

**“The Danish example” – the way to an energy efficient and energy friendly economy**

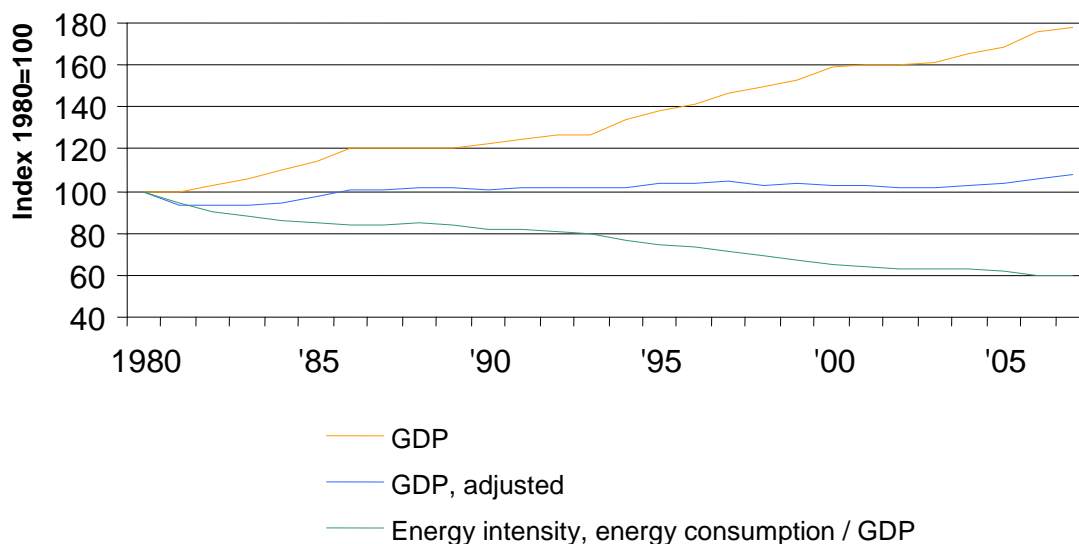
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Danish experience shows that through persistent and active energy policy focus on enhanced energy efficiency, it is possible to sustain high economic growth and at the same time reduce fossil fuel dependency and protect the environment.

In terms of production, Denmark is one of the most efficient users of energy compared with the other EU Member States and OECD countries. This also applies to CO<sub>2</sub> emissions in relation to production. Despite relatively low energy consumption, Denmark is among the best in the EU and the OECD at continuously reducing its energy dependency and CO<sub>2</sub> emissions. In an international perspective, Denmark therefore belongs to a group of countries that have relatively low energy and CO<sub>2</sub> intensities, while over the past more than 25 years, being able to achieve above-average reductions in energy and CO<sub>2</sub> intensity.

Since 1980, the Danish economy has grown by 78%, while energy consumption has remained more or less constant, and CO<sub>2</sub> emissions have been reduced. This development reflects an increase in energy and CO<sub>2</sub> efficiency. A majority of countries have seen underlying increases in their energy and CO<sub>2</sub> efficiencies, but the Danish increase is among the greatest in the OECD area.

**Energy consumption, GDP and energy intensity**



Furthermore, the composition of energy consumption in Denmark has changed significantly as a consequence of energy policy measures to promote the use of renewable energy. Renewable energy today makes up more than 19% of final energy consumption.<sup>1</sup>

This has increased the security of energy supply and has contributed considerably to fulfilling Denmark's climate goals. From 1990 to 2007, economic activity in Denmark increased by more than 45%, while CO<sub>2</sub> emissions (adjusted for fluctuations in the weather and in cross-border exchange in electricity) were reduced by more than 13%.

This paper describes how Denmark has been able to sustain economic growth while energy consumption has remained almost unchanged and CO<sub>2</sub> emissions have dropped.

### **Energy consumption and the development in energy and CO<sub>2</sub> intensity in an international perspective**

Today, Denmark's energy efficiency is one of the best in the EU and continues to improve year by year. Danish energy intensity is thus the lowest in the EU. Energy intensity is measured as the ratio of energy production<sup>2</sup> to real GDP.

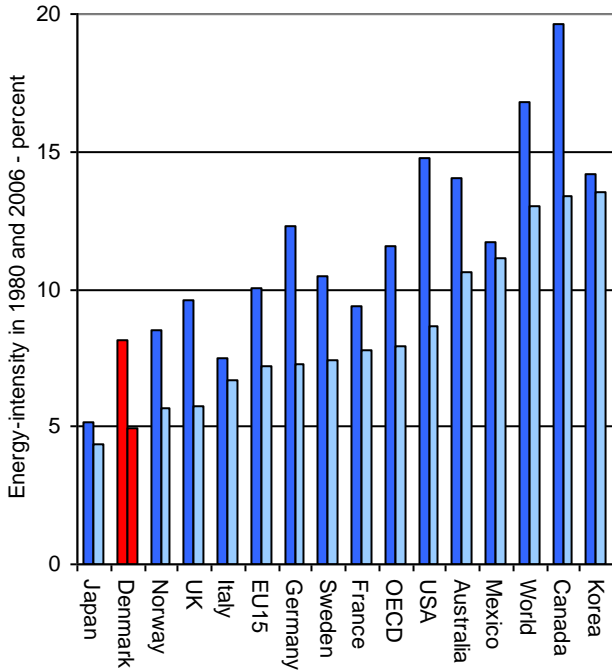
Since 1980, Denmark has reduced its energy intensity by more than the OECD average, and by noticeably more than for the world as a whole. At the same time, Denmark has one of the lowest energy intensities. However, several countries have seen a development in energy intensity similar to Denmark's, as can be seen in the figure on the next page to the right.

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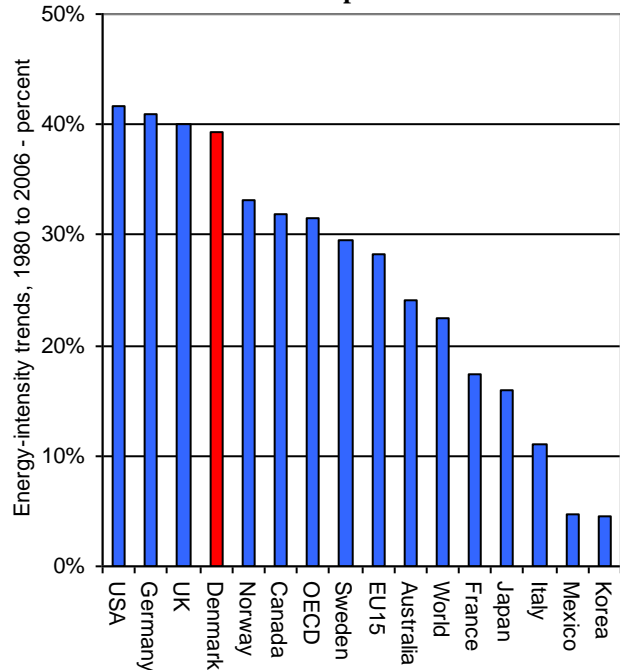
<sup>1</sup> When the share of renewable energy is calculated on the basis of final energy consumption rather than on the basis of gross energy consumption, the basis for calculating is energy consumption by end users, exclusive of cross-border trade and consumption for non-energy purposes. Distribution loss and own consumption from electricity and district heating production are included in final energy consumption.

<sup>2</sup> IEA data are used which does not include adjustments for cross-border electricity exchanges.

**Energy intensity in selected OECD countries, 1980 and 2006**



**Reduction in energy intensity in selected OECD countries in the period 1980-2006**

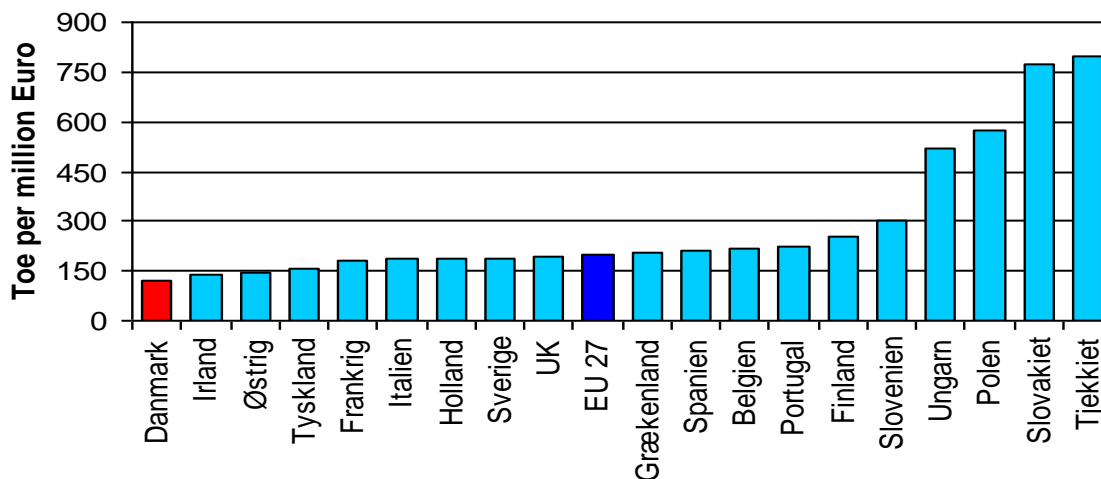


Note: In the figure to the left, the dark blue column (left column) indicates the energy intensity for the individual country in 1980, while the light blue column (right column) indicates the energy intensity for the individual country in 2006.

Note: Energy consumption for foreign shipping (foreign bunkering), according to international energy statistics standards, is not included in the energy consumption of the individual country, but is stated separately. This consumption therefore does not appear from the figure. The added value in Danish foreign shipping trade is included in GDP.

Note: These intensity figures are based on GDP at market prices. Please note that relatively high indirect taxes in Denmark, all things being equal, increase the nominally calculated GDP at market prices and thus reduce the calculated energy intensity. For the Eastern European countries in particular, a relatively lower price level will tend towards a lower calculated GDP at market prices and thus a higher calculated energy intensity for these countries. Source: IEA, 2008

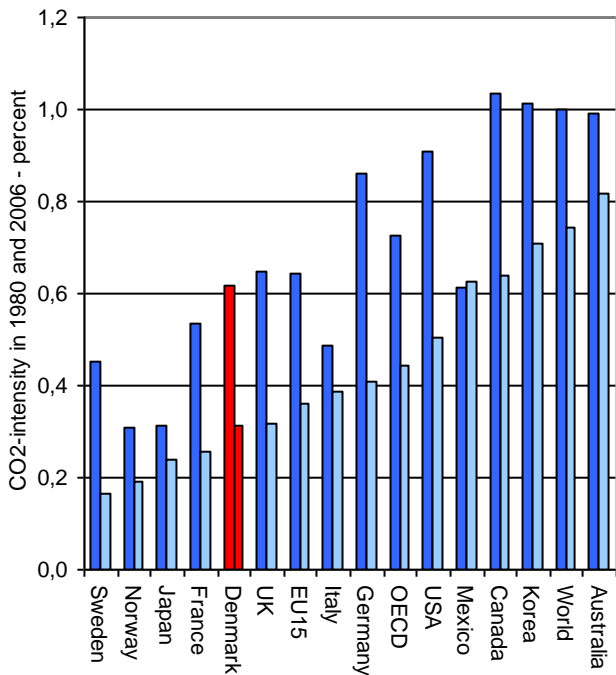
### Energy intensity in EU Member States, 2006



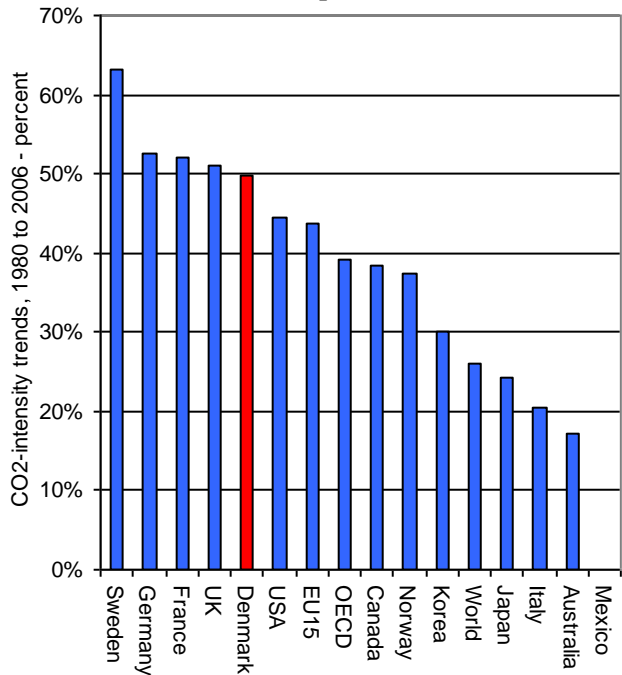
In addition to energy intensity, Denmark has also reduced its CO<sub>2</sub> intensity by more than the OECD average, and by noticeably more than for the world as a whole, just as Denmark has one of the OECD's lowest CO<sub>2</sub> intensities (CO<sub>2</sub> intensity is measured as the ratio of CO<sub>2</sub>

emissions to real GDP). Several other countries, however, have also seen a development in energy intensity in line with Denmark's. It is important to note that, amongst other things, differences in the structure of industry influence both energy intensity and CO<sub>2</sub> intensity across countries.

**CO<sub>2</sub> intensity in selected OECD countries, 1980 and 2006**



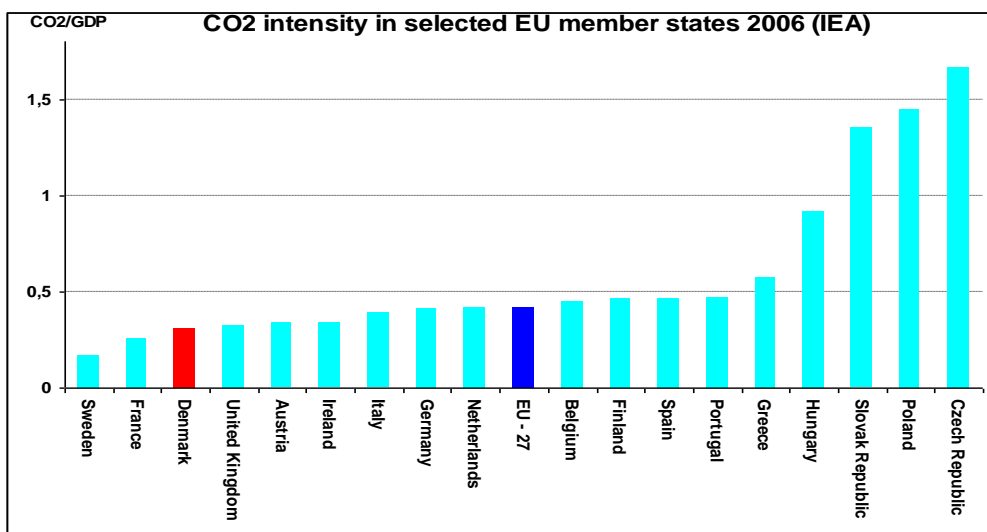
**Reduction in CO<sub>2</sub> intensity in selected OECD countries in the period 1980-2006**



Note: In the left figure, the dark blue column (left column) indicates the CO<sub>2</sub> intensity for the individual country in 1980, while the light blue column (right column) indicates the CO<sub>2</sub> intensity for the individual country in 2006.

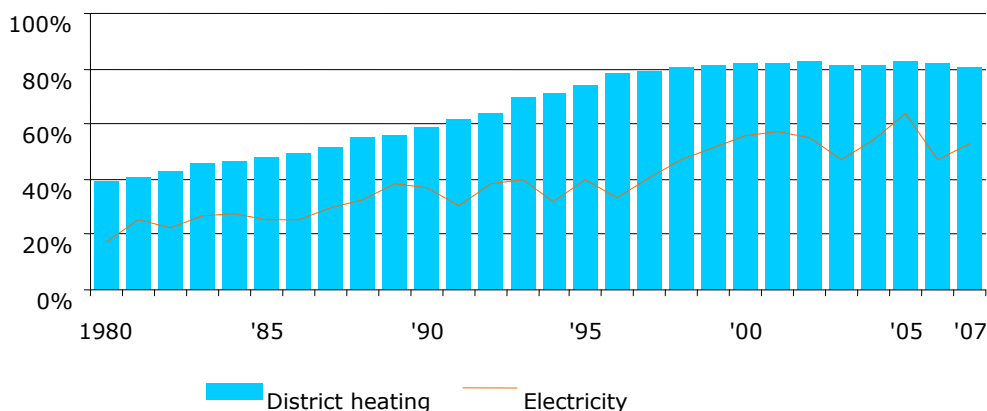
Note: See notes to figure above.

Source: IEA, 2008



The promotion of cogenerated electricity and heat, one of a long series of measures to improve energy efficiency, has been extremely important for Denmark's good results. Cogeneration of electricity and heat ensures far more efficient use of the fuels that are used in production. The most efficient CHP plants have an energy efficiency rate of more than 90%. As can be seen from the figure below, the share of district heating produced at CHP plants has more than doubled, from 39% to 80%, since 1980. Similarly, the share of electricity cogenerated with heat has gone up from just under 18% to almost 53%.

### CHP share of electricity and district-heating production



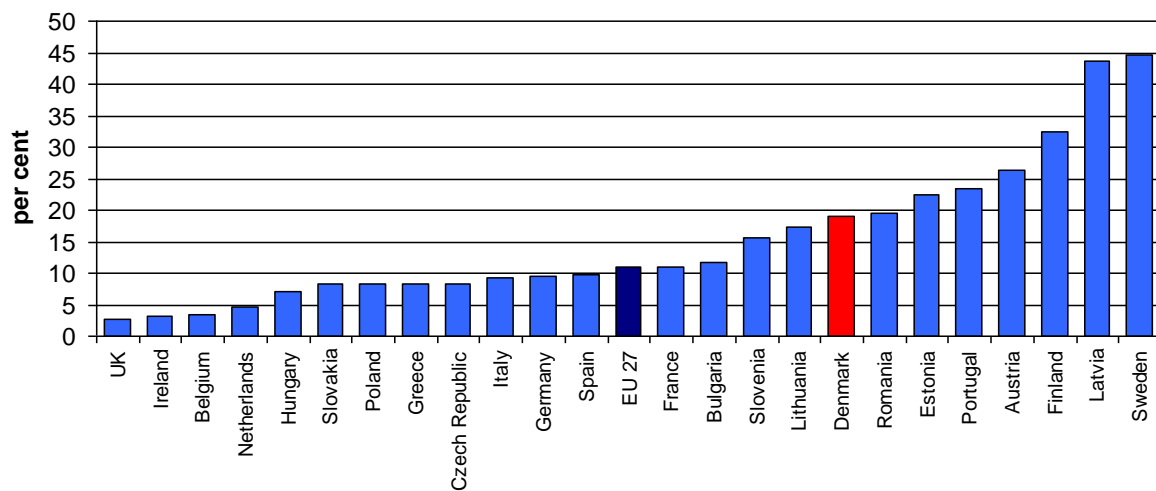
In addition to more energy efficient energy production, a number of initiatives have been carried out to increase the efficiency of end-user consumption, that is, consumption by consumers and enterprises. Initiatives include the establishment of high energy standards for buildings and energy labelling schemes for electrical appliances, public campaigns to promote energy savings in households, energy saving agreements with industry, and, not least, the implementation of taxes on energy consumption. Environmental and energy taxes in Denmark are therefore contributing factors in making the price of consuming energy better reflect the environmental costs of production, use and disposal.

Over the past five years there has been a slight increase in energy consumption in Denmark. This increase is expected to slow down, particularly due to the intense energy saving effort adopted in 2005 and followed up by the Energy Agreement of 21 February 2008 at an even greater level of ambition, both of which were adopted by a broad political majority. In the new policy agreement, the targets for the energy saving efforts are a reduction by 4% by 2020 and by 2% by 2011 of gross energy consumption compared to 2006.

## Renewable energy

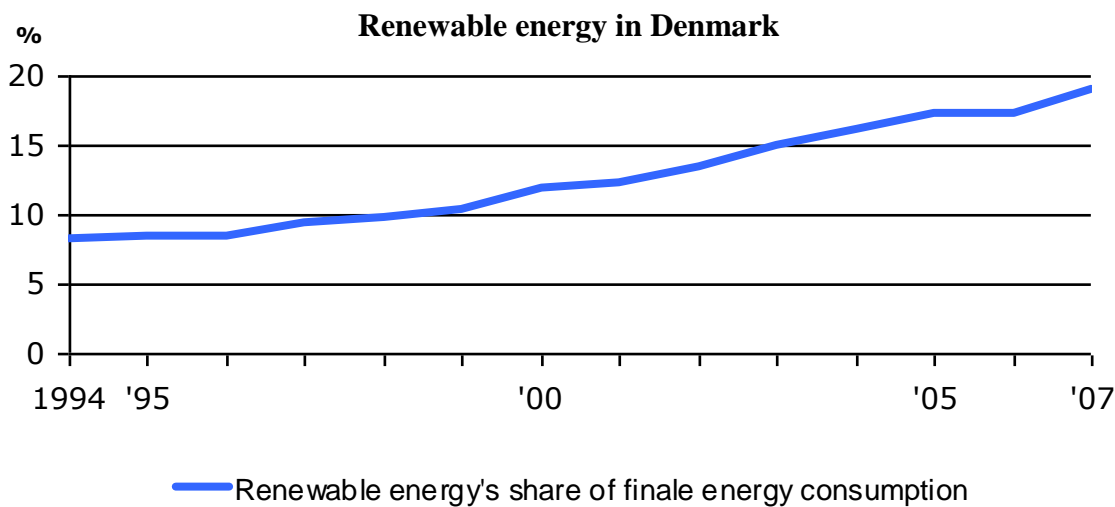
Despite almost no hydropower resources and the lack of a long tradition of utilising biomass, Denmark has managed to become among the leading countries in renewable energy.

**Renewable energy<sup>3</sup> - share of final energy consumption, 2006**

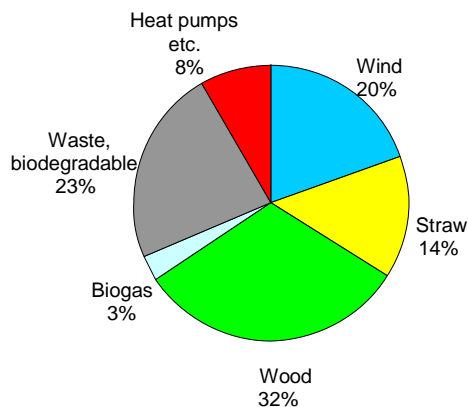


Renewable energy's share of final energy consumption in Denmark has been steadily increasing since 1980. Today, more than 19% of Denmark's final energy consumption is covered by renewable energy.

<sup>3</sup> Including waste and excluding nuclear power.



Renewable energy's contribution to *final energy consumption* is composed of several different forms of renewable energy. As can be seen from the figure on the right, various forms of biomass together contribute the largest share. Of this share, wood accounts for the largest share, followed by biodegradable waste and straw.



Looking at *electricity supply* alone, renewable energy today accounts for 28%, which is chiefly due to the incorporation of wind energy in electricity production. Denmark today has 3,150 MW of installed wind energy capacity, of which 420 MW are offshore wind turbines (July 2008).

The Energy Agreement of 21 February 2008 sets out a number of initiatives to ensure that renewable energy constitutes at least 20% of gross energy consumption in 2011 (corresponding to at least 22% of the final energy consumption). The Government's goal is furthermore that renewable energy constitutes at least 30% of gross energy consumption in 2025 (corresponding to at least 33% of the final energy consumption).

Renewable energy contributes to enhancing the security of energy supply and is an important element in meeting the Government's long-range vision to make Denmark entirely independent of fossil fuels. Furthermore, renewable energy sources are generally CO<sub>2</sub> neutral and therefore contribute to reducing the emission of greenhouse gases.

Analyses show that the costs of introducing renewable energy in Denmark have been relatively high, however falling costs over time and increasing prices of fossil fuels have

gradually made renewable energy sources more competitive against traditional energy sources.

### **Research and development**

Research, development and demonstration of new technologies and systems have been decisive for the Danish stronghold in the energy area. Likewise, Denmark has a well-developed tradition of broad cooperation on research and development in the energy area, including good experience and fine examples of effective cooperation projects and networking between enterprises and research and knowledge institutions. Research has received state support through a number of research and innovation programmes and through basic research at the research institutions.

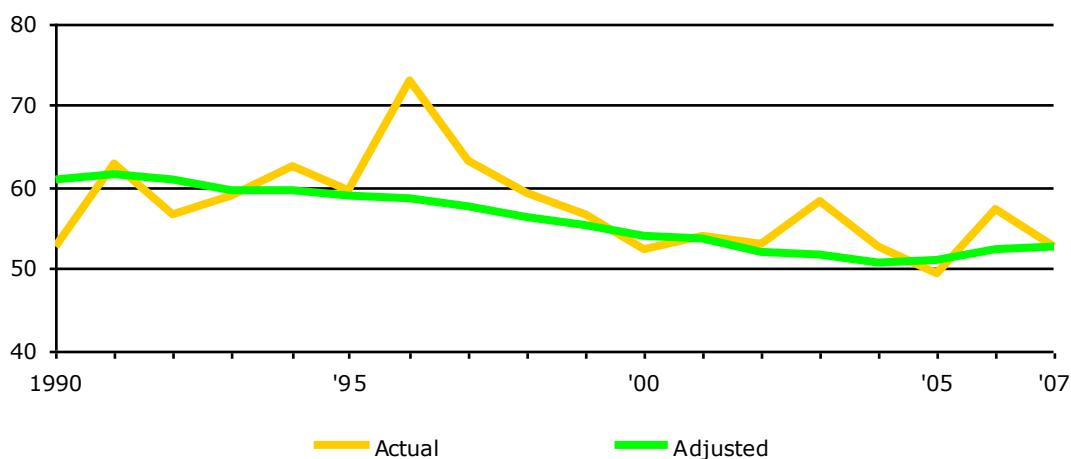
In recent years, the energy area has been allocated extra public funding, and the government's objective is to double public efforts up to 2010. Most recently, the Energy Technology Development and Demonstration Programme (EUDP) was established to help new energy technologies and solutions in the final steps towards market introduction.



## Greenhouse gas emissions reduction

As a consequence of the more or less stable trend in energy consumption and the increasing share of renewable energy, CO<sub>2</sub> emissions in Denmark (adjusted for fluctuations in the weather and in cross-border exchange in electricity) have been reduced by more than 13% since 1990. As can be seen from the figure below, there was a slight increase in adjusted CO<sub>2</sub> emissions from 2005 to 2007. This slight increase, however, does not influence the general trend which is that CO<sub>2</sub> emissions have been reduced since 1990.

**Trends in CO<sub>2</sub> emissions**

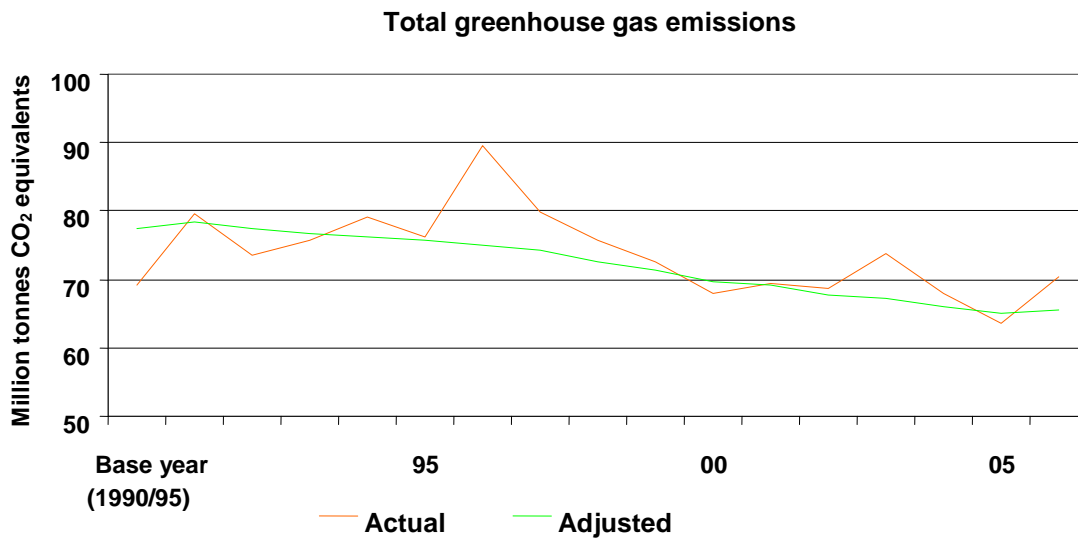


Note: The figure shows that actual CO<sub>2</sub> emissions fluctuate markedly from year to year because Denmark exports electricity in some years and imports in others. In the adjusted graph, imports and exports of electricity have been eliminated from the figures for CO<sub>2</sub> emissions.

The CO<sub>2</sub> emissions stated above concern only emissions of CO<sub>2</sub> from energy use, however these account for about 75% of Denmark's overall greenhouse gas emissions.

When calculating the total greenhouse gas emissions, the other greenhouse gas emissions must also be included. The total greenhouse gas emissions are decisive in relation to Denmark's ambitious Kyoto target, which is to reduce emissions of greenhouse gases by 21% in the period 2008-2012 relative to 1990. Total greenhouse gas emissions also include CO<sub>2</sub> from other, non-energy related activities, nitrous oxide coming primarily from agriculture, methane coming primarily from agriculture and landfills, and the so-called industrial greenhouse gases, which stem primarily from refrigerants and from protective gas in larger electrical installations.

The most recent historical statement of Denmark's total greenhouse gas emissions is from 2006 and, without adjustments, shows that emissions in this year were 1.8% above the base year 1990/95. With adjustments for fluctuations in the weather and cross border electricity exchange there was actually a 15% drop in emissions since the base year 1990/95.



Note: Denmark's base year under the Kyoto Protocol comprises emissions of CO<sub>2</sub>, methane and nitrous oxide in 1990 and emissions of the industrial greenhouse gases in 1995.

Due to the ambitious targets of a reduction in energy consumption up to 2020 and an increasing share of renewable energy, Danish CO<sub>2</sub> emissions will also follow a falling trend in the future.

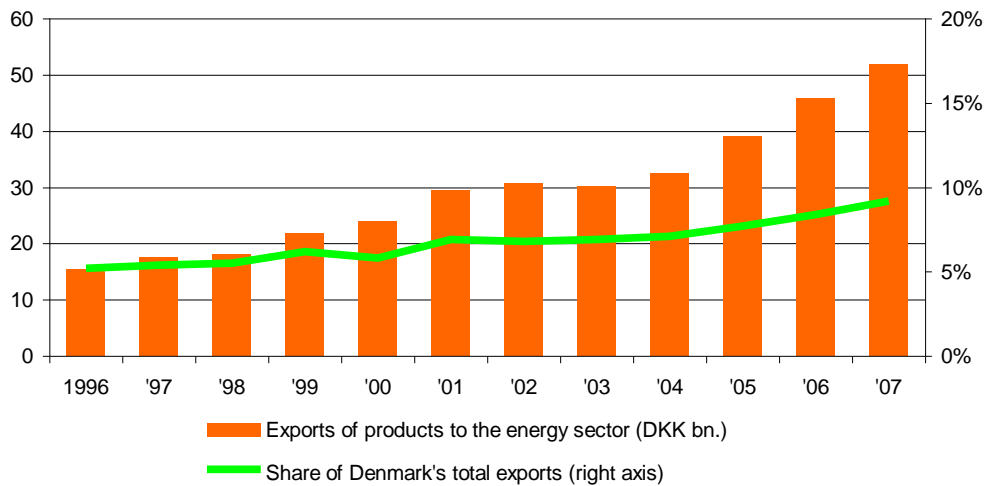
### **Denmark - a competitive country**

All in all, it must be concluded that since 1980 Denmark has been able to maintain its status as a wealthy country with sound economic growth, while energy consumption has remained more or less constant and greenhouse gas emissions have been reduced.

The persistent political and commercial focus on energy efficiency, along with the introduction of new technologies, have meant that Danish enterprises throughout several years have developed and gained valuable experience from new energy technology solutions. And these solutions have been converted into increased exports. For example, Denmark today is a leading player in wind turbine production, and covers about one-third of the global wind turbine market.

In total, Danish exports of energy technology increased to about DKK 52 billion in 2007. From 1996 to 2007 this figure more than trebled, and exports of energy technology now account for more than 9% of total exports.

## Exports of products to the energy sector



Not only in the energy area does Denmark excel as a competitive country. Danish enterprises are exploiting the opportunities offered by globalisation, and today Denmark is among the top ten most prosperous countries in the world. Denmark has a GDP per capita that is higher than the EU15 average and Danish unemployment is lower than the EU15 average.

Sources:

“Energy Statistics 2007”, the Danish Energy Agency, September 2008

“CO<sub>2</sub> from Fossil Fuel Combustion”, IEA 2008