denmark's success in this regard directly to other environments because it relies so heavily on its hydro-rich neighbours to the North as well as, to a lesser extent, the strong connections with the continent. While Denmark does not currently face grave energy supply threats, owing to its domestic oil and gas and capacity oversupply, renewables will surely play a positive role in this regard moving into the future.

These overlapping and often opposing effects of renewable energy policy suggest how complicated it is to perform a cost-benefit analysis of such policies. Some elements are even difficult to quantify and many are open to debate among well-informed people of good faith. Nevertheless, such analyses would better inform the policy-making for renewables in Denmark. A comprehensive analysis, whether done for renewables as a whole or particular sub-sections of the renewables picture is essential and could contribute substantially to the policy and public debates for ensuring more efficient and cost-effective renewable energy policies in Denmark. Equally important will be ensuring that such analyses form the basis for policy debate and formulation which, in the domain of renewables, tend to be highly emotional affairs.

The current government has a considerably different approach to renewable energy promotion than previous government. The Energy Strategy 2025 states that the market should be a basis for the continued increased use of renewable energy and that a market needing new capacity will be far more effective than a politically forced increase in renewable energy. Accordingly, the government has not set specific quantitative targets for renewable energy. The fixed feed-in tariff scheme has largely been replaced with a fixed premium on top of market prices. Incentives for owners of older, smaller and less efficient turbines are provided through an extra premium when the older plants are replaced by new turbines.

The government's attentiveness to cost-effectiveness and its market-based approach in promoting renewable energy is commendable. This is in line with the recommendation of the last in-depth review, which cautioned on the "over-stimulation" of renewable energies and recommended the improvement of cost transparency. The new premium system combined with market prices is a positive step to incorporate a market-based element into the support framework. The current support level is lower than in other countries that have guaranteed prices, such as Germany, France and Spain. It could provide a valuable lesson to some member countries where politically-driven renewable energy promotion policies with heavy direct and indirect subsidies result in high cost to consumers.

While market forces are used more than in previous renewables schemes, the government has still opted to maintain a range of support systems for various renewable energy technologies. As a transitional arrangement, the government is offering either the previous feed-in tariff scheme or the premium scheme with a cap for the total of market price as well as the premium to existing wind turbines depending on when the turbines came on line. Given that average production cost of onshore wind power plants has been continuously decreasing, the feed-in tariffs granted to wind plants purchased prior to the end of 1999 (60 øre per kWh) are probably in some cases higher than the long-term marginal cost of production from those plants. This could create an over-subsidisation, in particular for large wind turbines. The government has made efforts to reduce the problem of over-subsidisation through the move towards capped premiums and the gradual reduction of the level of capped premiums depending on the year of installation. These will make the chance of over-subsidisation less likely. Furthermore, it would have been politically impossible and inappropriate to change the support scheme for existing plants overnight because such investments were decided assuming the previous support scheme. The above issues demonstrate how difficult it is to ensure an appropriate support level in the system where the prices or premiums to be paid are administratively determined, relying on the government rather than on market competition. This could be a valuable lesson when considering a renewable energy support scheme in the future.

The risk of over-subsidisation does not completely disappear even under the new support mechanism. As for wind turbines that receive transitional arrangements with fixed price cap, over-subsidisation could occur when the production costs become lower than the price cap and wholesale market prices are lower than the price cap. The wind power plants connected to the grid from January 2005 will be eligible for a premium of 10 øre per kWh plus 2.3 øre per kWh without any price cap. While there has been no new installation under this scheme, this situation could change when the wholesale electricity market prices rise in the future, owing either to less overcapacity, high oil and gas prices and/or to the introduction of EU-ETS. In particular, depending on the prices of carbon credits and the pace of cost reduction of wind turbines, the wholesale market prices could be sufficient for cost recovery without any need of such a premium. The government needs to be attentive to the development of such factors with a view to avoiding over-subsidisation.

The government's policy for offshore wind is very different from its policy for onshore wind. Offshore wind plants are now the subject of a competitive tendering system by the government and the price of power generated is determined by a tender process to deliver a predetermined tariff for 12 years. The tendering of new offshore wind power plants incorporating competitive elements also offers a more market-oriented approach than the past feed-in tariff scheme with prices determined by government fiat. However, consistency between the tender approach, where the government mandates that large quantities of a particular technology are brought on line at a certain time, and liberalised electricity markets is questionable. The implication to the Nordic market as well as the government's basic position to let the market pick up new capacity needs to be observed.

Under the current premium of 12.3 øre per kWh plus market price, very few new wind power plants have been installed since 2004. One of the primary reasons for this modest development is that the replacement scheme rewards investors with an extra surcharge if the owner possesses a scrapping certificate for a wind turbine with installed power of 450 kW or less, which was decommissioned between 15 December 2004 and 15 December 2009. Thus, the older wind turbines will continue to operate under the previous more generous subsidy regime and then only be scrapped and replaced with new capacity at the end of the replacement surcharge window. The government has already taken steps to overcome difficulties with siting of new wind power plants. The Minister for the Environment and the Minister for Transport and Energy have already contacted the regional authorities and called attention to the importance of planning and selecting areas for new turbines regarding the replacement scheme. In addition, the Danish Forest and Nature Agency and the Danish Energy Authority currently meet with the regional authorities to discuss and overcome any difficulties that can also impede test facilities for further development of wind technology. The government is encouraged to continue this co-operation with local authorities to resolve siting disputes as a more cost-effective means of supporting wind power than an increase in the premium.

As discussed above, setting the appropriate level of feed-in tariff or premium is a challenging task because there is a risk of over-subsidisation. Another problem of the differentiated feed-in tariff scheme is "picking technology winners" by the government. Green certificates, which are priced according to the difference between the market price and production costs, could theoretically solve such problems.[23] Denmark has considered a green certificate scheme as an alternative to the feed-in tariff, but eventually

23. Tendering also has a competitive element to keep the renewables premium down, although there is no competition between technologies or real choice of the timing of entry.

abandoned this idea. Introducing a green certificate system in Denmark could pose three problems. The first is that a green certificate is a relatively new system and the experiences in other countries are mixed. Its effectiveness largely depends on the system design. The second is that so much existing renewable energy capacity is being paid under pre-existing tariff schemes. To deal with this, these plants would either have to be removed from the current system in a way that is fair to them, or they would not be part of the scheme, which would only apply to new plants. The third problem is the government's reluctance to set targets for renewable energy, which are the very essence of the certificate scheme. At the same time, the two tenders for offshore wind will constitute new capacity at a level and a timing determined by government mandate. Targets for renewables as a whole could create more competitive pressure (and lower prices) compared with targets for specific technologies, such as offshore wind.

However, the government should not rule out the possibility of green certificates as a more cost-effective way to reach its renewables objectives. Denmark could learn from the experiences, both successes and setbacks, in other countries, such as Sweden, the UK and Australia.

Increased penetration of wind power will inevitably increase intermittency of Danish power generation compared to conventional generating technologies. The import-export capacity with neighbouring countries allows Denmark to cope better with this intermittency. Because about one-third of Danish generation, namely, CHP (< 5 MW) and wind power, receives non-market support and is granted must-run status, at the time of strong wind and low demand, the market price of electricity has sometimes been driven to zero and excess electricity, supported by consumers, is exported to neighbouring countries. This exported electricity is valued at the average of Denmark's market price (zero in these cases) and the market price of the importing country. Often this value is less than the amount paid under the support schemes to generate it. In this context, the government's intention to use electricity in DH systems is valuable in that it provides a use for electricity that would otherwise have been exported at a loss. In particular, the government's December 2005 decision to remove tax-related obstacles for electricity use in DH systems could allow more electricity to be used domestically rather than exported at low, subsidised prices. Furthermore, the government may consider "managed feed-in" through a market-based instruments system rewarding the use of windmills for balancing the grid.

Currently, system operators are obliged to connect wind power plants, wherever they are located, and to make necessary grid investments for integrating them. Wind power investors are responsible solely for the cost of the line that connects the wind plant to the grid. While the same conditions apply to all generating technology, wind power plants can pose additional burdens on the transmission system as explained above. Efficient integration of wind power into the electricity grid requires efficient decisions by wind power investors, transmission grid owners and distribution grid owners. The efficient location of wind power is often a trade-off between the access to wind resources and the proximity to load centres. The current approach may not send an appropriate locational signal to wind power investors and could lead to an inefficient grid investment, the costs of which are ultimately borne by end-users.

The target of the Biomass Agreement requiring utilities to use 1.4 Mt of biomass per year for electricity and heat generation has been largely achieved. Potential for domestic production of wood chips and pellets has been almost exhausted and further use of biomass will necessitate imports.

RECOMMENDATIONS

The government of Denmark should:

- *Make greater use of cost-benefit analyses to assess the worth of various government support schemes for renewables.*
- *Continue the development of market-based approaches for any increased use of renewable energy, ensuring that caps and other measures limit the possibility of over-subsidisation.*
- *Closely monitor the impact of the tendering system for offshore plants on the functioning of the liberalised electricity market.*
- *Continue to take initiatives and co-operate with local authorities to overcome siting difficulties of wind turbines, including test facilities.*
- *Analyse the green certificate systems in other countries.*
- *Ensure that all power plants, particularly wind, pay their share of transmission upgrades needed to serve their new generating additions.*

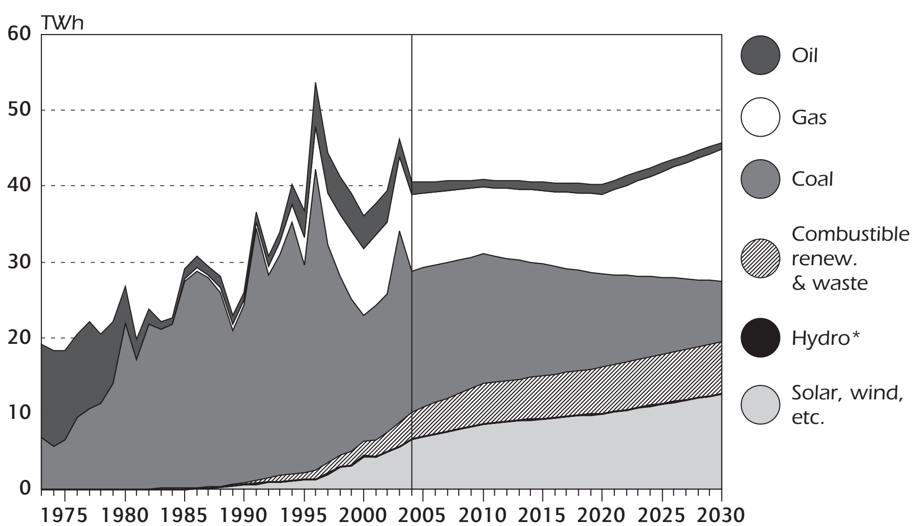
ELECTRICITY SUPPLY AND DEMAND

SUPPLY

Danish electricity generation is dominated by coal. In 2003, coal-fired power plants generated 54.7% of the country's total gross electricity production. This was followed by natural gas (21.2%), wind power (12.0%), oil (5.1%), biomass[24] (6.8%) and solar and wind combined (0.3%). The long-term trend has been the replacement of oil with other fuels, primarily coal. In 1973, oil-fired generation accounted for 64% of the total, but by 1990, oil's share had fallen to less than 4% while coal's share had risen to just over 90%. Since that time, coal's share has fallen and the Danish government expects this decrease to continue. In 2010, coal will account for 45% of total generation, 27% in 2020 and 15% in 2030. The largest single electricity source making up for the decrease in coal-fired generation will be natural gas, which is expected to represent 33% of the total by 2020 and more than 42% by 2030. The government also projects substantial increases for wind power, rising to 27% of generation by 2030. Figure 21 shows the trend in generation for the last 30 years, as well as a forecast to 2030 issued by the government.

Figure 21

Electricity Generation by Source, 1973 to 2030



* negligible.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2005 and country submission.

24. Including renewable and non-renewable municipal solid waste (MSW).

According to the Danish Energy Agency, at year-end 2003, the country had 13 638 MW of capacity available.

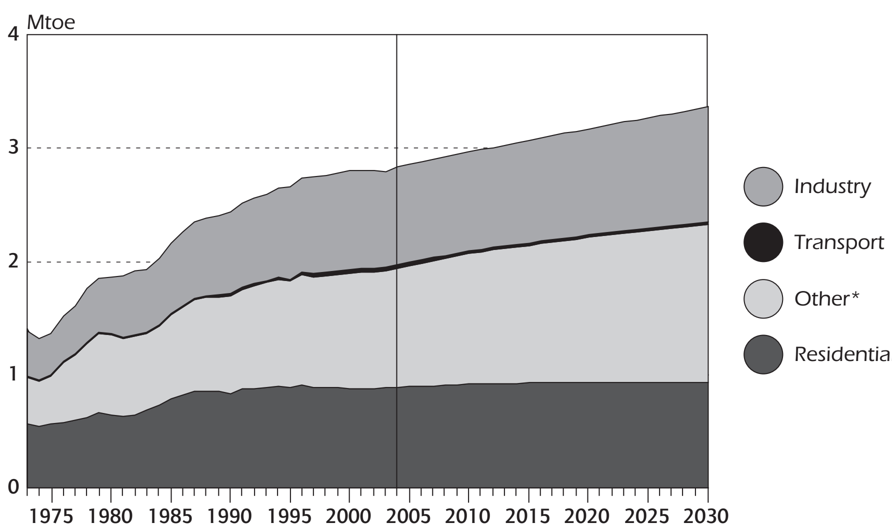
DEMAND

Danish electricity demand has grown faster than overall energy consumption. In the ten years from 1993 to 2003, electricity consumption grew at an annual average rate of 0.7%, more than twice the growth rate for total energy demand, 0.3%. The trend is even more pronounced over the longer term. From 1973 to 2003, the average annual growth rate for electricity demand was 2.4%, compared to an annual decrease in total energy demand of 0.2% over the same period. In recent years, however, growth in electricity demand has slackened, partly as a result of concerted government conservation activities that targeted electricity use, particularly in households. From 1998 to 2003, electricity demand was basically flat, growing at an aggregate rate of 0.9%. For IEA countries as a whole, electricity consumption grew by 2.8% annually from 1973 to 2002 and TFC by 0.9%. In 2003, Danish electricity consumption per unit of GDP was 0.218 kWh per 2000 USD and 6 599 kWh per person. This was well below the figures for the IEA as a whole, namely 0.344 kWh per 2000 USD of GDP and 8 871 kWh per person.

Trends of final consumption of electricity by sector from 1973 to 2030 are shown in Figure 22.

Figure 22

Final Consumption of Electricity by Sector, 1973 to 2030



* includes commercial, public service and agricultural sectors.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2005 and country submission.

GENERAL ELECTRICITY POLICY

The electricity market was liberalised in accordance with a decision of the Danish Parliament, the Folketinget, at the end of the 1990s. The two major consequences of this decision were that: *i)* production and trading in electricity is subject to competition with all parties free to supply and be supplied by whomever they wish, and *ii)* the electricity grid and its operation are subject to public price regulation, and all users of the system may make use of this infrastructure at equal terms and tariffs.

The demarcation between monopoly and areas of competition is defined by law. Since 1 January 2003, all electricity customers can purchase electricity in the open market and choose the supplier they prefer. Customers who do not wish to exercise their free choice are assured electricity supplies. Special supply obligation companies (suppliers of last resort) offer electricity to all costumers at prices and terms subject to regulatory oversight.

The prerequisite of the liberalisation of electricity markets has to a large extent been the establishment of the single energy market in the EU. The object of the single market is to enhance efficiency and competitiveness while ensuring security of supply and protecting the environment. In September 2003 the government issued a report, "Liberalisation of the Energy Markets", that focused on the following four key action areas:

- A wider choice for consumers.
- Increased competition and efficiency.
- High security of energy supply.
- Cost-effectiveness in achieving environmental goals.

INDUSTRY STRUCTURE

The Electricity Supply Bill ensures separation between generation, transmission and distribution of electricity. Section 47 of the Electricity Supply Bill sets the principle of unbundling of activities, whereby all supply-committed enterprises, system-responsible companies, grid companies and transmission companies must obtain a licence, and the licensee may only operate the activities that are within the terms of the licence in the company. Other activities that are outside the terms of licence, including production of or trade in electricity, must be carried out in autonomous, limited liability companies.

GENERATION

The two former power companies Elsam A/S and ENERGI E2 A/S – and DONG A/S – are in a process of merger. A large share of the generation activities of Elsam and ENERGI E2 (24%) are to be taken over by Vattenfall to make up for the Vattenfall acquisitions of shares in Elsam A/S. (See section on Supply Industry Consolidation in Chapter 3 for further details on this merger.) Elsam and ENERGI E2 currently own approximately 80% of total generating capacity, while the remaining 20%, entirely in small-scale CHP and wind, is owned by local DH companies, industries, co-operatives, farmers (wind power), etc.

As of year-end 2004, there were approximately 6 000 plants generating electricity in Denmark, which can be divided into the following principal types:

- Large-scale power stations (primarily CHP), with a total capacity of approximately 8 000 MW, are located at 15 special sites and primarily use coal and to a lesser extent gas and biomass.
- Decentralised CHP plants with a total capacity of approximately 2 200 MW, encompass around 600 generators, industrial and local plants. They typically use natural gas, waste, biogas and biomass.
- Wind turbines with a total capacity of approximately 3 100 MW, and a total number of around 5 400 wind turbines.

Danish energy policy has emphasised the combined production of electricity and DH. This facilitates the utilisation of the large amounts of heat that unavoidably result from traditional electricity generation. In 2003, 47% of thermal electricity (total generation excluding wind energy and hydropower) was generated in combination with heat as opposed to 55% the previous year. This decrease was caused by large electricity exports generated at separate electricity-generating power plants, largely because of low rainfall conditions in the Nordic countries at that time. The proportion in 1990 was 37%, while in 1980 it was only 18%. In 2003, 82% of DH was generated together with electricity. In 1990, the share was 59% and barely 39 % in 1980.

Resulting from a 1985 Parliament decision, Denmark has no nuclear power, and nuclear power is not considered in the energy planning.

TRANSMISSION

The political Agreement of 29 March 2004 to ensure a reliable energy infrastructure for the future defined the conditions and framework for the establishment of a single entity to own and operate Denmark's entire high-voltage electricity transmission system. The two transmission systems at the time (Elkraft for eastern Denmark and Eltra for western Denmark) were completely separated geographically and operationally, and each was communally owned by the respective region's low-voltage distribution companies. These distribution companies agreed to transfer ownership of the high-voltage transmission assets to the federal government on 1 January 2005. While there was no explicit payment made for these assets, as part of the agreement, the distinction between free and tied-up capital, which limited the use of equity within the distribution companies, was abolished. The government then placed the transmission assets into the new entity, Energinet.dk, which it would own. (The system of high-pressure transport pipes for natural gas was also added to Energinet.dk.)

On 24 August 2005, the Danish Minister for Transport and Energy, Mr. Flemming Hansen, together with the boards of Gastra, Eltra, Elkraft System and Elkraft Transmission, signed the legal documents concerning Energinet.dk, the new Danish state-owned TSO for electricity and gas. Energinet.dk is responsible for all operation and maintenance of the transmission system as well as acting as the system operator. In addition, Energinet.dk is responsible for general, long-term planning of the overall transmission network. It assesses the need for justified expansion of the general electricity infrastructure and ensures that any necessary infrastructure expansion is carried out. When Energinet.dk decides to establish a new transmission network, the need for the expansion must be explained in a plan submitted to the Minister of Transport and Energy, who decides whether an individual installation project may be approved. Some projects may require substantial investments, others may have a potential impact on the country's supply security and on co-operation with foreign enterprises/parties, while others may have a major environmental impact.

Denmark has strong electrical interconnections to its neighbouring countries. Figure 23 shows a map of the Danish transmission grid and international connections.

System operation

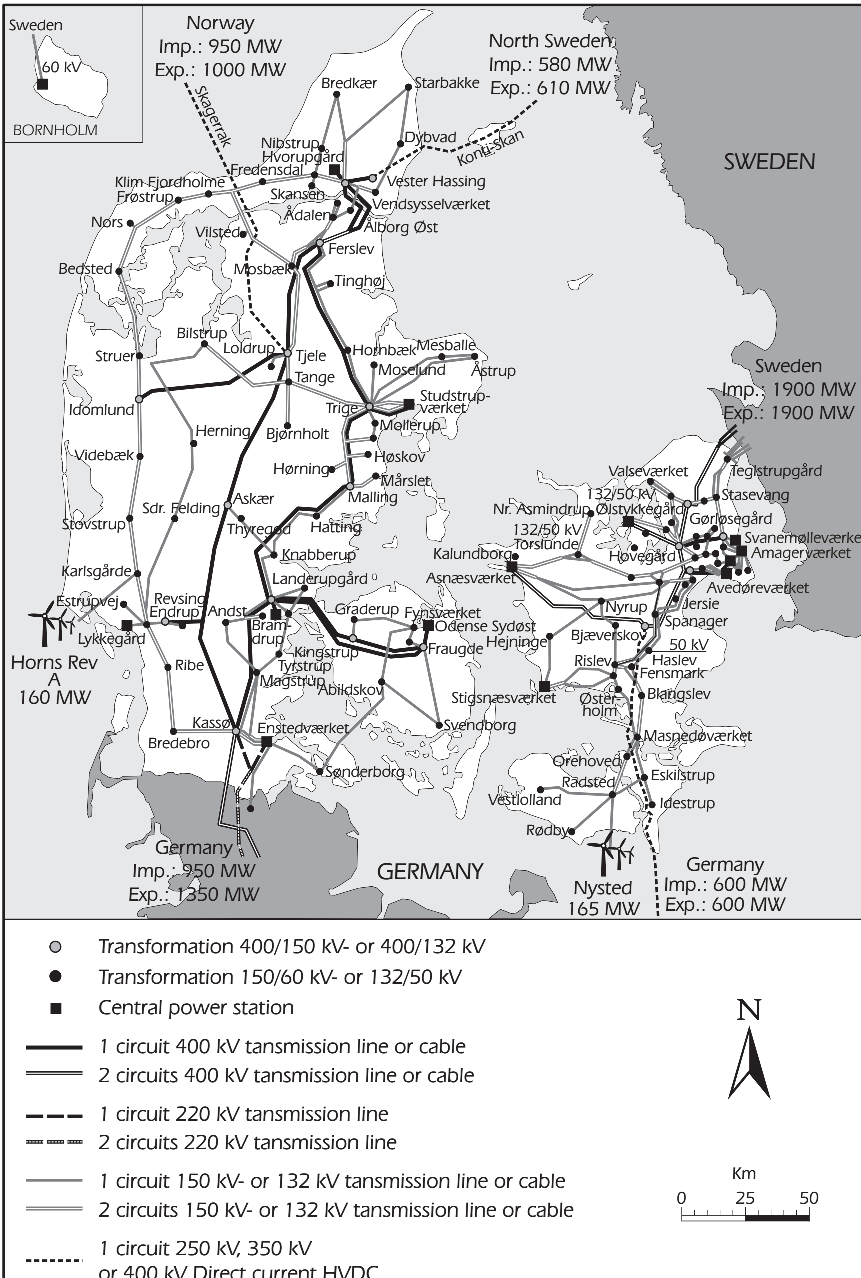
Previously, the TSOs (Eltra and Elkraft) were responsible for managing the balance of both physical and financial market conditions. In addition, many of the plant technologies were "must run" so that the TSO was obliged to dispatch them without the plants even bidding into the system. Now, the process has been changed. Every generating plant will be responsible for bidding into the system at a price it chooses. The market operator will select plants in ascending order of bid with the bid of the last dispatched plant setting the price for all generating stations. All plants will be responsible for their own balancing power through the market. Plants that bid a certain level of generation into the market and which are unable to deliver that amount, or that deliver more than foreseen, are responsible for compensating the TSO for the price of the balancing power needed to maintain system security. Such a set-up is common in liberalised electricity markets with all technologies, but it represents a change in the way renewable energy plants are treated in Denmark.

In June 2004, Nordel recommended reinforcement of the following five links in the Nordic transmission grid:

- Between central and southern Sweden (Snitt 4).
- Between Funen and Zealand in Denmark (a Great Belt connection).

Figure 23

Map of Transmission Grid with International Connections



Source: Danish Energy Authority.

- Between Finland and Sweden (a new Fenno-Skan connection).
- Between Norway and Sweden (a new Nea-Järpströmmen connection).
- Between Norway and Jutland in Denmark (a new Skagerrak connection).

Except for the Great Belt, the transmission projects involve expansion of existing capacity and improved capacity stability. The recommendations were given with the five reinforcements as a "package" without giving priority to any one reinforcement.

The Great Belt electricity link

In the Energy Strategy 2025, the government recommends a project for a Great Belt electricity link to be operational in 2010. This would be a direct current line that would link the previous unconnected and unsynchronised system for eastern and western Denmark. The Energy Strategy 2025 proposes a number of rationales for the link, stating that it will:

- Contribute to better market functioning.
- Improve supply security by improving possibilities to equalise imbalances between various parts of the country.
- Provide reciprocal access to reserve capacity on each side of the Great Belt.
- Make it possible to optimally exploit power plant capacity and production from wind turbines since production can take place at the power plants which have the lowest costs. The link will therefore also support introduction of more renewable energy to the electricity system.
- Reduce the risk for major power outages such as the one that took place on 23 September 2003. (If a power outage does occur, the link will improve the possibilities to rapidly restore electricity supply.)

The advantages of a Great Belt electricity link are measured against the costs involved. It is estimated that a 600-MW link would involve an investment of just under DKK 1.2 billion, corresponding to an annual cost of approximately DKK 85 million, to which must be added annual operational and maintenance costs of up to DKK 10 million. The value of the benefits in the form of supply security, stronger competition, daily operations and reduced costs for reserves have also been estimated, although they are subject to considerable uncertainty. Overall, it is estimated that a Great Belt link beginning operation in 2010 will result in a socio-economic surplus of more than DKK 400 million over the link's lifetime.

Expansion of the Skagerrak electricity link

Expansion of the Skagerrak link between Jutland and Norway is one of the grid strengthening projects prioritised by both the European Union (EU) and Nordel. A 600-MW Skagerrak link would involve an investment of approximately DKK 2 billion, corresponding to an annual cost of DKK 130 million. Previous studies have shown that expansion of the Skagerrak link has a lower use value than a Great Belt link. However, these studies evaluated only the direct operational benefit and consideration must also be given, as for the Great Belt link, to a range of other advantages.

The conditions in which the previous studies were carried out have changed. A decision has been made to build a 700-MW link between Norway and the Netherlands and it is to be expected that a Great Belt link will be established rather than a Skagerrak link. Both of the new links will reduce the use value of a Skagerrak link. Furthermore, the capacity between Jutland and Germany through Schleswig-Holstein is decisive for the profitability of a Skagerrak link.

Upgrading the link between Jutland and Schleswig-Holstein

The government considers it socio-economically profitable to upgrade the alternating-current link between Jutland and Schleswig-Holstein. Expansion of the link is also an EU priority. Increasing the capacity by approximately 200 MW has been estimated to cost approximately DKK 50 million. The government supports Energinet.dk's endeavours to establish a constructive dialogue with the German system operator on upgrading the link between Jutland and Schleswig-Holstein.

Increased domestic grid expansion to 2010

The government expects that Energinet.dk, as system operator, will prepare long-term plans up to 2010 and beyond, and that, on the basis of these plans, it will ensure necessary expansion of the overall electricity infrastructure in the most appropriate way and in accordance with general political priorities and guidelines. In its contribution to the government's draft infrastructure action plan, Energinet.dk described domestic grid expansions up to 2010, which it is considering at the present time and which is of significance to the national situation. In particular, this plan cites the expansion of interconnections (described above) as well as strengthening the 400-kV grid and 132/150-kV expansions in connection with the setting-up of offshore wind turbine farms.

DISTRIBUTION

At year-end 2004, there were 115 electricity distribution companies in Denmark. These companies are responsible for ensuring adequate line capacity, efficient electricity distribution, the connections with end-users and metering and billing of customers. From 1 January 2006, these companies became separate companies submitted to public economic control. As such, many are owned by local municipalities but all are subject to economic incentive regulations, where the Danish Energy Regulatory Authority (DERA) determines a cap for income from tariffs for each company.

ELECTRICITY RETAIL AND OBLIGATION-TO-SUPPLY COMPANIES

Electricity retail companies, including companies with the obligation to supply, provide electricity to final consumers. The retail companies also perform other tasks such as being responsible for balancing and portfolio administration. They purchase electricity on the electricity exchange, directly from generators or through another trading company. In 2004, there were about 25 such trading companies working in Denmark. The majority of industrial customers subject to metering on an hourly basis purchased their electricity through an electricity trading company.

Supply of electricity within the obligation-to-supply regime is regulated with regard to tariffs and is allowed profits. From 1 January 2000, the task of serving customers who were eligible but did not choose an alternative supplier was taken from the distribution companies. At the end of 2004, there were about 40 companies that provided electricity to such customers. As of 1 January 2005, obligation-to-supply companies have been allowed to sell outside their supply areas.

ELECTRICITY PRICES

RETAIL PRICES

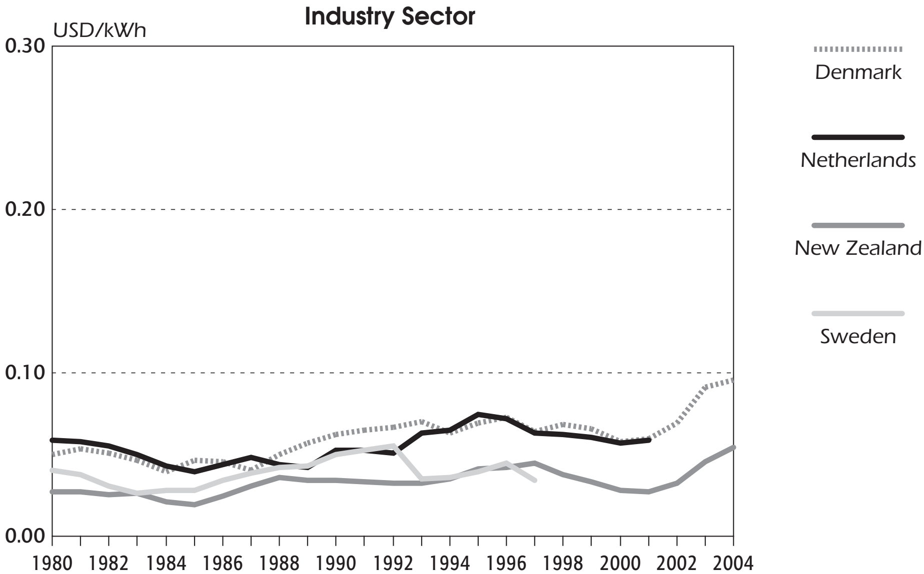
Denmark has some of the highest retail electricity prices in the IEA. For household customers, Danish prices were the highest in the IEA in 2004, at USD 0.28 per kWh (all taxes and charges included).[25] This was 94% above the IEA average. For ex-tax prices, Denmark's retail price for households is almost exactly at the IEA average of USD 0.11 per kWh. For industrial customers, Denmark had the fourth-highest retail prices in the IEA in 2004 (all taxes and charges included).[26] Prices in Denmark are 18% above the average retail price. For ex-tax prices, Denmark's retail price for industry is also 18% above the IEA average. The following figure shows electricity prices over time for industrial and household customers compared against selected IEA countries.

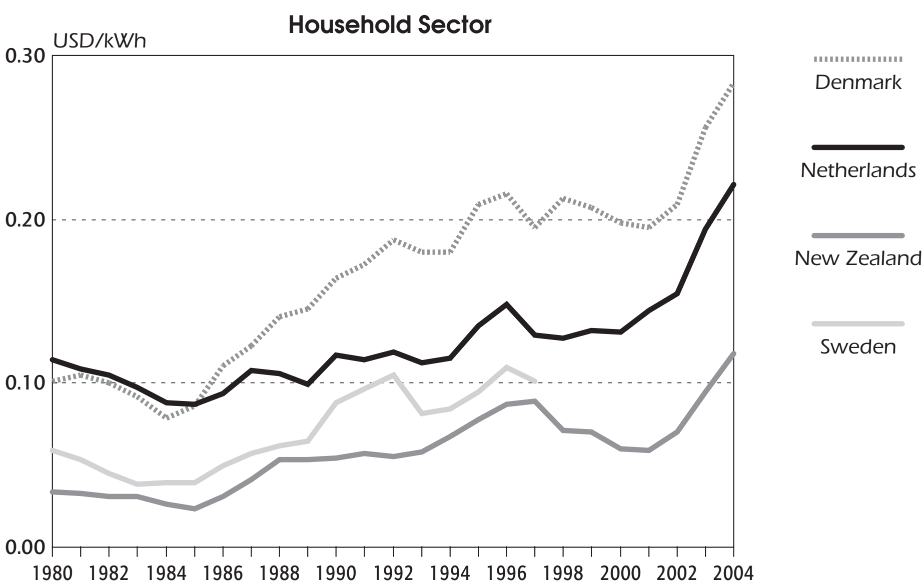
---

25. Data on household electricity prices not available for Australia, Belgium, Canada, Germany, Spain and Sweden.
26. Data on industrial electricity prices exclude Australia, Belgium, Canada, Germany, Luxembourg, the Netherlands, Spain and Sweden.

Figure 24

Electricity Prices in Denmark and in Other Selected IEA Countries, 1980 to 2004





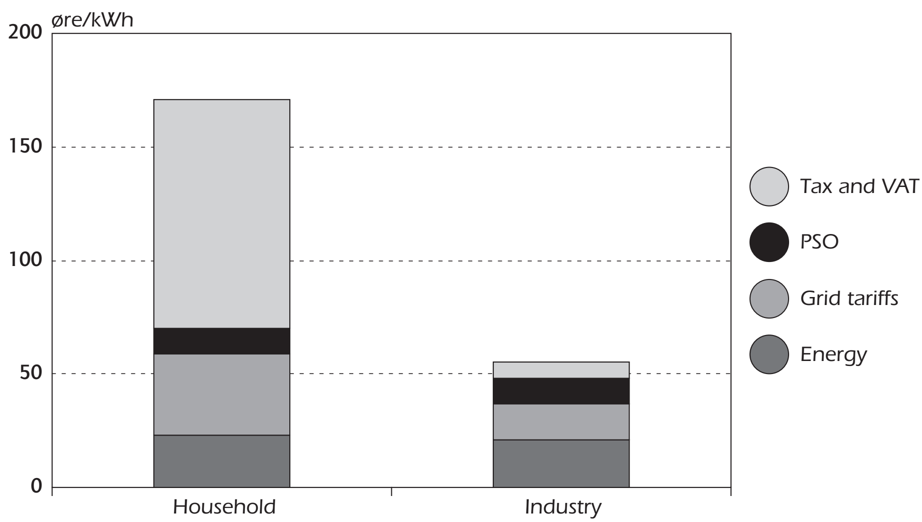
Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2005.

RETAIL PRICE COMPONENTS

Retail prices in Denmark are made up of a number of components: *i)* electrical energy, *ii)* transmission and distribution grid charges, *iii)* the PSO (a charge to support renewable energy, explained below), and *iv)* taxes. In 2005, the DEA calculates that the actual electricity generated and purchased is equivalent to only 14% of a household customer's bill and 41% of an industrial customer's bill. The breakdown is shown graphically in Figure 25.

Figure 25

Components in Retail Electricity Billing, 2005



Source: Danish Energy Authority.

PUBLIC SERVICE OBLIGATION (PSO)

Public Service Obligations (PSOs) are compulsory services the State applies to companies designed to satisfy public interests. These interests include:

- Payment of subsidies for environment-friendly electricity, primarily renewable resources.
- Research and development of environment-friendly production technology.
- Supply security.

The support of renewable energy generation through subsidies constitutes the majority of the PSO revenue. This is explored more in Chapter 6 along with a general description of the historical and likely future trends for the PSO in general.

The provision for security of supply is paid to assure the presence of a sufficient production capacity in the interconnected grid system. In 1999, the government agreed with the two power production companies on this payment to maintain the necessary minimum production capacity for four years. This initiative should be seen as a concomitant to the liberalisation of the Danish electricity sector. In these circumstances, it was felt necessary to assure the continuing security of supply in a transition period, until a functioning market would be in place. The terms were negotiated between the producers and the Danish TSOs. The costs would be paid by the consumers as a PSO, the payment being levelled out over ten years although the payments by customers continue for another few years.

Demand price response

With the introduction of the liberalised electricity market and the establishment of the electricity exchange, Nordpool, Danish electricity consumers are now able to purchase electricity on an hourly basis. This means that consumers are able to reduce electricity purchase expenditures by focusing their consumption on the times of day when the market price for electricity is low. Nordpool statistics show that there is significant potential for reaching a lower electricity price given that the hourly prices vary considerably.

Even though the large swings in the price of electricity mean that consumers could save considerably by choosing the time of day when they consume electricity, their reaction to market prices is limited. Hence, both consumers and society are losing out on a considerable financial gain, which could be achieved with limited effort. Industry's electricity consumption has the largest and most obvious potential for being moved to other parts of the day. The government will establish an action programme to encourage more flexible electricity consumption and thereby a well-functioning electricity market.

SWITCHING RATES

The right of supplier choice was gradually extended to smaller and smaller Danish electricity companies until, by 1 January 2003, everyone was free to choose one’s supplier. As is the case in many liberalised markets, the switching rates for the larger customers are significantly more than for the smaller customers. In 2004, about 33 000 customers representing approximately 13% of total Danish electricity customers switched to another supplier.[27] The year before saw much more switching with about 77 000 customers changing supplier, representing around 25% of total demand.

27. All figures in this section include switches within the same company/group, notably from the obligation-to-supply company to a trading company with the same ultimate owner.

Table 24

Switching Rates for Eligible Electricity Customers

	Households/Small Companies			*Metered Customers*		
	No. of eligible customers	*Customers who changed supplier*	*% of customers who switched*	*No. of eligible customers*	*Customers who changed supplier*	*% of customers who switched*
1st Qtr 2004	3 083 900	17 618	0.6%	22 400	2 945	13.1%
2nd Qtr 2004	3 090 100	4 141	0.1%	22 300	794	3.6%
3rd Qtr 2004	3 098 700	3 497	0.1%	23 400	376	1.6%
4th Qtr 2004	3 046 900	3 418	0.1%	22 300	574	2.6%
All 2004	3 079 800	28 674	0.9%	22 700	4 689	20.7%

Source: "Danish Electricity Supply, Statistical Survey 2004", Dansk Energi.

WHOLESALE PRICES AND INTERNATIONAL COMPARISONS

Wholesale electricity prices in Denmark are influenced not only by domestic supply and demand but also by market conditions in neighbouring countries. The transmission interconnections with other countries equal more than half the domestic demand. Although these can become constrained and are limited in use through domestic grid constraints in the other countries, the Danish market is nevertheless strongly affected by these other markets. In general, electricity flows from the North – where Norway and Sweden have low, variable cost hydropower – to the South, where German prices tend to be higher. However, a number of circumstances can reverse this trend. In late 2002, rainfall in Sweden and Norway was considerably less than normal and the water level in the reservoirs fell considerably. The resulting high prices in these countries caused electricity flows to go North. As members of Nordpool, the eastern and the western parts of Denmark have Nordpool prices, which are subject to price splitting during times when the transmission connections are constrained.

CRITIQUE

The Danish Energy Strategy 2025 sets out the government's long-term goal of balancing the objectives of environment, competition, security of supply and business potentials. Since 2001, the government has shifted the focus of energy policy. The objective is to unlock the full benefits of liberalisation and competition. A significant element of this objective is the development of a well-functioning electricity market.

Denmark's wholesale electricity sector has made considerable progress towards a liberalised operational environment in which market forces and transparency drive competitive operational outcomes. This trend is expected to accelerate with Denmark's policy focus shifting towards the use of market forces to guide investment capital allocation and operational decision-making. However, several challenges remain. If not addressed, these challenges have the potential to limit Denmark's ability to capture the benefits of system security and economic efficiency available from a competitive Danish and broader Nordic market.

The Danish electricity sector is currently in a state of oversupply. Maximum demand (load) in Denmark was 6 267 MW in 2004 whereas the DEA estimates that capacity was 13 638 MW. However, this very high reserve margin (almost 120%) is somewhat misleading. A lot of the capacity (more than 3 GW) is wind power, which is considerably less reliable given the vagaries of the weather and will, in any event, have a much lower capacity factor throughout the year. Some of the other capacity is either CHP, which is less flexible, or is old and inefficient and/or mothballed. Nevertheless, supply far exceeds demand under any type of assessment, a condition which results to a great extent from Denmark's renewable energy policy. The feed-in tariffs and premiums were intended to encourage substantial renewable capacity even though the system was not in need of new capacity and the market was not demanding it, from renewables or other technologies. The role of subsidies and schemes adopted to encourage investment in a specific renewable energy generation technology is discussed further in Chapter 6.

The effect of this generating overcapacity resulting from the renewable energy policy must be taken into account when assessing market efficiency. While Denmark is not currently in need of new capacity, it will be in the future and the precedent set by the influx of substantial, subsidised generation could deter investment in the market, resulting in tighter supply and higher prices. The government must build confidence in the marketplace that any future renewables (or other) policy will not undermine investments in the liberalised Danish electricity sector.

The change in system operation to place greater responsibility for balancing on the individual plants and less on the TSO is a positive development and should be commended. The new system enables electricity producers to respond to market conditions and thus improves overall system efficiency. Continued development of this approach will facilitate the resource allocation mechanisms provided by a competitive electricity market and lead to efficient production decisions. Denmark's geographic position between two complementary electricity systems (hydro-rich Nordpool and baseload-heavy Germany) allows it to benefit from trade to and from these regions. The freer the generators are to dispatch and provide balancing power, the more the Danish producers will be able to exploit this position through exports and the more consumers will be able to benefit from times of imported cheap power.

Denmark does not need its current high reserve margin to maintain electricity security. For one thing, the substantial transmission interconnections to various countries enhance security, although this of course depends on availability of power from these other regions. This is not always certain given hydro-dependence and internal grid constraints in those countries. Another way to augment security without paying for a lot of idle capacity is to have demand-side participants incited by market signals to shed load in response to high prices or a system security event. Just as demand should be encouraged to react to low prices by increasing load, so high prices resulting from a tight supply situation should encourage demand to shed load (this could occur in both the energy and balancing markets). While the current supply/demand balance in Denmark makes it unlikely that the need for such arrangements would emerge in the short term, it would be prudent to consider improvements to the market framework for demand-side participation in a liberalised market. This would continue to strengthen the ability of market forces to guide investment capital allocation and operational decision-making.

"Priority" or "must-run" treatment of wind and CHP electricity output also results in uncertainty for system operators, other participants and electricity traders. This uncertainty translates into a "risk premium" that is included in the energy price, partly through the balancing cost charged by the TSO. The impact of this generation uncertainty can be reduced by increasing the capacity of the market and network to absorb variability. A market-based solution to generating overcapacity and production uncertainty is important if policies on renewable energy technologies are to continue within a market context. Market solutions, such as enabling heat producers to source low or zero priced electricity as an input to heat production, should be progressively expanded to facilitate a commercial response to policy-driven market conditions.

The governance arrangements in Denmark provide for a ministerial role in approving or directing network investment decisions. Energinet.dk originates and implements all network additions. The minister rather than the energy regulator has the authority to approve such additions. While this can, and has been, a positive feature of current arrangements within the broader Nordic market (providing a forum for a holistic approach to planning across Nordic countries), its implications in the future should be carefully considered. Both the minister and Energinet.dk are tasked with ensuring that the network optimally provides for security of supply and a well-functioning competitive market and, as such, there should be little difference between their respective positions on planned additions. Care should be taken that the required ministerial approval and any possible political considerations in no way undermine objective cost-benefit analyses when determining network capacity additions.

Transmission assets are of strategic importance for managing competitive market operation and investment outcomes. Balancing the investment and operational decisions in the whole network sector with the commercial signals in the generation sector is an important step towards co-optimising various elements of the energy supply chain. Denmark should consider the development of a regulatory framework which explicitly considers competitive market outcomes in the transmission operation, planning and investment decision-making process. Furthermore, maximising the ability to co-optimise system-wide network investment/operational decisions relies on operational and planning control of all elements of the transmission system. There may therefore be benefits in accelerating the transfer of responsibility for all transmission assets in Denmark to the TSO.

Economic inefficiencies can arise when regulatory instruments or policy objectives differ within a single network system. One specific example is the uniform pricing policy of the Swedish government and its impact on locational investment signals and market outcomes in Denmark. The uniform pricing policy in Sweden has hidden/removed market signals for locational investment in generation, demand-side participation or network infrastructure. The transmission bottleneck in central Sweden has developed (as a result of load growth in SW Sweden) without providing price signals that would encourage additional generation investment and/or demand-side participation. The result is that the price impacts of a constraint within a single-price region will be shifted to the boundary of that pricing region. Another example is the access issues within the northern part of the German system, which differ from those of Denmark. Such regulatory differences within the interconnected system can lead to inefficient and uneconomic market operation. Denmark should continue to work towards the harmonisation of regulatory and policy arrangements across Nordic countries and Germany.

RECOMMENDATIONS

The government of Denmark should:

- *Continue the work to improve the market framework for the use of demand-side response in day-to-day energy trading as a way to enhance market efficiency and as an alternative mechanism to reserve margin management.*
- *Review the arrangements applying to the use of electricity in district heating (DH) to improve commercial market incentives to use electricity at times of high production and low price.*
- *Ensure that objective cost-benefit analyses drive investment decisions for the network.*
- *Provide a more stable operational and investment planning framework for the removal of transmission bottlenecks through market-linked regulatory incentives on the TSO.*
- *Work towards the harmonisation of regulatory instruments across countries participating in the Nordic market and Germany.*

COAL

In 2003, coal accounted for 5.67 Mtoe of primary energy supply, or 27.3% of national TPES. Coal's contribution to Danish TPES has risen substantially since 1973 when it accounted for just 9.7% of all energy supply. Its use rose steadily as it replaced oil as the major fuel used in electricity generation. Coal's largest share of Danish TPES was in 1991 when it accounted for 41.9% of all energy supply and its largest absolute supply was in 1996 when it supplied 8.91 Mtoe.

Denmark has no indigenous coal resources and thus must import all its needs from the international market. In 2004, Denmark imported 7 594 Mt of steam coal from ten different countries. The leading exporter was Russia with 1 960 Mt, followed by South Africa (1 845 Mt) and Colombia (1 462 Mt).

The large majority of coal in Denmark is used for electricity and heat generation. From 1993 to 2003, the percentage of coal going to heat and power ranged between 93% and 97%. The percentage of all Danish electricity produced from coal rose steadily from the early 1970s to a peak in the late 1980s before falling a bit to its current position. Coal accounted for only 31% of Danish electricity generation in 1974, then rose to a peak of 95.8% of the total in 1984 and stayed above 90% through 1991. This figure has fallen considerably (to 54.7% in 2003) as gas and, to a lesser extent wind, replace coal-fired generation. Coal often fuels power plants at the margin of the Danish resource stack. Its use varies considerably with changes in electricity imports/exports, which are dependent on rainfall (and hydroelectric generation) in the Nordic countries. Consequently, coal serves an important function of providing reliability in the electricity sector.

The final consumption of coal constitutes a rather modest share of coal supply, ranging from 1993 to 2003 between 4% and 8% of the total. Most of the coal used as an end fuel (between 80% and 95%) goes to industry. The remainder is used in agriculture.

OFFSHORE OIL AND GAS PRODUCTION INFRASTRUCTURE

The following sections describe the physical parameters of offshore oil and gas production, licensing procedure and reserves, actual production amounts and the downstream oil and gas sectors.

PRODUCTION INFRASTRUCTURE

In 2004, oil and gas production came from 19 fields in the North Sea. Oil and gas production in the North Sea is carried out by three operators, namely Mærsk Olie og Gas AS, DONG E&P A/S and Amerada Hess ApS. Production comes from 48 platforms; 37 of these are permanently manned, while eleven of them are unmanned satellite platforms. Oil and gas production is also sustained by three subsea facilities.

Mærsk Olie og Gas AS operates three production centres: Dan, Gorm and Tyra. The oil produced at these centres is transported to the Gorm E riser platform in the Gorm field, where the stabilised crude oil is pumped through the oil pipeline to the oil terminal in Fredericia on the east coast of Jutland. The gas produced at the Mærsk Olie og Gas AS installation is transported to the riser platform, TEE, at the Tyra field where the compressed, dried gas is piped to the gas processing facilities at Nybro on the west coast of Jutland, which are connected to the Danish natural gas transmission system. From the Tyra field, some of the gas is transported to the TWE platform in the Tyra field and then through the gas export pipeline, connected to the NOGAT pipeline via the F3 riser platform on the Dutch continental shelf.

DONG E&P A/S operates the Siri production centre, including the associated satellite installations, Stine segment 1, Nini and Cecilie. From here, the oil is transported to a storage tank placed on the seabed under the Siri platform. When the tank is full, buoy-loading facilities are used to transfer the oil to a tanker. The gas produced in the Siri field and its satellite fields is reinjected into the subsoil.

Amerada Hess ApS operates the South Arne installation. From here, the oil produced is transported to a storage tank placed on the seabed under the platform. When the tank is full, buoy-loading facilities are used to transfer the oil to a tanker. The compressed, dried gas from South Arne is conveyed through a gas pipeline to Nybro on the west coast of Jutland.

DONG Naturgas A/S owns the gas transmission pipelines in the North Sea connecting the offshore installations to shore, as well as the gas pipeline from Tyra East and Harald to the gas processing facilities at Nybro. The gas pipeline connecting Tyra West to F3 on the NOGAT pipeline on the Dutch continental shelf is owned by A.P. Møller-Mærsk, Shell Olie- og Gasudvinding BV (Holland), Danish Branch, Texaco Denmark Inc., Delaware Branch in Denmark, and DONG Naturgas A/S, with Mærsk Olie og Gas AS as operator. DONG Olierør A/S owns the oil pipeline between the Gorm field and Fredericia, including the Gorm E riser platform in the Gorm field and the oil terminal in Fredericia.

PRODUCTION POLICIES AND LICENSING

The government policy on hydrocarbon exploration is to locate as many resources as possible and thus extend the country's self-sufficiency in oil and gas. Companies are required to have a licence to explore for hydrocarbons. At the granting of a licence, one or more companies are given the right to explore and produce within a defined area. Licences are granted through licensing rounds and via the Open Door procedure. In Denmark, six licensing rounds have been held, the latest in 2005. In 1997 the Open Door procedure was introduced, with an annual open period from 2 January until 30 September 1997. The Open Door procedure covers all non-licensed areas east of 6°15' eastern longitude.

The Minister of Transport and Energy grants licences to private companies. The State participates in each licence group generally with a 20% share. This is a standard licence requirement in the latest licensing rounds and for licences granted according to the Open Door procedure. To date, DONG E&P A/S has managed state participation in hydrocarbon production. Following the political agreement to partially privatise DONG E&P A/S, the company will not manage the State's participation in new licences and a new organisation has been set up to undertake this responsibility. In the future, this new state-owned entity, established on 26 June 2005, will manage the State's 20% interest in new licences.

From 2012, the state-owned entity may also be in charge of the State's 20% share of DUC (the Danish Underground Consortium: A.P. Møller 39%, Shell 46% and Texaco 15%). The state participation in DUC is a consequence of the agreement of 20 September 2003 made between the Minister for Economic and Business Affairs and A.P. Møller- Mærsk.

The Sixth Licensing Round was opened in May 2005 with the deadline for applications on 1 November 2005. As in the Fifth Round, the areas offered for licensing comprise all unlicensed areas in the so-called Central Graben with adjoining areas. In recent years, oil companies have focused their interest on this area. The DEA had received 17 applications for oil and gas exploration and production licences from 20 different companies, including several not previously holding licences in Denmark. The licences are expected to be issued in spring 2006. Under the provisions of the Danish Subsoil Act, the Minister for Transport and Energy is required, before awarding licences, to submit a statement to the Energy Policy Committee setting out the licences to be awarded.

RESERVES

On the basis of the assessment of reserves, the Danish Energy Authority (DEA) prepares production forecasts for the recovery of oil and gas in the next five and 20 years, respectively. Table 25 shows the DEA's estimates of historical production and likely reserves as of 1 January 2005.

Table 25

Danish Historical Oil and Gas Production and Likely Reserves

	Oil, million m³	*Gas, bcm*
Production (to 1/1/06)	255	109
Total reserves	268	142
Ongoing and approved reserves	211	88
Planned recovery	8	7
Possible recovery	49	37
2004 production	22.6	10.9
Reserve lifetime at current production level	11.9 years	13 years

Source: "Oil and Gas Production 2004"; Danish Energy Agency (DEA).

NATURAL GAS

NATURAL GAS SUPPLY AND DEMAND

In 2003, natural gas accounted for 4.66 Mtoe of primary energy supply, or 22.4% of the total for all fuels. The gas supply share is down slightly from 23.5% in 2002, which was gas's highest share ever. Gas supply was only introduced to Denmark in 1981 and its share has been rising steadily since then, reaching 10% of total supply in 1990 and 20% in 1998. The government projects that gas's share of TPES will be 27% in 2020 and 32% in 2030.

Slightly more than half of the Danish gas supply is used to generate electricity and heat. In 2003, gas final consumption accounted for 37% of supply. Industry accounts for most of this final consumption (around 45%), followed by residential (40%) and the commercial, public sector and agricultural sectors (a combined 15%). Gas's share of national electricity and heat generation has steadily increased since the mid-1980s. In 1985, gas accounted for 1% of electricity generation and 8% of heat generation but by 2003, these figures had risen to 21% and 32%.

GAS PRODUCTION AND TRADE

In 2004, Denmark produced 10.93 billion cubic metres (bcm) of natural gas, somewhat below the record set in 2000, when production totalled 11.31 bcm. Natural gas sales, however, rose to an unprecedented 8.26 bcm in 2004, beating the previous record of 7.3 bcm in 2001. The difference between production and sales results from the amount of gas reinjected into the fields. In 2004, 1.73 bcm was reinjected, down by about 30% from 2.4 bcm in 2003.

The amount of gas used as a fuel in offshore oil and gas production increased by 4% to 0.68 bcm in 2004. In addition, 0.26 bcm of gas was flared for technical and safety reasons.

The government projects that Danish gas production will rise to 10.2 Mtoe by 2010 before falling to 4.81 Mtoe by 2020 and then 4.69 Mtoe by 2030.

Table 26 includes figures on Danish gas production and trade for 2005.

Table 26

Danish Gas Production and Trade, 2005

Production/Flow	*Billion cubic metres (bcm)*
Danish production	9.5
Danish consumption	4.5
Export to Germany	2.5
Import from Germany	0.5
Exports to Sweden	1.0
Exports to the Netherlands	2.0

Source: Energinet.dk.

PIPELINE NETWORK

Offshore pipelines

All offshore pipelines connecting the North Sea to the Danish coast are owned by DONG. Third parties can access the pipelines, but must negotiate the terms and tariffs of this access with DONG.

A recent addition to the offshore pipeline system has allowed for more production and sales: a new 26-inch gas pipeline from Tyra West E to the F/3 platform in the Dutch sector where it can be conveyed through the existing NOGAT pipeline to the Netherlands. The pipeline began operations in 2004. The new pipeline, with a capacity of 15 million Nm^3 per day, is owned by DONG (50%), Shell (23%), A.P. Møller (19.5 %) and Texaco (7.5%) and operated by Mærsk Olie og Gas AS.

Onshore high-pressure network

In June 2003, the responsibility for onshore transmission of the natural gas ashore was transferred to DONG Transmission A/S. As of 1 January 2004, DONG Transmission was sold to the Danish State and changed its name to

Gastra. By 1 January 2005 Gastra merged with the electricity TSOs Elkraft and Eltra to form the newly established Energinet.dk. Energinet.dk transports all natural gas used in Denmark, together with the gas transported between Denmark, Germany and Sweden. The domestic high-pressure (80 bar) gas pipeline system runs 860 km.

Access to Energinet.dk's network is subject to regulated conditions with tariffs based on a postage stamp system.[28] All prices and terms for using the transmission network are publicly accessible and under the supervision of public authorities. Gastra has published a network code (Rules for Gas Transport ["Regler for Gastransport"/"RfG"]), which regulates access to the Danish natural gas system. The rules have been prepared pursuant to the Danish Natural Gas Supply Act by Gastra in co-operation with the distribution companies (Naturgas Fyn A/S, HNG (Hovedstadsregionens Naturgas I/S), Naturgas Midt-Nord I/S and DONG Distribution A/S) and the storage company (DONG Lager A/S).

The Gas Transfer Facility (GTF) opens the possibility for shippers to trade gas in the Danish gas transmission system. Transfers can be effectuated within a short notice to Energinet.dk and cover gas amounts which the shipper wants to transfer on a single day or up to a whole calendar month. The service is suitable for shippers who have either a surplus or a shortfall of gas in the transmission system. The GTF is for shippers who principally want to deliver natural gas into the Danish gas transmission system, and thus have only booked entry capacity or a very small exit capacity. The system is also useful for shippers who have mainly bought exit capacity, if they deliver gas to the distribution areas or for transit. Gas transfer through GTF does not require reservation of both entry and exit capacity. Energinet.dk has also introduced a Capacity Transfer Facility (CTF) and a Balance Transfer Facility (BTF).

There are three entry/exit points to the transmission system: *i)* at the gas treatment plant at Nybro on the west coast of Jutland where the gas is delivered from the North Sea; *ii)* at the border station between Denmark and Germany; and *iii)* at the border station between Denmark and Sweden. On 1 January 2004, Gastra introduced a new market model with a so-called "entry-exit system" as recommended by the EU Commission and the European regulators. Gastra also introduced a system with only one exit zone for Denmark. Consequently, shippers can purchase gas transportation for the whole of Denmark instead of for the individual physical take-off points. By the end of 2004 ten shippers had registered with Gastra, including the companies DONG Naturgas, ENERGI E2, E.On-Ruhrgas, Shell, Statoil Gazelle and Sydkraft Gas.

28. This is an entry-exit system. However, as entry tariffs are identical in all entry points and exit tariffs are identical in all exit points/zones, it works like a postage stamp system.

When Energinet.dk decides to build an addition to the high-pressure pipeline network, the need for this expansion must be explained in a plan to be submitted to the Minister of Transport and Energy who will ultimately grant approval to any given project. Some projects may require particularly substantial investments, some may have potential impact on the country's supply security and on co-operation with foreign enterprises/parties, and others may have major environmental impact.

Distribution companies

There are four distribution companies, namely Naturgas Fyn A/S, HNG I/S, Naturgas Midt-Nord I/S and DONG Distribution A/S. Access to their pipelines is open to all third parties at tariffs and terms that are subject to approval by the regulator.

Gas storage

DONG Storage A/S owns and operates all of Denmark's gas storage facilities. Total capacity is 760 mcm, an amount equivalent to approximately 60 days of domestic average demand. There are two storage facilities of approximately identical size: one a salt cavity in Lille Torup and the other an aquifer in Stenlille. While Danish gas storage capability in relation to domestic demand is below many of the other European countries, security is enhanced through domestic production and the country can modulate its production to meet the seasonal demand profile.

In pursuance of the Danish Natural Gas Supply Act, all market players have the right to use the storage facilities if this use is technically or financially necessary to provide effective access to the transmission and distribution system. The Danish Natural Gas Supply Act distinguishes between access to storage facilities and access to the transmission and distribution network. Third-party access (TPA) to DONG storage facilities and agreements concerning such access must therefore be negotiated with DONG Storage rather than being made available at regulated rates and terms. DONG, however, does offer standardised storage products at published tariffs, which are not subject to prior negotiation.

MARKET REFORMS

The Natural Gas Supply Act regulates the natural gas industry except the production of natural gas. The objective of the act is to ensure that gas supply takes into consideration security of supply, the national economy, the environment and consumer protection. The act applies to the transmission, distribution, supply and storage of natural gas, including liquefied natural gas (LNG). The act also applies to biogas, gas from biomass and other types of gas, to the extent that these gases may be technically and safely injected to and transported through the natural gas system.

The EU's second gas market directive was implemented into Danish law effective 1 July 2004. In a number of areas Denmark is ahead of the requirements established by the new directive, including the date of market opening. All Danish gas consumers have been free to choose their supplier since 1 January 2004, whereas, at the European level, this is not required until July 2007. The market was opened on time, and the first change of supplier took place as planned at the beginning of 2004. While relatively few customers changed suppliers in 2004, by November 2005 an estimated 20-30% share of gas TFC had changed supplier. The Danish gas market is still characterised by a few large players but is still developing.

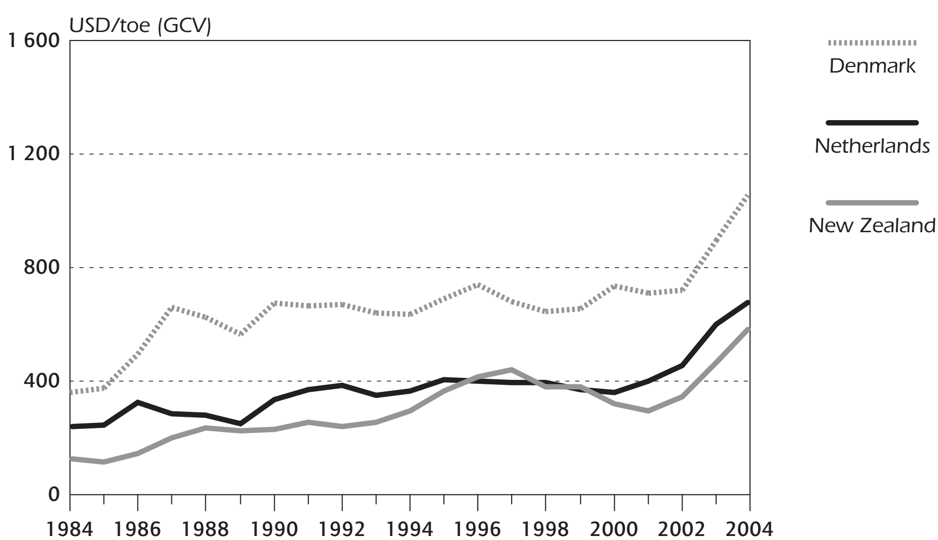
In January 2005 Gastra introduced Gaspris-guiden.dk, where domestic gas consumers can compare different suppliers' prices. The Web site is administered by Gastra and the prices are updated by the gas suppliers. Gaspris-guiden.dk is intended to increase transparency and competition for the domestic consumers.

NATURAL GAS PRICES AND TAXATION

While ex-tax gas prices in Denmark are roughly equal to those found in other EU countries, the final retail price faced by consumers is easily the highest in the IEA given the high taxes. The Danish household gas price was twice the average price paid in other IEA countries for which data are available.

Figure 26

Gas Prices in Denmark and in Other Selected IEA Countries, 1984 to 2004

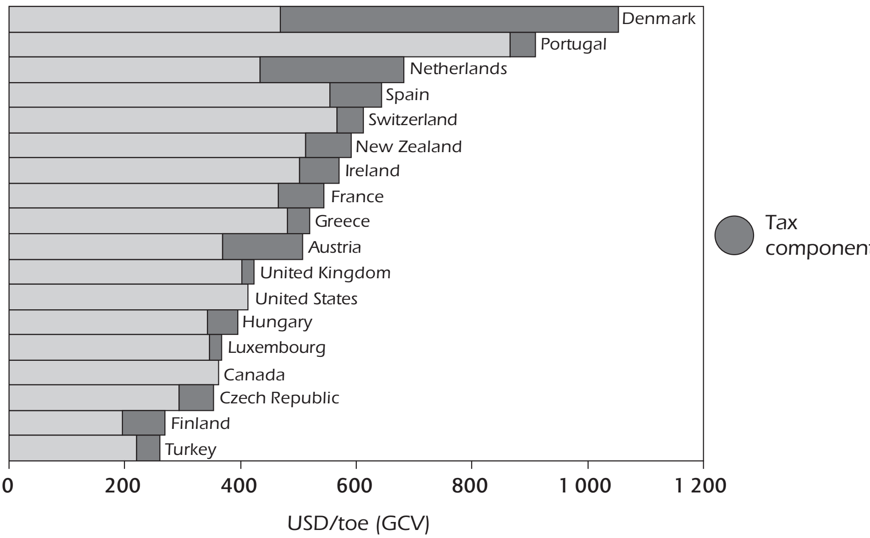


Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2005.

Figure 27

Gas Prices in IEA Countries, 2004

Household Sector



Note: Tax information not available for the United States. Data not available for Australia, Belgium, Germany, Italy, Japan, Korea, Norway and Sweden.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2005.

OIL

SUPPLY AND DEMAND

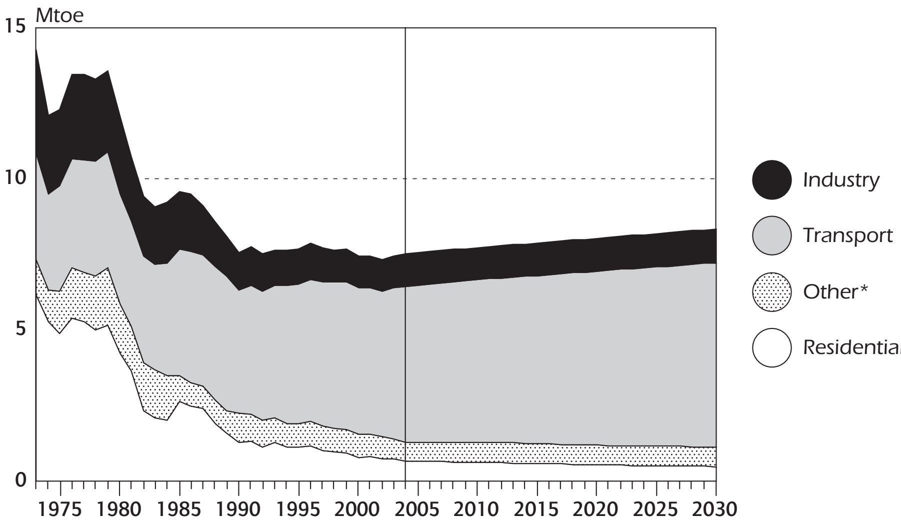
In 2003, oil was Denmark's most widely used fuel, accounting for 40.3% of national TPES. Oil's share of TPES for all IEA countries combined was 40.6% in 2004. The government forecasts that oil supply in Denmark will grow in absolute terms from 8.37 Mtoe in 2003 to 8.70 Mtoe in 2010 and 9.38 Mtoe in 2030. Its share of TPES is projected to stay at slightly above 40%.

Oil's share of electricity generation has fallen substantially since the 1970s. In 1974, oil accounted for 69% of total generation although this fell steadily through the 1970s and 1980s until reaching its lowest point at 3.5% of the total in 1991. This figure increased to more than 10% by 1996 and stayed at that level until 2003 when it dropped to 5.1%. This rise and subsequent fall resulted from the conversion of the 640-MW Asnaes No. 5 plant to Orimulsion in the early 1990s. The operation continued for several years although the plant faced a number of technical problems and was mothballed in 2003. The government oil's share of overall power generation will continue to fall, reaching 3.2% in 2020 and 2.0% in 2030.

In 2003, transport accounted for 67% of oil TFC with road transport accounting for 80% of this amount. Industry followed with 10.6% of oil TFC, then residential (9.7%) and then other sectors including commercial, public and agriculture (9.1%). From 1993 to 2003, oil TFC decreased annually by 0.3%, although oil use for road transport rose at an average annual rate of 1.7%

Figure 28

Final Consumption of Oil by Sector, 1973 to 2030



* includes commercial, public service and agricultural sectors.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2005 and country submission.

PRODUCTION AND INTERNATIONAL TRADE

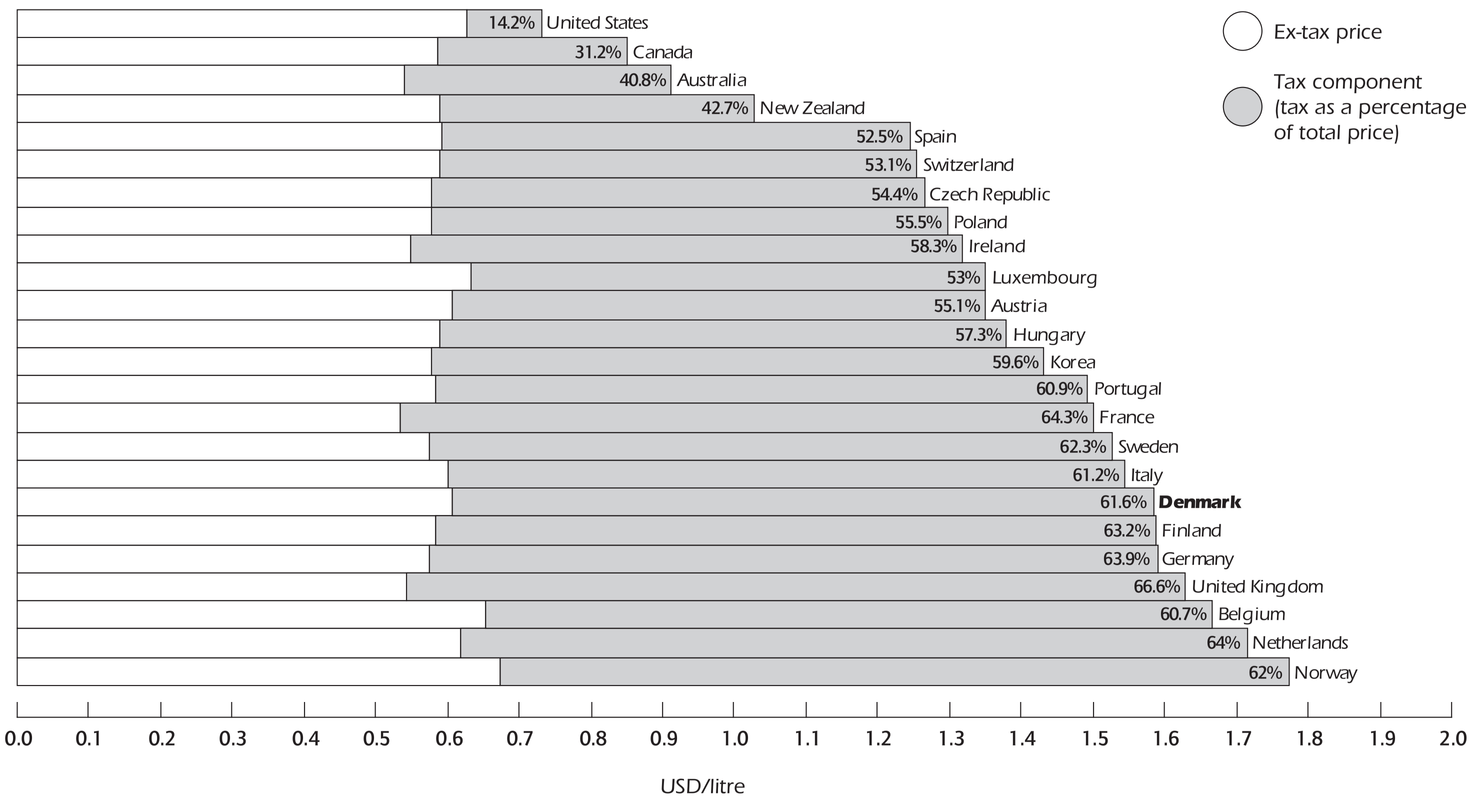
Denmark has substantial oil reserves in the North Sea. It has been steadily increasing its oil production since the 1970s, although it was only in 1997 that the country first became a net exporter. In 2003, Denmark produced 18.6 Mtoe, of which 10.3 Mtoe was net export. The government projects that oil production will rise to 19.96 Mtoe in 2010 before falling to 13.29 Mtoe in 2020 and 12.36 Mtoe in 2030. Future oil production can change owing to numerous factors, including the oil price, technological development and success of further exploration.

OIL PRODUCT PRICES AND TAXATION

Ex-tax prices for petrol and diesel fuel are near the average for OECD countries although high taxes make the final retail price faced by the consumer among one of the highest of the surveyed countries. In the third quarter of 2005, ex-tax prices for diesel were 2.7% below the OECD average, but petrol tax was 18% above the average and the final price was 7.4% above the average. For petrol, the ex-tax price was 2.9% above the average, taxes were more than 24% above the average and the final price was 15% above the average.

Figure 29

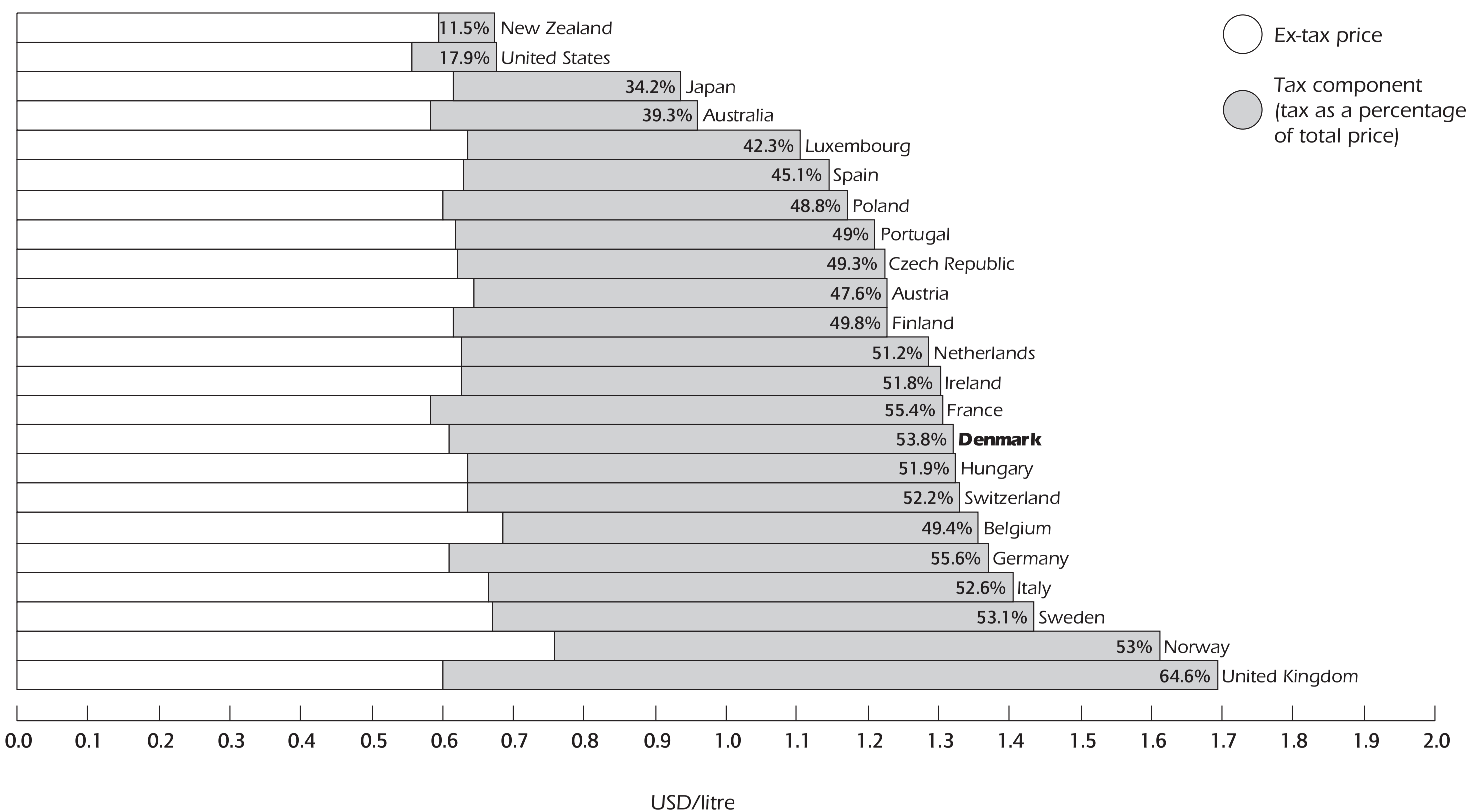
OECD Unleaded Gasoline Prices and Taxes, Third Quarter 2005



Note: data not available for Greece, Japan, Mexico the Slovak Republic and Turkey.
Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2005.

Figure 30

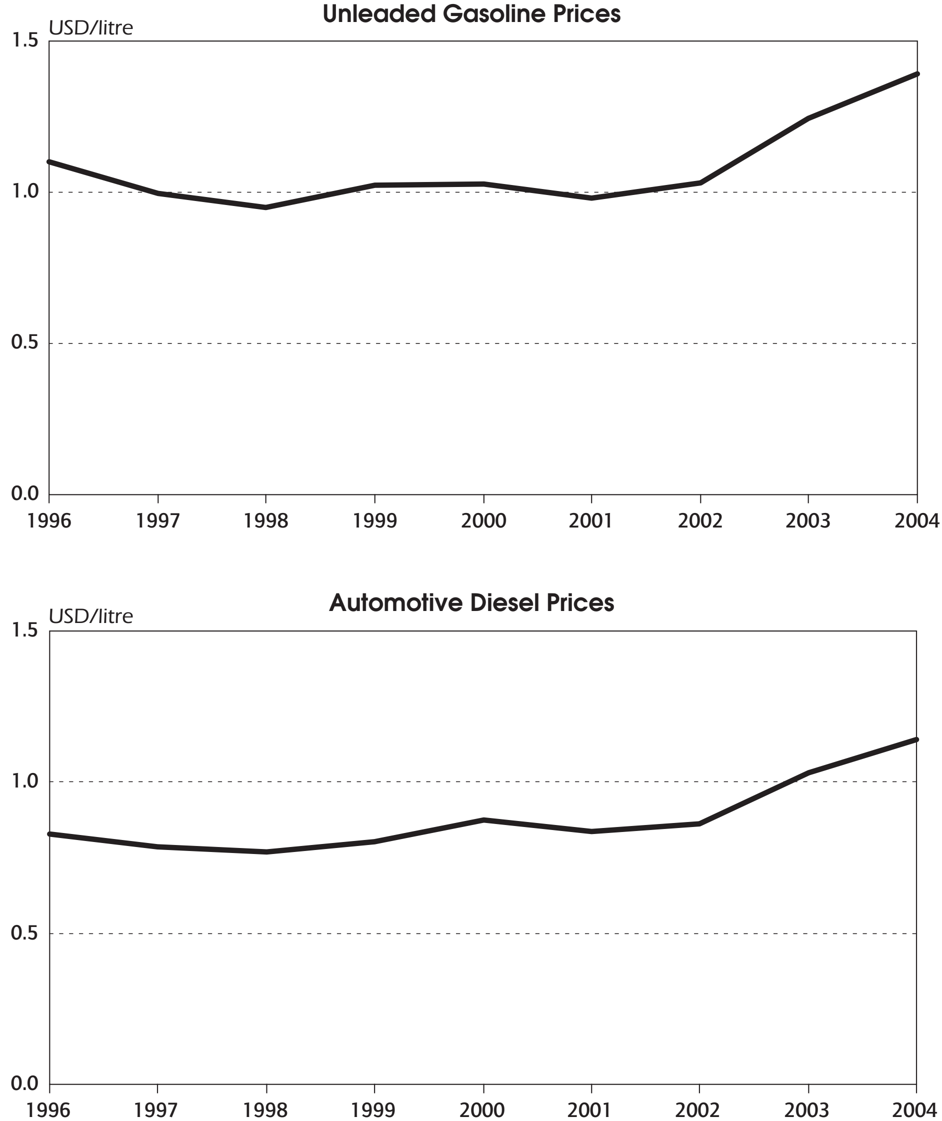
OECD Automotive Diesel Prices and Taxes, Third Quarter 2005



Note: data not available for Canada, Greece, Korea, Mexico, the Slovak Republic and Turkey.
Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2005.

Figure 31

Unleaded Gasoline and Automotive Diesel Prices, 1996 to 2004



Source: *Energy Prices & Taxes*, IEA/OECD Paris, 2005.

EMERGENCY PREPAREDNESS

Since Denmark achieved self-sufficiency in oil and gas in 1991, the country has had no stockholding obligation to the IEA, but it continues to have an obligation to the EU. The estimate of oil production from the North Sea made by the Danish Energy Authority (DEA) in 2005 shows that the country is expected to continue to be a net oil exporter at least until 2014. The break-even may be extended by additional production potential facilitated by new technology and further research.

Denmark has successfully maintained stocks of crude and oil products corresponding to 81 days of consumption, which is well above the EU stockholding obligation of 67.5 days of consumption. The Danish emergency policy is consistent with all commitments requested by IEA emergency collective action plans.

Denmark is well prepared in terms of emergency response organisation and its procedures for releasing stocks. The decision process will start with a recommendation by the DEA to the Minister for Transport and Energy. The DEA is responsible for Denmark's emergency response, consulting with the Danish Oil Reserve Stock Association (FDO) and other *ad hoc* organisations and parties. It will also be in contact with the EU Commission and other IEA and EU countries, in particular other Nordic countries.

An IEA Emergency Response Review of Denmark was carried out on 20 June 2005. The IEA review team commended the government for its thorough evaluation of Denmark's emergency policies, in which a vulnerability analysis regarding contingency planning and preparedness for all types of risks, including the Danish downstream sector, was undertaken. The review team also praised the Administration's proactive approach in holding crude and products stocks well above the EU stockholding obligation of 67.5 days, and that Danish emergency preparednesses policies are fulfilling all IEA emergency response commitments and are fully agreeable to the objectives of CERM-type emergency co-ordination.

The only substantive point of critique made by the review team concerned the government's lack of plans to conduct training beyond what is required for the IEA Emergency Response Exercises. They also noted that Denmark has a tendency to hold a surplus of heavy products and a deficit of light products, especially diesel, owing to the lack of sufficient capacity in the country's two main refineries.

CRITIQUE

COAL

In 2003, coal was the second most important fuel for the Danish economy behind gas, accounting for 27% of TPES. The large majority of coal is used to generate heat and electricity. Coal's importance to the economy has been falling from its highest point in the early 1990s, replaced by both natural gas and wind power. The government expects this trend to continue with coal eventually accounting for only 7.8% of TPES in 2030.

Although there is no domestic coal production, the international market is considered very secure in terms of reliability of supply and prices. The run-up in coal prices in recent years has been one of the most pronounced in recent memory and yet still lags behind changes in gas and oil prices. While coal will understandably be a target when reducing GHG emissions in the short, medium and long term, its benefits in terms of security of supply and relative price stability should always be taken into consideration.

OFFSHORE PRODUCTION

Production from Denmark's oil and gas fields has provided a boon to the economy. However, at current production levels, ongoing and approved reserves will be depleted in eight years for gas and just over nine years for oil. Expected new discoveries and enhanced recovery techniques will likely boost those figures to 13 years for gas and 12 years for oil. Reduced exports, which account for about half of total production, as well as domestic demand restraint would certainly extend these lifetimes although, on the other hand, the government is projecting a growth in domestic demand for both fuels. Under every reasonable scenario, depletion of domestic oil and gas reserves will have a substantial impact on the Danish energy sector, including security of supply, within the next 15 to 20 years.

The two important policies available to the government to extend the useful lifetime of the oil and gas reservoirs are already in place. One method is to continue the policy supporting an open and competitive investment climate in exploration and production. This is the most likely way to attract companies interested in participating in Danish production. The second is to continue with a tax policy that favours investments in new technologies and new recovery methods. World oil and gas prices will no doubt motivate the producers to maximise their recovery, but a well-planned tax regime can at the same time introduce new technologies that effectively prolong the lifetimes of existing fields as well as bringing new ones within reach.

NATURAL GAS

The introduction of natural gas to the Danish energy sector has been a major benefit in a number of ways. Domestic gas production has brought substantial revenues to both the government and Danish industry. As an additional domestic fuel source, it has enhanced security of supply and, as the lowest-emitting fossil fuel, it has decreased GHG emissions from what they otherwise would have been. Finally, gas is often the lowest-cost energy option to the Danish consumer, thus decreasing energy payments. The Danish gas policy has been, for the most part, effective in exploiting these advantages.

The future depletion of domestic fields will certainly diminish these benefits, particularly concerning security of supply. Along with demand restraint (see Chapter 5) and prolonged recovery from domestic fields (see above), one effective means of addressing this issue is greater connections to other gas-producing regions. These would include Norway and Russia as well as more distant regions through LNG facilities. While the subsea offshore pipeline networks of Norway and Denmark are relatively close, they are not directly connected. As for Russian gas, the connection with Germany gives Denmark indirect access to that resource, while the planned Northern European Gas Pipeline through the Baltic Sea could provide another means of connecting to Russian gas. While the need for such connections is not pressing, the country currently exports more than half its production, the lead times for such projects are substantial and the government is advised to consider the best responses to the future depletion of domestic gas reservoirs.

The high-pressure gas pipeline network is owned and operated by the newly formed Energinet.dk, which itself is entirely owned by the government. While Energinet.dk has the authority to propose additions or expansions to this system, final approval of any such plans must come from the Ministry of Transport and Energy. While this can and has been a positive feature of the investment process, particularly with international connections, its future implications should be carefully considered. Both the minister and Energinet.dk are tasked with ensuring that the network optimally provides for security of supply and a well-functioning competitive market and, as such, there should be little difference between their respective positions on planned additions. Care should be taken that the required ministerial approval and any possible political considerations in no way undermine objective cost-benefit analyses when determining network capacity additions.

While liberalisation legislation has been implemented and some industrial consumers have changed supplier, the concentration on the supply side is preventing consumers from profiting from the advantages of choosing their own supplier and from real competition. In addition, DONG ownership of the storage facilities gives this company a competitive advantage as access to storage is an important access barrier for newcomers to the market.

Gas storage is essential to compete in the market, especially for companies that do not have interests in domestic production. Regulations allow any company to access DONG's two storage facilities through a negotiated access regime. However, such access rights can be insufficient when gas from storage is in high demand and incumbents are given priority. While not strictly a natural monopoly, gas storage requires the proper geological conditions as well as substantial capital to fill and thus, during this transitional phase towards competition, can easily constitute a barrier to entry. The government should ensure that this is not the case and that true equal access is given to both incumbent and new entrant companies.

Even given proper access rules to storage, as well as transmission and distribution pipelines, companies with production in Denmark will enjoy an advantage on the retail level. While some companies have entered the gas retail market, the concentration on the supply side is clearly and logically correlated with those companies also involved in domestic consumption. One tactic used in other countries to induce new entrant competitors is a gas release programme. The government is encouraged to explore this option as a means of increasing competition.

RECOMMENDATIONS

The government of Denmark should:

- *Maintain a policy supporting an open and competitive investment climate in the exploration and production sector.*
- *Maintain a tax policy in the exploration and production sector favourable to investments in new technologies and new recovery methods to prolong the life of the existing fields and produce new discoveries.*
- *Consider the effects of gas reservoir depletions on security of supply as well as possible medium-term responses such as enhanced connections with other North Sea gas infrastructures, the possibility of connecting to the Russian fields (through the North European Gas Pipeline project) and LNG facilities.*
- *Ensure that objective cost-benefit analyses drive investment decisions for the gas transport network.*
- *Ensure that all companies, whether incumbents or new entrants, are given true equal access to storage facilities and that this in no way becomes a barrier to competition.*
- *Evaluate whether a gas release programme for domestically produced gas might induce new suppliers into the market and thus facilitate more competition.*

ENERGY RESEARCH, DEVELOPMENT AND DEMONSTRATION (RD&D)

RD&D POLICY AND PARTICIPANTS

The major policy objectives for Danish government research, development and demonstration (RD&D) are: *i)* to secure energy supply at efficient prices, and *ii)* to protect the environment. According to the government's recent Energy Strategy 2025, it is expected that demand for renewable energy and energy-efficient technologies will increase considerably over this period. Consequently, it is the ambition to strengthen energy RD&D in order to benefit from the potential for increased exports of energy technology and the creation of new jobs. The government has focused on the need to increase demonstration of new technologies and to bring research and industry together. At the same time, RD&D priorities are not explicitly set by the Energy Strategy 2025 with specific new technologies being favoured. It is generally expected that new technologies will develop according to market conditions.

The stakeholders of energy RD&D are the following:

- *Administrators* of energy RD&D programmes: the Danish Energy Authority (DEA), the national TSO Energinet.dk, the national organisation of electricity net companies ELFOR and the Strategic Research Council.
- *Research Institutions:* Risø, Forest and Landscape KVL, Food and Resource Institute KVL, Danish Building Research Institute SBI, Geological Survey GEUS and others.
- *Universities:* Technical University of Denmark DTU, Aalborg University, Roskilde University RUC, University of Southern Denmark and others.
- *Technological Institutes:* Teknologisk Institut, FORCE and several others.
- *Private companies:* Danfoss, Grundfos, Velux, Topsøe, IRD Fuel Cells, Power Lynx, Topsil, Vestas, Bonus/Siemens, LM Glasfiber, Thomas Koch Energi and consulting companies (COWI, Rambøll, Birch & Krogboe, Esbensen and others).

Traditionally, research institutions and universities have been encouraged to involve industry in R&D projects – this was one of several evaluation criteria – when public support was being applied for. In recent years, however, this involvement seems to have decreased and this is one of the reasons why the government intends to increase its efforts to involve industry more in RD&D.

FUNDING TRENDS

Denmark has traditionally been one of the biggest spenders on energy RD&D as a percentage of GDP. However, with the change in government in 2001, the budget for energy RD&D was cut dramatically, falling from DKK 328 million in 2001 to DKK 168 million in 2002. However, government spending has increased steadily since then and the proposed spending for 2006 is only slightly below the figure for 2001.

Additional project funding comes from the private sector and the basic research funds for the national universities and institutes. Generally, every krone spent by the government directly on energy RD&D results in two kroner coming from these other sources.

MAJOR RESEARCH PROGRAMMES

Denmark has four major energy RD&D programmes.

- **The Danish Energy Research Programme for New Energy Technologies**

The Danish Energy Research Programme was launched in 1977 as a sectorial R&D programme involving applied strategic research for medium- and long-term technologies. It covers all energy technologies, including heat, power, transportation, end-use, oil and gas exploration and production. More recently the programme has pursued advances in renewable energy and biomass, fuel cells, superconductors, energy-efficient products and processes, energy-efficient buildings, oil and gas exploration and production and energy system analysis. The programme is administered by the DEA and has an annual budget of around DKK 65 million.

- **The Clean Electricity Production Research Programme**

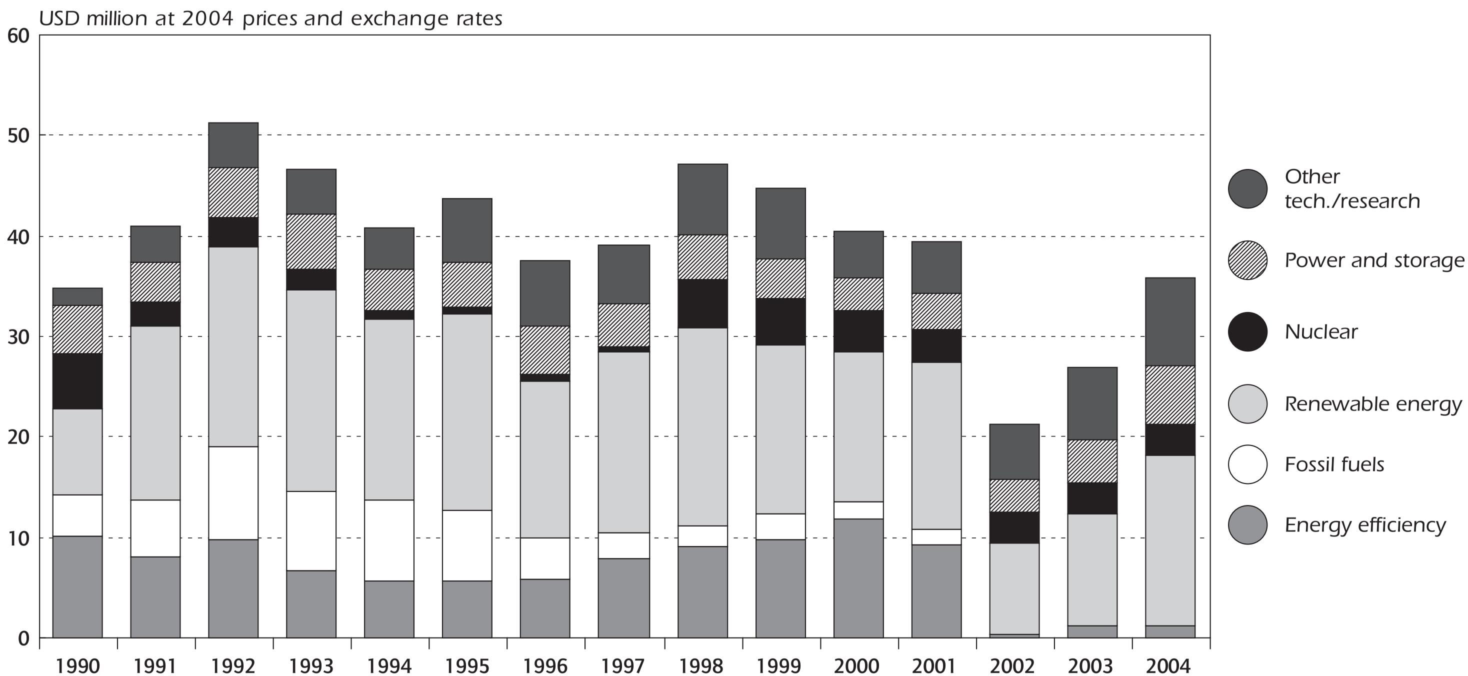
The Clean Electricity Production Programme was created in 1999 as a Public Service Obligation (PSO) for electricty companies in the private sector. It was intended as a way to ensure that these companies continue to undertake research as the sector moved towards liberalisation with greater competition and fewer assured revenues. It is financed by a customer levy on all electricity sales of DKK 0.004 per kWh. All funded research must be strictly non-commercial. Research areas in recent years have included renewable energy (biomass), waste, fuel cells and CHP. The programme is administered by Energinet.dk and has an annual budget of around DKK 130 million.

- **The Energy Efficiency Programme**

The Energy Efficiency Research Programme was launched in 2002. It is financed by a customer levy on all electricity sales of around DKK 0.0008. In recent years, it has focused on buildings, lighting, electronics for effect and

Figure 32

Government RD&D Spending on Energy, 1990 to 2004*



* 2004 = estimates.

Sources: *OECD Economic Outlook*, OECD Paris, 2005 and country submission.

measuring, behaviour, freezing and cooling, and industrial processes. The programme is administered by ELFOR (Association of Danish Electricity Distribution Companies) and has an annual budget of around DKK 25 million.

- **The Renewable Energy Research Programme**

The Renewable Energy Research Programme was launched in 2003 as a vehicle for technological advances in renewable energy. It is administered by the Programme Committee on Energy and Environment of the Ministry of Science and has a budget of approximately DKK 60 million per year.

TECHNOLOGIES WITH HIGH RESEARCH POTENTIAL

The government has identified the following eight technology areas to pursue with its RD&D efforts:

- CHP using biomass.
- Wind energy.
- PV – solar electricity.
- Fuel cells.
- Liquid biofuels.
- Hydrogen.
- Energy efficiency.
- Wave energy.

INTERNATIONAL COLLABORATION

Denmark is active in several international efforts in energy RD&D. It is a partner in 18 different IEA Implementing Agreements as well as a number of EU ERA-nets and Technology Platforms. It is also a member of the Nordic Energy Research Programme to which it contributes around DKK 15 million per year. The DEA is currently investigating the future priorities within international collaboration.

CRITIQUE

Denmark's energy RD&D record is sound. The country's expenditures have been substantial relative to its economic size. Although the political change in 2001 prompted a massive cut in spending that must have disrupted numerous programmes, Denmark has steadily increased the budget since then and is currently almost at the level seen before the cuts took place. The IEA encourages this recent trend and hopes that any RD&D budget cuts in the future would be carried out in a more measured fashion.

Denmark has also been successful in pursuing technologies that: *i)* are consistent with their overall energy policy strategies and *ii)* play to the strengths of Danish industry. For example, the money spent on wind power was consistent with government's renewable energy support schemes as well as Danish industry capabilities. Those research funds were a means of providing Denmark with lower-cost wind turbines and boosting an important Danish industry. The future technology priorities also appear consistent with overall energy policy and Danish industrial capacity.

The move towards liberalised electricity and natural gas markets has undermined utility research in a number of countries. As the utilities become more profit-focused and less reliant on assured revenues, their RD&D budgets are the first to be cut. Denmark is to be commended for the way in which it has handled this problem by creating funds explicitly focused on continuing the utility RD&D. Utilities are in a unique position to perform fruitful energy research given their continual hands-on experience and regular contact with customers. The Clean Electricity Production Research Programme and the Energy Effiicency Programme are two solid ways to ensure that this research can continue.

RECOMMENDATIONS

The government of Denmark should:

- *Continue the recent trend of increased government spending in energy RD&D activities.*
- *Ensure that energy RD&D continues to be consistent with domestic energy policy to support Danish industries in order to extend their success in the international market.*
- *Continue to ensure that transformations in the energy sector, most notably the creation of Energinet.dk from existing electricity and gas transmission companies, and the DONG acquisition of Elsam A/S and ENERGI E2, do not result in decreased or disrupted RD&D activity in the relevant sectors.*

ENERGY BALANCES AND KEY STATISTICAL DATA

Unit: Mtoe

SUPPLY		1973	1990	2003	2004P	2010	2020	2030
TOTAL PRODUCTION		**0.43**	**10.00**	**28.50**	**31.11**	**33.47**	**21.91**	**21.07**
Coal		–	–	–	–	–	–	–
Oil		0.07	6.03	18.63	19.78	19.96	13.29	12.36
Gas		–	2.77	7.20	8.49	10.17	4.81	4.69
Comb. Renewables & Waste[1]		0.35	1.14	2.09	2.16	2.46	2.81	2.83
Nuclear		–	–	–	–	–	–	–
Hydro		0.00	0.00	0.00	0.00	0.00	0.00	0.00
Geothermal		–	0.00	0.00	0.00	0.03	0.02	–
Solar/Wind/Other[2]		–	0.06	0.57	0.67	0.85	0.97	1.19
TOTAL NET IMPORTS[3]		**19.85**	**7.69**	**–7.93**	**–10.87**	**–12.21**	**–0.56**	**0.54**
Coal	Exports	0.04	0.03	0.09	0.09	–	–	–
	Imports	1.91	6.25	5.66	4.52	3.91	2.71	1.69
	Net Imports	1.87	6.22	5.57	4.42	3.91	2.71	1.69
Oil	Exports	2.89	5.84	17.80	19.56	10.46	3.37	2.18
	Imports	21.58	8.58	8.50	8.83	–	–	–
	Bunkers	0.69	0.96	0.99	0.80	0.80	0.80	0.80
	Net Imports	18.00	1.79	–10.29	–11.54	–11.26	–4.17	–2.98
Gas	Exports	–	0.93	2.59	3.69	4.53	–	–
	Imports	–	–	–	–	–	0.95	2.15
	Net Imports	–	–0.93	–2.59	–3.69	–4.53	0.95	2.15
Electricity	Exports	0.11	0.42	1.34	0.99	0.33	0.05	0.33
	Imports	0.09	1.03	0.60	0.75	–	–	–
	Net Imports	–0.02	0.61	–0.74	–0.25	–0.33	–0.05	–0.33
TOTAL STOCK CHANGES		**–0.44**	**0.17**	**0.18**	**–0.12**	**–**	**–**	**–**
TOTAL SUPPLY (TPES)		**19.83**	**17.85**	**20.76**	**20.12**	**21.26**	**21.35**	**21.61**
Coal		1.93	6.09	5.67	4.36	3.91	2.71	1.69
Oil		17.57	8.13	8.37	8.36	8.70	9.13	9.38
Gas		–	1.82	4.66	4.63	5.64	5.76	6.85
Comb. Renewables & Waste[1]		0.35	1.14	2.21	2.35	2.46	2.81	2.83
Nuclear		–	–	–	–	–	–	–
Hydro		0.00	0.00	0.00	0.00	0.00	0.00	0.00
Geothermal		–	0.00	0.00	0.00	0.03	0.02	–
Solar/Wind/Other[2]		–	0.06	0.57	0.67	0.85	0.97	1.19
Electricity Trade[4]		–0.02	0.61	–0.74	–0.25	–0.33	–0.05	–0.33
Shares (%)								
Coal		*9.7*	*34.1*	*27.3*	*21.7*	*18.4*	*12.7*	*7.8*
Oil		*88.6*	*45.6*	*40.3*	*41.5*	*40.9*	*42.7*	*43.4*
Gas		–	*10.2*	*22.4*	*23.0*	*26.5*	*27.0*	*31.7*
Comb. Renewables & Waste		*1.8*	*6.4*	*10.7*	*11.7*	*11.5*	*13.2*	*13.1*
Nuclear		–	–	–	–	–	–	–
Hydro		–	–	–	–	–	–	–
Geothermal		–	–	–	–	*0.1*	*0.1*	–
Solar/Wind/Other		–	*0.3*	*2.8*	*3.3*	*4.0*	*4.5*	*5.5*
Electricity Trade		*–0.1*	*3.4*	*–3.5*	*–1.2*	*–1.5*	*–0.2*	*–1.5*

P is preliminary. 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. For forecast years. electricity exports may be lower when the CO_2 quota system is taken into account.

Unit: Mtoe

DEMAND

FINAL CONSUMPTION BY SECTOR

	1973	1990	2003	2004P	2010	2020	2030
TFC	**16.26**	**13.87**	**15.32**	**15.60**	**16.20**	**16.43**	**16.81**
Coal	0.34	0.40	0.21	0.26	0.22	0.23	0.24
Oil	14.26	7.56	7.42	7.52	7.73	8.03	8.34
Gas	0.12	1.16	1.71	1.71	1.82	1.72	1.69
Comb. Renewables & Waste[1]	0.16	0.56	0.72	0.72	0.80	0.79	0.81
Geothermal	–	–	–	–	–	–	–
Solar/Wind/Other	–	0.00	0.01	0.01	0.01	0.01	0.01
Electricity	1.39	2.44	2.79	2.84	2.97	3.17	3.36
Heat	–	1.76	2.46	2.54	2.67	2.48	2.36
Shares (%)							
Coal	*2.1*	*2.9*	*1.4*	*1.7*	*1.3*	*1.4*	*1.4*
Oil	*87.7*	*54.5*	*48.5*	*48.2*	*47.7*	*48.9*	*49.6*
Gas	*0.7*	*8.3*	*11.2*	*11.0*	*11.2*	*10.4*	*10.0*
Comb. Renewables & Waste	*1.0*	*4.1*	*4.7*	*4.6*	*4.9*	*4.8*	*4.8*
Geothermal	–	–	–	–	–	–	–
Solar/Wind/Other	–	–	*0.1*	*0.1*	–	–	–
Electricity	*8.5*	*17.6*	*18.2*	*18.2*	*18.3*	*19.3*	*20.0*
Heat	–	*12.7*	*16.1*	*16.3*	*16.5*	*15.1*	*14.1*
TOTAL INDUSTRY[5]	**4.10**	**3.00**	**3.15**	**3.25**	**3.28**	**3.34**	**3.45**
Coal	0.21	0.32	0.17	0.24	0.18	0.19	0.20
Oil	3.41	1.23	1.05	1.10	1.07	1.09	1.12
Gas	0.02	0.54	0.77	0.73	0.81	0.78	0.78
Comb. Renewables & Waste[1]	0.06	0.11	0.16	0.11	0.16	0.16	0.16
Geothermal	–	–	–	–	–	–	–
Solar/Wind/Other	–	–	–	–	–	–	–
Electricity	0.40	0.73	0.84	0.86	0.87	0.94	1.01
Heat	–	0.07	0.17	0.20	0.19	0.19	0.18
Shares (%)							
Coal	*5.2*	*10.7*	*5.5*	*7.3*	*5.4*	*5.6*	*5.7*
Oil	*83.3*	*40.9*	*33.2*	*33.9*	*32.6*	*32.6*	*32.5*
Gas	*0.4*	*17.9*	*24.3*	*22.5*	*24.7*	*23.2*	*22.5*
Comb. Renewables & Waste	*1.4*	*3.8*	*5.1*	*3.4*	*4.9*	*4.8*	*4.6*
Geothermal	–	–	–	–	–	–	–
Solar/Wind/Other	–	–	–	–	–	–	–
Electricity	*9.7*	*24.2*	*26.6*	*26.5*	*26.6*	*28.1*	*29.4*
Heat	–	*2.5*	*5.3*	*6.3*	*5.9*	*5.7*	*5.3*
TRANSPORT[6]	**3.52**	**4.11**	**5.02**	**5.16**	**5.39**	**5.78**	**6.12**
TOTAL OTHER SECTORS[7]	**8.65**	**6.77**	**7.15**	**7.19**	**7.54**	**7.31**	**7.25**
Coal	0.13	0.08	0.03	0.03	0.04	0.04	0.04
Oil	7.34	2.24	1.39	1.29	1.29	1.18	1.13
Gas	0.10	0.62	0.95	0.98	1.01	0.94	0.91
Comb. Renewables & Waste[1]	0.10	0.45	0.56	0.60	0.64	0.63	0.65
Geothermal	–	–	–	–	–	–	–
Solar/Wind/Other	–	0.00	0.01	0.01	0.01	0.01	0.01
Electricity	0.98	1.70	1.92	1.94	2.07	2.21	2.33
Heat	–	1.68	2.30	2.34	2.47	2.29	2.18
Shares (%)							
Coal	*1.4*	*1.2*	*0.5*	*0.4*	*0.5*	*0.6*	*0.6*
Oil	*84.9*	*33.1*	*19.4*	*17.9*	*17.2*	*16.2*	*15.6*
Gas	*1.2*	*9.2*	*13.2*	*13.6*	*13.4*	*12.9*	*12.5*
Comb. Renewables & Waste	*1.2*	*6.7*	*7.8*	*8.4*	*8.4*	*8.7*	*9.0*
Geothermal	–	–	–	–	–	–	–
Solar/Wind/Other	–	–	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
Electricity	*11.3*	*25.1*	*26.8*	*27.0*	*27.5*	*30.3*	*32.1*
Heat	–	*24.9*	*32.1*	*32.5*	*32.8*	*31.3*	*30.1*

Unit: Mtoe

DEMAND

ENERGY TRANSFORMATION AND LOSSES

	1973	1990	2003	2004P	2010	2020	2030
ELECTRICITY GENERATION[8]							
INPUT (Mtoe)	**4.60**	**7.08**	**10.44**	**9.15**	**8.88**	**8.42**	**8.64**
OUTPUT (Mtoe)	**1.64**	**2.23**	**3.98**	**3.48**	**3.51**	**3.46**	**3.94**
(TWh gross)	19.12	25.98	46.26	40.48	40.84	40.21	45.76
Output Shares (%)							
Coal	*35.8*	*90.3*	*54.7*	*46.1*	*42.0*	*30.6*	*17.7*
Oil	*64.1*	*3.7*	*5.1*	*4.0*	*2.4*	*3.2*	*2.0*
Gas	–	*2.7*	*21.2*	*24.7*	*21.7*	*26.3*	*37.9*
Comb. Renewables & Waste	–	*0.8*	*6.8*	*8.8*	*12.7*	*15.0*	*14.9*
Nuclear	–	–	–	–	–	–	–
Hydro	*0.1*	*0.1*	*0.0*	*0.1*	*0.1*	*0.1*	*0.1*
Geothermal	–	–	–	–	–	–	–
Solar/Wind/Other	–	*2.3*	*12.2*	*16.3*	*21.3*	*24.9*	*27.5*
TOTAL LOSSES	**3.66**	**4.02**	**5.42**	**4.62**	**5.06**	**4.92**	**4.80**
of which:							
Electricity and Heat Generation[9]	2.96	2.64	3.36	2.49	2.04	1.88	1.78
Other Transformation	0.44	–0.03	–0.00	0.08	0.08	0.08	0.08
Own Use and Losses[10]	0.26	1.41	2.07	2.05	2.93	2.96	2.93
Statistical Differences	**–0.08**	**–0.05**	**0.01**	**–0.09**	**–**	**–**	**–**

INDICATORS

	1973	1990	2003	2004P	2010	2020	2030
GDP (billion 2000 USD)	98.76	125.72	163.04	166.95	186.80	215.93	237.81
Population (millions)	5.02	5.14	5.39	5.41	5.43	5.41	5.38
TPES/GDP[11]	0.20	0.14	0.13	0.12	0.11	0.10	0.09
Energy Production/TPES	0.02	0.56	1.37	1.55	1.57	1.03	0.98
Per Capita TPES[12]	3.95	3.47	3.85	3.72	3.92	3.95	4.02
Oil Supply/GDP[11]	0.18	0.06	0.05	0.05	0.05	0.04	0.04
TFC/GDP[11]	0.16	0.11	0.09	0.09	0.09	0.08	0.07
Per Capita TFC[12]	3.24	2.70	2.84	2.88	2.99	3.04	3.12
Energy–related CO_2 Emissions (Mt CO_2)[13]	56.6	50.7	56.2	..	..	..	..
CO_2 Emissions from Bunkers (Mt CO_2)	4.5	4.8	5.3	..	..	..	..

GROWTH RATES (% per year)

	73–79	79–90	90–03	03–04	04–10	10–20	20–30
TPES	1.2	–1.6	1.2	–3.0	0.9	0.0	0.1
Coal	14.4	3.1	–0.6	–23.1	–1.8	–3.6	–4.6
Oil	–1.4	–6.1	0.2	–0.2	0.7	0.5	0.3
Gas	–	–	7.5	–0.5	3.3	0.2	1.7
Comb. Renewables & Waste	6.9	7.3	5.2	6.0	0.8	1.4	0.0
Nuclear	–	–	–	–	–	–	–
Hydro	–	–	–	–	7.0	–	–
Geothermal	–	–	5.5	–50.0	53.3	–2.1	–
Solar/Wind/Other	–	44.0	19.7	18.0	4.1	1.3	2.1
TFC	0.7	–1.8	0.8	1.8	0.6	0.1	0.2
Electricity Consumption	4.9	2.5	1.0	1.7	0.7	0.7	0.6
Energy Production	14.7	23.6	8.4	9.2	1.2	–4.1	–0.4
Net Oil Imports	–2.6	–17.8	–	12.1	–0.4	–	–3.3
GDP	1.5	1.4	2.0	2.4	1.9	1.5	1.0
Growth in the TPES/GDP Ratio	–0.3	–2.9	–0.8	–5.3	–1.0	–1.4	–0.8
Growth in the TFC/GDP Ratio	–0.9	–3.1	–1.2	–0.6	–1.2	–1.3	–0.7

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 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 main activity producer utilities (formerly known as public) and autoproducers. For non-fossil-fuel electricity generation, theoretical losses are shown based on plant efficiencies of approximately 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 2000 prices and exchange rates.

12 Toe per person.

13 "Energy-related CO_2 emissions" have been estimated using the IPCC Tier I Sectoral Approach. In accordance with the IPCC methodology, emissions from international marine and aviation bunkers are not included in national totals.

INTERNATIONAL ENERGY AGENCY "SHARED GOALS"

The 26 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 IEA members wish to retain and improve the nuclear

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

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

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

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

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

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

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

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

GLOSSARY AND LIST OF ABBREVIATIONS

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 subsequently abbreviated, this glossary provides a quick and central reference for many of the abbreviations used.

bcm	billion cubic metres.
CCGT	combined-cycle gas turbine.
CHP	combined production of heat and power.
CO_2	carbon dioxide.
DC	direct current.
DEA	Danish Energy Authority.
DERA	Danish Energy Regulatory Authority.
DH	district heating.
DONG	Danish Oil and Natural Gas group.
EC	European Commission.
EEC	Energy Efficiency Commitment.
ERP	Energy Research Programme.
ESCO	energy service company.
EU	European Union.
EUA	EU allowance.
EU-ETS	European Union Emissions Trading Scheme.
FSE	Federation of Large Energy Consumers.
GDP	gross domestic product.
GHG	greenhouse gas.
GJ	gigajoule.
GW	gigawatt, or 1 watt × 10^9.
GWh	gigawatt-hour = 1 gigawatt × 1 hour.
IEA	International Energy Agency.
IPCC	Intergovernmental Panel on Climate Change.

IPO	initial public offering.
km	kilometre.
km^2	square kilometre.
kW	kilowatt, or 1 watt × 10^3.
kWh	kilowatt-hour = 1 kilowatt × one hour.
LNG	liquefied natural gas.
mcm	million cubic metres.
MSW	municipal solid waste.
Mt	million tonnes.
Mtoe	million tonnes of oil equivalent.
Mt CO_2-eq	million tonnes of CO_2 equivalent.
MW	megawatt, or 1 watt × 10^6.
MWh	megawatt-hour = 1 megawatt × one hour.
NAP	National Allocation Plan.
Nm^3	normal cubic metre.
NO_X	nitrogen oxide.
OECD	Organisation for Economic Co-operation and Development.
PJ	petajoule
PPP	purchasing power parity.
PSO	Public Service Obligation.
PV	photovoltaic.
R&D	research and development, especially in energy technology; may include the demonstration and dissemination phases as well.
SO_2	sulphur dioxide.
SO_X	sulphur oxide.
TFC	total final consumption of energy.
toe	tonne of oil equivalent.
TPA	third-party access.
TPES	total primary energy supply.
TSO	transmission system operator.
TWh	terawatt-hour = 1 terawatt × one hour = 1 million MWh.
UNFCCC	United Nations Framework Convention on Climate Change.

The Online Bookshop

International Energy Agency

All IEA publications can be bought online on the IEA Web site:

www.iea.org/books

You can also obtain PDFs of all IEA books at 20% discount.

Books published before January 2005 - with the exception of the statistics publications - can be downloaded in PDF, free of charge, on the IEA website.

IEA BOOKS

Tel: +33 (0)1 40 57 66 90
Fax: +33 (0)1 40 57 67 75
E-mail: books@iea.org

International Energy Agency
9, rue de la Fédération
75739 Paris Cedex 15, France

CUSTOMERS IN NORTH AMERICA

Turpin Distribution
The Bleachery
143 West Street, New Milford
Connecticut 06776, USA
Toll free: +1 (800) 456 6323
Fax: +1 (860) 350 0039
oecdna@turpin-distribution.com
www.turpin-distribution.com

You can also send your order to your nearest OECD sales point or through the OECD online services:

www.oecdbookshop.org

CUSTOMERS IN THE REST OF THE WORLD

Turpin Distribution Services Ltd
Stratton Business Park,
Pegasus Drive, Biggleswade,
Bedfordshire SG18 8QB, UK
Tel.: +44 (0) 1767 604960
Fax: +44 (0) 1767 604640
oecdrow@turpin-distribution.com
www.turpin-distribution.com

IEA PUBLICATIONS, 9, rue de la Fédération, 75739 PARIS CEDEX 15
PRINTED IN FRANCE BY STEDI MEDIA
(61 2006 04 1P1) ISBN : 92-64-10971-4 – 2006