DANISH PROGRAMS FOR EFFICIENT USE OF ENERGY

Bent Sørensen
COWIconsult
Virum, Denmark

Abstract

As in most industrialized countries, a number of programs aimed at increasing the efficiency of energy use have been established in Denmark since 1974. Examples include publicity campaigns, R&D efforts, financial incentives to developers, manufacturers and consumers, and differentiated taxation schemes. This paper discusses the prospects for carrying through an evaluation of these efforts, and identifies some elements to consider in such an evaluation.

Overview of Programs

Since 1974, the Danish government has been running a number of programs related to efficient use of energy: information campaigns (organized by a "Committee on Energy Savings" formed by the government), economic support for customers using new energy technologies (as well as for manufacturers and developers of such technology), and an energy research program directed by the Department of Energy. Impact on the use of energy has also been exerted through legislation, which is either regulating the use of energy (*e.g.*, compulsory inspection of boilers) or affecting the cost of energy. An example of the latter is a differentiated taxation scheme, which taxes desirable technologies less than undesirable ones, and even varies the rate of taxation with time, so that short-term fluctuations in the prices of various fuels are not felt by the customers (see Figure 1). Further financial support for energy efficiency efforts have been made by local governments, and considerable investments have been made by utility companies, by private companies, and by individual citizens.

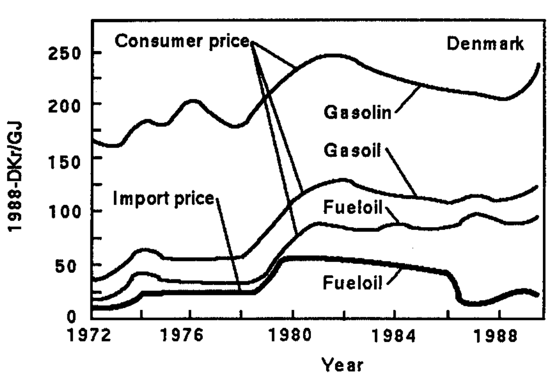

Figure 1. Variations in Fuel Prices,1972-1988

The energy research program of the Danish government has spent between 10 and 40 million kroner a year on energy efficiency during the period 1974-1989, the highest amounts being spent during the early and mid-1980s.[1] A little over half of these amounts went to energy use programs; the rest, to energy conversion projects. Some 2 to 10 million kroner a year were spent on energy saving campaigns during the same years. Government subsidies to energy efficiency measures in the buildings sector reached about 300 million Danish kroner in the mid-1980s. During the same period, some 10 million kroner a year were spent on other energy efficiency projects. Additional support have been de-rived from general support of programs in industry, and by support to individual projects from the European Community. Private investments in the buildings sector were required to match the subsidy in the ratio 7:3. Additional private investments not countered by subsidies have been estimated to amount to about 25% of the investments made within the programs. Total investments in energy efficiency since 1975 are thus estimated to be at least 12 billion Danish kroner (roughly 300 US$ per inhabitant).

Additional programs aimed at stimulating the introduction of renewable energy sources and at increasing the efficiency of primary extraction of fuel resources have been ongoing. Some of these programs also make the entire energy system more efficient. However, it would be very difficult to sort out the energy efficiency impact of these programs, and the study considered here is confined to considering the efficiency of further conversion of energy already extracted.

Despite adjustments in the programs, there has been an overall stability in the effort (no stop-go effects in re-sponse to fluctuating fuel prices), which may be ascribed to the political consensus backing the programs. The basis for the programs has been a series of statements and energy plans (some of which have offered alternative plans for political consideration), produced by the rele-vant departments. Action plans based on these statements and suggested plans have, in turn, been adopted by the several governments succeeding each other during the period. The latest overall government energy plan, from 1982,[2] calls for the use of three main tools in carrying through the energy policy:

- Increased information on efficient use of energy
- Taxation and rate policies
- Making the long-term energy policy visible to users

These general guidelines are translated into specific requirements in each area of policy:

Supply:

- More combined heat and power (retrofitting existing pure power plants and pure district heating plants) and cogeneration (in industry).
- Heat cascading (reuse at lower and lower temperatures).
- Adapting energy supply system to accept larger shares of renewable energy.

Demand:

- Sharpened building regulations, compulsory burner inspection, and minimum performance criteria.
- Energy declaration of energy-using equipment.
- Tighter and more intelligent regulation of energy flows in industry.
- Banning of electrical resistance heaters for space heating.
- Controllable regulation of electricity use (*e.g.* by signals sent through the grid to suppress low-priority uses in peak-demand periods).
- Optimized flow of goods in the transportation sector.
- Upgraded public transport.

The latest Department of Energy statement, from 1988,[3] prepares for a plan of action (to be discussed by the government in late 1989 or 1990), which places high emphasis on environmental problems associated with energy production and use. The stated basis for the analysis is the "Brundtland report."[4]

Coarse-grain Analysis

As a first approach to evaluating the efforts for increasing energy efficiency, one may compare the actual total energy use with a "business-as-usual" case. The two scenarios would be compared, assuming identical economic activity and thus neglecting the indirect implications of pursuing energy efficiency on a number of social indicators.

Figure 2 shows the Danish gross energy use, along with the aggregate activity measure provided by the Gross National Product. The trends during the 1960s were unusual, in that energy use grew much more rapidly than the growth in the economy, indicating wasteful use of energy. During the 1970s, the overuse of energy disappeared, and during the 1980s, GNP and energy again follow each other closely. It is, of course, too early to say if this is a long-term trend. The GNP has been increasing very steadily, except for the two years following the oil crises in 1973 and 1979.

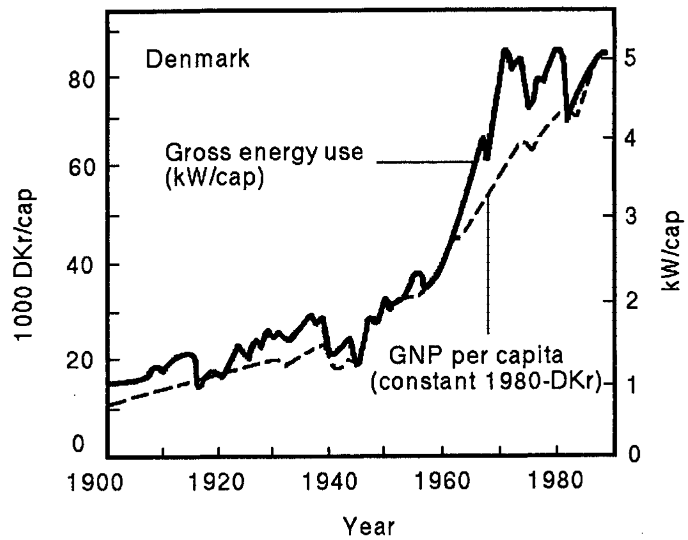

Figure 2. Historical Trends of Danish Gross Energy Use vs.GNP

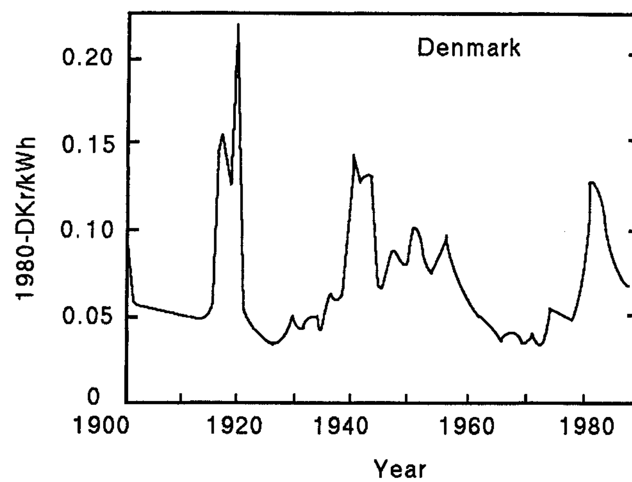

Figure 3. National Cost of Energy in Denmark, 1900-1981

The national cost of energy is shown in Figure 3. As explained above, the consumer price has been artificially kept close to the 1981 level. Expected energy growth (found in the energy statements made by the governments during the period 1974-1981) was much higher than the actual one, but the same was to some extent true for GNP.

Taking the difference between the projected and the actual energy use as a measure of the saving accomplished, the value of this saving may be estimated as 10 billion Danish kroner,[5] or roughly the same as the cost of the investments in energy efficiency, as given above. In other words, the investment is recovered over about 10 years, which is close to the assumption made when the Danish government passed the energy efficiency related legislation.[6] Since the physical lifetime of most of the measures is much longer than 10 years, a considerable economic gain is forthcoming as a result of the effort: The expected lifetime of the measures taken until now varied from a low of about 10 years (equipment) to a high of the order of 100 years (housing shells), and since the largest investment is in the building sector, the average is about 50 years. This implies that the program carried out so far may give Denmark a net surplus of over 20 billion Danish kroner (depending, of course, on future energy prices).

This result is in agreement with a theoretical analysis that found the investments needed for halving residential heat use in countries such as Denmark or the USA to be recoverable over a period of about 10 years, while the capital recovery times for other efficiency measures were longer.[7] The Department of Housing estimates that an investment of an additional 20 billion kroner is required if all buildings are to be brought to an energy standard comparable with current practice. Some of these investments may have a longer recovery time than the ones already made.[8]

Fine-grain Analysis

In a more detailed evaluation program, one would have to consider each program aimed at increasing energy efficiency separately, and I would suggest that a much wider range of impacts be considered, beyond the eco-

Table 1. Evaluating Energy Efficiency Programs on a Scale from -1 (Strongly Negative Impact) to 4 (Strongly Positive Impact)

	PROGRAMS			
Impact on	***Retrofitting buildings***	***Displacing imported fuels by efficiency measures***	***Displacing domestic fuels by efficiency measures***	***Displacing renewables by efficiency measures***
Health	-1	2		
Risk	1	1	1	1
Physical environment	2	2	2	
Work environment	-1			
Global environment	1	2		
Structure of society	0			
Energy system infrastructure	1			
Energy institutions	0			
National economy	2	4		
Personal economy	1	1	1	
Global economy	1			
Global development	1			
Trade balance	2	4		
National independence	2	4		
Supply security	2	4		
Impact estimate uncertainty	1	2	2	
Uncertainty of future	2	4	2	4

Cost of Program	10 billion DKr
Estimated lifetime fuel saving	1260 PJ
Lifetime fuel cost saving	33 billion DKr

nomic ones.[9] Table 1 lists a number of such impact areas and estimates, for each program, the impact on a scale from -4 (strongly negative impact) to +4 (strongly positive impact). The entries that should go into the table are subject to detailed study, either by juxtaposing existing numerical data (such as emission of pollutants and medical statistics) or by performing interview studies.[10] Some areas would remain highly uncertain, as they depend on impacts in the future (*e.g.*, climatic ones), on which there is incomplete consensus at present. The values presented in the table are "common sense" values, with all the bias involved in personal judgement.

The partially filled-in Table 1 specifically deals with the program for increasing the efficiency of space heating (other examples would be the program for process heat and for electricity use). The basis for the evaluation of health impacts is the outgassing of building materials, which presents a problem where adequate ventilation has not accompanied the addition of insulation and tightening of the building shell. The risk impact is associated with manufacturing and handling rock- or glass-based insulation material. The impact on the immediate physical environment is through reduction of fuel burning emissions, such as particles, sulphur and nitrous oxides, while the impact on global environment is related to the greenhouse effect of carbon dioxide. The impact on work environment is through working with glass- or rockwool. The impact on energy system infrastructure is associated with reducing the required capacity of heat pipelines. (Since 1974, the percentage of Danish buildings receiving heat from district heating lines has increased from roughly 20% to 50%.) The impacts on national economy, trade balance, independence, and supply security is due to the displacement of imported, fuels (by 1972, nearly 100% of fuels used in Denmark were imported; by 1989, the figure is close to 30%, due to exploitation of Danish North Sea resources). Finally, the impacts on global economy and development are through making more fossil fuels available to the world market (by drawing less), and thereby contributing to keeping the price of these resources down.

Similar considerations are made for the displacement of either imported or domestic fuels, while most of these impacts are absent, if the displaced energy source is renewable (currently, about 4% of the primary energy used in Denmark is from renewable sources).

Concluding Observations

A study for evaluating the Danish energy efficiency programs is proposed, and some of the considerations to be made in delimiting the study area have been discussed in this paper. For a proper political evaluation, we need a comparison between two or more scenarios, involving various degrees of emphasis on energy efficiency, and comparing them with a scenario of not making any effort. This reference scenario is in any case poorly known, because an "uninfluenced" development will not necessarily be the same as one with no efficiency improvements. Some energy efficiency improvements arise as side-effects of making products and services better, and simply by using new technology warranted solely for reasons of business economy. However, even if it is very hard to establish a reference scenario, against which to measure various policy proposals, this may not be so bad, if one accepts that policy making is a process of choosing between internally consistent alternatives. The "fine grain" method of evaluation should prove a useful tool in deciding among different paths, based on an evaluation of each one and accepting that there may be even better scenarios which have escaped attention or which depend on technologies yet unknown or not being prone to this kind of evaluation (*e.g.*, because some impacts are as yet insufficiently understood).

Endnotes

[1]Danish Department of Energy, Energy Research Program 1987-89, (1987, in Danish); Danmarks Statistik, ***Statistical Yearbooks*** (1974-1988).

[2]Danish Department of Energy, ***Energiplan 81*** (1981).

3Danish Department of Energy, ***Statusnotat: Energy Planning***, (1988); ***Brundtland-note***, (1988); ***Energy Policy Statement***, (1989) (all in Danish).

[4]Brundtland Commission (The World Commission on Environment and Development), ***Our Common Future***, United Nations (1987).

[5]J. Lorentzen. In "Seminar of European Federation of Energy Managers, Copenhagen 1986," ***Energistyring*** 1/87, p. 19.

[6]See Endnote 2.

[7]B. Sørensen, "Energy Choices: Optimal Path between Efficiency and Cost," pp. 279-286 in ***Energy, Resources and Environment*** (S. Yuan, ed), Pergamon Press 1982.

[8]Danish Department of Housing and Building, ***Energy Savings in the Heating Sector—A Status Report***, (1986, in Danish); Guide: Energy in Danish Building, (1988); Danish National Building Agency, ***Denmark Uses Energy Better***, (1987).

[9]B. Sørensen, ***Renewable Energy***, Ch. 7, Academic Press, 1979; "Health Impacts of Different Sources of Energy," IAEA Publ. No. SM-254/105, Vienna 1982

[10] See Endnote 4.