Denmark:

Energy Efficiency Policy 1990-2008

Indhold

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Abbreviations

BR	Building Regulation
CHP	Combined Heat and Power
DEA	Danish Energy Agency
EAU	Emission Allowance Unit
EC	European Commission
EE	Energy Efficiency
ESCO	Energy Service Company
ETS	Emission Trading System
EU	European Union
EUA	European allowances
FEC	Final Energy Consumption
FEI	Final Energy Intensity
GHG	Greenhouse Gas
GJ	Giga Joule
IEA	International Energy Agency
HGV	Heavy Goods Vehicle
kWh	Kilowatt Hour
Mtoe	Million Tons of Oil Equivalent
MURE	Mesures d'Utilisation Rationnelle de l'Energie
O&M	Operation and Maintenance
OBU	on-board unit
PAC	Particulate Abatement Categories
PEI	Primary Energy Intensity
PPP	Public Private Partnership
R&D	Research & Development
R&D&D	Research & Development & Demonstration
RE	Renewable Energy
TFEC	Total Final Energy Consumption
TJ	Terra Joule
Toe	Ton of Oil Equivalent
TWh	Terra Watt Hour

Executive Summary

The energy intensity of Denmark's GDP is the lowest in the EU. Denmark's *gross energy consumption per capita* in 2009 of 147 GJ was slightly above the EU-27 average of 143 GJ; the difference *in final energy consumption per capita* is higher: 112 GJ in Denmark versus 93 GJ for EU-27. Denmark's final energy intensity (FEI) declined by 22 percent from 1990-2009 (EU-27 average 26%) which equates to an annual rate of energy efficiency increase of 1.3%/year (EU-27 average 1.6%). However, the evolution in Denmark's primary and final energy demand and in primary and final energy intensity is in line with the average of EU-15 countries.

The main elements of Denmark's energy efficiency policy and programs and main lessons learned include:

1. **To secure long-term stability, EE-policies are made through broad political agreements involving Government and opposition parties**. The political agreement of February 2008 set a target for EE-measures up to 2013 to reduce total final consumption excluding transport by 1.5% per year.

2. **Energy taxes are used in all sectors, without them the Danish energy consumption would be at least 10% higher**. In 1977, an energy tax was introduced in the residential sector, in 1996, a CO2 tax was introduced in all sectors. Compared to other EU-countries, Denmark makes little use of "public finance instruments" and subsidies in its EE-policies; instead, fuel and electricity tax rates are among the highest in the EU.

3. **The Danish Energy Agency (DEA's) portfolio review of Danish EE-measures in 2008 ranked their socio-economic cost-efficiency as follows (lowest cost-benefit ratio first):** (i) energy audits and tax rebates for industry, (ii) EE-obligation scheme on energy suppliers, (iii) energy savings in the public sector, (iv) energy labeling of appliances, (v) Electricity Saving Trust (consumer information), (vi) building codes, (vii) energy labeling of buildings, which was the only measure not to pass the test of having a cost-benefit ratio lower than 1.

4. **Evaluating the impact and efficiency of EE-measures through the entire portfolio of policies (as opposed to only selected policies) gave way to findings that would otherwise not have been captured**. With its broad perspective, the evaluation found that the policy instruments prioritized the commercial and industrial sectors less than the household and public sectors and that the Governance structure for EE-policy implementation needed to be changed to improve coordination of efforts.

5. **The Danish EE obligation scheme on energy supply companies provides half of all annual savings in Denmark.** Originally introduced as a DSM-obligation on electricity utilities in 1990, the obligation scheme introduced in 2005 involves energy supply companies in four supply sectors: electricity, district heating, gas and oil. They are obliged to reduce final consumption of their consumers in the included sectors by 1.2 per cent annually; and by 1.8% per year from 2012 onwards. The energy companies have freedom to choose which EE- measures to implement at consumers and how: whether through own EE-service companies or through outsourcing of EE-services or in what form: energy audits, targeted information, subsidies or a combination of these. Two trends can be noted over time. One is that the "additionality effect" goes down. From 2005 to 2008, about half of the recorded savings at end-user level would not have been realized without the intervention of the energy company. From 2009 to 2011, two thirds of recorded savings represented free riding. The other is the change in the composition of instruments used by the scheme: subsidies to physical investments in EE make up an increasing share of annual expenditures.

6. **EE-Agreements with industry combined with a lower CO2-tax and subsidies to EE-investment have been effective.** EE agreements for a duration of three years between energy intensive industries and Danish Energy Agency provided these with a lower CO2 tax rate in return for implementing energy management and carrying out all EE-investments found to be cost effective in an energy audit. Some categories of EE-investments were eligible for subsidy support.

7. The **building code,** one of the strictest in the world, has been important in reducing the energy consumption of new buildings.

8. **As a stand-alone measure, building energy labeling is not cost-effective: few investments are made by building owners in response to the information.** The scheme requires that all buildings are labeled before they are sold; however, house owners without an energy label seem to implement as many EE-projects as owners with a label.

9. **Individual instruments have modest impact; packages of interacting instruments for each sector are needed** to get significant results. The experience of building labeling versus the green tax package illustrate the point.

10. **High quality statistical information can be used effectively for energy management.** The information from the EE-building certificates assists energy supply companies in targeting their public service obligations for promoting end-user efficiency. The Danish Building Register has detailed information on all individual buildings in Denmark (including characteristics of individual heating systems); a new law requires energy suppliers to report annual sales to each individual building.

11. **Directives on public sector savings encompass demands that the possibilities for energy savings are made publicly available and that these are realized within certain conditions**. Yet, the public sector has not been able to "lead the way" for other consumers. Until recently it has lagged behind.

12. **Targeted technical information to consumers and training-programs for the supply side in EE-construction is cost-effective**. A tax on every kWh sold in the household and service sectors finances various information and certification schemes aimed at consumers and at the supply side.

Table 1: Effective Energy Efficiency Policies in Denmark by Sector

Policy	Expected Outcomes	Targeted Agents	Design	Monitoring and Evaluation	Implementation Costs	Achieved Results	Cost Effectiveness	Factors Important for the Policy Success
Cross-Cutting								

Green Tax Reform 1996	(i) reduce energy consumption and CO2 emissions; (ii) promote development of cleaner technologies; (iii) reduce labor costs and increase employment	All sectors	Energy tax and CO2 tax rates on mineral oil for fuel, gas and heating oil increased; electricity tax introduced. Reduced tax rates for energy intensive industries and processes in order not to affect competitiveness of industries Revenue-neutral tax: tax revenues are used to reduce pension insurance contributions and for EE-investment subsidies	Evaluations by cross-ministerial committees set up ad-hoc to review changes in taxation	No reported estimates exist concerning the size of the transaction costs.	Without high energy and CO2 taxes, energy consumption would have been 10 percent higher in 2008 Price elasticity of own energy demand estimated at -0.25 for Danish economy; for industry at -0.38.	---	Broad political consensus. Tradition of broad political agreements for major policy reforms, including in energy, ensures long-term continuity and stability
Energy Companies Obligation to implement EE at consumers	Reduction in energy consumption of 2.95 PJ/year during 2006-2009 at consumers; 2008-2010 raised to 6.1 PJ/year roughly equal to 1.5% of energy sales	All sectors	The obligation is imposed in the form of 3-year contracts with DEA on 509 energy companies, of which 428 are district heating companies, 77 are power grid operators and 4 are natural gas distribution grid operators. The energy companies have freedom of choice in terms of instruments to use specific investments to support: energy audits, campaigns to change consumer behavior, targeted information / personalised technical advice, investment subsidies, market transformation activities	DEA contracted evaluation and by academia	The 2006-2009 scheme cost the companies around 300 m DKK (€40 m). The 2010-12 cost is around €100 m/y.r	The 2006-2009 scheme saved 13,252 TJ	The 2008 portfolio evaluation estimated the cost-benefit ratio at 0.6.	Simplified ex-ante determination of types of investments that qualify for support by the scheme for small investments and feasibility study defined investments for larger projects
Public Funding of R&D&D	Promotion of EE through introduction of new EE-technologies; green employment	Public research institutions and private energy technology companies	Public grant programs focusing on energy technologies in various stages of development chain, managed by Boards composed of research and private sector representatives and having large freedom of decision taking.	Annual reports by each grant program and ad hoc eveluations of specific programs	1 billion DKK (130 million euro) representing 7-8 percent of the total public R&D&D funding	In 2006, the energy technology industry employed 29,000 people, equal to 8 percent of the total employment in Danish manufacturing industry. In 2008, Danish exports of energy technology reached 64 billion DKK (8.6 billion euro), equal to 11 percent of Danish exports of goods and services	-	Not applicable. No direct link can be established

2008 Portfolio Evaluation of Danish Policy Measures	Establish: (i) To what extent the EE-policy instruments in place enable policy targets be reached? (ii) Are the energy efficiency policies cost-effective? (iii) Is the portfolio composition and design appropriate	Evaluation of ten major EE-policies in Denmark in use in 2008	A *consortium of consulting firms* won the contract for carrying out the evaluation The *steering group for the evaluation* was composed of three independent researchers from academia, each of them experts within their field (evaluation theory, economics and energy systems) and two representatives from DEA.	n.a.	n.a.	The evaluation showed that the impact of the evaluated policies is not as high as expected and that the target for final energy consumption for 2013 will not be reached with the current policy portfolio except in the case of considerable economic recession and high energy prices.	**n.a.**	The presence of independent researchers in the Steering Committee provided the evaluation team with independent professional sparring (feedback)
Policy	**Expected Outcomes**	**Targeted Agents**	**Design**	**Monitoring and Evaluation**	**Implementation Costs**	**Achieved Results**	**Cost Effectiveness**	**Factors Important for the Policy Success**
Industrial Sector								
Subsidies to investments in CO2 reductions in industry	4,5 PJ energy savings target for the 1996-2000 scheme amounting to 1.8% of Danish industry's energy consumption in year 2000	Industry including trade and service sector	Companies applied to the DEA for grant support. Grants were given to investments in EE technologies, industrial cogeneration, R&D&D projects, EE-advise to companies and EE-information. The subsidy rate depended on the type of project as well as on EU competition rules on corporate size, as there were more grant opportunities for small and medium enterprises (SMEs).	Evaluation during and ex-post	DEA costs 10 to 20 manyears per year. Costs for businesses 540 euro per application Grants: 360 million euro	Investments of 7.1 billion DKK (750 million euro) in EE and fuel switching Savings of 1 million tons CO_2 per year from 2001 onwards, including for the crucial 2008-2012 "Kyoto" period	n.a.	Standard investment packages for grant eligibility for small investments by SMEs. Co-finance by private firms of minimum 50%

Voluntary Agreements	(i) encourage energy-intensive companies to improve their EE. (ii) Protect international competitiveness of energy-intensive companies against impact of high green taxes	Energy intensive industries representing roughly 50% of industrial energy consumption.	Three-year agreements between DEA and individual companies and industry associations. The scheme addresses company-level barriers in the form of *lack of information* through the requirement for companies to set up an energy management system. The *competitiveness* issue is addressed by: (i) increasing the tax rates gradually, thus giving companies time to improve energy efficiency and switch to fuels with lower emissions; (ii) applying differential tax rates depending on the use of energy, thus lowering rates for energy-intensive production and (iii) redirecting the additional tax revenue from the Green Tax Package directly to trade and industry (and through the lowering of industry's labor market contribution).	Ad hoc evaluations	Corporate administrative costs 27,000 euro for entering agreement, half that cost for follow-up agreements. Annual costs of 9,000 euro for the energy management system, 6,700 euro for annual report	Between 1996 and 2004, the companies entering the agreements, represented close to 60 percent of total industrial energy consumption in Denmark. The largest number of companies was reached in 2003, when 397 were in the scheme, 154 through individual agreements, 243 through collective agreements with the business organizations for horticulture, milk condensing and brickworks. Since 2005, companies in the ETS-sector dropped out		The combination of the high CO_2 and energy tax rates and the ability to get a substantial reduction in these by concluding a three year agreement was important for the motivation of companies to engage.

Transport Sector

Policy	Expected Outcomes	Targeted Agents	Design	Monitoring and Evaluation	Implementation Costs	Achieved Results	Cost Effectiveness	Factors Important for the Policy Success
Taxes on transport fuels and on vehicles	No specific target for the measure. The Government's 2001 Action Plan for reducing CO_2 emissions in transport foresaw that changes in the tax laws for transportation would provide a two percent reduction in 2010 CO_2 emissions below the business as usual trend	All vehicle transport	Taxation composed of three elements: (i) Registration tax of roughly 170% on import price of car paid the first time a vehicle is to be used on public roads in Denmark. (ii) Annual vehicle tax the rate of which depends on the car's CO2-emissions per kilometer, measured by the ECE-norm. (iii) High taxes on gasoline and diesel for transport. Until 2015, electric vehicles are exempt from payment of registration fee.	n.a.	n.a.	The high car registration tax keeps the Danish car fleet at a level about 20 percent lower than in the absence of the tax Policy failed during the 2000 decade to prevent the price for public transport to outpace the prices for petrol and diesel.	n.a.	Continuity in tax levels in real prices.

Households

Policy	**Expected Outcomes**	**Targeted Agents**	**Design**	**Monitoring and Evaluation**	**Implementation Costs**	**Achieved Results**	**Cost Effectiveness**	**Factors Important for the Policy Success**

Building Standards	(i) reduce energy consumption in heating, climate control and hot-water provision; (ii) reduce CO_2 emissions	New buildings; substantially renovated existing buildings	Each BR fixed targets for the maximum energy consumption per square meter. Compared to the EE-requirements in 1982 BR, the net heat consumption is reduced by 25% by the tightening imposed by BR98 The BR98 imposes restrictions on heat loss through outer walls, windows, roof and ground deck. The Danish building regulation has moved from being a technology specification (prescribing the standard of the materials used) to a performance specification in BR 98 (prescribing the outcome of the energy saving effort for the whole building). Under BR98 a choice can be made between complying with the reduced building component U-values or the heat loss of the entire building	Several evaluations have been made as part of the preparatory work for new revisions of the BR	n.a.	Significant reduction of energy consumption during different construction periods due to EE-requirements in BRs. Recently constructed houses use almost 50 per cent less natural gas per m2 than houses constructed in 1931-1950. Even the latest changes in BR show a significant reduction when comparing houses built before and after 1998	Cost-benefit ratio of 1	Compliance monitoring and upgrading of qualifications of construction workers
Grant for energy saving measures in pensioners dwellings	Reduction in energy consumption of an important percentage of the Approximately 285,000 dwellings are occupied by low-income pensioners Reduction in energy poverty	Low-income pensioners Approximately 285,000 dwellings are occupied by low-income pensioners	Pensioners receiving "heating assistance" (income dependent financial support) were eligible for a subsidy The scheme granted subsidies up to 50% of costs for EE-investments covered by the scheme. Subsidy support could be granted several times, but not in excess of a total of Euro 3,334 per dwelling	Annual reports based on approved subsidies	From 1993 to 1998, approximately Euro 34.67 million were granted in subsidies	At the end of 1998, subsidies amounting to an average of Euro 1,734 per dwelling had been granted in 24,000 cases, at an estimated average investment of Euro 4,667	Average energy savings per dwelling of 35 GJ per year,, generally of heating oil	Standardised investment items for eligibility
Awareness campaigns by Electricity Saving Trust	The target for the Fund was to generate annual electricity savings of 750 to 800 GWh per year by 2007.	Electricity consumers in the public sector and in households	The fund is managed by a board consisting of a chairman and eight other members appointed by the Government. The annual budget of the Trust was financed through a fee on electricity of 0.6 øre per kWh (=0.08 eurocents). The board had full liberty to identify initiatives best capable of fulfilling the objective. The Fund's daily operation was handled by a secretariat with six employees who outsourced many functions to external consultants.	Results of projects published on Trust website. Included in 2008 portfolio evaluation	The Trust had an annual budget of approximately 90 million DKK (=12 million euro),	Fund implemented a number of different projects and programs. The accumulated EE-impact of these projects and programs is not published	Cost-benefit ratio estimated at 0.5	Independent, highhy qualified board and creative, technically knowledgeable staff

Agreement on EE windows	To reduce the market share of traditional double glazed panes from 30% in 2003 to less than 10% by 2006.	glass industry and actors involved in selling and installing windows in new and existing buildings.	Two initiatives: 1)Making the energy-pane a standard product in any company's portfolio and working towards a reduction of the price difference. 2) An awareness effort directed at the wholesale market which accounts for the largest portion of the sales of traditional double glazing windows. Labeling system for panes categorizing their EE.	An evaluation was made for DEA in 2007	20 million DKK (2.7 million euro)	The market share of energy-panes reached the targeted 90 percent Labeling system critizised for being inferior to systems in some other EU-countries	n.a.	Effective labeling, consumer awareness campaigns and technical support to improvement of EE-panes.
TERTIARY SECTOR								
Policy	**Expected Outcomes**	**Targeted Agents**	**Design**	**Monitoring and Evaluation**	**Implementation Costs**	**Achieved Results**	**Cost Effectiveness**	**Factors Important for the Policy Success**
Heat inspection of small oil-fired heat furnaces	Improved EE of small oil heat furnaces	700,000 small oil heat furnaces in Denmark	Statutory annual inspection of small heat furnaces (120 kW or less). The owner has to show the chimney sweeper a contract with an authorised service provider or pay the chimney sweeper for the inspection. The inspection includes measurement of temperature, CO and CO2 content of the smoke and a report including evaluation to the owner. Based on fixed maximum values for these figures, the chimney sweeper can impose the owner to have the oil burner adjusted within 4 weeks	DEA had an evaluation made of the scheme	n.a.	The average chimney loss has been reduced from 19% to 12-13%. 2,500 educated consultants offer services	n.a.	Compliance monitoring
Reverse-the-trend agreements	Energy savings in the tertiary sector.	Municipalities, municipal-/regional-/state institutions and large private office enterprises	Implemented by Energy/Electricity Saving Trust. In the ”reverse-the-trend agreements”, with the Trust, the institutions set targets for their energy savings. E.g. to save two per cent each year from 2008 to 2010 compared with year 2007 electricity consumption. . The institutions commit themselves to be open and transparent about how their savings are achieved, so others can learn from the experience. The agreement commits the Trust to provide technical assistance to the institution to help achieve the goal	Institutions are obliged to publish their electricity consumption on the website of the Trust so achievement of the targets can be monitored.	The Trust has annual budget of 7.5 million euro. The share of budget spent on the “turning the trend agreements” is not published	More than 130 “turning the tide agreements”, some covering electricity savings only, some covering heat energy and electricity, have been signed with: state ministries and agencies, municipal administration and institutions, regional institutions (mainly hospitals), foreign embassies, private firms in the service and trade industry. The energy savings fixed in the agreements range from 2% to 20%.	n.a.	Public awareness of importance of EE gives participating institutions good PR. Strong technical and marketing expertise in the Fund

Methodology: Identifying cost-effective EE Policy Measures

Use of MURE and ODYSSEE data bases

The objective of the following sections is to identify EE-policy measures that had a demonstrated quantitative impact on EE and FEI in Denmark. The methodology for the study uses analysis of FEI evolution and other EE indices, to identify periods when improvement in EE had a more than average impact on decline in FEI. The analysis has three steps:

1. Data from the *ODYSSEE*[1] data base is used to show the trends in EE from 1990 to 2007/09. The ODYSSEE data base contains a number of global and sectoral EE-indicators: evolution of primary energy intensity (PFI), final energy intensity (FEI) and energy efficiency indices (ODEX). ODEX is defined as the ratio between the actual energy consumption of the sector in year t and the sum of the fictive energy consumptions on each underlying subsector/end-use that would have been observed in year t had the unit consumption of the subsector been that of year 2000 (reference year). Hence, a decrease in ODEX represents an efficiency gain.[2]
2. The *MURE* (*Mesures d'Utilisation Rationnelle de l'Energie, Measures for Rational Energy Use*) database[3] is used to select measures that were introduced prior or during the identified periods, and which by MURE are classified as having high and medium impact.
3. The selected measures are analyzed systematically, drawing on existing literature and evaluations performed by different agencies, in particular, the Danish Energy Agency (DEA).

Changes in FEI from one year to the next are influenced by several factors other than policy measures. Some of these factors are addressed directly in the Odyssee data base, others need separate qualitative assessment.

- *Climate variations from one year to the next* are taken into account in the Odyssee data base which has indices for EE (FEI, PEI, ODEX) adjusted for variations in climate.
- The way ODEX is calculated isolates – up to a degree - the impact of *structural changes in the composition of GDP and in sectors;* the same result is achieved in FEI indices showing the evolution of EE at constant industry structure.
- *Changes in economic growth rates* impact EE: high growth leads to higher capacity utilization, which lowers the energy consumption per unit of value added.
- *Shifts in the market prices (net of taxes) of fossil fuels* impact the rates of return on investments in EE and shift the long-term price expectations of investors.
- It is difficult to disintegrate the impact of a particular policy measure (program), *when a number of policy measures were simultaneously introduced* in a sector.

The improvement in the EE of Danish industry from 1993 to 2000, for example, is ascribed both to above average economic growth, as well as to the introduction of DSM in Danish utilities and a CO_2-tax on emissions in industry.

[1] http://www.odyssee-indicators.org/
[2] ODEX indices are described in more detail in Annex 2.

Selecting EE policy measures for analysis in this report

MURE lists 54 policy measures for promoting EE that were implemented in Denmark.[3] This report looks at 24 interventions after eliminating: (i) measures with only "low" or "unknown" impact (as assessed by MURE); (ii) measures pertaining to biofuels in transport; (iii) measures adopted after 2007; (iv) measures being policies and action plans rather than instruments. The processed is summarised in table 1 below.

Table 1: Screening of Measures for Selection

Sector	Measures	High Impact	Medium Impact	Of which post 2007	Retained	Of which ad-hoc campaigns
Household Sector (i)	24	6	8	1	13	5
Industry Sector (ii)	3	1	2	0	2	0
Tertiary Sector	8	2	1	0	3	0
Transport Sector (iii)	13	1	3	0	3	0
Cross-cutting (iv)	6	4	1	3	4	0
TOTAL	54	14	15	4	24	5

(i) 3 of these are revisions of building code over time

(ii) EU-related: - Emissions Trading Registry

(iii) 6 measures after 2007; 2 are RE;

(iv) 2 are policies/action plans, not instruments

Some measures, e.g. financial support to EE-investments made by pensioners in their dwellings, target social support more than EE. Other measures are short term campaign measures, not longer term structural instruments. Such instruments do not individually have such a major impact on EE that it can be detected in the Odyssee EE-indices, They are not discussed at length in this report. But since many contributions are required to achieve sectoral EE, policy makers have an interest in minor measures that are deemed to be cost-effective, they are reviewed shortly.

[3] A database developed under the framework of the Intelligent Energy Europe Program which provides information on EE improvement policy measures that have been implemented in the EU Member States, as well as Croatia and Norway http://www.isisrome.com/mure/

Development in Danish Energy Efficiency from 1990 to 2007/09

Drivers for EE-Policy

During the 1970s and 1980s, Danish EE-policy was driven by security of supply concerns. The minimization of imported oil was the main policy driver.

From 1990, climate policy became the main driver for the introduction of new EE-instruments. The discourse was no longer about security of supply and the reduction of oil dependency: Danish North Sea oil and gas production had turned Denmark into a net-exporter. Instead, the reduction of CO2-emissions became the key success parameter for EE-policy: the fulfillment of the Kyoto obligation requires Denmark to reduce the emission of greenhouse gasses in 2008-12 by 21% compared to the 1990 emission level. The "social-democratic" coalition Government in office from 1991-2001 had a high green profile and supported EE&RE through high taxes on fossil fuels and electricity consumption and subsidies to EE-investments.

A new, liberal Government, taking office in 2001, reduced the level of ambition in climate policy and replaced the "high tax + subsidy" approach with a "free market, barrier removal" approach: tax levels were frozen in nominal terms, EE-subsidies eliminated, focus was on making energy and technology markets more efficient and transparent. As COP-15 in Copenhagen came closer, the Government took on a greener mantle and adopted in 2009 of the policy goal to achieve a zero-fossil fuel Danish economy by 2050. With this, EE-policy achieved added urgency: without a very strong reduction in energy consumption, a fossil-energy-free Denmark will not be feasible. *Decoupling of energy consumption from economic growth* - flat energy consumption - is no longer sufficient, the success criterion is *absolute decrease in consumption*.

Final energy consumption, final and primary energy intensity

Total final energy consumption (TFEC) was only 6 percent higher in 2009 than in 1975.[4] The progress in controlling TFEC has not been linear over time:

- From 1990 to 1997, climate corrected TFEC increased about 8 percent.
- From 1997 to 2003 TFEC was constant.
- From 2003 to 2007 TFEC increased 6 percent despite increasing prices for fossil fuels and for electricity.
- The economic crisis starting in 2008 and structural shifts in industry induced an 8 percent fall in TFEC, bringing it back to the level of the mid-1990s by 2010.

The overall stagnation on TFEC since 1975 hides diverging sub-sector trends: energy consumption for *transport* increased 60 percent, the FEC of *households* decreased 13 percent and of *industry* 11 percent.

From 1990-2007 Denmark's GDP increased by 44 percent**,** growing at an average annual rate of 2.2 percent. In 2008-2009 GDP contracted, as the credit bubble imploded also in Denmark. The downturn reduced the GDP growth rate for the 1990-2009 period to 1.6 percent. As BNP-growth outpaced the growth in energy consumption, **Denmark's final energy intensity (FEI)** declined by 22 percent from 1990-2009, a 1.3 percent average decrease per year.[5].

[4] Source: ENS, Bagggrundsnotat 2010-

[5] Here, and elsewhere in the paper, the source of data is ODYSSEE database and DEA data (which is passed on to ODYSSEE in any case), unless otherwise indicated.

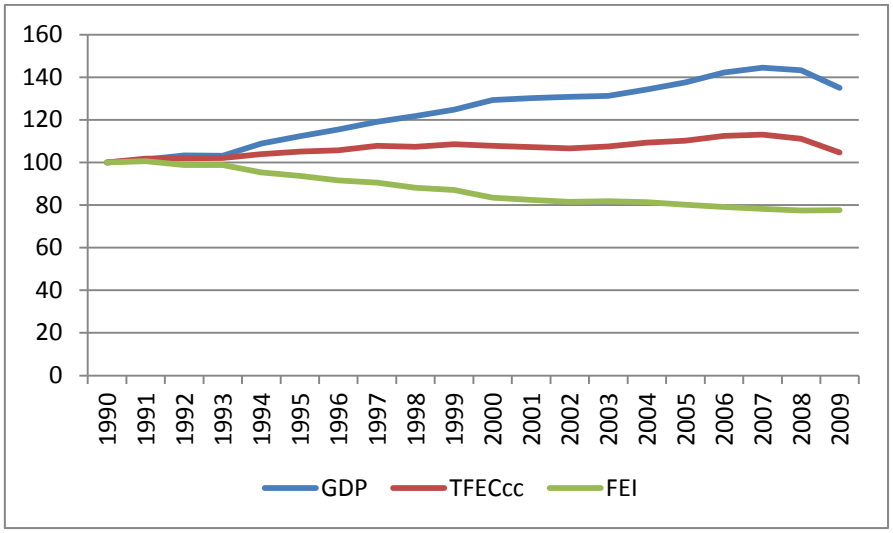


Figure 1: GDP, TFEC and FEI in Denmark (Index 1990=100)

Source: ODYSSEE

The EU's decoupling of economic growth from final energy consumption was particularly rapid from 2005 to 2009 when a 2.2%/year rate of energy intensity reduction was achieved. During that period the annual rate of decrease in Denmark's FEI was a meager 0.8% per year. The sharpest decline in FEI took place between 1993 to 2000, when the rate of decline in FEI averaged 2.4% per year; between 2000-2007 it averaged only 0.9% per year. The economic crisis from 2008 further decreased the rate of improvement to 0.7% per year between 2007 and 2010.

ODEX decreased from 100 in 1990 to 85.9 in 2007, that is, by 14.1%. *Primary energy intensity (PEI)* declined by a faster 26.3% from 1990 to 2007, an average annual decline of 1.7%, see figure 3. [6]

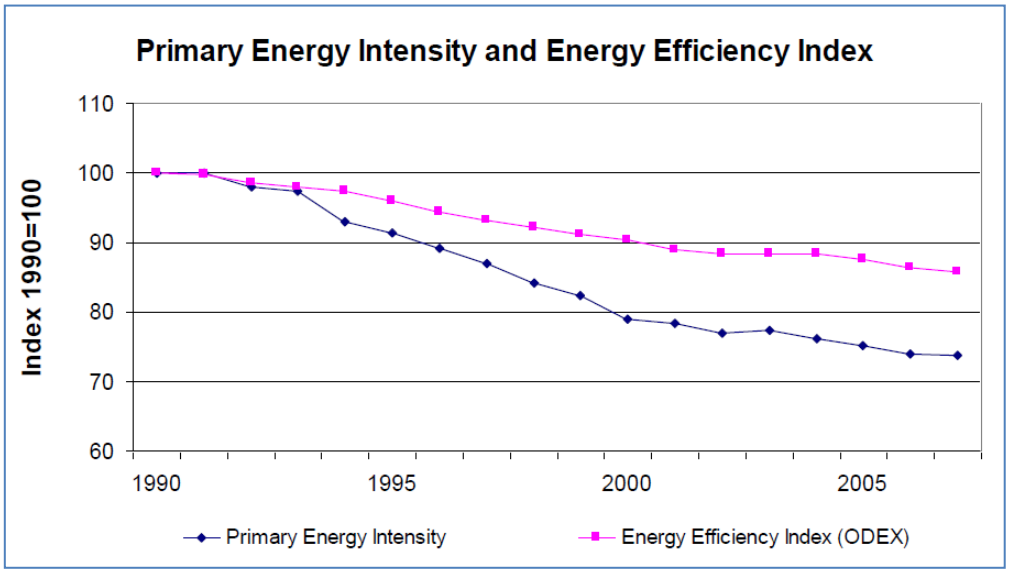


Figure 2: Primary Energy Intensity and Efficiency Index 1990-2007

Source: Odyssee/DEA

[6] Source: DEA (2009)

The "*final energy consumption / gross energy consumption" ratio* increased from 74% to 78% from 1990 to 2007, see figure 3. The difference between final energy consumption and gross energy consumption represents the energy consumption in extraction and refining, transformation losses during production of electricity and heat (in district heating) and losses in the distribution of energy.

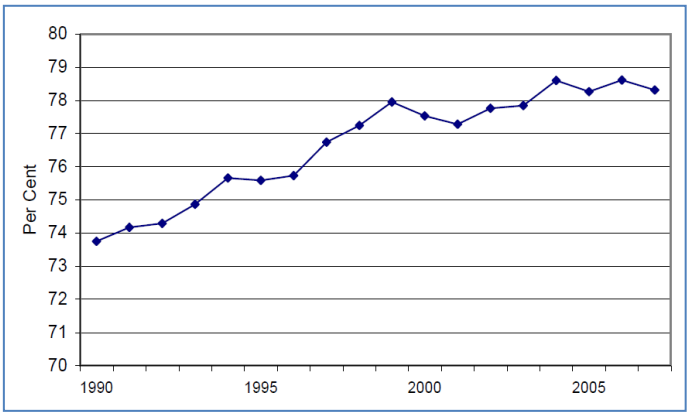


Figure 3: Ratio between Final and Primary Energy Consumption

Source: Odyssee/DEA

The increase in the ratio is an indicator of increased efficiency of the energy supply system. A continued penetration of CHP (combined heat and power- plants) in heat supply and higher shares of wind energy in power generation contributed to the increase. The two factors more than offset the opposite impact on the ratio of the increasing share of electricity in final energy consumption.

Structural changes and energy efficiency

The structural changes in the economy from 1990 to 2010 are summarized in table 2 showing the evolution in the composition of Denmark's GDP by major economic sectors.[7] From 1990 to 2007, the share of industry (including mining) in GDP remained constant: the increase in the value of oil and gas production in the Danish North Sea compensated for the 'de-industrialisation' of the economy, which became pronounced during the 2000s-decade. The share of services increased by 2.8% and the share of agriculture declined.

Table 2: Composition of Denmark's GDP 1990 to 2010

	1990	2000	2007	2010
Agriculture	3.9%	2.5%	1.0%	1.3%
Mining (mainly oil & gas)	1.0%	3.0%	3.9%	3.4%
Industry	24.5%	23.6%	21.7%	18.7%
Services & Transport	70.6%	70.9%	73.3%	76.5%
TOTAL	100	100	100	100

Source: Danmarks Statistik

[7] ***Agriculture*** corresponds to International Standard Industrial Classification (ISIC) divisions 1-5 and includes forestry and fishing. ***Industry*** corresponds to ISIC divisions 10-45 which comprises value added in mining (however deducted and shown separately above), manufacturing, construction, electricity, water. ***Services*** correspond to ISIC divisions 50-99 and they include value added in wholesale and retail trade (including hotels and restaurants), transport, and government, financial, professional, and personal services such as education, health care, and real estate services

Figure 4 shows the changes in the composition of energy consumption by sector. From 1990 to 2007, the *share of transport in final energy consumption* increased from 28.2% to 32.8%, which is remarkable since the share of 'trade and transport' in GDP remained constant (20.3% in 1990 and 20.6% in 2007). The share of *industry* declined from 19.1% to 18.1% and the share of *agriculture* from 7.3% to 5.3%, the share of household energy from 31% to 29%. The share of the *tertiary sector* in final energy consumption was fairly constant around 12%.

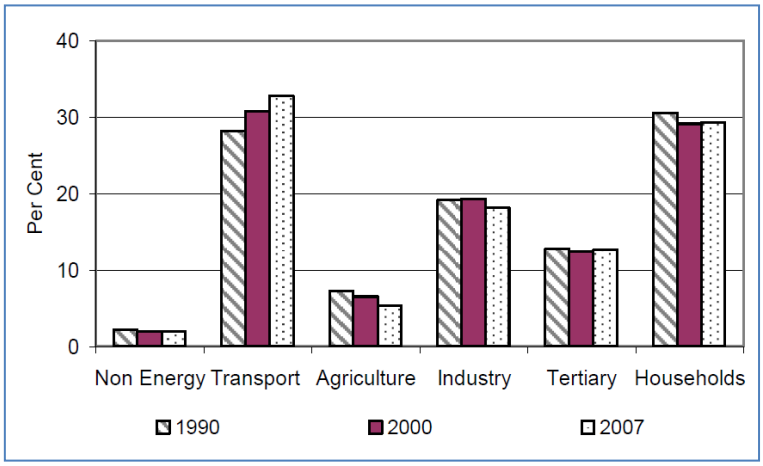


Figure 4: Breakdown of Final Energy Consumption by Sector 1990-2007

Source: DEA

The impact of the changes in the economic structure of GDP on FEI can be estimated by looking at the difference between the development in *FEI* and the development in either *ODEX* or *FEI measured at constant economic structure*.

Table 3: Change in FEI induced by Changes in Economic Structure, 1990-210

Climate adjusted development in:	1990-2007	1990-2000	2000-2007	2007-2010
FEI	-21.4%	16.7%	-4.0%	
FEI constant structure (FEIcs)	--17.0%	14.9%	-2.0%	
OPEX	-14.3%	10.8%	-2.6%	
Change in FEI due to changes in economic structure if measured by FEIcs	-4.4%	-1.8%	-2.0%	
Change in FEI due to changes in economic structure if measured by OPEX	-7.1%	-5.9%	-1.4%	

The information in table 3 reinforces the statement of the charts of figures 1 and 2 about the differences in the EE-effectiveness of Government policies during the 1990s and the 2000s, respectively. Whereas only 11% of the decline in FEI during the 1990s is due to changes in the economic structure, that percentage raises to 50% for the 2000-2007 period. For the period from 1990-2007 as a whole, the split is 20% industry structure/80% EE.

Denmark's achievement compared to EU-27 and EU-15

Denmark's *gross energy consumption per capita* in 2009 of 147 GJ was slightly above the EU-27 average of 143; the difference in *final energy consumption per capita* was slightly higher: 112 GJ in Denmark versus 93 GJ for EU-27. However, Denmark's GDP-energy intensity is lower than those of other EU-15 and EU-27 countries, see the year 2007 ranking in figure 5**.**

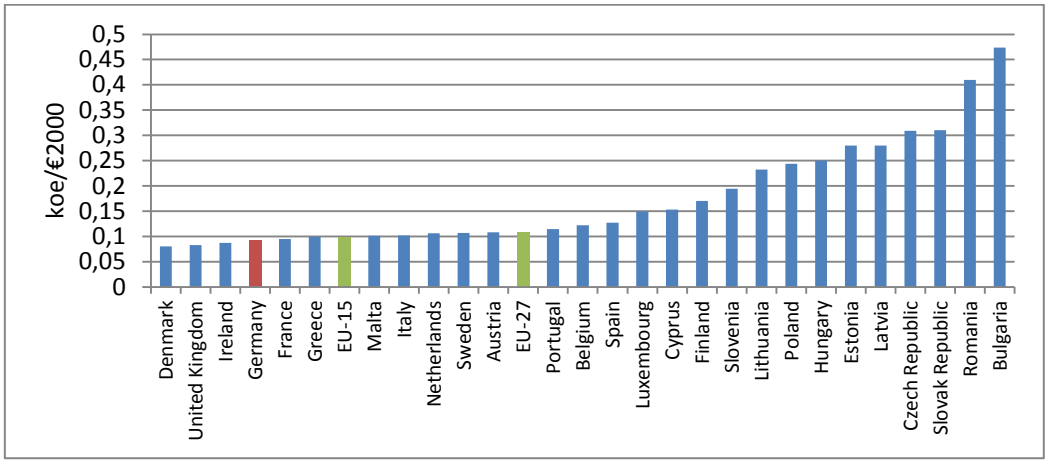


Figure 5: FEI, Cross-Country Comparison, 2007

Source: ODYSSEE

EU-27 FEI decreased by 26% (= an annual average rate of 1.6% per year) over the period 1990-2009. The decline in Denmark's FEI of 22% (a 1.3% decrease per year) was lower than that. [8]

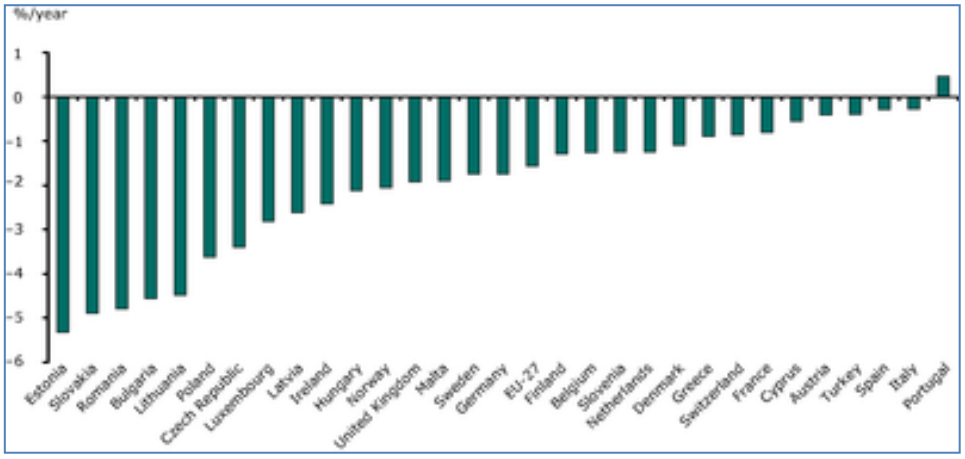


Figure 6: Variation of final energy intensity in EU and EEA countries, 1990-2009

Source EEA (2012)

Figure 7 compares the evolution in climate corrected FEI at constant industry structure from 1991 to 2006 for EU-15 and Denmark. The green tax policy of the 1991-2001 administration generated twice the rate of annual EE improvement achieved by EU-15: 1.7% versus 0.8%. The barrier-removal strategy of the 2001-

[8] European Environment Agency (EEA): Final energy consumption intensity (ENER 021) - Assessment April 2012. The EEA also gets information from the ODYSSEE-MURE data base. Please note that EEA countries also include countries other than EU countries.

2011 administration achieved half the EU-15 rate only: 0.5% versus 0.9%. During the first period, economic growth in Denmark of 3.3 percent per year led to better EE because of accelerated replacement of equipment and better capacity utilization. But that explains only a small part of the higher EE-productivity increase.

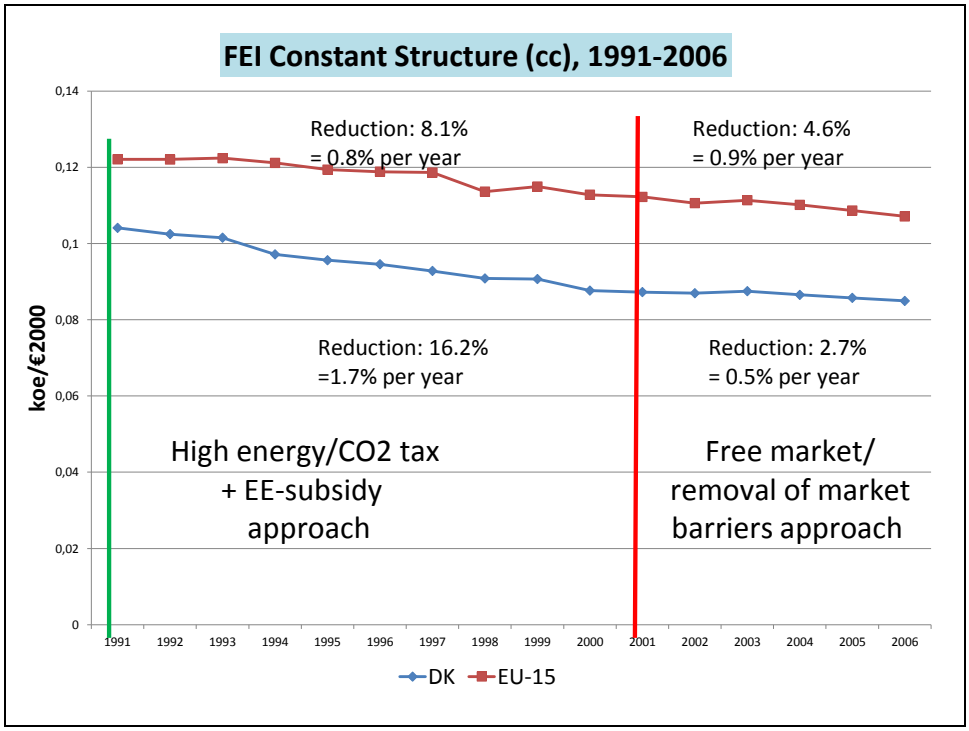


Figure 7: Results of "green pricing" versus "barrier removal" policy appraches 1991-2006

Source: Odyssee

The "barrier removal policy" overestimated the importance of improved information as policy instrument in generating energy savings.[9] In addition, its emphasis on cost-effectiveness meant that CO2-reduction measures having a total economic cost higher than a defined threshold were not accepted. That position, supported by the elimination of subsidies to EE-investments as policy instrument, of course limited the scope of EE-investments that could be and were undertaken post-2001.

Yet, overall, the evolution in Denmark's primary and final energy demand and primary and final energy intensity is in line with the average of *EU-15 countries*, see table 4.

[9] The policy concept of the 2001-2011 administration was laid out in *Energispareredegørelse Maj 2003*, the annual report on the status of EE, introduced by the Energy Saving Law of 2001. "The government's puts emphasis on that energy saving initiatives are cost effective both for society and for consumers. This means that the cost of achieving the savings in a few years must be covered by the resulting energy savings. At the same time, the efforts must be able to help in promote promising technological solutions. Cooperation between industry and government must be developed so that energy conservation efforts can support the market maturing of new innovative energy solutions. The government's position is that energy conservation efforts must be based on market initiatives rather than on grants or new taxes. Energy conservation must be promoted by making markets work more efficiently. The markets must be more transparent and inappropriate barriers must be removed so that more economically attractive energy savings are realized. The intention is to make it easy for consumers and businesses to choose energy efficient products and identify good energy savings. At the same time the supply of energy efficient products and solutions is encouraged. Competition between market players is promoted to ensure that energy saving devices, products and services are delivered efficiently and as cheaply as possible."

Table 4:FEC, PEI, FEI: Denmark and EU-15, 1990-2007

	Denmark	EU-15
Primary energy consumption	+14%	+16%
Final energy demand	+16%	+15%
Primary energy intensity	-21%	-19%
Final energy intensity	-19%	-19%

Source: ODYSSEE

Cross-Cutting Energy Efficiency Policy Measures

Selection Criteria

The MURE database lists six cross-cutting measures for Denmark. Two of these were declarations of policy strategy and actions, rather than measures: "Action Plan for Renewed Energy Conservation" adopted in 2006 and "A Visionary Danish Energy Policy 2025" from 2007. Two measures were adopted after 2007: 'Ecocities from 2008' and "The Danish Energy Saving Trust" from 2010. That left two measures from the database for the analysis in this report:

i. The Energy Companies' saving effort (H) [10]
ii. Public funding for energy research, development and demonstration (M)

In addition to the cross-cutting measures listed in the MURE database, the following policy measures are added to the analysis:

iii. Energy taxes/green taxes
iv. Evaluation of the Danish energy efficiency policy portfolio in 2008

An evaluation is not a policy measure. But the portfolio approach of the evaluation provided insights into the composition of Danish EE policy measures, which led to some restructuring both in the governance structure for EE-policy implementation and to some rebalancing of efforts.

In the following, the analysis in this chapter starts with the key energy saving instrument since the 1970s: energy taxation. Then follows the analysis of the "obligation scheme", the most important instrument after green taxes and the main instrument the Government relies on since 2006. The review of "energy R&D" enters the overlapping areas of energy and industry policy. As exports of EE&RE technology amount to 12 percent of annual Danish exports, the experience is of interest for international debates about the "green growth" potential of national economies: to what extent can the success of the Danish RE&EE industry be ascribed to Government support to R&D?

[10] The capital latter in the brackets indicates the impact of the measure as assessed by MURE. Thus, H and M – mean "high" and "medium" impact.

Energy Taxes

Background

Compared to other EU-countries, Denmark has made *little use of subsidies* to promote EE-investments. The preferred economic instrument has been *energy and CO2-taxes* leading to Denmark being the EU-country with the highest level of energy and CO2-taxes. Households and public agencies have paid *energy taxes* since 1977, industry since 1996. In 1990 the Danish Parliament adopted a national energy plan, Energy 2000. This plan called for a reduction of the Danish CO_2 emissions from 61.1 million tonne in 1988 (corrected with respect to climate) to 48.9 million tonne by 2005, i.e. a 20% emission reduction. In order to meet this target, a *CO_2 tax* was introduced in 1992.

The chart below, showing the evolution in green tax revenue during four decades, identifies four categories of green taxes: *vehicles taxes*, *energy taxes*, *CO2-tax* and *environmental taxes* (on raw material production, packing/wrapping materials, water use, etc).

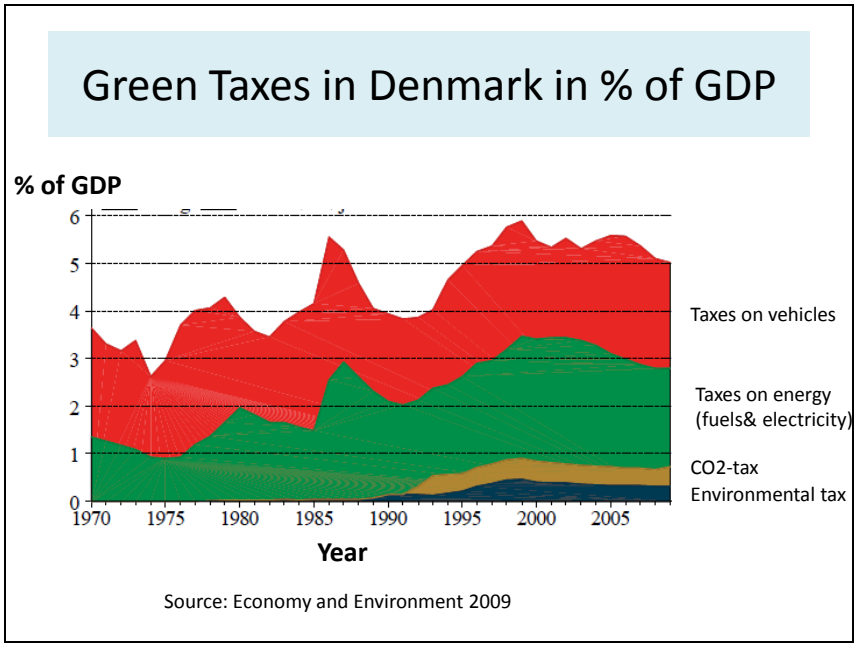


Figure 8: Green Taxes in Percent of GDP, 1970-2009

Green tax revenue increased from 3.5 percent of GDP in 1970 to more than 5 percent in the 2000- decade:

- The *vehicle tax* amounts to roughly 44 percent of total green taxes; if one adds taxes on gasoline and on diesel for transport; *the transport sector* contributes two thirds of green taxes.
- The *revenue from taxes* on energy consumption, the sum of the CO_2-tax and the energy tax, amount to roughly 50 percent of green tax revenue, or of 2.5 to 3 percent of GDP.
- *Environmental taxes*, a relatively new component in green taxation, generate 6 percent of green revenue.

One notes three breaks in the evolution of green taxation. (i) The 1973 oil crisis motivated a doubling of energy taxes from 1 percent to 2 percent of GDP between 1975-80. (ii) Energy taxation jumped in 1985/86 as the Danish Government reacted to the steep decline in the international prices for crude oil in 1985 by introducing off-setting taxes to maintain the level of consumer prices for transport fuels and for heating oil

unchanged.[11] The high environmental policy ambitions by the social-democratic Government during the 1990s led to an upward parameter shift in environmental taxation, which raised the level of green taxes from 4 to 6 percent of GDP. It began with the introduction of a *CO_2-tax* in 1992. In 1996, the introduction of the socalled *Green Tax Package* - including an additional CO_2 tax, a new SO_2 tax and new energy taxes on space heating - was part of a larger tax reorganization, where revenue from the green taxes was used to lower taxes on labour income. The social disparities of indirect environmental taxation on lower income groups were compensated through reductions in low-income taxation and an increase in child support.

A further element was added with the introduction of the *EU's Emission Trading System (ETS*). The trial period from 2005-2007, where allowances given to participants were issued free of charge. Then the scheme for the 2008-12 period, where power companies had to pay for most of their allowances. Allowances that are purchased are a kind of carbon tax. But most importantly, the ETS for EE-policy introduced a distinction between ETS and non-ETS sectors, which focused the attention of national EE policy targets and measures onto the latter. It also attracted criticism that savings in electricity consumption in the non-ETS sector had no impact on the total reduction of CO2-emissions in the EU, as it reduced the need for companies in the ETS sector to reduce their emissions.

Targets/Expected Outcomes

Taxes on energy are primarily motivated by: (i) the wish to raise government revenue, (ii) environmental impact (emissions of CO2, NOx, SO2 particles), (iii) security of energy supply.

In the late 1970s, yet another concern dominated: balance of payment deficits and high import prices of energy. Faced with a soaring deficit in the *balance of payments*, Denmark imposed energy taxes on the consumption of mineral oils, coal and electricity in order to reduce the deficit and, simultaneously increase tax revenue.[12]

According to the Ramsey-principle in taxation policy, taxing products and services with a low price elasticity of demand minimizes the distortion effect, and thus, the socio-economic welfare loss imposed by taxation. From this point of view energy taxes are ideal: *energy has a low own price elasticity of demand*: -0.25 in Denmark.[13] The belief in the low distortion effect of energy taxation explains the continued implementation of new *green tax reforms*, the first was introduced in 1996; subsequent reforms increased the tax rates. The benefits of reduced demand for energy and environmental policy are always present in the mind of politicians, when a new green tax is introduced. Yet, the *revenue objective* dominated: several green taxes were introduced without a prior assessment of the environmental damage and without a quantified environmental target.

A desired side effect of green taxation is the *development of cleaner technologies*, which fulfills energy as well as industrial policy objectives. But above all, the expectation of a 'double dividend' from environmental taxation, the generation of a positive effect both for the environment and for the economy, stems from the supposed economic growth impact of *green tax reform*. The strategy is to use increased energy taxes and CO2 revenue to restructure the tax system towards lower taxes on labor income. The

[11] A previous Danish minister of energy jokingly motivated the increase in taxation with the "need to protect the population against the negative impact of falling oil prices".
[12] Natural gas, which started to be introduced in Denmark in 1980, was not included in the energy tax schemes before 1996. The purpose of the exclusion from taxation was to promote the penetration of natural gas on the energy market and safeguard the financial viability of investments in pipeline infrastructure.
[13] Source: Estimated by the Council of Economic Advisers in Energy and Environment 2008.

theory is that lower taxes on labor will increase the supply of labor and have a dampening effect on wage increases, which in turn increases the demand for labor. . It was assumed that the green tax reform would have a positive impact on economic growth for a number of reasons. The energy taxes would increase EE which together with the lower labor costs would improve the international competitiveness of Danish industry. The high taxes on transport fuels would move demand to other less import-intensive products and services.

Targeted Agents/Coverage

In the late 1970s, *energy taxes* covered only households and non-VAT-registered businesses including public bodies. Energy taxes for VAT-registered businesses were introduced gradually, first for building heat and beginning 2013 also for process heat.

Since 1997, energy taxes are imposed on *all fossil fuels and electricity*. From 2013 the scope of energy taxation is expanded to include: tax on air conditioning, on road lighting, on lubricants.

All sectors pay energy taxes. However, certain applications are not charged: energy products used for electricity production, for air and sea transport, for public transport (trains and boats), the extraction of oil from the North Sea. Special exemptions are applied in the case of energy intensive industry, which mainly is charged for energy consumption for space heating.

In 1993, a *CO2 tax* was introduced for *all sectors* and levied on *all fossil fuels and electricity*.

The energy taxes are levied on the oil companies that produce and import the fuels.

Electricity taxes are levied on the power companies that produce and supply electricity.

Design

A theoretically optimal design can be constructed from the following principles:

- Taxes with the purpose of *financing government expenditures* should be imposed on the broadest possible tax base. Taxes on energy for the sole purpose of raising government revenue should be levied on households only to avoid distorting the allocation of the industries' use of inputs.
- Taxes targeted at *market failures that cause pollution* – CO2, SO2 og Nox – should as far as possible reflect the marginal cost of pollution and be imposed on all polluters across sectors.
- *Security of supply* concerns are relevant for natural gas and for oil products and should be addressed by a security of supply tax on the consumption of oil and natural gas charged to households and businesses.
- Taxes on energy and CO_2 emissions from fossil fuels can be an effective tool in addressing the climate problem, and *without negative effects for a country's competitiveness* so long as the taxes do not go into the public purse, but are used to reduce other distortionary taxes and charges.
- Taxation policy must not impose an *energy poverty burden* on low income households.

The green tax system for energy is kaleidoscopic in Denmark, representing a compromise between different objectives and concerns. Household electricity bills, for example, include on top of the payments for the power supply, VAT, energy tax, CO_2 tax and a Public Service Obligation (PSO)-fee (indirectly, as it is imposed on transmission) to cover incremental costs of supply from RE-power and support to energy R&D. The 2012 reform also introduced a *security of supply tax* (it has a flavor of Orwellian newspeak attached to it) on energy for space heating and a *NOx tax* on emissions. The same reform renamed the CO_2-tax on

electricity consumption into "energy saving tax" (to reflect that RE-power plants will generate more than 50% of electricity by 2020).

Whereas minor details changed, the basic design concept introduced by the Green Tax Package in 1996 remains: to achieve a targeted reduction in *energy consumption and CO2 emissions* with due consideration for the protection of the *competitiveness of Danish industry* and the avoidance of *household energy poverty:*

- The package addressed the competitiveness issue by: (i) redirecting the additional tax revenue from the Green Tax Package directly to trade and industry through a reduction in employers' labour market contributions and in employer payment of supplementary labour market pension and through subsidies to EE measures and special EE subsidies for small companies; (ii) increasing the tax rates gradually, giving companies time to improve their EE and switch to fuels with lower emissions; (iii) applying differential tax rates depending on the use of energy with lower rates for energy-intensive production.
- The purchasing power of households was protected by reducing the taxation of labour; the 2012 package uses the alternative of an annual "green check" to households.

As a result of the competitiveness concerns household energy consumption is taxed more heavily than for business and within businesses, energy intensive industry is taxed less than other industry. Figure 9, which shows the share of taxes within the prices of electricity for the three consumer categories in 2008, gives a good graphic expression of the tax policy.

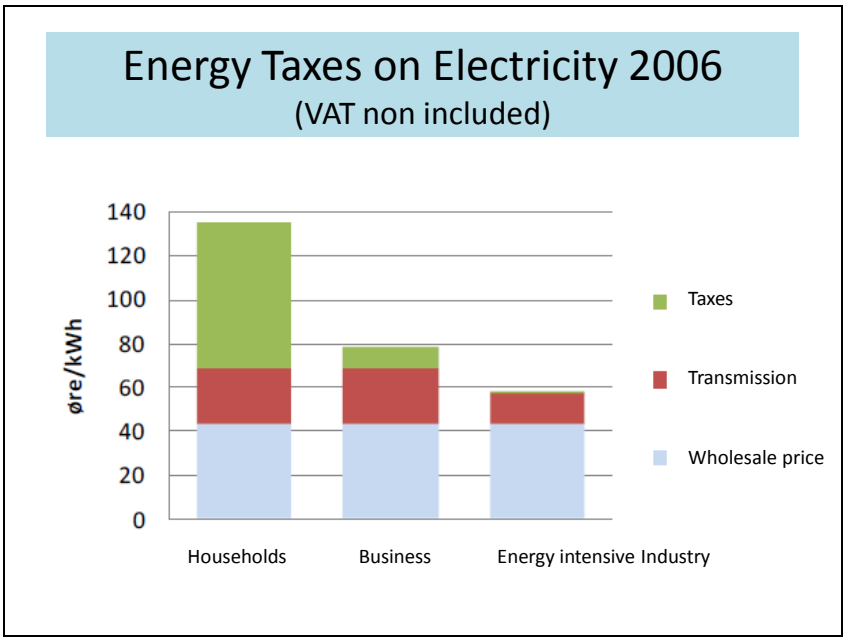


Figure 9: Energy taxes on electricity for households, business and energy intensive industry

Source: Portfolio evaluation 2008

The following sections explain how different concerns affected the design and how it evolved over time.

Energy tax

The energy tax is levied on all *fossil fuels and electricity*; a tax reform in 2012 expanded the scope of energy taxation to include: taxes on *air conditioning, road lighting and on lubricants*.

Fuels used for electricity production are not liable to the energy tax; instead the tax is levied on the output: the electricity itself. Due to this, the tax in itself does not incentivize a shift to less polluting fuels in electricity production at least cost to the economy. The highest level of tax on electricity was that applied to the residential and the public sectors which in 2008 paid electricity taxes corresponding to 0.09€/kWh plus 25% VAT; a typical tax rate for electricity in trade and industry was 0.013€/kWh.

The tax rate on energy products is based on the *gross energy content* of each specific fuel.

Different tax rates apply according to the *usage of energy in industry* which is divided into the categories of 'space heating' and 'process energy'. Energy tax for industry is only paid for energy consumption used for ordinary space heating including hot water; industries that sign a Voluntary Agreement with the DEA get a small rebate. Energy taxes on energy used in production processes (except for small part of the electricity tax) are fully refunded by the Customs and Excise Department and are combined with the collection of VAT.

There are no energy taxes on space heating based on bio fuels and renewable energy.

Since energy use for heating buildings makes up only around 10 percent of total energy consumption in industry, the other 90 percent of energy used for process energy industry paid only CO_2- and SO_2-taxes until the 2010 tax reform. Since then, businesses will for their production processes no longer obtain a full refund of the energy tax and will, with some exemptions, be levied energy taxes on electricity and fuels at approx 15 DKK (€2) per GJ. The energy tax burden levied on businesses will then be approximately ¼ of the energy taxes levied on households, see figure 10.

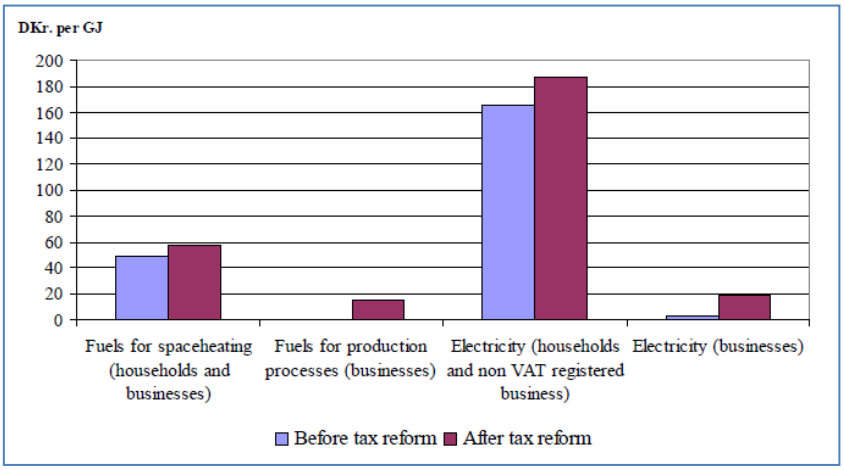


Figure 10: Energy taxes before and after 2010 tax reform

Source: Danish Ministry of Taxation (2009)

Security of supply tax

The 2012 green tax reform introduced yet another energy tax: a *security of supply tax*. The tax is levied on energy used for heating and is intended to cover (i) the cost of state subsidies to biogas, to industrial heat and

power and to RE in industry as well as (ii) the loss of revenue the Government is due to incur because of the targeted lower consumption of fossil fuels. The new tax can best be interpreted as a revenue-motivated expansion of the energy tax. But instead of expanding the 'general energy tax" with a number of exceptions a "specific energy tax" limited to energy for heating was introduced.

SO2 tax and NOx tax

The ***SO_2 tax*** was introduced gradually from 1996 to 2000 on all fuels containing sulphur.[14] The companies were entitled to a basic allowance from the sulfur tax paid. The allowance was temporary and digressive, except for certain 'heavy process' uses (following the definition from the energy and CO_2-tax scheme). Fuels with a sulphur content below 0.05% are exempt from the tax. No rebates are given to industry. The tax paid is based either on SO_2 emitted or on the sulfur content of the fuel: companies are given the option to pay for the actual SO_2-emission on combustion if they are able to document the results of SO_2 emission measurements. The tax rates on emitted $S0_2$ per kg and on per kilo sulfur content in fuels are shown in the table below.

Table 5: SO2 tax rates 1996-2012

	1996 -2007	**2012**
Tax rate on sulphur in fuels	20,0 DKK/kg 2.7 eurocents	21,8 DKK/kg 2.9 eurocents
Tax rate on SO_2 emitted in the air	10,0 DKK/kg 1.3 eurocents	10,9 DKK/kg 1.5 eurocents

The rates were unchanged between 1996 and 2007. Since then the tax rate is increased 1,8 percent per year.

The tax assists the achievement of the anticipated reductions through four mechanisms:

(i) The tax increases the cost of energy of production using fuels that contain sulfur. Consequently, total energy consumption would decline.
(ii) The tax will change the energy price structure, thereby providing an incentive to substitute high sulfur content fuels (like coal and oil) with fuels with lower sulfur content (like gas and gas oils), as the latter become relatively cheaper.
(iii) The tax gives an incentive to introduce new low sulfur fuels within each type of fuel.
(iv) The tax promotes improvements in existing end-of-pipe cleaning equipment for reducing emissions of SO_2.

[14] The background for this tax was an international obligation imposed by the UN-ECE Convention on Long Range Tran boundary Air Pollution to attain a national emission ceiling of 90,000 tonnes SO_2 in year 2000. This amounted to an 80 percent reduction of the 1980 level by the year 2000. As an effect of various measures, such as emission quotas for power plants, mandatory desulphurisation units in new power plants and limit values for the sulphur content in fuels, emissions declined significantly during the 1980s. However, in 1994 it was apparent that additional measures were needed if the reduction target was to be met. Source: UCD Dublin (2009)

CO2 taxes and the ETS

In 1992 a CO_2 tax was introduced on households and public buildings, since 1996 businesses pay a CO_2-tax as well. The CO_2-tax taxes fuels - oil, coal, gas and electricity - according to their CO_2-content. The rates reflected competitiveness concerns:

- *Households and the public sector* are taxed at a higher rate than *industry;*
- Within industry, the rates differ by use of energy: '*space heating' (*energy used for heating purposes is subject to the same rate as households), *'heavy processes'* (specifically defined energy-intensive processes) and '*light processes'* (energy consumption that is neither heavy process nor space heating).
- The levels were until 2009 reduced for companies that signed an *agreement with the DEA* to invest in $C0_2$ reduction measures.[15]

The outcome, as shown in the table below, is wide discrepancies in the level of the rates.

Table 6: Burden of CO_2 tax by sector (€/tonne CO2)

		1993	**1996**	**2000**	**2002**	**2005**	**2009**
Household		13.17	13.59	13.42	13.46	12.10	20.5
Light Industry	With Agreement*		6.79	9.12	9.15	9.15	n.a.
	Without Agreement	6.58	6.79	12.07	12.11	12.11	
Heavy Industry	With Agreement*		0.41	0.40	0.40	0.40	n.a.
	Without Agreement	0.66	0.68	3.35	3.36	3.36	

*Companies entering into an agreement with the DEA are eligible for a tax rebate provided they invest in measures to improve energy efficiency

Source: Ministry of Taxation

The introduction of the EU's *Emission Trading System (ETS*) in 2005 divided the economy into sectors that are within the ETS (the ETS sector) and sectors that are outside the ETS (the non-ETS sector). The ETS sector is regulated by the EU quota trading system, while national CO_2-reduction targets are determined for the non-ETS sector. This made adjustments to the CO_2 scheme and to the energy tax scheme necessary.

The adjustments pose a challenge for policy makers. Firstly, because two principles clash:

1. Equality of treatment calls for and an economically rational allocation of resources is promoted by *applying a CO_2-tax rate similar to the price of EAUs*. This will create a uniform incentive to reduce CO2 emissions and CO2 reductions will take place where the costs are lowest.
2. The regulation of GHG emissions in the non-ETS sector requires a *CO_2 tax rate which is continuously adjusted in order to reach the non-ETS sector's CO_2 reduction target in 2020*. Since the marginal reduction costs in the non-ETS sector are significantly higher than the expected quota

[15] The details of the scheme are explained in the chapter on instruments for EE in industry.

price in the ETS sector up to 2020 either much higher rates must be imposed or supplementary instruments, e.g. subsidy schemes must be introduced.

The first principle is taken into account by a deduction scheme which reduces the payment of CO_2 taxes for energy intensive industries in the non-ETS industries as a means to ensure equal treatment of these with similar industries in the ETS that get quotas free-of-charge. It also explains the up-and-down adjustments in the level of the CO_2 tax during the 2000s that can seen in table 6:

- In 2005 a revised CO_2 tax scheme entered into force, which lowered the CO_2 tax rate from €13.5 to €12) per ton CO_2 emissions. To maintain the overall tax burden, the energy tax was increased accordingly and a number of tax expenditures and special arrangements were abolished or reduced.
- Already in 2009 the CO2 tax was raised above the pre-2005 level, as one expected significantly higher EAU-prices during the 2008-2012 period than during the 2005-2007 trial period.

A second challenge for CO_2-pricing policy stems from the fact that the mechanism of the ETS breaks the neat correspondence between the Government revenue objective, the EE&RE objective and GHG reduction objective: that a high energy/CO_2 tax increases revenue as well as EE&RE and thereby reduces CO_2 emissions. The CO_2 tax rate on electricity has come under attack for representing double-taxation as electricity generation since 2005 is covered by the ETS. The high taxation of electricity consumption is criticized in general for failing to promote CO_2-reduction as reduced demand for electricity does not reduce CO_2 emissions within the ETS-sector. In addition it was said that taxation exclusively for revenue purposes gives the wrong incentives to industry for the choice of inputs; that therefore, taxes for revenue should be levied on households only.

Total Tax Burden on different energy sources

The total taxation burden on household electricity consumption (energy + CO_2 mainly) , amounting to about two thirds of the consumer price, is the highest in the EU. According to Eurostat data, the Danish *household electricity price in 2011* of around 29 eurocents per kWh is 1½ times as high as the average household electricity price in the EU; the *household gas price* of 10.8 eurocents per kWh in 2011 is the second highest in the EU.

Rate adjustments

Between 1996 and 2001 the rates for the energy tax were increased in line with inflation. The liberal Government coming to power in 2001 imposed a general tax freeze from 2002 to 2008, which also included energy and CO_2 taxes. Between 2008-2015 the rates increase 1.8 percent per year nominally, probably slightly less than the rate of inflation; annual increases will continue also after 2016. The evolution in the tax rates, including the CO_2, in nominal and in real terms from 1985 to 2012 is shown in the table below. The table shows energy taxes on various sources of fuels, excluding sulfur and NO_x taxes. The jump from 1985 to 1990 shows the reaction of Danish energy policy to falling prices of fossil fuels from late 1985: to offset the impact on consumer prices by increasing energy taxation. The jump in 1996 shows the green tariff reform. During the 2000s, the new Government's tax stop replaced the upward movement in green taxation by a downward movement in real price terms.

Table 7: Total tax burden on energy sources

		1985	1990	1996	2002-2008	2012	2012 tax in 1996 constant price	% change in real terms
Light fuel oil (euro cent/l)	energy tax	4.61	22.4	20.25	24.63	28.4		
	CO_2 tax	4.61	22.4	3.67	3.23	6.8		
	Total tax			23.92	28.26	35.2	24.6	3%
Heavy fuel oil (euro cent/kg)	energy tax	5.11	25.2	22.56	27.72	32.1		
	CO_2 tax	5.11	25.2	4.35	4.31	6.1		
	Total tax			26.9	32.03	38.2	26,7	-0.7%
Natural Gas (euro cent/nm^3)	energy tax			0.14	27.19	39.0		
	CO_2 tax			2.99	2.96	4.9		
	Total tax			3.13	30.15	43.9	30,7	881%
Pit Coal (euro cent/kg)	energy tax	1.62	9.8	11.69	19.25	22.2		
	CO_2 tax	1.62	9.8	3.26	3.23	5.7		
	Total tax			14.95	22.47	27.9	19,5	30%
Electricity (eurocent/kWh)	CO_2 tax					0.9	0,6	

Source: Ministry of Taxation plus author

Taxes on transport

Emissions from the transport sector are growing, and it is expected that they will represent approximately 45 per cent of the emissions from the non-ETS sector in 2020.

The 'green taxes' on transport come in the form of (i) the *fuel taxes*, (ii) the *registration tax* amounting to roughly 170% of dutiable value and paid as soon as a vehicle is imported and used in Denmark and (iii) an *annual tax for owning a vehicle*. The taxes generate around 35 billion DKK annually, of which 20-25 billion DKK are generated by the registration tax.

Petrol and diesel taxes have been set to more or less follow German rates, in order to avoid border trade problems. Gas oil is taxed lower than petrol, but higher than heating gas oil. The tax difference between gas oil and petrol is to some extent evened out by a higher vehicle tax on diesel vehicles. The rates in 2007 were:

Table 8: Petrol and diesel taxes, 2007

Petrol (leaded)	0.62 euro
Petrol (unleaded)	0.54 euro

Diesel	0.40 euro
Diesel (low sulphur)	0,37 euro

The *registration tax* and *annual owner tax* are differentiated according to fuel efficiency and purpose of use (i.e. business or private). For petrol powered/diesel powered cars the registration tax is reduced with DKK 4.000 (€533) for every kilometre that the car covers more than 16/18 km pr. litre fuel and raised with DKK 1.000 (€133) for every kilometre less than 16/18 km. The annual owner fee is a function of the car's CO2-emissions per kilometer.

Implementation/Costs

The transaction costs associated with the green energy tax taxes are very modest as far as the energy tax is concerned. The CO_2 tax on businesses with its numerous and complicated exemptions imposed costs on businesses in metering and reporting on their CO_2-consumption to the DEA, filings to the tax authorities for reimbursement of paid CO2-taxes and applying to the DEA for subsidy payments for EE-measures. DEA and the Ministry of Taxation incurred administrative costs. No reported estimated exists concerning the size of the transaction costs.

Monitoring and Evaluation

Being a tax instrument serving multiple purposes, the green taxes are monitored and evaluated at different times by the Ministry of Taxation, the Ministry of Finance, the Council of Economic Advisors and by the DEA.

Achieved Results

The *Government revenue objective* was fulfilled: the overall revenue from green taxes in Denmark increased from 500 million euros in 1970 to 10 billion euros in 2010. Expressed in constant prices this equates a tripling of revenue. Transport fuel is included under energy in the chart below. With this definition, the sectors 'vehicles' and 'energy' each provide approximately 5 billion euro towards the 10 billion euro in revenues. The SO_2-tax provides around 14 million euro per year.

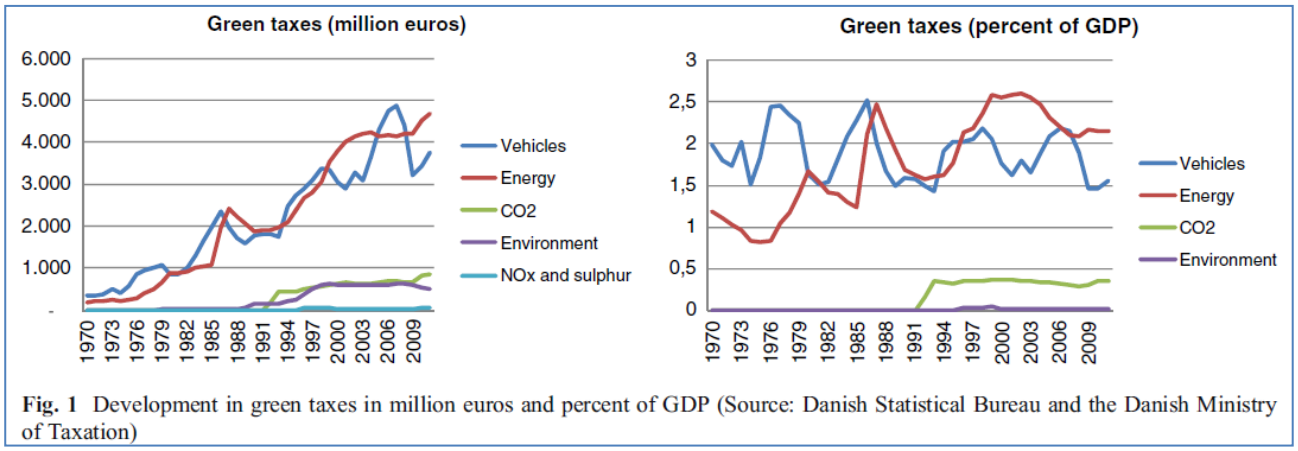


Fig. 1 Development in green taxes in million euros and percent of GDP (Source: Danish Statistical Bureau and the Danish Ministry of Taxation)

Figure 11: Green Tax Revenue 1970 to 2009

Source: Economy and Environment 2009

Measured as in percentage of GDP, the green taxes increased from 3% to a peak of 5% of GDP in 2000, after which the freeze in taxes imposed by the Government in 2001 reduced the level to 4% of GDP. Relative to the total tax revenue, the green taxes amounted to 8%.

A clear objective of energy taxation, particularly in the aftermath of falling market prices for fossil fuels from the second half of the 1990s and until the beginning of the 2000s, was to *provide the population with a clear pricing signal for their consumption of energy*. As we can see in the chart below, the policy succeeded in keeping household energy prices constant in real terms.

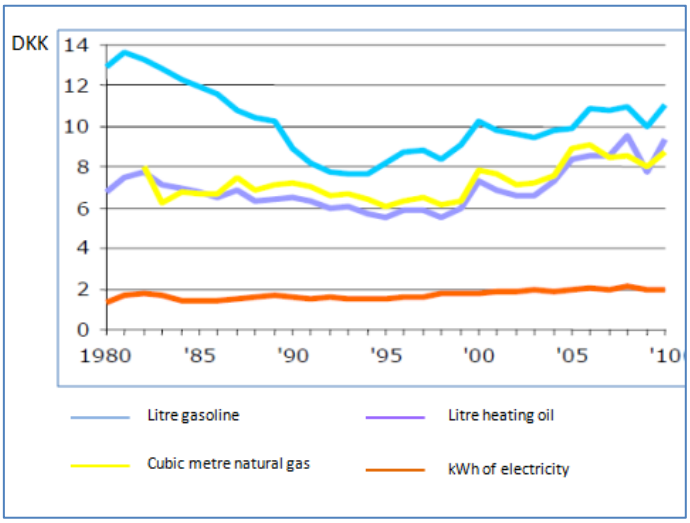


Figure 12: Development in Household Energy Prices 1980-2010, Constant 2010 DKR

Source: DEA Energy Statistics 2010

The impact of green taxation on growth in GDP has been modest, estimated at around 0.2 percent of GDP. Compared with the growth-impact of green tax reforms in six other EU-countries, only Slovenia had a lower economic growth impact than Denmark.

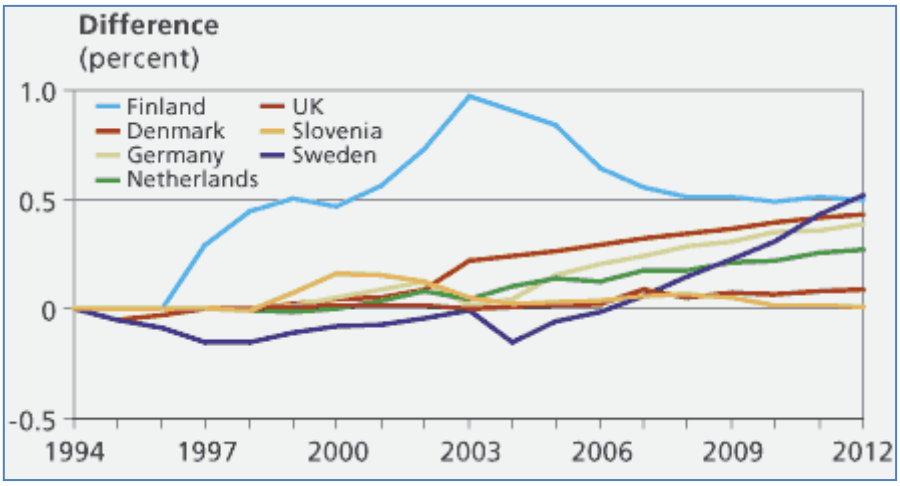


Figure 13: Impact of Green Tax reform on economic growth in seven EU countries

Source: Mikael Skou Andersen (2011)

Impact on Energy Consumption and on CO_2 emissions

The impact on energy consumption of an economic incentive instrument such as green taxes depends on the price elasticity of demand. The Council of Economic Advisors estimates that the overall price elasticity of demand for energy is –0.25. Schou-Andersen (2010) arrives at a price elasticity of industrial energy demand of -0.38.

According to an assessment based on analyses in a macroeconomic model, the Danish Ministry of Economy and Business estimates that without *energy taxes* the Danish energy consumption would be at least 10% higher in 2008.

Looking at the development in FEI in the chart below, we see:

- that EE increased in reaction to the introduction of the CO_2-tax I 1993;
- that the introduction of the green tax reform in 1996 kept the progression in EE on course;
- that the tax stop introduced late 2001 slowed down the progression to insignificance.

In addition, the political signals changed overall: from a very active pro-environment stance to a situation where environmental policy attracted minimal attention from the Government and its rethoric.

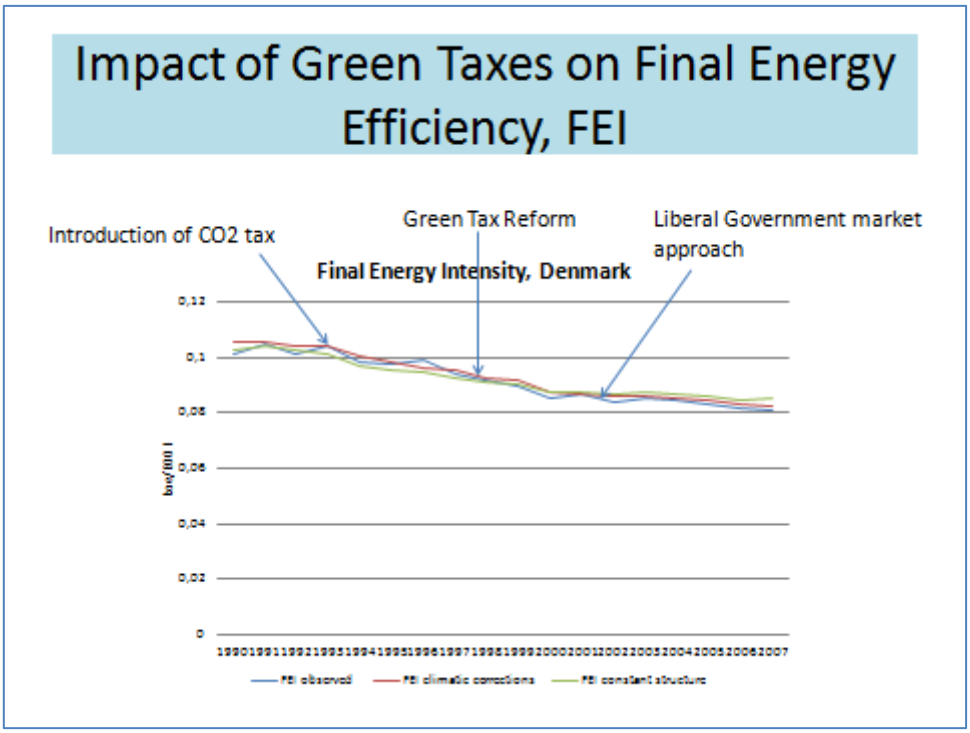


Figure 14: Green Taxes and Development in FEI 1990-2007

The development in FEI from 1993 to 2001, shown in the chart above, reinforces the view that the green tax reform introduced in the 1990s had an important on energy demand and that the subsequent tax freezes introduced by the new Government after 2001 made progress stall.

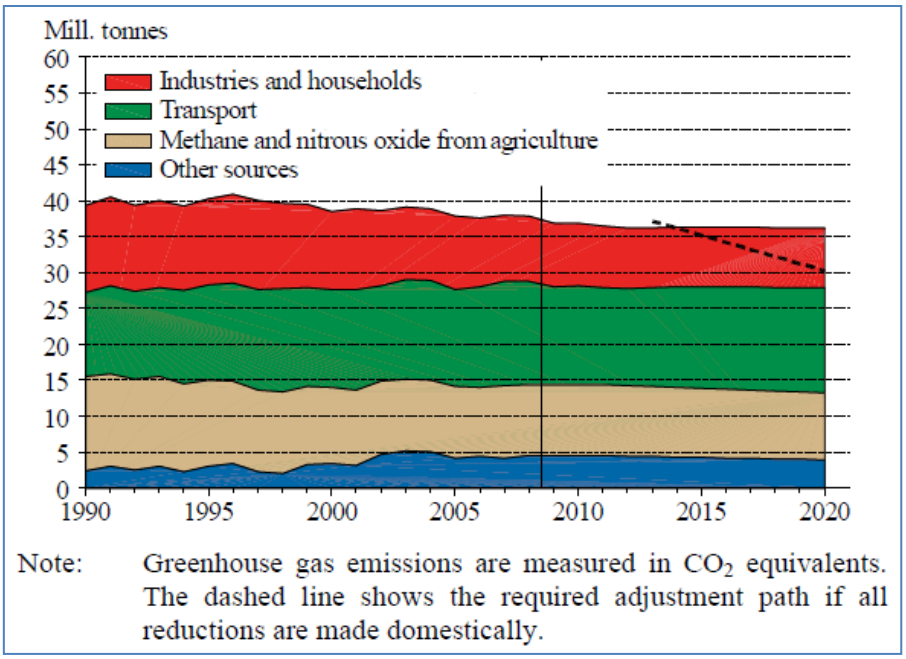


Figure 15: Greenhouse gas emission from the non-ETS sector 1990-2020

Source: Economy and Environment 2010

The Energy Companies' EE obligation to Final Users

Background[16]

The obligation on regulated energy utilities to assist customers with the realization of energy saving potentials is, next to green taxation, by far the most important EE-policy instrument in Denmark, accounting for more than 50 percent of annual energy savings since 2006. It evolved gradually from a semi-voluntary start made by individual power utilities. Inspired by the 'integrated resource planning' concept, some Danish power utilities started in 1986 with implementing 'demand side management' (DSM) schemes assisting their clients with energy saving efforts. By the early 1990s all power utilities were engaged in DSM. The 1994 Electricity Act then imposed providing assistance in EE to clients as a public service obligation. The 1999 Electricity Act, which introduced vertical separation and liberalization in power supply, imposed the obligation on the distribution system operators. In 2000, an energy policy agreement in Parliament expanded the EE obligation to natural gas distribution and to district heating companies. The commercial oil companies entered the system on a voluntary basis in 2006.

Until 2005, the EE-promotion activities to be performed by the energy companies were defined in annual contracts with the DEA. Since 2006, the companies have to achieve a minimum energy saving target and are free to choose through which activities they are to achieve it.

Targets/Expected Outcomes

The annual savings targets are fixed in the energy policy agreements concluded by Parliament: the 2005 agreement for the 2006-2009 period, the 2009 agreement for the 2010-2012 period and the 2012 policy agreement for the 2013-2020 period.

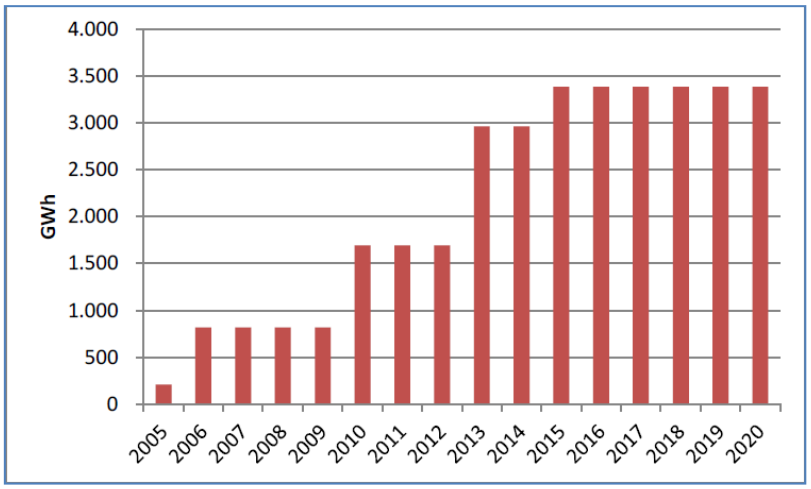


Figure 16: Annual EE-Obligation 2005 to 2020

Source: EA, NIRAS, Wiegand&Maagø (2012

[16] Discussion follows MURE : DK-6 The Danish Energy Companies Saving Effort (2011), EA, NIRAS: Portfolio Evaluation (2008). EA, NIRAS, Wiegand&Maagø: Evaluation of Obligation Scheme (2012)

In the chart, the GWh for the year 2005 represent the estimated savings resulting from the annual contract with the DEA; the GWh for the following years show the system of ex-ante quantitative targets. The quantitative obligation increased strongly with each agreement:

- The 2005 policy agreement fixed an obligation to save 2.95 PJ/year during 2006-2009, which roughly tripled the level of previous achievements.
- The 2008 agreement doubled the obligation to 6,1 PJ/year as of 2010.
- The 2012 energy policy agreement increased the obligation by an additional 75% beginning year 2013 and by 100% beginning in year 2015.

The targets for the 2010-12 period were fixed to achieve a reduction in final consumption in the included sectors by 1.2 per cent annually; as part of the national effort to achieve annual energy savings for 1.5 pct. of the end use of energy in Denmark, which is the aim of the 2008 energy policy agreement. For 2013-2020, the savings rate is raised 50 percent.

Targeted Agents/Coverage

The eligible sectors are *industry*, *tertiary sector*, *households*, and in *district heating*: connection of residences using electricity for heating, use of solar heat and reduction of system losses in heat distribution. EE *transport* is not eligible; but may become so in a future year.

Design

The obligation scheme has undergone substantial changes since its beginning in 1994.

In the *pre-2006 scheme*, the activities of companies were detailed in service letters from the DEA; the companies had to submit annual reports detailing their compliance. Activities were broad-based: energy audits in companies, advice to households and schools, general awareness campaigns.

The following sections look exclusively at the scheme in use from 2006 onwards: the key trade-offs in the choice of design details and how the scheme changed in response to experience.

Governance

The obligation is imposed on 509 energy companies, of which 428 are district heating companies, 77 are power grid operators and 4 are natural gas distribution grid operators. 456 energy companies had during the 2010-2012 period an annual EE-saving target of less than 5 GWh, meaning that the annual cost of the scheme to the company was around 250,000 euro only.

The pluri-annual framework for the saving effort of the energy companies is formulated in an agreement between the companies and the *Danish ministry of Climate and Energy;* the first from August 2006, the second from November 2009 is in force from 2010 to 2012. During 2012 the conditions for the following 3 year period will be agreed after an evaluation of the effort.

Implementation is monitored by the *DEA*, which receives the EE-documentation for registered projects and organizes mid-term evaluation to provide recommendation for the next pluri-annual framework.

Since the costs of the support is covered by fees raised by the companies on the energy invoices to their consumers, the *Energy Sector Regulatory Agency* is involved also. It receives information from the companies on the annual cost of their obligation, benchmarks costs and achievements between companies and approves the annual fee to raise.

Choice of instruments

The energy companies have a large degree of freedom of choice in terms of instruments to use and in terms of specific investments to support: energy audits, campaigns to change consumer behavior[17], targeted information / personalised technical advice, investment subsidies, market transformation activities (improving the value chain from manufacturer, supplier, installer, user).

Before 2006, the companies relied mainly on awareness campaigns, technical information and consulting services. Within their distribution area, they provided free-of-charge: (i) general information on EE to consumers, (ii) individual information to households (advisory services, information on energy consumption in appliances and heating systems), (iii) direct visits to business and public institutions to inform about EE-opportunities and identify these. Since 2006, direct support to specified investments has become the preferred approach and investment and subsidies take up an increasing share of annual expenditures made by the energy companies. Interviews performed for the portfolio evaluation in 2008 showed, that in 56% of the cases, the energy company was involved in an economic analysis, in 41% in designing the project idea, in 31% in the technical analysis, in 11% of the projects in their implementation; while a subsidy was given in 23% of the cases. The 2012 evaluation report of the scheme showed that investment subsidies were given in 86 percent of registered savings in 2011 and that the level of the subsidy is between 0.20-0.40 DKK (2.7-5.4 eurocents) per kWh saved the first year.

The *investment subsidy* can be given as part of a package, which includes also documentation, technical information and technical advice for implementation. Or, it can be a stand-alone measure: the final user presents an EE-project before it is implemented; the energy company acquires the right to register the project in return for providing a subsidy. In the former case, the subsidy to the investment amounts to 75% as a minimum. In order to reduce the free-rider problem, the energy companies limit their subsidies to a maximum of 35% of the cost of investment and attempt to exclude subsidy support to investments having payback periods of less than or equal to a year. The 2012 evaluation showed that they are not entirely successful in the latter: some of the investigated projects had pay-back periods below 1.

The general information and awareness campaigns which were the focus of the efforts in the early 2000s, comprised (i) activities targeted at residences (advice given by phone, advice in demonstration rooms, campaigns in schools, specific theme events and campaigns for EE in residences; (ii) general information activities targeting businesses as well as households; (iii) joint campaigns with actors in the technical supply chain (EE motors, system optimization, stand-by consumption of electricity, EE-lighting). The latter included development of joint information tools e.g. for planning and documentation, energy invoices with comparative information on energy consumption, forecasts for development in energy consumption, etc.

The 2008 portfolio evaluation was critical of the tool of campaigns to change consumer behavior and to influence market penetration of EE-products. Partly because campaigns to change behavior usually have a short term effect only and impacts on energy consumption are difficult to estimate, partly because the campaigns had a high level of PR for the energy companies. The evaluation recommended that the tool no

[17] E.g. a campaign to use clothes-/washing lines instead f dryer.

longer to be eligible for registration of savings under the obligation. The 2010-2012 framework no longer accepts behavioral changes in the calculation of energy saving impacts.

Organisation of service delivery and support

The energy companies have freedom of choice whether to provide assistance through own EE-service companies or through outsourcing of EE-services. As summarized in the chart, the energy company raises finance for the activity through a levy on its consumers. The EE-service company which implements the project for the end-user can be a service subsidiary of the energy company, or an outside service company (consulting firm or installer) or an ESCO. The customer receives the subsidy for audits or for investments directly from the energy company.

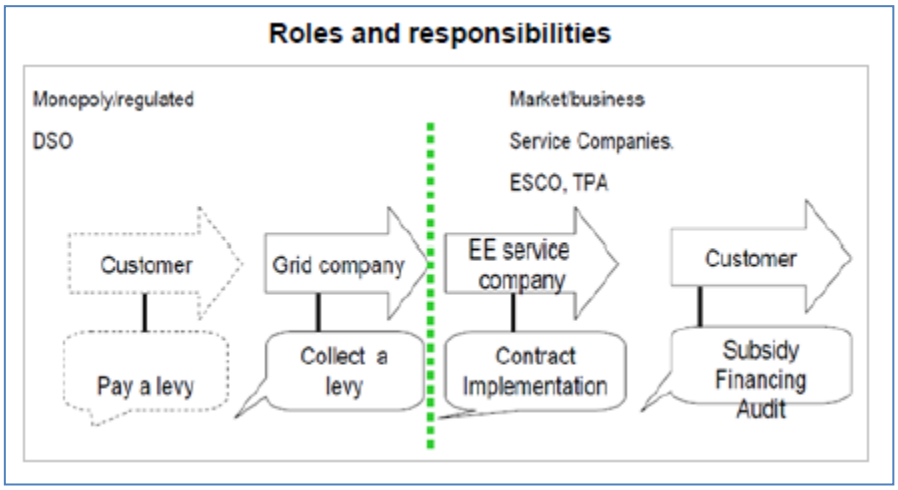


Figure 17: Organisation of the Obligation System

Source: Dong (2012)

The majority of the EE-projects are implemented through service subsidiaries of the energy companies; of the 77 power grid companies 40 have set up such a subsidiary. In part the development was driven by a management fad: the slogan to become an energy service company rather than an energy company. This raised criticism from the association of engineering companies and from the installers' association that the energy companies were trying to monopolize the market for such services. Claims were made that outsourcing would lead to the introduction of more innovative ideas and reduce program costs per achieved GWh of savings. The Government attempted to increase competition, obliging the energy companies to put aside a specified amount of their obligation revenue for outsourcing a part of the obligation through tender. Yet, tenders asking for bids by third parties (engineering consulting firms, craftsmen, etc) to offer most energy savings for a specified amount, say 10 million DKK (1.3 million euro) did not generated convincing results: bids were too few and too expensive. And because customers express overall satisfaction with the scheme – customers trust their energy companies more than installers when it comes to providing energy advice – there has not been a big push for outsourcing.[18] Another reason for reduced pressure for outsourcing is that the energy companies have 1200 cooperation agreements for the scheme with installers,

[18] An interview survey made by the Association of Danish Energy Companies of 1000 Danish households that had made investments in EE of their homes showed that only 16% of households had implemented EE-solutions based on advice from a craftsman/installer.

craftsmen, consulting engineers and suppliers of EE-equipment.[19] Roughly 40 percent of the annual amount spent on the scheme is implemented through the external partners or contracted by the end-users themselves. The collaboration agreements are simpler than tenders and the external partners are quite satisfied with the arrangement: installers see the cooperation as a good possibility for coming in dialogue with new customers. In principle, the cooperation can be expanded through framework agreements with the business association of installers/craftsmen.[20]

Competition between energy companies in delivering EE-saving services has been encouraged since 2006. Before, companies assisted only their own customers, and only with savings in their own type of energy: power companies with electricity, natural gas companies with saving natural gas. Since 2006 companies can assist with EE anywhere in Denmark and within any

In 2010 a further instrument was added to stimulate competition and innovation in the market place: the energy companies can trade documented energy savings between themselves on a bilateral basis: an overachieving company can sell the right to registered savings to an underachieving company.[21]

End-users can also submit a self-developed EE-project to an energy company for inclusion in its obligation activity, in return for receiving a subsidy from the energy company in line with projects developed with assistance of the energy company. The condition is that the implementation of the investment has not started before the energy company has accepted it and an agreement between the two parties has been signed.

Methodology for estimating savings from implemented activities and investments

The savings are documented and reported according to agreed methods that are primarily ex-ante assessments. Three methods of calculation are used:

1. Engineering estimates made for specific projects. This is the normal method for EE-projects in industry.
2. Standardised values based on a catalogue including a couple of hundred normal types of savings; the catalogue has values for a couple of hundred of these. This is the normal method for EE in households and public sector.
3. Market impact and campaign assessments, the calculation of which is based on values from samples.

Because most savings are achieved in industry, the specific project method dominates: During the 2006-2008 period, 59% of registered savings were calculated according to the specific project methodology, 38% by standardised values and 3% by campaign methodology. The results for the year 2010 are shown in the chart below.

[19] As example: an energy company informs its customers through its quarterly newsletter that they can get free-of-charge thermography done of the rooms in their residences to identity meaningful EE-investment opportunities. A website link or a by phone contact directs the customer to the craftsman with whom the energy company has agreed to pay for his thermographies. The customer agrees day and time for the thermography to be done. Based on the results of the thermography, the craftsman submits a proposal of rational EE-investments with their costs and estimated savings to the customer. If interested, the customer gets the investments done by the craftsman and pays him for the investment.

[20] The Association of Danish Energy Companies has suggested a framework agreement for cooperation in capacity building and certification of installers.

[21] The Danish Government has looked into the experiences of other countries with white energy certificates.

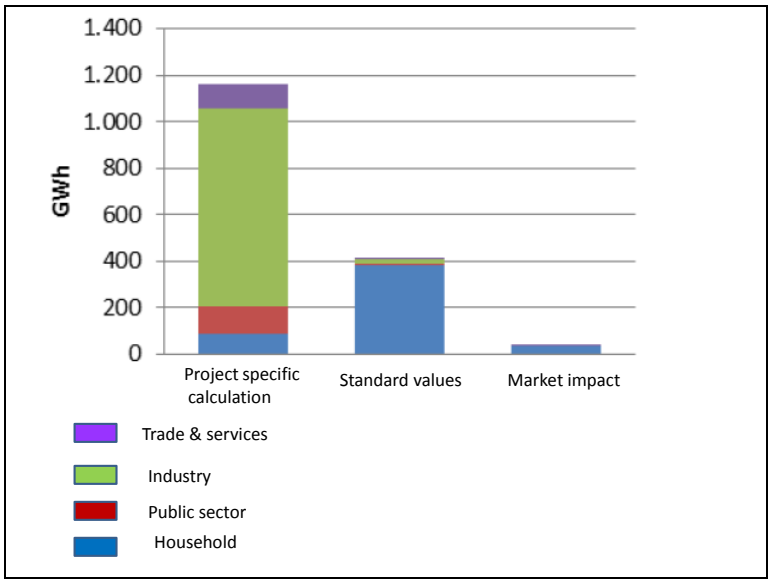


Figure 18: Reported Savings by Estimation Method and by Sector, 2010

Source: EA, NIRAS, Wiegand&Maagø (2012)

For reasons of simplicity, the *estimated savings in GWh refer to the savings within the first year only*. Since some investments lead to energy savings during years – e.g. weatherization methods for buildings, others generate savings for a much shorter period - for example, EE- campaigns. *Nor was a distinction made between the types of energy*: a saved GWh of electricity counted as much as a GWh of saved natural gas of or saved oil. The simple GWh-approach did not provide incentives to bring EE-efforts of the scheme in line with national energy policy priorities and with the socio-economic returns of alternative EE-investment. The relavnce of type of fuel and of lifetime of the investment is vividly illustrated in the chart below. It show the result of calculations made in the background report for the reform of the Danish EE-eefort in 2004.

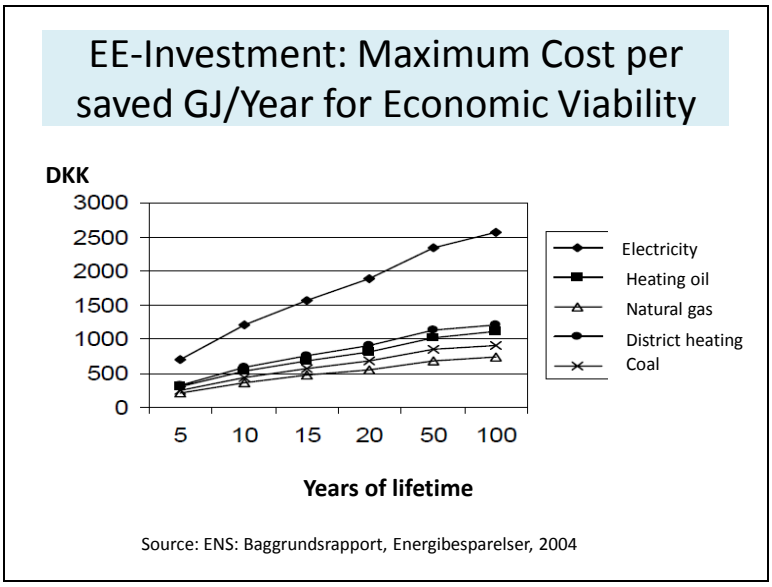


Figure 19: Impact of Type of Fuel and Lifetime of Investment on Economic Feasibility

The 2008 portfolio evaluation report, therefore, recommended the introduction of priority factors, e.g. multiplying GWh-savings by 0.5, 1 or 1.5 depending on the lifetime of savings, energy type and whether the addressed end-use is encompassed by the European Emission Trading System (ETS) or not. Priority factors were introduced in 2011: EE-savings with an estimated lifetime below 4 years are multiplies by 0.5, savings with a long lifetime by 1.5. For fuel switching projects special factors are applied.

The scheme *does not require that the reported energy savings must be additional*, meaning that they would not have been undertaken by the end-user also in the absence of assistance. However, adjustments are feasible to reduce the free-rider level:

- The energy companies try not to give investment subsidies to projects having a pay-back period less than a year.
- Some standard EE-technologies can not longer be counted in the energy saving estimate.
- The expected level of additionality (or free-rider probability) can be reflected in a priority factor for standard technologies.

Implementation/Costs

In line with the increase in the emnergy saving obligation, the cost of the scheme for the companies (and ultimately, its customers) has increased:

- The 2006-2009 scheme cost the companies around 300 million DKK (€40 million).
- The 2010-12 cost is around €100 million per year.

About 15 % of the annual cost, or €14 million is spend on the administration of the scheme covering quality control, reporting and advertisement of the scheme, not directly linked to individual projects. [22]

In 2010, on average, the energy companies spent 0,37 DKK/kWh saved during the first year (= 5 eurocents).

Monitoring and Evaluation

Savings are reported to the Danish Energy Agency bi-annually in a simplified format indicating:

- the *energy carrier*: district heating, electricity, natural gas, oil and other;
- *customer segment*: households, public and businesses and
- *method of calculation*: specific projects, standardised values and methods for campaign assessments.

The companies do not submit the *documentation for the individual projects,* how the savings are arrived at, *to the DEA*; but must keep the documentation for a period of five years. Each year, a sample is controlled.

The *cost of the activities* to the companies is not reported to the Danish Energy Agency. This information is monitored by the Energy Sector Regulator.

[22] Source: 2012 evaluation based on interviews with the largest energy companies.

Achieved Results

Registered savings

The registered energy savings of the scheme during the 2006-2009 period are recorded in the MURE database as shown in the tables 9 and 10.

Table 9: Energy Company EE Obligation: EE Savings by Sector 2006-2009

TJ	Household	Public sector	Industry	Total
Electricity companies	1,751	435	3,891	6,076
Natural gas companies	1,406	92	737	2,234
District heating companies	2,272	633	1,572	4,477
Oil companies	406	0	58	464
All energy companies	**5,835**	**1,159**	**6,258**	**13,252**

Source: MURE/Odyssse DK- 6 The Energy Companies' saving effort

A little less than half of the registered savings were in industry, around 8 percent in the public sector, a little above 40 percent in the household sector. The ranking of the companies in terms of achieved savings reflects the size of their respective customer base: the power distribution companies serve more customers than anybody else, and the district heating companies have more customers than the natural gas distribution companies and have higher annual revenue than the other distribution companies. The highest level of savings were achieved in the industry sector, because that is where the investments with the shortest pay-back periods are found.-

Table 10: Energy Company EE Obligation: EE Savings by Type of Fuel 2006-2009

TJ	District heating	Natural gas	Oil	Electricity	Other	Total
Electricity companies	472	1,894	756	2,791	164	6,076
Natural gas companies	22	1,331	508	373	0	2,234
District heating companies	2,695	659	580	435	108	4,477
Oil companies	0	0	464	0	0	464
All energy companies	**3188**	**3884**	**2308**	**3599**	**272**	**13,252**

Source: MURE/Odyssse DK- 6 The Energy Companies' saving effort

The savings per type of fuel are quite evenly distributed, with oil being the lowest at a level about two thirds of the other fuels: natural gas highest, then electricity and district heating.

Target achievement for energy savings

The energy companies reported energy savings of more than 100% of their obligation both for 2006-2009 scheme and for the 2010-2012 scheme (status end-2011). In the period 2006-2009 the obligation companies reported energy savings for a total of 13.252 TJ, whereas the objective was 11.650 TJ; the achievement ratio was thus 114 pct.

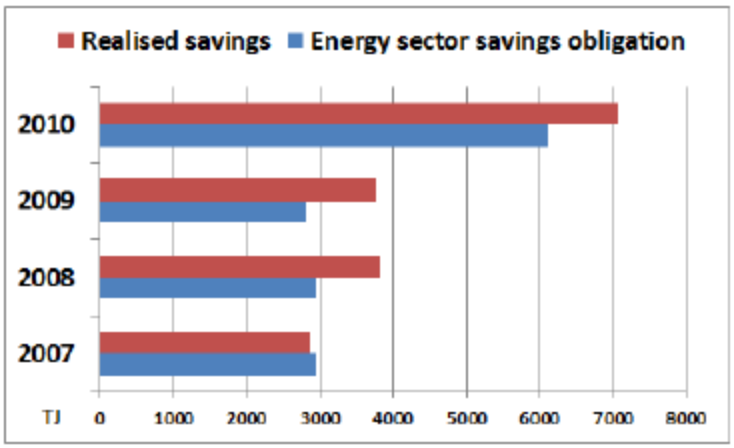


Figure 20:Realised savings versus obligation 2007 to 2010

Source: DongEnergy 2012

The chart below shows the evolution over time by final use. The *violet* area represents reported savings in "reduction in district heating system losses, solar heat supply to district heating networks, connection of dwellings heated by electricity to district heating". *Green* is savings in "business", *red* public sector, *blue* "households".

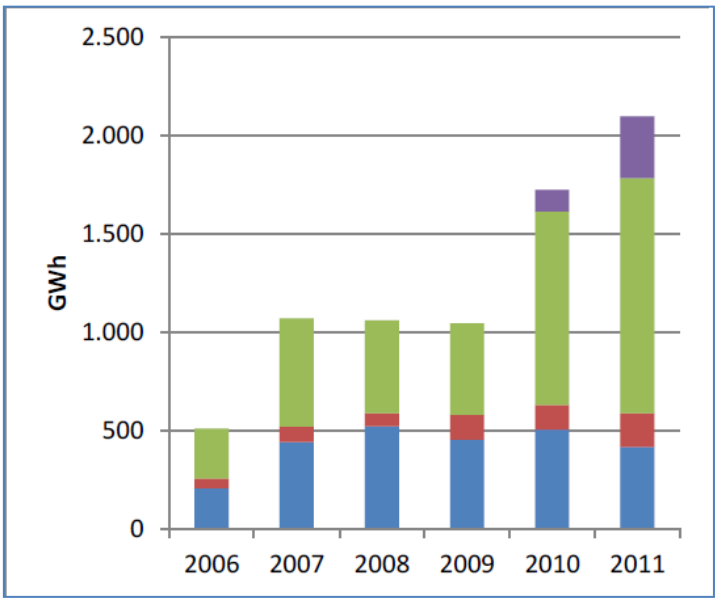


Figure 21: Annual Savings as reported to DEA by Energy Companies 2006-2011

Source: EA, NIRAS, Wiegand&Maagø (2012)

Impact on investment in EE

The money spent by users on supported investments is, on average, *twice the amount spent by the obligation* scheme. For businesses the ratio is about 1:1, for households about 4.

However, due to free-rider effects the *effective leveraging effect of "private investment" by the "public finance support of the scheme" is lower* than 2. As the annual obligation is expanded, the free,-rider effect seems to go up, and hence, the leveraging effect on private investment to go down:

- The portfolio evaluation in 2008 covering the results at that time for the 2006-2009 scheme, estimated that about 50 percent of the recorded savings at end-user level would not have been realized without the intervention of the energy company.
- The 2012 evaluation of the results at that time of the 2010-2012 scheme concluded reduced that the net additionality impact for household investments was around 20 percent of reported savings (60% of households reported that the support from the scheme had had no importance for their investment decision), whereas it was 45 percent for businesses.

This leads to the conclusion that the investment leveraging ratio for the 2010-2012 scheme is around 0.65.

Opening a market for EE-services

The annual investment supported by the 2010-2012 scheme amounts to 4 billion DKK (=540 million euro).

Financial value of annual EE-savings for customers

Based on the documentation of the scheme, the 2012 evaluation report and the Association of Danish Energy Companies claim that the investment generates around 7 billion DKK (=0.9 billion euro) in financial savings on energy the bill of customers.

Economic cost-benefit ratio of the scheme

The methodology used by the 2008 and 2012 evaluations is explained in the section at the end of this chapter on the portfolio evaluation. It includes as costs (i) the distortion cost of the scheme's financing (estimated at 15% of the financial volume) and (ii) the cost of the investment in EE. On the benefit side (i) the value of energy at market prices + (ii) environmental benefits. For supported business investments in EE, the cost benefit ratio was calculated as 0.5, and for household investments as 3, meaning the economic rate of return for the latter was negative.

Impact on Energy Consumption

The registered savings refer only to the savings during the first year after the investment. For the total impact the economic lifetime of the investment must be taken into account. The savings obligation in 2012 amounts to about 1,5 percent of the annual energy supply of the energy companies. If one assumes a lifetime of 10 years and that the impact net of the free-rider-effect is 35 percent, then a continuation of the savings obligation during ten years will lead to a reduction, at the end of the tenth year, of 5 percent of Danish energy consumption excluding transport.

Public Funding for Energy Research, Development and Demonstration

Background

In 2006, the energy technology industry employed 29,000 people, equal to 8 percent of the total employment in Danish manufacturing industry. It is an export-intensive industry with a higher export share than industry as a whole. In 2008, Danish exports of energy technology reached 64 billion DKK (8.6 billion euro), equal to 11 percent of Danish exports of goods and services, higher than the share in any other EU-country.

When the Danish Government in 1979 created a separate Ministry of Energy for the first time, the ministry had from the beginning an office for energy R&D&D with annual budgets to support activities at public research institutions and private businesses in accordance within areas of priority for energy policy. Danish industry was successful in exploiting early mover advantages in district heating, energy saving technologies for buildings and wind energy to build internationally competitive positions in these and in a number of other niche areas. Supply reacted to demand created by energy policy; the R&D&D support programs certainly helped to push where demand pulled.

From the start, energy R&D&D support had a particular focus on cluster initiatives: programs organized as collaborations between a diverse number of public and private sector actors, such as firms, government agencies, and academic institutions. From the early 1990s, cluster and resource area analysis became part and parcel of Government sponsored industrial analysis. The outcome has been the development of policies that promote public-private-partnerships in the whole product-to-consumer chain: from public-private co-managed and co-financed energy R&D-programs to joint public-private implementation of programs for EE&RE. The strategy was reinforced by the findings of Prof. Michael Porter's cluster research, which was published in the early 1990s and attracted considerable interest in Danish industrial policy circles.

However, the Council of Economic Advisors has been critical of the economic value of the energy R&D&D support programs since the late 1990s. The basic position of the Council is that support is tantamount to futile efforts at picking winners and that the creation of green industries does not promote more economic benefits than investments in alternative businesses. The Council makes a number of arguments. (i) General support to R&D&D provides superior results to sector/technology specific support. Private energy research does not have higher spillover effects (a positive externality effect justifying public support) compared to other private research.[23] (ii) Rates of return are not higher in the energy technology industry than the average in Danish industry. (iii) As Denmark has had high levels of employment since 1993, labor employed

[23] "An empirical analysis based on Danish data has been carried out to test whether there are higher spillover effects from private energy research compared to other types of private research. The analysis is carried out using an unbalanced panel containing information on research activities, use of labour, capital and value added for more than 1,000 Danish firms over the period 2000 to 2007. Spillover effects are identified using the so called direct production function approach, where a spillover knowledge pool enters directly into the firm's production function. That there are higher spillovers from private energy research as compared to other types of private research is rejected by the empirical analysis. Actually, the analysis suggests that external spillover effects from energy research may even be lower than the spillover effects from other types of private research. In that case the large earmarked subsidies to energy research have led to a relatively small overall social return as compared to general research subsidies not restricted to energy research only." Source: Economy and Environment (2011)

in the green industry would have found alternative employment if the green industry had not existed.[24] The Council prefers a rise in the CO_2 tax to create demand for clean energy technology and then let it to market forces to decide whether Danish or imported technology will be developed and used. The Council's analysis can be summed up as follows: "In general, Danish firms seem to have succeeded in developing and exporting energy technology over the past decade. This is confirmed by a relatively large number of (renewable) energy patents in total Danish patent applications. Furthermore, an econometric analysis of patent citations, based on the OECD's citations database, confirms that Danish (renewable) energy patents receive a relatively high number of citations. This indicates that Danish energy patents are of relatively high scientific value. However, since this apparent Danish success was initiated prior to the recent increase in public energy research appropriations, it can be argued that Danish firms have been fully capable of exploiting a growing market for energy technology without being granted a significant share of the public support for R&D."[25]

Influenced by such arguments, the liberal Government in power from 2001-2011 reduced public funding to energy R&D&D during its first years in office. But it soon changed its mind as can be witnessed in the chart below, which shows the development in public energy R&D&D funding from 2001 to 2010.

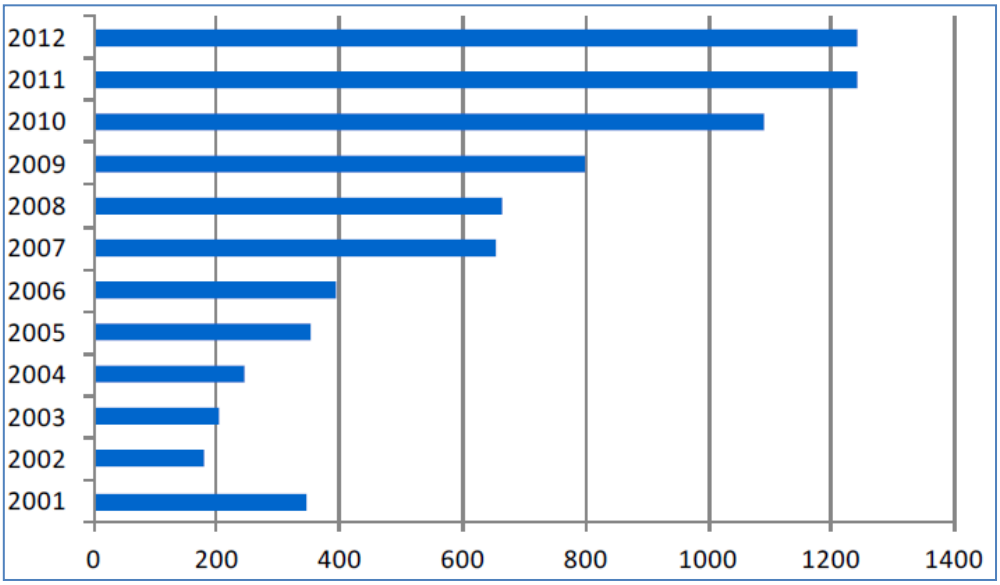


Figure 22: Public Budgets for Energy R&D&D 2001-2012

Following the decline in public funding for energy research in 2002, the budgets soon saw new increases. By 2005 the allocations had doubled over the 2002 level, the 2010 budget of 1 billion DKK (130 million euro) tripled the 2005 budget. But compared to the 1990s, there was a change in strategic focus: rather than funding more fundamental research, the additional funds were allocated to strategic energy research programmes directed towards R&D with an immediate commercial potential. The increase was primarily in additions to strategic energy research programmes that support research carried out in specific strategic

[24] "Even if selective public support for research in specific technological areas or industries contributes to a high level of exports, employment, and patents in the supported industries, one must keep in mind that without public support, labour and capital would have been used in other industries where they could potentially have generated even higher returns." Source: Economy and Environment (2011)
[25] Economy and Environment (2011)

areas. In contrast, funding for more basic energy research performed by universities and other research institutions did not increase correspondingly.

Consequently, the share of public energy R&D expenditure allocated to energy research programmes has increased from around 50 percent in the period prior to the mid-00s to around 90 percent in 2010

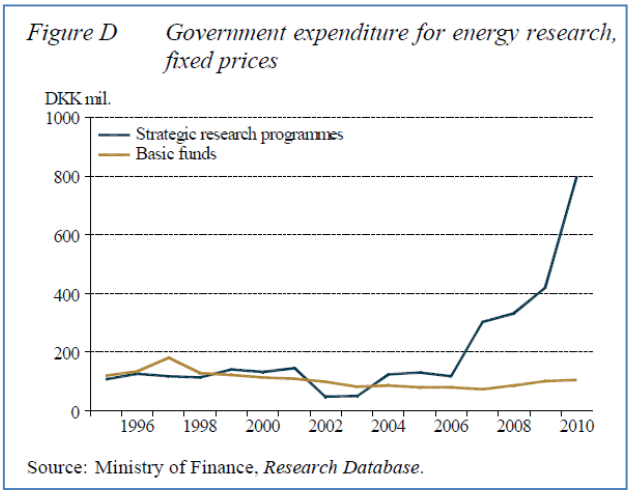


Figure 23: Government funding of basic and strategic energy research 1995 to 2010

Source: Energy & Environment 2011

Targets/Expected Outcomes

The long term objective of Danish energy policy is to phase out use of fossil fuels by 2050. By 2020, more than 50 percent of power generation is Denmark is to come from renewable energy. Both goals require massive technological progress in clean energy technologies.

Support to R&D&D is expected to help bring improved technologies to the market helping to achieve the energy transformation. The market success domestically and abroad of supported technologies is expected to lead to an increase in industrial value added and in industrial and overall employment.

For the ELFORSK program, the only R&D program specifically focusing on efficient use of energy, the success criterion for the program is saved kWh.

Targeted Agents/Coverage

Public research institutes and universities and private firms involved in developing and marketing new and improved clean energy technology.

Design

A number of public grant programs focus on energy technologies in various stages of development chain. The Strategic Research Council (DSF) appropriations target strategic energy research. Development and demonstration are covered by: the Energy Technology Development and Demonstration Program (EDDP), Labs Green DK, a program for environmentally friendly power generation, ForskEL and the only program for efficient energy use, ELFORSK. Programs putting special emphasis on market entry and penetration are: ForskVE (program for RE) and the Renewal Fund (a broad program, where energy is part of the effort).

Some broad R&D&D support programs include energy as a focal area: the Foundation, Green Development and Demonstration Program (GDDP), the National Programme for Research Infrastructure, the Council for Technology and Innovation and the Growth Fund.

The ELFORSK program is an applied-oriented R&D program for the efficient use of energy, which is administered by the Danish Energy Association. The budget is 25 million DKK (3.4 million euro) per year. The priorities for 2009 were: buildings, ventilation, lighting, cooling, power and control electronics, industrial processes, EE-behavior, barriers and tools.

Together the programs attempt to cover the development chain from basic research to initial market introduction. As can be seen in the chart below, the Government believes it has succeeded in the effort: the chart gives an overview of the public R&D&D programs in 2011 and which phases they are supporting.

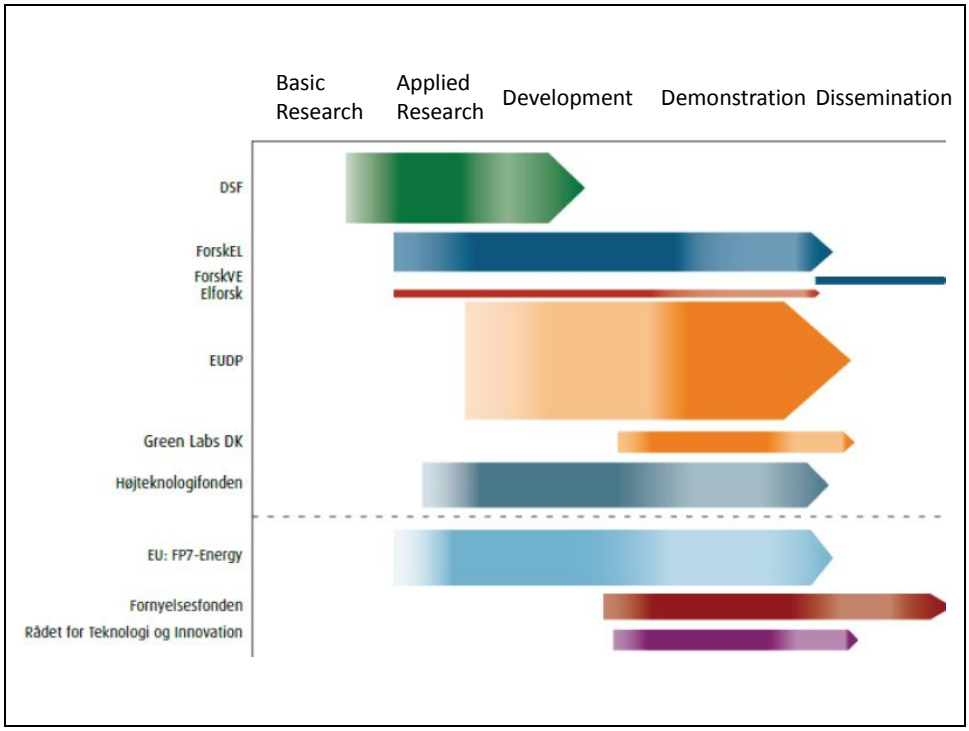


Figure 24: Public R&D&D support programs 2011 and R&D&D phases

Source: Ministry of Climate et al (2012)

Coordination between the programs is promoted through (i) the publication of a joint annual report listing all supported projects; (ii) joint annual 1 ½ days discussion meeting for the secretariats of the programs; (iii) publicly accessible data base for all supported development projects; (iv) horizontal research evaluations, (v) annual joint energy research day for presentation of key results.

Some programs get their funding from annual budget allocations. The programs managed by Energi.net, the Danish transmission company and system operator, are financed by a small levy on electricity consumption for PSO (public service obligation). Some are Trust Funds endowed with an initial allocation by Government.

For logical reasons, governance of these programs varies. But common for all is reliance on boards with strong private sector participation or expert committees for decision approval of applications for funding.

EUDP (the Energy Technology Development and Demonstration Program), for example, is housed within DEA but funds are awarded by an independent board; Energinet.dk's funds are awarded by Energinet.dk's board of directors upon the recommendation of external experts.

The reference framework to align funding with the priorities of energy policy is provided by research strategies defined for the following technology areas: bioenergy, wave energy, CO_2 storage, energy efficiency, geothermal, solar energy, wind power, biogas.

Due to the emphasis on commercial viability of received proposals, the eligibility criteria include private co-finance as a must in most projects. The private sector co-financing in the near commercial applications is now 50 percent on average. EDDP, for example, received during the period 2008-11 applications from 793 projects requesting grants totaling 5 billion DKK and offering self-finance of almost 5.4 billion DKK (720 million euro).

The average grant size of the Strategic Research Council is 20 million DKK (2.7 million euro); the average commitment of EDDP for the 2008-2011 period was 5 million DKK (0.7 million euro). The average covers commitments of varying size from large scale demonstration projects to very small grants for international cooperation.

Implementation/Costs

The public sector budget for R&D&D amounts to about 1 percent of GDP; private R&D&D finance amounts to an additional 2 percent of GDP. The 1 billion DKK (130 million euro) of total public funds for energy research represent 7-8 percent of the total public research funds; the share corresponds to OECD average during the last 20 years.

Monitoring and Evaluation

There has been no shortage over time: by the individual programs separately, overall by DEA, by the Ministry of Climate and Energy, by the Ministry of Research, by the Council of Economic Advisors and by the industry association Danish Energy.

Not surprisingly, in view of the above description of funding sources, the evaluations found that the system is characterized by many "little boxes" that are not functioning optimally together. There is insufficient coordination among schemes and applicants find it difficult to "navigate" between these. Also, as can be seen in the evolution of the budget from 2001 to 2012, there was considerable instability in funding over a longer period of time; "stop-go" funding, as is well-known, is not conducive to rational use of research resources. Critique was also raised against insufficient coherence in the chain, from basic to applied research although efforts were made to cover gaps.

The lessons learned from ELFORSK, the support programme for EE-R&D, were that the best results occur:

- when research teams from manufacturing companies are involved, the team has a broad mix of competences, and there are large differences in team members' educational and experiential background;
- starting up a project with a groundbreaking and visionary scope motivates project participants and results in better outcomes;
- when the project operates in areas where there is already a strong R & D environment, where there is a good overview of what has been done previously and there are strong Danish manufacturers of high international level.

Achieved Results

To be able to assist the achievement of clean energy objectives and to fulfill the industry policy and employment objectives, the supported research must lead to patentable products. The Ministry of Science's "Research Barometer," from 2009, shows how Denmark compares for certain patent categories of energy with the OECD average. It shows for EE-technologies that Denmark is significantly above the OECD average in "lighting" and that the "engines", "pumps" and "heating" is also above average. By contrast, the "electricity" is below OECD average. Since the bulk of public R&D support is spent on RE-technologies, the effective of the support programs in term in terms of outcome is best judged by looking at RE-patents. The chart below compares the number of patents per 1 million inhabitants in Denmark, USA and EU.

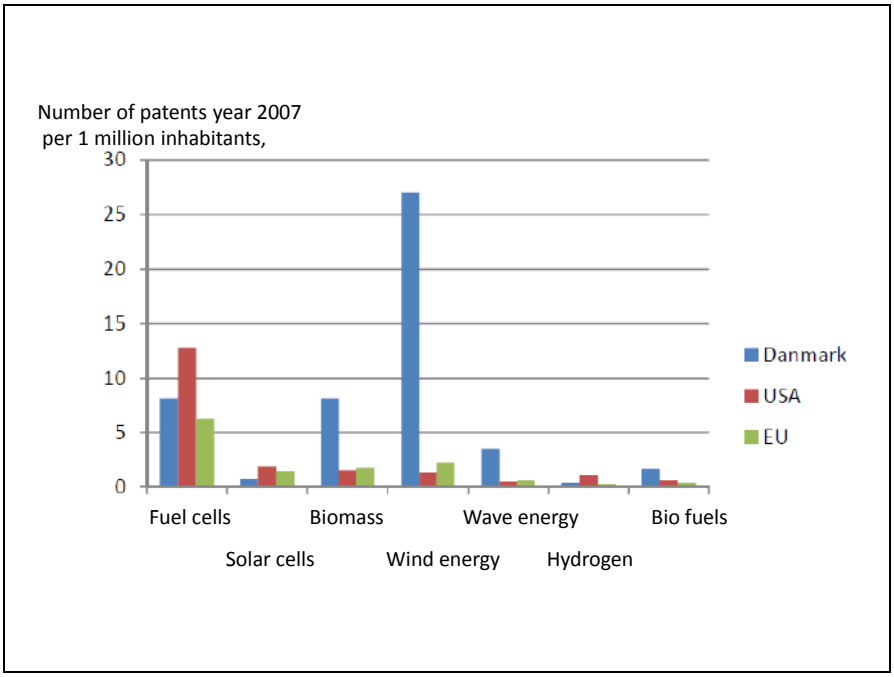


Figure 25: RE-Energy patents Year 2007, USA, Denmark, EU

Source: CEBR (2009)

The chart shows that the areas of comparative strengths are wind energy, biomass, wave energy and biofuels. In fuel cells the performance is above EU-average. In hydrogen and hydrogen it is below average.

To what extent companies were able to get technologically in front can be seen by the prices they attract on export markets. To fulfill the industrial policy goals energy technology of high quality most be promoted, which is capable of charging prices on export prices that are higher than the average for the product category. The chart below shows the share of Danish energy technology exports, which are made up of "up-market", "medium" and "low" products. "Up-market" is defined as products achieving prices more than 15% higher than the average for the category; "low" is defined as products being paid a price more than 15% lower than the average price.

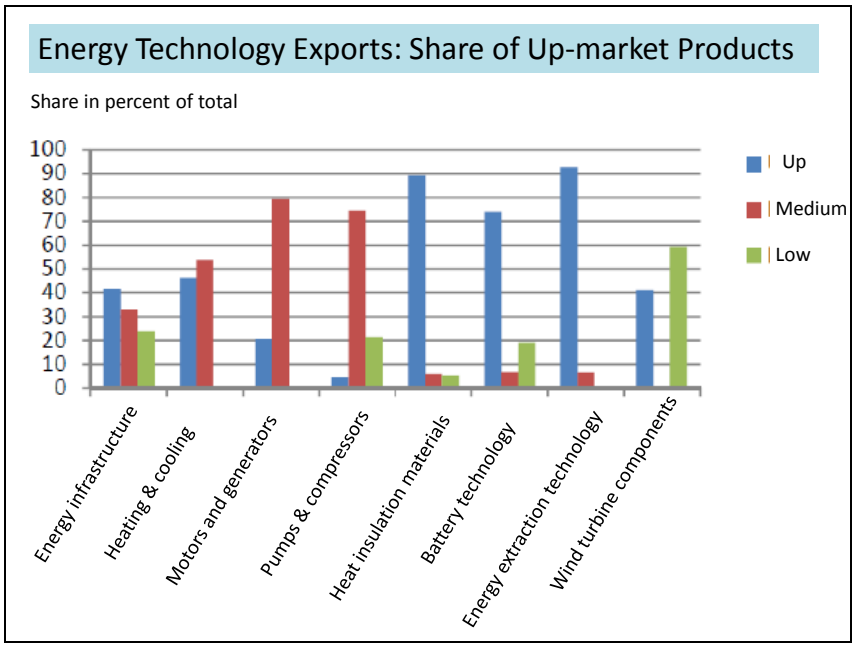


Figure 26: Up-market, medium and low products in energy technology exports

Source: Source: CEBR (2009)

The chart shows strong performance in terms of up-market shares for heat insulation materials, battery technology and energy extraction technology.

From 2000 to 2011, exports of Danish energy technology increased by 140 percent; the average for EU-15 for the same period was 80 percent.

Impact on Energy Demand

Not applicable. No direct link can be established.

Portfolio Evaluation of Danish Energy Policy Measures

Background

A comparison of the National Energy Efficiency Action Plans as required by the EU Directive 2006/32/EC on energy end-use efficiency and energy services was carried out in June 2009. (EU NEEAP Assessment 2009). The comparison shows that only three of the analysed 27 EU member states choose not to make use of grants, soft loans and tax rebates to achieve EE, namely Denmark, Estonia and Latvia.[26]

A political agreement from 2005 stated that an evaluation of the entire Danish EE policy portfolio had to be carried out before the end of 2008, with the findings put forward for discussion among governing parties no later than February 2009. The evaluation was to assess the following: (1) Is the policy portfolio sufficient to meet the energy efficiency targets? (2) Do the policies enable the national goals to be met in a cost-effective manner? (3) Is the overall design of the policy portfolio appropriate? In short, the purpose was to assess whether the current measures were sufficient and whether their organisation was efficient.

There were, at the time of the evaluation in 2008, ten major EE-policies in Denmark, see the Table.

Table 11: Ten EE policies evaluated in the 2008 portfolio evaluation

Table 2 The coverage of the ten policies across end-user sectors

	Energy efficiency policies	Distribution of the annual target in the 2005 agreement (PJ)	Residential sector	Public sector	Private business sector	Energy intensive industry
1	EU CO_2 emissions trading scheme	n.a.	X	X	X	XX
2	Energy taxes	n.a.	XX	XX	X	
3	Energy efficiency obligations for energy companies	2.95	XX	XX	XX	XX
4	Energy labelling of buildings	0.5	XX	X		
5	The Electricity Saving Trust	0.6	XX	XX		
6	Building codes	1.75	XX	X	X	
7	Energy labelling and standards for appliances	0.4	XX			
8	Directives on energy savings in the public sector	0.5		XX		
9	Energy efficiency agreements with industry	0.5				XX
10	The energy saving programme (subsidy to NGOs)	n.a.	XX			

n.a. not available, *XX* the sector is fully covered, *X* the sector is partly covered by the policy

Source: Togeby, et al (2008)

The "X" in the table indicate the sectors that are affected by a measure. The residential and public sectors are covered by more schemes than the private business sector and energy intensive industry.

In 2007, approximately 86 million euros were spent on the three main policy measures to promote EE:

- 40 million euros for the activities of the energy companies (paid by all endusers),
- 32 million euros for energy labelling of buildings (paid by those acquiring the label),

[26] Source: Togeby, Bach et al.. (2011)

- 14 million euros for the Danish Electricity Saving Trust (collected by a special tariff on electricity for households and the public sector).[27]

Targets/Expected Outcomes

The political agreements from 2005 to 2008 fixed future targets for final and gross energy consumption:

- Final energy consumption (excluding transport and non-energy purposes) is to be decreased 1.7% per year on average between 2006 and 2013 by 2013.
- Gross energy consumption is to be decreased 2% by 2011 and 4% by 2020 relative to the consumption in 2006.

The objective of the review was to contribute to the strengthening and further development of the Danish energy saving activities by providing recommendations after answering the three evaluation questions:

1. Will energy policy targets be reached?

2. Are the energy efficiency policies cost-effective?

3. Is the portfolio design appropriate?

Targeted Agents/Coverage

The portfolio review looked at all EE-policy measures. But the main focus was on three schemes: EE obligations for energy companies, energy labelling of buildings, the Danish Electricity Savings Trust.

Design

Organisation of the evaluation

The contract for the evaluation was tendered; a *consortium of consulting firms* won the contract.

The *steering group for the evaluation* was composed of three independent researchers from academia, each of them experts within their field (evaluation theory, economics and energy systems) and two representatives from DEA. The presence of independent researchers in the Steering Committee provided the evaluation team with independent professional sparring (feedback) and ensured a high-quality evaluation was undertaken.

The work of the consultants was provided through four work packages: (i) Description of the ten EE policy measures, including a critical review of existing reporting, documentations and evaluations. (ii) A qualitative comparative study of EE policies in Denmark, Finland, Norway, Sweden, Austria, Italy, Netherlands and Spain. (iii) A quantitative comparative study of trends in energy consumption in Denmark, Finland, Norway, Sweden, Austria, Italy, Netherlands and Spain. Data from the EUdata base ODYSEE was used. (iv) Evaluation of each policy measure, with original empirical data collection for selected policies.

Methodology for calculating cost-effectiveness

The core of the evaluation was to assess the cost-effectiveness, ie. the relationship between the costs and the benefits from energy savings. In the context of a social assessment of instruments to promote energy

[27] Source: Togeby, Bach et al.. (2011)

conservation, it is essential to get information about the additionality effect of energy saving activity: the extent energy savings resulting from or accelerated by the instrument. If the value of the additional energy savings are greater than costs, the instrument is economically efficient for society.

The assessment of the cost-benefit effectiveness of the measures used the conventional approach supported by the Ministry of Finance.

The *cost side* includes (i) user incremental costs in EE-investments and EE-O&M, (ii) instrument costs (the costs are directly applied by the activity to save the activity, eg for information activities and for scheme administration) and (iii) economic costs. The latter, in the methodology, include a "tax distortion factor" of 20 per cent of Government revenue spent on the instrument to account for that public spending gives rise to secondary welfare losses. The argument is that the spending creates a "hole" in the public budget, which creates a need for new funding, which is ultimately likely to increase the marginal tax rate and that the effect of this to reduce labor supply. This creates distortions in the economy, and the cost associated with this distortion is called "tax loss".

On the *benefit side*, the socio-economic energy price (value of saved energy) includes environmental impact (CO2. SO2, NOx) but not fuel security.

Implementation/Costs

Information on the cost of the evaluation nit available.

Monitoring and Evaluation

Not applicable for the evaluation itself.

Achieved Results

The response to the first question was negative: the evaluation concluded that the Government could not reach its EE-targets with the existing portfolio of instruments. The evaluation showed that the impact of the evaluated policies is not as high as expected and that the target for final energy consumption for 2013 will not be reached with the current policy portfolio except in the case of considerable economic recession and high energy prices. The DEA in its policy assumptions – and also the projects in their reporting - assumed full energy savings effect, whereas the evaluation showed that there is a additionality effect of around 50% for energy companies' activities and a very limited impact from energy labeling of buildings. DEA also assumed also that energy conservation efforts give rise to spillover or market transformation: that promotion of energy saving activities to one audience has an effect that spreads to other consumers. For example, by stores beginning to bring in more efficient appliances, which give other users the opportunity to buy these. The extent of such spillovers, however, can be exceedingly difficult to document.

The evaluation gave recommendations on how to improve and develop the portfolio, mainly using cost-effectiveness as criteria.

The socio-economic cost-effectiveness of the evaluated policies was deemed positive for all instruments except one: labeling of buildings, which had a cost-benefit ratio of 15:1. As a stand-alone measure, labeling is not worth its costs.

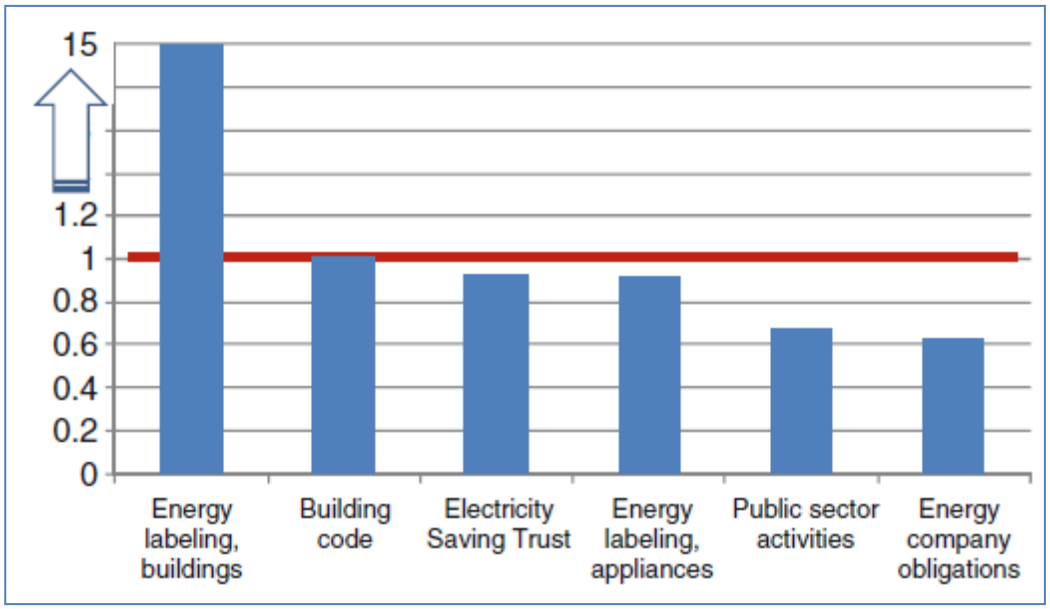


Figure 27: Socio-economic cost-benefit ratios for EE policy measures, 2008

Source: Togeby et al (2008)

Concerning the *composition of the portfolio* the evaluation noted that the various energy saving activities were developed over a period of time as responses to very different challenges and under different conditions. As a result, the coordination between the various activities could be improved. In addition, thanks to its broad perspective, the evaluation found that the policy instruments prioritized the commercial and industrial sectors less than the household and public sectors.

The evaluation provided insights on the value of proper M&E.

First, it reinforced the critiques made in earlier evaluations of individual instruments that practices in relation to the *documentation and evaluation of policies* had to be improved. Documentation of results and of total costs was too imprecise in most reporting. There was a need for better market data and better data for assessing the organization's ongoing effects. A number of schemes had too little focus on systematically documenting their effect in terms of realized energy savings. This applied in particular to the energy companies scheme, the Electricity Saving Trust, and energy labeling for buildings. The evaluation recommended that annual reporting of evidence of actual, tangible energy savings had to become a natural part of the schemes. Each year, the costs and documented energy saving effects had to be described for all schemes.

Secondly, it concluded that both *portfolio evaluation* and *more focused evaluations* have their justification and complement each other:

- The strength of the portfolio evaluation is that it can assess appropriateness of the relative weight of individual policies as well as their possible synergies and overlaps.
- Focused evaluations on the other hand can provide more detail relevant to optimising the individual policy

Impact on energy consumption

The recommendations made by the authors contributed to the implementation of new taxes for the commercial and industrial sectors together with the reform of the Electricity Saving Trust to a Centre for Energy Savings charged with energy savings within all sectors, except transport

EE Improvement Measures Implemented in Industrial Sector

Evolution of EE in Industry

Industry includes mining and quarrying, manufacturing, and construction. In 2007, *manufacturing* accounted for more than 90% of the sector's energy consumption and for 72% of the gross value added in the sector.

Of all sectors, industry has the highest economically/financially viable potential for EE. It is well-known, however, that the accepted maximum pay-back periods for EE investments in industry are in the range of 3 to 5 years. A report published in 2010, analysing the 11 most frequent final energy uses in industry, concluded that:[28]

- 10% of energy consumption could be saved if all investments with a payback period of up to two years were implemented;
- 15% of energy consumption if payback periods of 4 years were accepted;
- 32% if the payback periods up to 10 years were accepted.

The *green tax reform of 1996*, expanded the CO_2-tax regime introduced in 1992, and was accompanied by the introduction of the *Voluntary Agreement* scheme. The two policy measures formed an intertwined package: industries who enter an agreement receive a rebate on the green taxes. It makes no logical-practical sense to analyse the two measures separately. Therefore, this report analyses the reforms as one integrated package of measures.

From 1990 to 2007, the *energy intensity* in *industry* fell from 0.087 toe/1000 €2000 to 0.071 toe/1000 €2000 or by 18.0%, the *electricity intensity* fell from 269 kWh/1000 €2000 to 247 kWh/1000 €2000 or by 8.3%. The evolution can be sub-divided into three sub-periods: (i) The sub-period 1990-93 saw an increase in energy intensity and in electricity intensity (partly due to a continuation of a shift from fossil fuels to electricity). (ii) From 1993 to 2000 both energy intensity and electricity intensity decreased. (iii) From 2000 to 2007 neither energy intensity nor electricity fell significantly: after an increase up to 2005, they had decreased again by 2007.

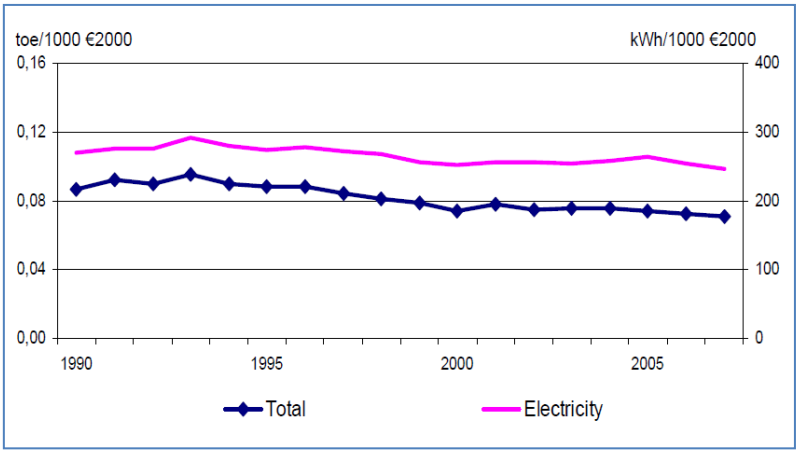


Figure 28: Energy and electricity intensities in industry

Source: Odyssee/DEA

[28] Source: EA & Viegand & Maagøe(2010)

The chart below relates the difference in the EE-performance of manufacturing industry during the 1993-2000 and the 2000-2007 periods to major changes in EE policy instruments:

- From 1993 to 2000 actual energy intensity decreased by 22%, from 2000 to 2007 by 4%.
- From 1993 to 2000 constant structure energy intensity decreased by 15.5%, from 2000 to 2007 it increased by 1.6%.
- The development in ODEX, on the other hand, was similar: 1993 = 112, 2000 = 100, 2007 = 90.

Judging from the difference between the 18% decrease in actual energy intensity and the 5% decrease in constant structure energy intensity, *changes in the structure of manufacturing* seem to account for a remarkable 73% of the reduction in energy intensity from 1990 to 2007.

EE-Measures for Industry in the MURE Data Base

The MURE database lists three measures for the industrial sector.

1. Agreements on energy efficiency between DEA and industry since 1996 (M)
2. Green taxes on energy use in Industry since 1996 (M)
3. Emissions Trading Registry since 2005 (H)

The *Emissions Trading Registry* is an institutional prerequisite for Denmark's participation in the ETS; not an instrument with an independent impact on energy efficiency. Therefore, it is not discussed in this report.

Instead, this report reviews another measure:

4. The subsidy scheme to investments by businesses in EE and in fuel switching which existed from 1993 to 2001

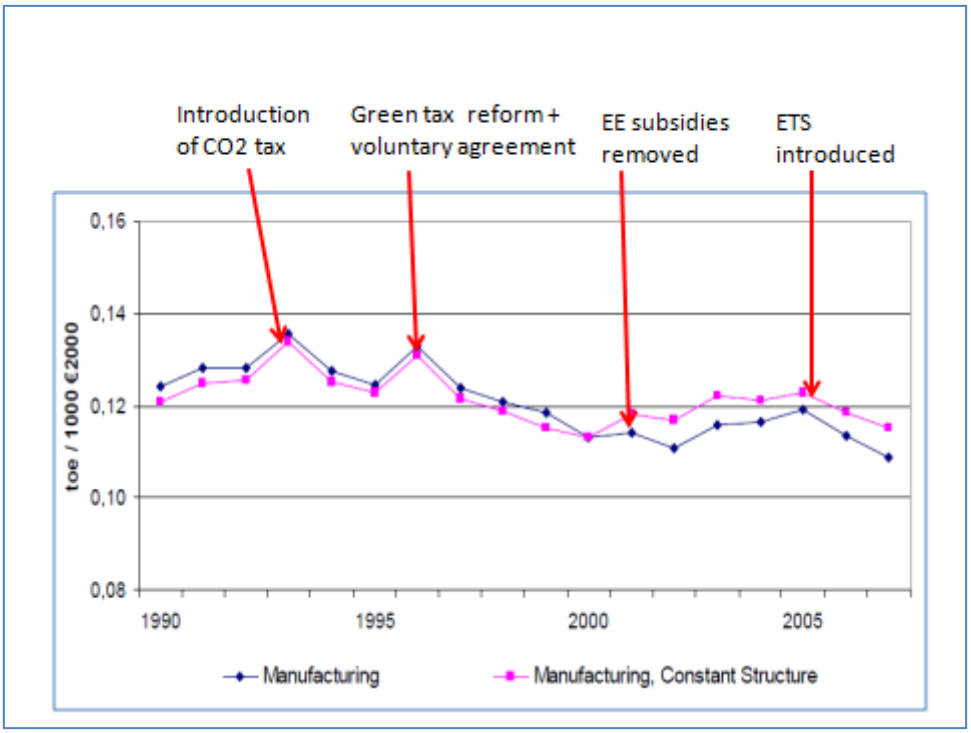
Subsidies to investments in CO_2 reductions in industry

Background

The grant scheme for investments in the reduction of CO_2-emissions in industry was introduced in 1993 and ended in 2001. It was administered by the DEA. The grant scheme received an allocation of 600 million DKK (81 million euro) for the 1993-1995 period. In 1996, in connection with the adoption of the green tax package and the Voluntary Agreement scheme, 1.8 billion DKK (240 million euro) were allocated for the 1996-2000 period. Being an instrument for CO_2-reductions, the scheme supported both EE as well as industrial fuel switching to natural gas.

During the 1990s, the industrial energy-, CO_2- and SO_2 tax rates had been increasing. This made investments in EE-investments financially more attractive. The voluntary agreement scheme provided energy and CO_2 tax rebates to participating companies, reinforced the incentives for EE-investments. The Government assumed that this eliminated the need for direct EE-investment subsidies. The elimination of the scheme was also due the decision by the Government to support only CO_2-reduction initiatives having a shadow price of less than 250 DKK (34 euro) per ton saved CO2; the shadow price for the scheme was in 2000 calculated at 400 DKK (54 euro).

1.



2. Figure 29: Final energy intensity in manufacturing

However, the direct EE-investment subsidies reappeared already in 2005, but this time under the obligatory energy savings promotion scheme for energy distribution companies. Since 2005, the energy companies give a steadily increasing share of the financial support to their clients in the form of investment subsidies; the majority of these to industry.

This development indicates a need for investment subsidies as a supplement to the economic incentives provided by the green taxes if the Government's energy saving targets are to achieved in industry.

In 2013 a new *subsidy scheme for the greening of industries* will supplement the green tax package. Some 33 million euro will be made available for 2013 fiscal year and from then on twice the amount in subsidies to promote the *use of RE in process industry*. However, roughly 20% to 25% of the amount is expected to be spend on EE-measures linked to the introduction of RE.

Targets/ Expected Outcomes

It was assumed that the 1996-2001 scheme would generate savings of 0.1 PJ/year in 1996, increasing to 4.5 PJ in 2001, after which the savings were kept at that level until the end of the technical-economic lifetimes of 15 years. These targets do not take into account the free-rider effect, assumed to be around 25 percent. The 4,5 PJ target amounts to 2.7% of Danish industry's[29] energy consumption in year 2000. Inclusion of trade and industry in the denominator reduces the percentage to 1.8%. Total energy consumption in Denmark in 1998 was 640 PJ.

[29] Not including trade and service industries

Targeted Agents/Coverage

All Danish businesses outside the public sector.

Design

Companies applied to the DEA for grant support.

Grants were given to investments in EE technologies, industrial cogeneration, R&D&D projects, EE-advise to companies and EE-information. Eligible projects can be divided into the following categories: individual projects, standard solutions cogeneration projects, development test and demonstration projects and other projects. The subsidy rate depended on the type of project as well as on EU competition rules on corporate size, as there were more grant opportunities for small and medium enterprises (SMEs).

- Individual projects with simple payback periods of between two to nine years and leading to CO_2 reductions of more than 0.15 kilo/year per invested DKK (13 eurocents) - in 1999 increased to 0.20 kilo/year - could receive up to 30 per cent grant support. Only projects receiving more than 100,000 DKK (13,000 euro) in grant support could apply**.**
- Industrial cogeneration was supported as individual project with a subsidy rate up to 40 per cent.
- Certain standardized types of investments, some 40 standard solutions, could receive grants up to 26 per cent.
- Grant for research & development, pilot and demonstration projects was determined individually taking into account the EU's rules.
- For some general information projects, there was potential for up to 100 percent grants

The 1993-95 scheme had a maximum grant limit of 10 million DKK (1.3 million euro). Due to the wish to promote investments in cogeneration, the limit was eliminated in 1996. The lower limit raised to 10,000 DKK (1,400 euro) in 1996, was after protests from small companies reduced back to the original 2,000 DKK (240 euro).

Implementation/Costs

The administrative costs for DEA amounted from 10 to 20 years per year, increasing with the amount if applications. The administrative costs per application for the businesses were estimated at 540 euro in 1994-prices. The awarded grant payments amounted to 2.7 bio DKK (360 million euro).

Table 12: Costs and Impact on energy consumption of subsidies to EE in industry 1993-2001

	Grant	Investment	O&M/Year	Fuel savings and fuel switching
	mio DKK	mio DKK	mio DKK	TJ/first year
1993	18	48	8	48
1994	118	307	8	301
1995	206	540	8	519
1996	201	528	16	498
1997	345	906	17	837
1998	447	1178	17	1067
1999	575	1512	17	1343
2000	407	1064	13	926
2001	375	974	9	831
1993-2001	2692	7057	113	6307

Source: DEA (2005)

Monitoring and Evaluation

Official evaluations of the subsidy scheme were carried out in 1999 by the Ministry of Finance as part of an overall evaluation of the costs and benefits of Danish energy policy instruments. Similar exercises were carried out by the Council of Economic Advisors in 2002 and by DEA in 2005.

Achieved Results

Annual applications for grants increased from 2,800 in 1996 to more than 7,000 in 1998.

The supported businesses invested 7.1 billion DKK (750 million euro) in EE and fuel switching.

Impact on CO_2 emissions

The 2005 evaluation estimated the savings from 2001 onwards at 1 million tons CO_2 per year, including for the crucial 2008-2012 "Kyoto" period. Danish CO2 emissions average around 52 million tons per year during the 1999-2007 period. Compared to these, the scheme reduced emissions in Denmark by 2% before correction for free-rider effects.

Green Taxes combined with Voluntary Agreements with Industry

Background

The *Green Tax Package* in 1996 increased the CO_2 tax on trade and industry and expanded taxation on industrial energy to include also an energy tax on space heating and a SO_2 tax.

In order not to increase the overall tax burden on trade and industry, the additional revenues from the green taxes were be recycled to these sectors by reducing the employers' non-wage costs for labour. Since such transfers as a stand-alone compensation would disadvantage the energy-intensive industry over the trade sector, the green taxes were supplemented with the *Voluntary Agreement* (providing CO2 tax reduction) and an associated *subsidy schemes for EE-measures*.

Targets/ Expected Outcomes

The Voluntary Agreement (VA) 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.

The expected reduction in EE of the individual measures in the package was not quantified. Only the contribution of industry to the 2005 CO_2 reduction objective. The VA and subsidy scheme were expected to jointly reduce the Danish CO_2 emissions by 1.8% (-1.1 million tones CO_2) for 1996-2005.

Targeted Agents/Coverage

The green tax reform targets all businesses. The VA targets energy intensive industry, representing roughly 50 percent of industrial energy consumption. Only energy-intensive companies can enter a VA. A company

can be classified as energy-intensive if: (i) the company carries out one or more heavy processes identified on a "process list" (among others production of cement, paper and condensed milk) or (ii) the company has a green tax liability of more than 4 per cent of value added. Since the introduction of the ETS, the VA is primarily for companies in the non-ETS sector.

Design

The package is composed of different components, each addressing a particular *market failure*.

- The CO_2 tax addresses *misplaced incentives* in industry: unless external costs for CO_2 emissions are accounted for by industry, companies have relatively weak incentives for improving EE.
- The combination of sticks and carrots raises *awareness* at management level lifting EE-investments higher up in the hierarchy of investment priorities.
- The voluntary agreement scheme addresses company-level barriers in the form of *lack of information* through its requirement for an energy management system.
- The *competitiveness* issue is addressed by: (i) increasing the tax rates gradually, thus giving companies time to improve energy efficiency and switch to fuels with lower emissions; (ii) applying differential tax rates depending on the use of energy, thus lowering rates for energy-intensive production and (iii) redirecting the additional tax revenue from the Green Tax Package directly to trade and industry (and through the lowering of industry's labor market contribution).

(i) The CO2- tax on industry

Gradual phasing in

The CO_2 tax took effect from 1992. Industry obtained concessions permitting a low rate of about 4 euro per tonne CO_2 during the first years of the tax. A more comprehensive taxation (including also the 'energy tax') was phased in for industry from 1996 with the green taxation package. The tax rates varied according to type of use and according to whether or not the company had signed a voluntary agreement with the DEA.

Table 13: Energy and CO2 tax rates for industry in 2001

TAX LEVELS

	Heavy Process		Light Process		Space Heating	
	With Agreement	Without Agreement	With Agreement	Without Agreement	With Agreement	Without Agreement
Energy Tax (The full tax is 6.8 euro/GJ)	0%	0%	0%	0%	78%	100%
CO_2-Tax (The full tax is 13.4 euro/ton CO_2)	3%	25%	68%	90%	78%	100%

Source: DEA (2002b)

The CO_2 taxes were introduced gradually from 1996 and 2000 to give companies time to improve EE, switch to fuels with lower emissions, enter agreements, etc. From 1996, the standard rate for light industrial

processes was set to 7 EUR and then gradually increased to 12 EUR per ton CO_2 in 2000, or 90% of full CO_2 tax rate.

YEAR	1996	1997	1998	1999	2000	2001
Heavy process – no agreement	0.7	1.3	2.0	2.7	3.4	3.4
Heavy process – with agreement	0.4	0.4	0.4	0.4	0.4	0.4
Light process – no agreement	6.7	8.0	9.4	10.7	12.1	12.1
Light process – with agreement	6.7	6.7	6.7	7.8	9.1	9.1
Space heating	13.4	13.4	13.4	13.4	13.4	13.4

Figure 30: CO2 taxes in euro per ton

Source: DEA (2002a)

Electricity taxed differently than fuels

Until 1995, industry was exempt from *taxes on electricity;* both the CO2 tax and the energy tax on electricity could be deducted via the VAT accounts. The CO_2 tax rate applies uniformly to the fossil fuels employed by industry according to CO_2-content. Fuels used to produce electricity are exempt from carbon and energy taxes. Instead, a CO_2 tax is levied on electricity consumption. As see in the chart, the tax rate was increased gradually, doubling from 2006 to 2001 to 1.3 eurocents per kWh; equivalent to about 30 euro per ton CO_2.

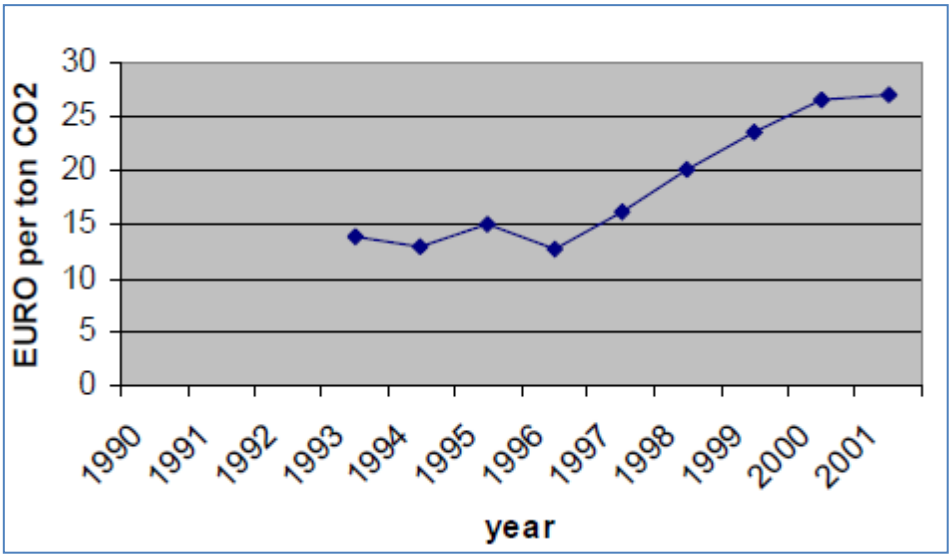


Figure 31: CO2 tax on electricity 1993-2002 (year 2000 constant price)

Source: Nordic Council (2006)

Higher taxation of energy for heating than for process heat

Energy used for heating in industry is subject to the same tax level as households, about 80 euro per tonne CO_2.

Lower rates for process energy in energy intensive industries

For a predefined list of energy-intensive industries, a lower rate of 3.3 EUR per tonne CO_2 applies for specific process purposes.

A general clause allows any industry to benefit from agreed reductions, if the tax burden exceeds 3% of value added.

Adjustment caused by ETS:

Due to the start of the ETS from 2005, Denmark passed a CO_2 quota law in 2004. The law removes the CO_2 tax from the *process energy to which the ETS* applies. *Electricity consumption* and *fuels used for space heating* are still levied a CO_2 tax.

(ii) Energy tax (not including NOx, CO2, SO_2 taxes)

Until 2010, energy taxes on energy used in production processes (except for a small part of the electricity tax) were fully refunded by the Customs and Excise Department in combination with the collection of VAT.

No refunds are given for energy used for what is defined in the law as "space and water heating": "household type" energy consumption, such as the heating of rooms and the heating of water used in bathrooms and in kitchens.

Since 2010 the tax refund is reduced. But, the refund in 2012 still amounts to 87 % of the energy tax on process energy.

There are no energy taxes on space heating based on bio fuels and renewable energy.

No refunds are paid for NOx and SO_2 taxes.

(iii) Voluntary agreements

All companies with *heavy processes* are eligible to enter a voluntary agreement with the Danish Energy Agency (DEA). About 30 industrial sectors, responsible for one third of industrial energy consumption, are included on the energy-intensive list. Companies with *light processes* can enter a VA if the company's tax on energy use exceeds 4% of the company's value added. In return for obtaining a CO_2 tax rebate, the VAs obligate the companies to implement all "profitable" energy savings projects, defined as projects with payback periods of up to four years, as identified in an energy audit or through internal investigations. In addition, companies must introduce energy management and motivate staff to ensure that investments in new equipment are energy efficient.

The VAs are signed for a three-year period. There are two kinds of agreements: individual and group agreements. Group agreements are specially designed for companies with similar processes, products or energy consumption patterns. Businesses such as structural clay products manufacturers and greenhouses have used this type of agreement.

The VAs contain four key elements which form the basis for the EE activities, which the companies are required to undertake in return for tax rebates and EE-investment subsidies:[30]

- the energy management system

[30] Se ….

- the energy audit/energy flow screening

- the special investigations focusing on improving energy efficiency of the core/primary production

- investments in energy saving projects.

In order to enter a VA the company must implement an *energy management system (EMS)*. The purpose of the EMS is to ensure that energy savings achieved in daily operations can be maintained, that intervention takes place in cases of inefficient operations and that new possibilities for energy efficiency are continuously evaluated. In addition, the EMS comprises guidelines on energy efficient procurement.

In the pre-2002 scheme, the *energy audit* played a central role. The purpose of the energy audit was to identify all "profitable" energy measures, which the company then was obliged to undertake. In heavy processes, "profitable" referred to energy efficiency measures with a payback period of less than four years. In light processes "profitable" was defined by a payback period of less than six years. The payback period is calculated based on energy prices including taxes in the absence of an agreement. The energy audits were conducted by authorized energy consultants or by company staff. In any case they had to be verified by an independently certified organization.

The obligation to do an energy audit before signing a VA was removed in the revised scheme, which came into force in 2002. Instead of the energy audit, the participating companies must now do an *energy flow screening* covering the most energy-intensive parts of their production process. The purpose of the energy flow screening is not to identify profitable energy saving projects, but to identify areas or parts of the production process that are relevant to study further in a special investigation.

The *special investigations* supplement the energy audit/ energy flow screening and EMS. As part of their agreement companies must carry out a number of special investigations focusing on specific areas of their primary production processes. The aim of the investigations is to determine the possibilities of improving the energy efficiency of the process concerned. An agreement typically includes between two and five special investigations. Their purpose is to identify energy saving projects. In the pre-2002 scheme, the special investigations mainly concerned complicated processes that were not covered in the energy audit. In the post-2002 scheme, these investigations focus on the core processes of the company. In the case of a collective agreement, the special investigations are co-ordinated between the companies.

All profitable *energy saving projects* generally have to be carried out. In the pre-2002 scheme, all profitable energy saving projects identified in the energy audit were to be listed in the VA. If no profitable projects were identified, the company was considered to be energy efficient. In the revised scheme, where no audits are carried out, no energy saving projects are listed in the VAs. However, profitable energy saving projects that are identified in the special investigations or by working with the EMS should be carried out during the contract period.

The CO_2-tax is partly refunded (75 percent of the CO_2-tax paid) for energy used for heavy energy intensive process purposes. Combined this makes a total of six tax levels in the business CO_2/energy tax scheme.

Table 14: Business CO2- and Energy Tax Refunds up to 2008

Energy used for:	
(a) heat production, space and water heating/no agreement	No refunds

(b) space and water heating/with agreement	22 % of energy and CO2-taxes
(c) process use/no agreement	100 % of energy taxes
(d) process use/with agreement	Around 24,4 % of CO2-taxes + 100 % of energy taxes
(e) heavy process use/no agreement	Around 72,2 % of CO2-taxes + 100 % of energy taxes
(f) heavy process use/with agreement	Around 96,7 % of CO2-taxes + 100 % of energy taxes

(iv) Subsidy scheme: recycling of CO2-revenue to investments in EE

Revenue from the Danish CO2 tax was recycled to support EE improvements: In the year 2000, 26% of the revenue was earmarked directly for such measures. *Subsidies* were provided for up to 30-50% of the cost of energy efficient investments until 2001, from 2002 this support was abolished.

Implementation/Costs

The evaluation of the energy tax system shows that the administrative costs for the companies of entering into an agreement are between 10 and 20 percent of the *tax subsidy*. Corporate administrative costs by entering into a three-year agreement are estimated at 27,000 euro on average and at half that cost for follow-up three year agreements. The average annual operating costs are 9,000 euro for the energy management systems and 6,700 euro for the annual reports.[31]

The annual cost of administration for the DEA amounted to 36 man-years, of which 11 were used for the voluntary scheme and 20 for the administration of the investment subsidy scheme discussed above. The evaluation reports do not provide information on the administrative costs of the Danish Tax Authority for the administration of the tax rebates.

The taxes paid by industry amount typically to between 10-20% of the total cost of energy, including taxes. The green taxes resulted in increased energy costs for trade and industry of approximately 0.2% of the GNP in 2000. But since approximately the same amount was redirected, trade and industry as a whole have felt no noticeable consequences.[32]

[31] Source: DEA (2000)
[32] Source: DEA 2002

Table 15: The total of green taxes for various energy sources for different energy use in 2000

Energy source	Unit	Sulphur content	Heavy process no agreement	Light process no agreement	Space heating
Electricity	euro/MWh		5	14	87
Natural gas	euro/1000 m^3	0	7	27	244
Gas oil	euro/m^3	0.1	10	34	269
Fuel oil	euro/t	0.5	21	49	315
Coal	euro/t	0.6	22	43	221

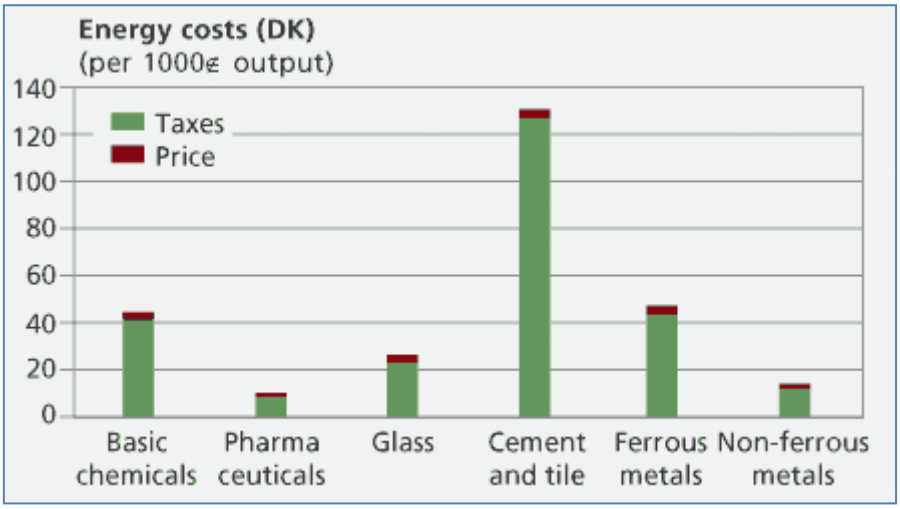


Figure 32: Cost of energy in euro per 1000 euro production value in 6 industries

Source: Skou Andersen (2005)

The chart illustrates the modest tax burden imposed on Danish industry by the carbon tax. It shows the energy costs in Denmark in euro per 1000 euro value of production in six energy-intensive sectors. The red shaded areas show the share in the cost of energy relating to the CO2 tax - before revenue recycling!

Monitoring and Evaluation

The DEA carried out a number of evaluations since 1996 of the green tax package and of the voluntary agreement separately.

Achieved Results

Between 1996 and 2004, the companies entering the agreements, represented close to 60 percent of total industrial energy consumption in Denmark. The largest number of companies was reached in 2003, when 397 were in the scheme, 154 through individual agreements, 243 through collective agreements with the business organizations for horticulture, milk condensing and brickworks. Since 2005, companies in the ETS-

sector dropped out (it is still possible for these companies to conclude a voluntary agreement concerning their electric energy consumption). In 2007, the VAs comprised 295 firms, 96 individual and 199 collective.

Impact on Industrial Energy Consumption

Evaluations have shown that both the green tax reform and the VA scheme reduced the energy use in the participating companies. However, there are no truly reliable estimates of the net impact of each.

The *green tax effect* is estimated to have contributed to an overall reduction in energy consumption levels of 10%. The effect is derived from estimates of the price elasticities of energy demand. Econometric analysis of the relationship between energy consumption and energy prices (the combined effect of *market price fluctuations* and *policy-induced price fluctuations arising from taxes)* led to a price elasticity of industrial energy demand in Denmark of -0.38.[33] The elasticities by type of fuel are shown in the table below.

Table 16: Price elasticities of demand for fuels

	Denmark
Natural Gas	-0.11
Oil products	-0.42
Coal products	-0.37
Electricity	-0.10
Waste energy	-0.51

Source: Schou-Andersen (2010)

A 1999 evaluation of the Green Tax Package estimated a reduction in CO_2 emissions in 2005 of 3.8 percent, corresponding to 2.3 million tons. According to the estimates, shown in the table below, that half of the savings were due to the *taxes*, one third to the *investment subsidy* and the rest due to the *agreement system*.

Table 17: Estimated reduction in CO2 emissions in 2005

	Per cent	Million of tons
Taxes	2.0	1.2
Subsidies	1.2	0.7
Agreements	0.6	0.4
Total	**3.8**	**2.3**

Source: DEA (2002)

Concerning the individual measures of the VA, the evaluations estimate that 60% of the CO2 emissions reduction resulted from the implementation and maintenance of an *Energy Management System (EMS)* in the

[33] Source: Schou-Andersen (2010)

participating companies, a quarter from general investment projects and the rest from measures resulting from the special investigations.

Table 18: CO2 reductions until 2005 of Voluntary Agreements made 1996-2000

CO2 reductions in 2005	
Investment projects	1.5%
Special investigations	1.0%
Energy management	3.8%
Total impact	6.3%

Due to the three-years length of the VAs, the DEA has signed successive agreements with companies since 1996. Provided that companies continue to work on improving their systems, the relative importance of the EMS will increase with each successive VA: the share of concrete investment projects in total savings falls because an energy audit, carried out after only three years, will identify fewer EE-projects; the same is true for special investigations unless new criteria are applied. The EMS was estimated to improve the energy efficiency by 0.44% per year in a 1998 evaluation and by 0.4% in an evaluation made in the year 2000.

Above all, the evaluations made show the uncertainty in the estimates:

- One estimate concluded that the VAs led to a reduction in energy consumption of 9%.
- Another found that the result of voluntary agreements was a reduction in energy consumption of 2% to 4% of total energy consumption per agreement after three years (thereby exceeding business-as-usual by about 1 percent per year).
- Another evaluation concluded that most EE measures would have been pursued, even without the VA scheme, but that the VA sped up the process.
- Yet another study concluded that companies seemed to take energy management more seriously as a result of the VAs

The two charts below look at the developments in the highly energy intensive branches (food, beverage and tobacco, wood, non-metallic minerals and primary metals) and the low energy intensive branches of industry (textile and leather, paper industry, chemicals, machinery and transport equipment) respectively.

The first chart shows an increase in the energy intensity of production in the energy intensive industries from 1990 to 2007.

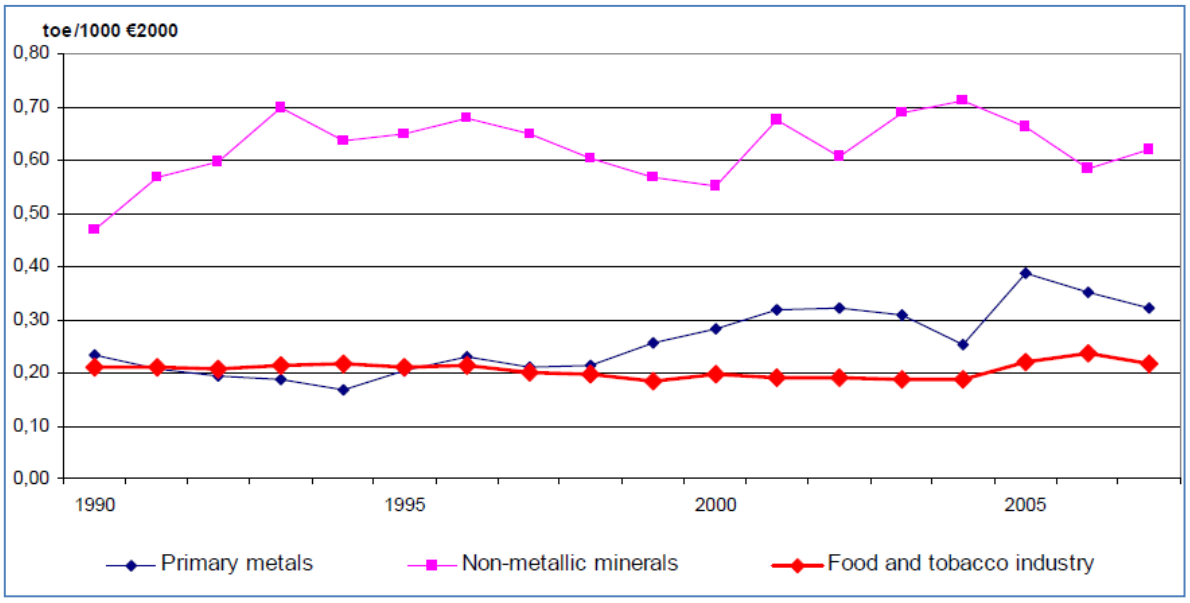


Figure 33: Energy intensity in manufacturing in highly energy intensive branches

The next chart depicting the tendency in the low energy intensive branches shows a large drop in FEI for c*hemicals*, which started off as the most energy intensive of the category and a modest drop in the lowest, which was transport equipment. The FEI for the others was at the same level in 2007 as it was in 1990.

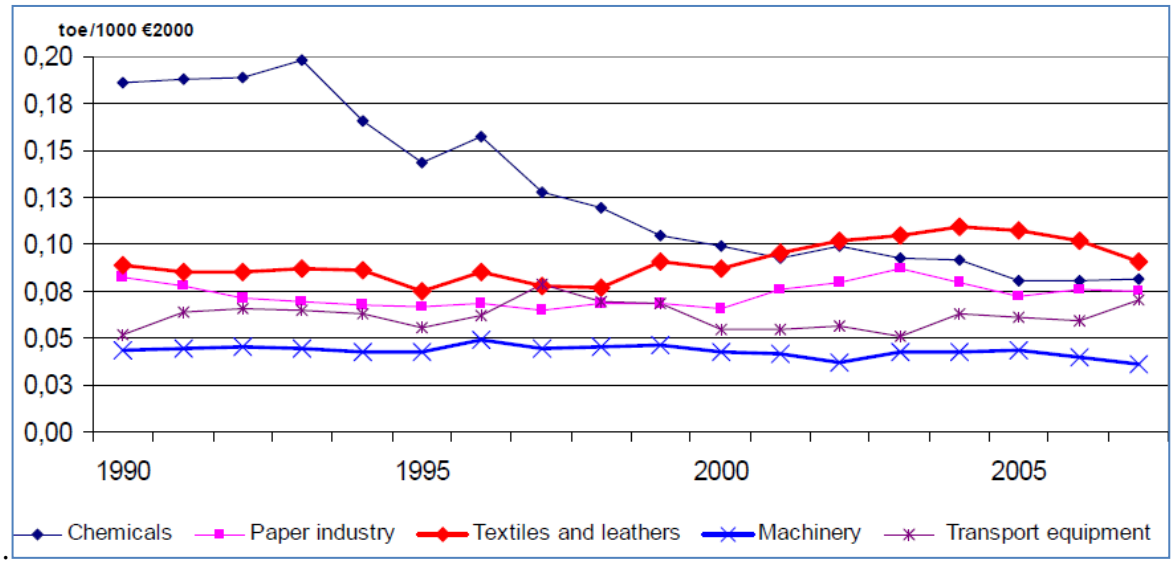
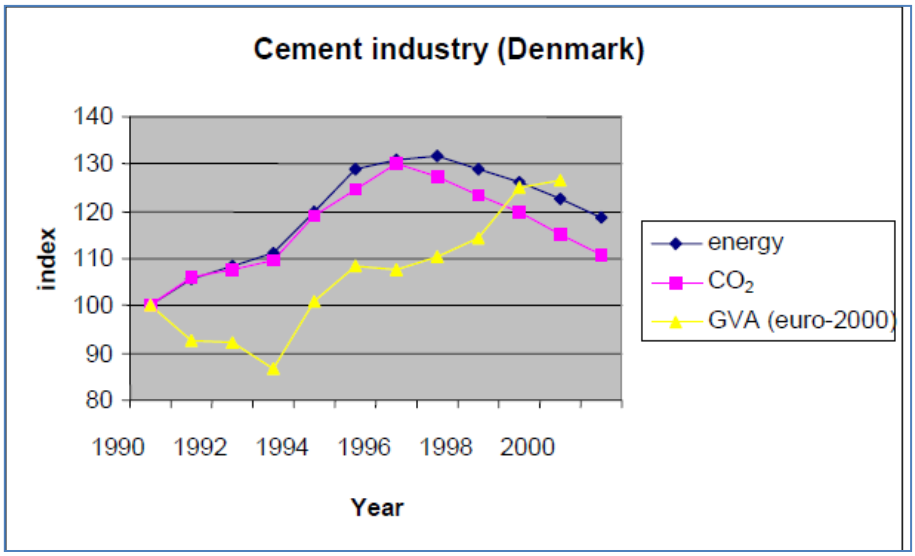


Figure 34: Energy intensity in manufacturing in low energy intensive branches

Source: Odyssee

The charts below show strong decoupling between the development in value added and the development in energy consumption in the cement industry, pulp and paper industry, sawmill industry, veneer sheet industry, and furniture industry and glass industry with the strongest gains being made from 1993 to 2000.[34]

[34] Charts reproduced from Nordic Council (2006)


Cement industry (Denmark)
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Year
energy
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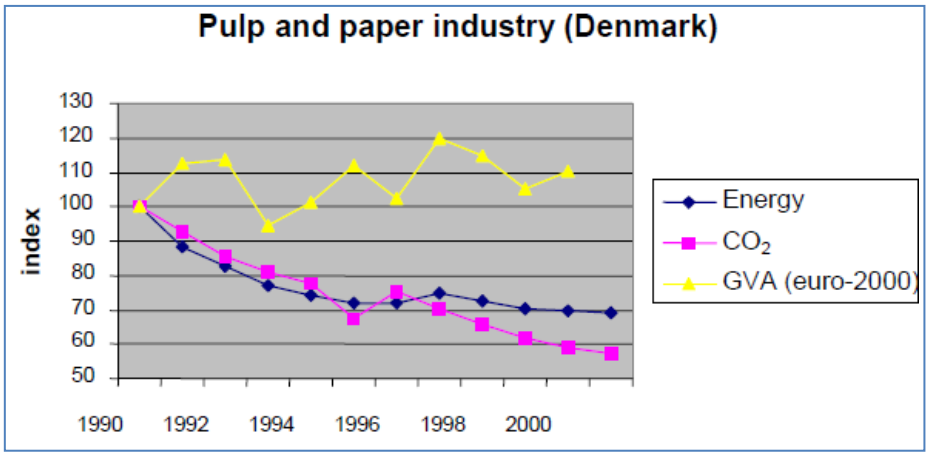
GVA (euro-2000)


Pulp and paper industry (Denmark)
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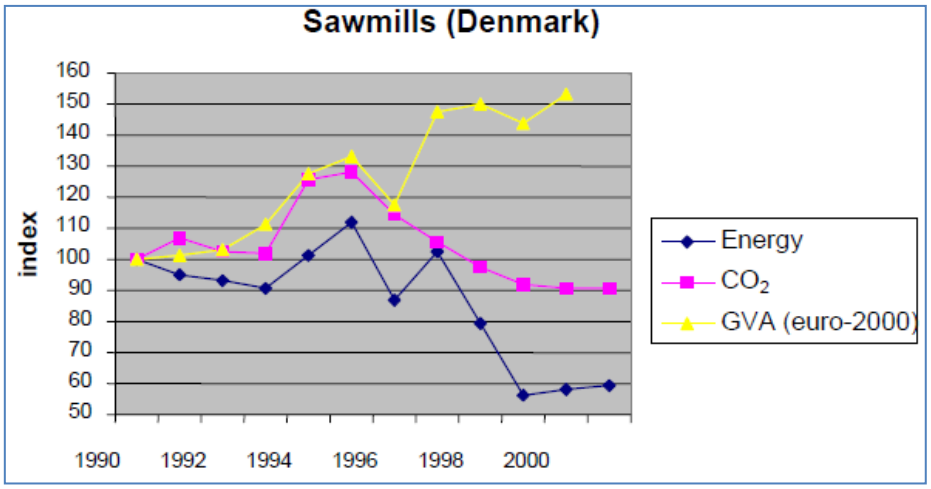
Sawmills (Denmark)
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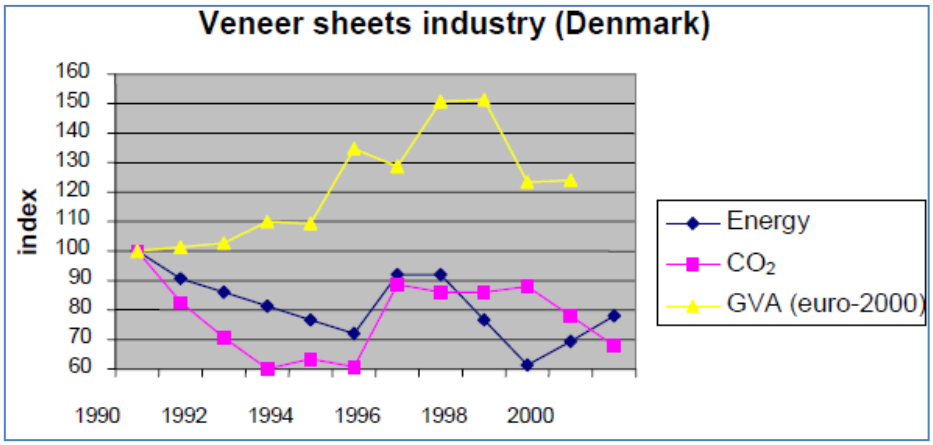
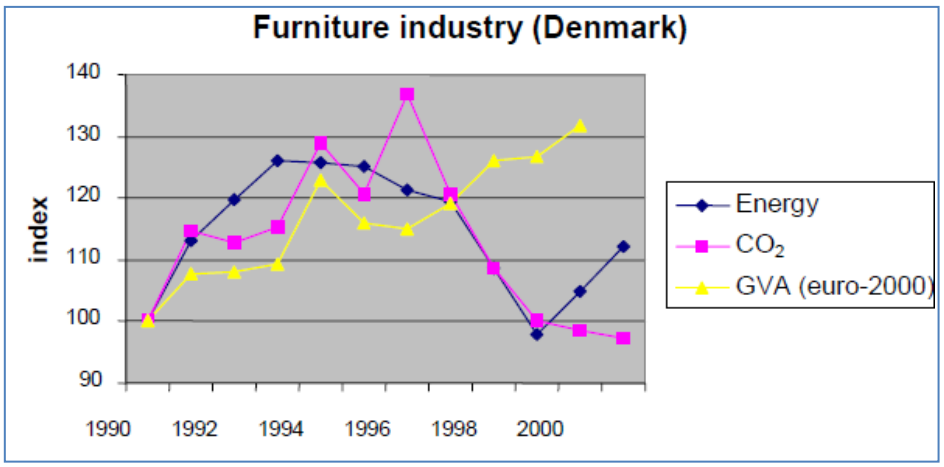
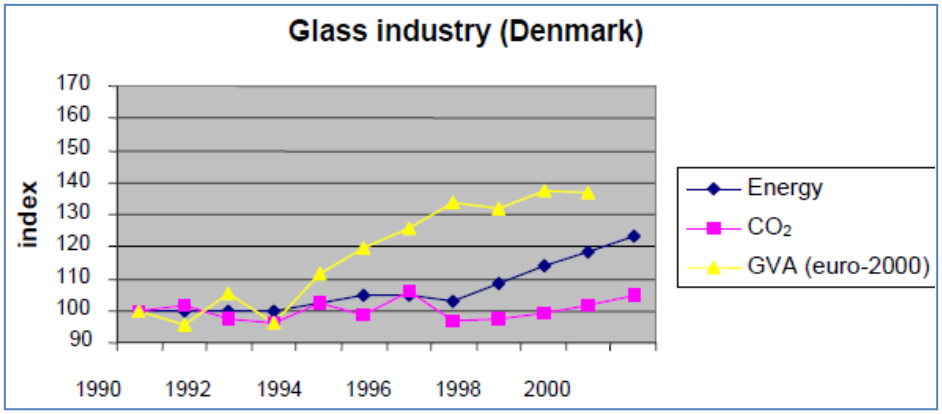
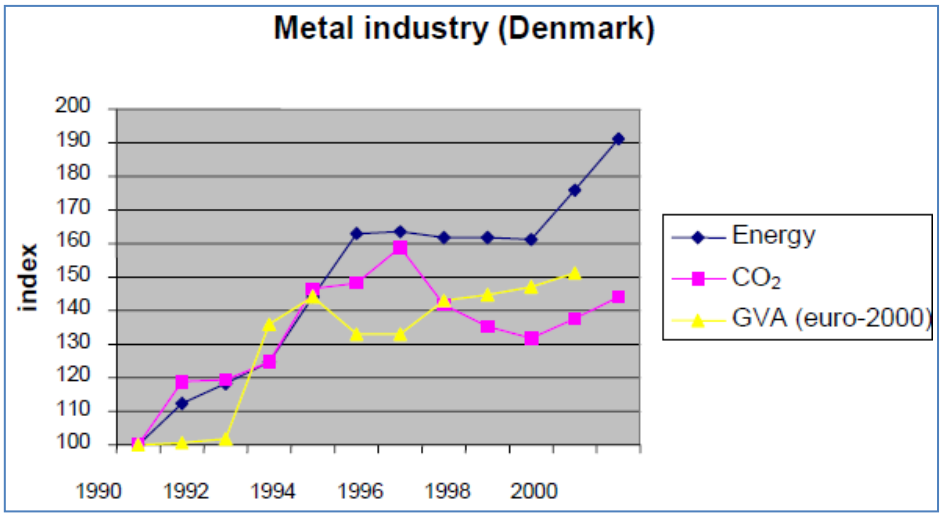






Neither the metal industry, nor the fish industry, showed progress in decoupling.


Metal industry (Denmark)
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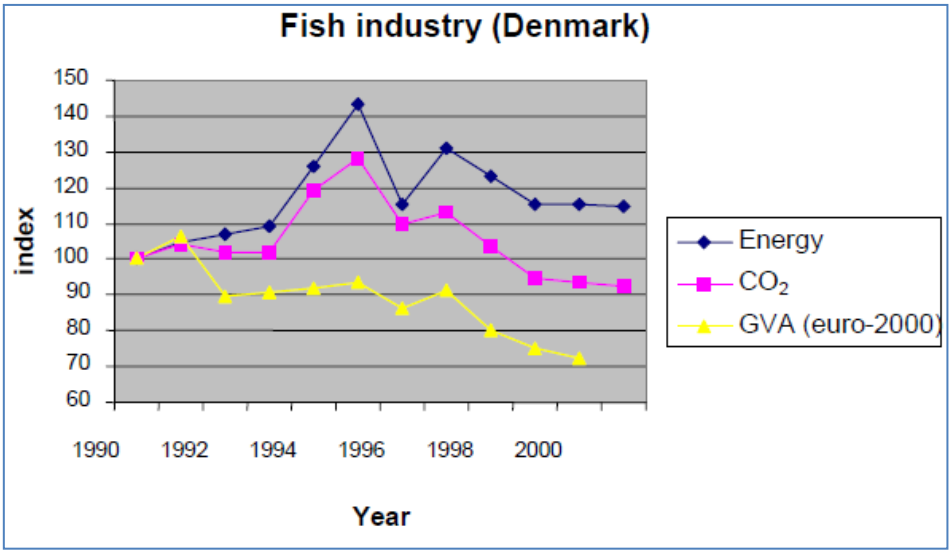
CO2
GVA (euro-2000)


Fish industry (Denmark)
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CO2
GVA (euro-2000)

EE Measures Implemented in Transport Sector

Evolution of EE in the Transport Sector

Measured by the ODEX index, the EE of the transport sector improved 11.2% between 1990 and 2007. Once more, the general pattern is relative good progress in the 1990s and slow progress in the 2000s: from 2000 to 2007, the EE of the transport sector increased 3.9% only. The improvement from 1990 to 2007 is mainly due to the 31% improvement in the EE of *air transport*; for *road transport*, EE increased 5.7% only.

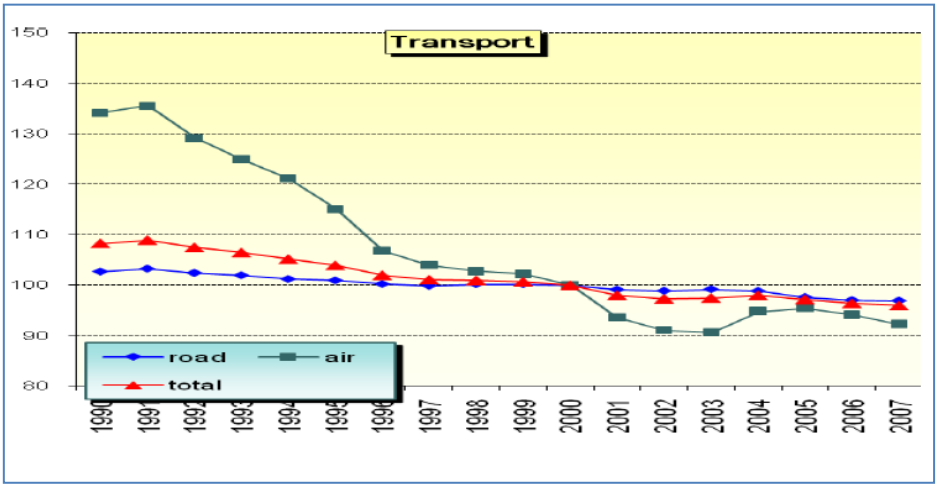

Figure 35: Evolution in Transport EE 1990 to 2007, ODEX

Source: DEA/Odysseee

The evolution in EE of the transport sector can be tracked alternatively by the development in the *"energy intensity in transport", defined as the sector's energy consumption in toe per 1000 euro of value added* (to GDP) by the transport sector. The chart below measures value added in year 2000 price level. It shows a clear decline in energy intensity from 1993 to 2000, followed by an increase (of 0.7 percent) up to 2007. For the period 1990-2007, as a whole, energy intensity in transport declined 8.7 percent.

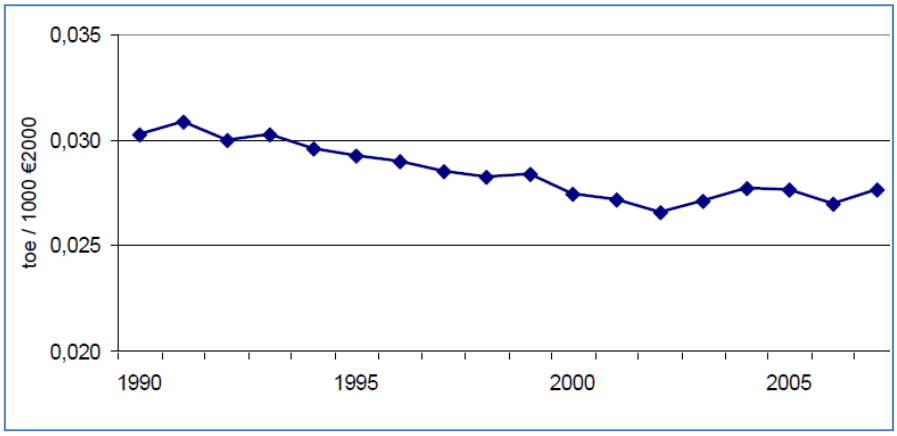

Figure 36: Energy intensity of transport 1990-2007

Source: DEA/Odyssee

The energy consumption for transport is dominated by the consumption for road transport: in 2007, the share of energy for road transport was 78%, roughly the same as in 1990.

The composition of fuels changed significantly: the consumption of diesel increased at the expense of gasoline. In 2007, the share of diesel was 55% compared to 42% in 1990. The higher share of diesel has had a positive influence on the efficiency in road transport in so far as diesel cars provide more mileage per liter than gasoline cars.

The *average specific consumption of new cars (total)* depends on several factors. The most important ones are technical standards, size of the cars and fuel mix. From 1997 to 2007:

- The composition of the car fleet changed toward diesel cars. Since diesel cars are more efficient than gasoline cars, this contributed to the reduction in the average specific consumption for cars (total).
- The average specific consumption for new gasoline cars fell 13.7% and for new diesel cars 11.9%.

New cars became more efficient. From 1990 to 2007, the average specific consumption for cars (total) measured as liter of fuel per 100 km fell 26.6% corresponding to an average annual reduction of 1.8%. From 2000 to 2007, the average specific consumption fell 12.8% corresponding to an average annual reduction of 1.9%.

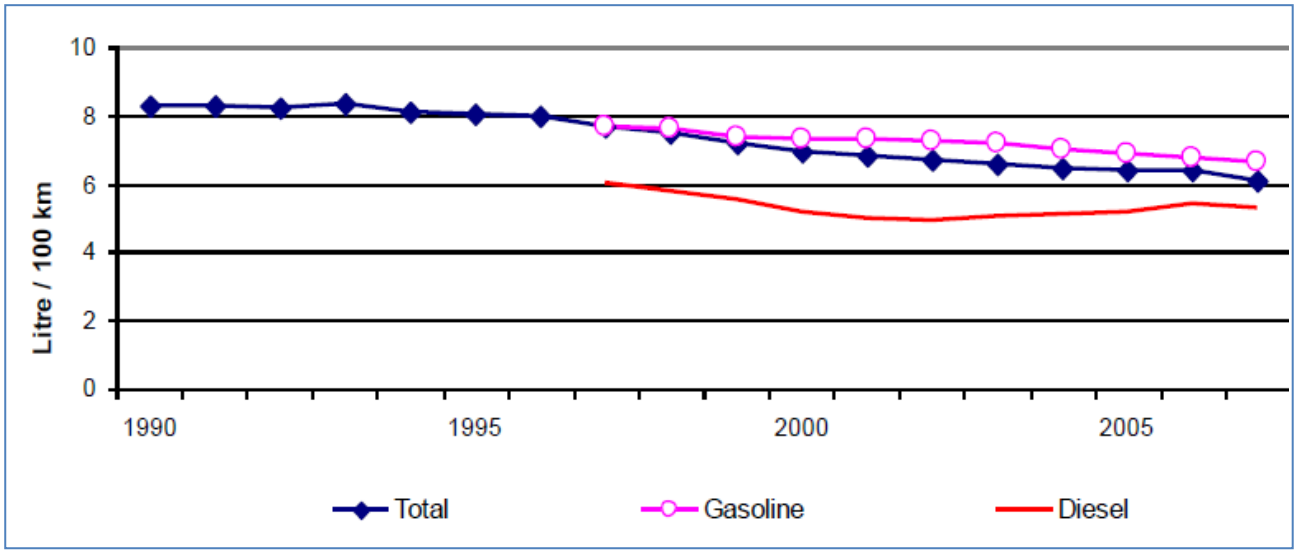

Figure 37: Specific energy consumption of new cars 1990-2007

However, the impact of the increased unit efficiency of vehicles on energy consumption per passenger kilometer was offset by the increase in the of passenger cars per capita, which led to a lower passenger rate in the cars. This why, as seen in the chart below, unit consumption for *passenger transport measured in toe per 1000 passenger-kilometer* increased for cars from 1990 to 2007. In 2000, the unit consumption per passenger-km *for cars* reached its highest level - 0,043 toe per 1000 passenger-kilometre, after which it decreased slightly. For *rails*, the unit consumption per passenger-km fell 22.1% in the period 1990-2006, with most of the gains occurring during the 1990s.

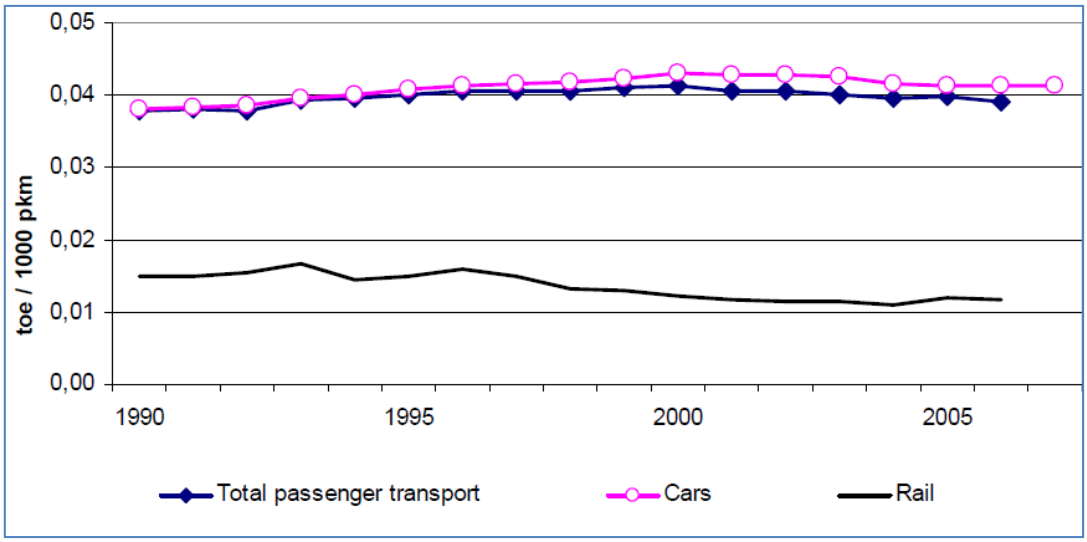

Figure 38: Unit consumption in passenger transport

According to the Odysee data base, the unit consumption of *road transport of goods by trucks* – measured as toe per 1000 ton kilometer - increased 10.4% from 1990-2007. Whereas unit consumption fell 4.5% from 1990 to 2000, it increased 15.6% from 2000 to 2007. The DEA points out, however, that the information may be misleading: a problematic definition of the denominator (number of ton kilometer) results in an underestimation of the number of ton kilometer in the years after 2000.

Policies to promote EE in transport

The Year 2001 Action Plan for reducing CO2 emission in transport sector fixed CO2 emission reduction targets for the year 2010. The measures and their CO2 reduction targets are shown in the table below.

Table 19: Year 2001 Action Plan for reducing CO2 emission in transport sector - policy measures and CO2-reduction targets

Strategy	Measures	Approximate CO_2 reduction	
		2005	2010
Increased energy efficiency	Information about new cars' energy efficiency	0,5 pct.	1 pct.
	Eco-driving	0,5 pct.	1 pct.
	Make drivers observe road speed restrictions	0,5 pct.	app. 1 pct.
	Working Group on tax-measures to encourage energy efficiency in transport		app. 2 pct.
Increased transport efficiency	Promote infrastructure for intermodal transport		
	public transport		
	bicycle transport	0,5 pct.	0,5 pct.
	environmentally friendly freight transport	0,5 pct.	app. 1 pct.
	transport plans for environment and traffic safety		app. 0,5 pct.
	Pilot project on car pooling		
	car sharing		
Reduction of CO_2 emissions	Fesibility study of adaptation of the tax system.		
Reduction of transport demand	Road pricing		
	Better transport habits		
	Reduction of transport demand		
Total		app. 2,5 pct.	app. 7 pct.

Source: DK-8 Action Plan for Reducing CO2 in the Transport Sector, MURE/DEA

The two main strategies are "increased EE" and "increased transport efficiency". The "*EE strategy*" has four measures one of which is a study on the promotion of environmentally friendly transport technology through adaptation of the tax system. The other three seek behavioral changes through information and awareness

campaigns. The "*increased transport efficiency*" strategy seeks to promote more bicycling, improve public transport and more environmentally friendly freight transport. The action plan included also preparatory work towards the development of a national road pricing scheme with the main objective of reducing motor traffic in major Danish cities.

The political agreement on a green transport policy from January 2009 is a long-term plan for investing in a green transport system with increased mobility and reduced CO_2 emissions. Up to 2020, more than DKK 150 billion will be invested, primarily in public transport; the railway infrastructure will receive significant modernization. What is new is the intention to introduce road pricing by 2015 and promote new sustainable technologies: the promotion of electric cars in particular and some support being given to hydrogen fueled cars.

EE-Measures for Transport in the MURE Data Base

A total of 17 measures for the transport sector are listed in the MURE database. Selection criteria for retention of measures for analysis were as follows:

- Measures which had "low" or "unknown" effect as evaluated by MURE were left out.
- Measures directly related to EU directives were left out for not being Denmark specific: "Promotion of Biofuels or other Renewable Fuels for Transport. Trials of biodiesel and rape oil used as fuel for light and heavy duty vehicles (Directive 2003/30/EC)", "Passenger Car Labelling on fuel economy rating (Directive 1999/94/EC) - Energy label of new passenger cars".
- The "Action Plan for Reducing CO2 in the Transport Sector" is a policy statement rather than a policy measure; therefore, it was left out.

This left two measures for the analysis:

- Increased taxes on gasoline
- Green owner fee

Because both measures are part of the general "green taxation" policy for vehicle transport, they are described and analyzed together.

Taxes on transport fuels and vehicles

Background

Emissions from the transport sector are growing. It is expected that they will represent approximately 45 per cent of the emissions from the non-ETS sector in 2020.

The green tax reform is discussed in detail in Cross-Cutting Policies Section. This section deals exclusively with the taxes of relevance for car transport.

Targets/ Expected Outcomes

Because the transport taxes were all implemented with a strong revenue objective in mind, the reforms in car taxation did not include specified quantitative targets for energy savings or for CO_2 emission reductions. But the Government's 2001 Action Plan for reducing CO_2 emissions in transport foresaw that changes in the tax laws for transportation would provide two percentage-points towards the plan's quantitative target for in

2010 of a seven percent reduction in CO_2 emissions below the business as usual trend. The target represented an actual increase in emissions of 19 percent over 1990 levels.

Targeted Agents/Coverage

Car purchases and fuel consumption of vehicles.

Design

The chart below provides an overview of the price/tax instruments which the Danish Government uses to increase EE in the transport sector. For comprehensiveness also the price instruments used by municipal administration for control of car transport into and in urban areas are included.

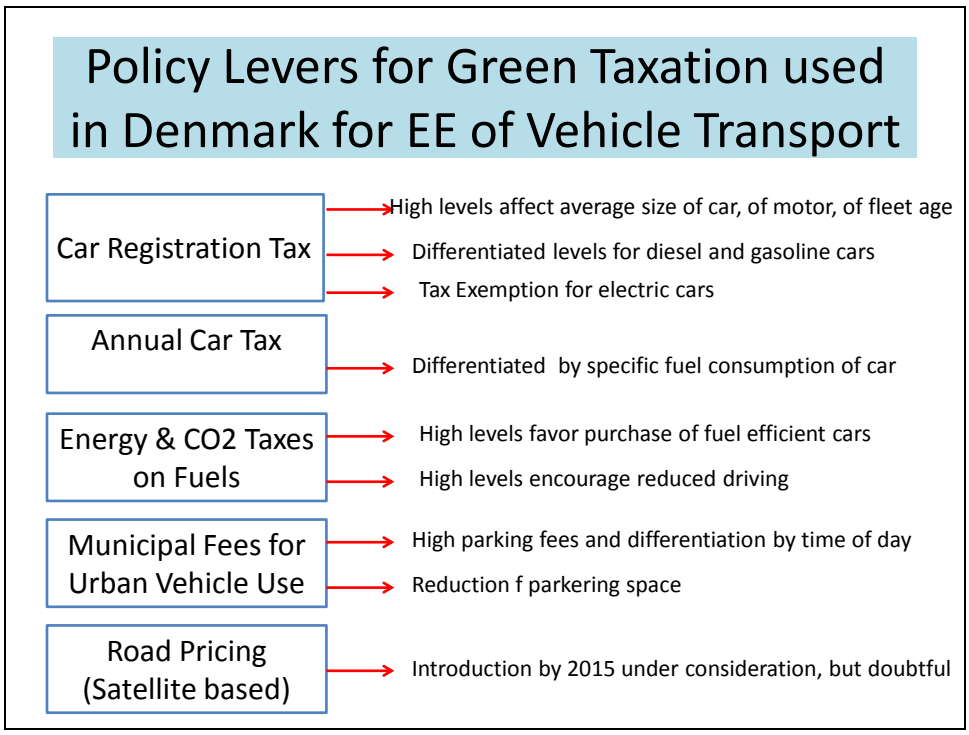

Figure 39: Policy levers for green taxes on transport in Denmark

Source: Author

Taxes on cars generate around 35 billion DKK annually of which 20-25 billion DKK are generated by registration tax. Because of limits to how much total taxation on vehicle use is politically acceptable, all of the instruments are both complementary as well as alternatives. The relative weight between the individual levers is, therefore, subject to political discussion every year.

Registration tax for cars

The registration tax is paid the first time a vehicle is to be used on public roads in Denmark. It is levied on all newly registered cars, motorcycles, vans and lorries with a permissible total weight of up to 4 tons, taxis, busses and other vehicles. Registration tax is calculated on the dutiable value, which is the vehicle's normal price including VAT on sale. At least 9 % trade profit is always included in the dutiable value. All equipment supplied with the car is also included, except radios and other extra equipment installed by the supplier. The tax is differentiated according to fuel efficiency and purpose of use:

- Cars for business use are taxed much lighter than cars for private use. For new private cars, the registration tax is generally calculated as 105 % of the part of the dutiable value under DKK 76.400 (10,000 euro) and 180% on the part of the dutiable value exceeding that. Roughly, the tax adds 170 percent on top of a typical middle class import price of the car net of duties.
- For petrol- powered cars the registration tax is reduced with DKK 4.000 for every kilometre that the car covers more than 16 km pr. litre fuel and raised with DKK 1.000 for every kilometre that the car covers less than 16 km pr. litre fuel.. For diesel-powered cars the registration tax is reduced with DKK 4.000 for every kilometre that the car covers more than 18 km pr. litre fuel.
- Since 2009, electric and hydrogen cars are exempt from the tax up to 2012. In the period 2012-2015, the government has pledged that electric cars will be favoured by a significantly lower car tax to the extent this is necessary to ensure more electric cars on the streets.

Tax revenue from the registration tax varies greatly from year to year, since car sales are extremely sensitive to changes in the national economy, see the fluctuations in revenue from vehicle tax in percent of GDP in the chart below.

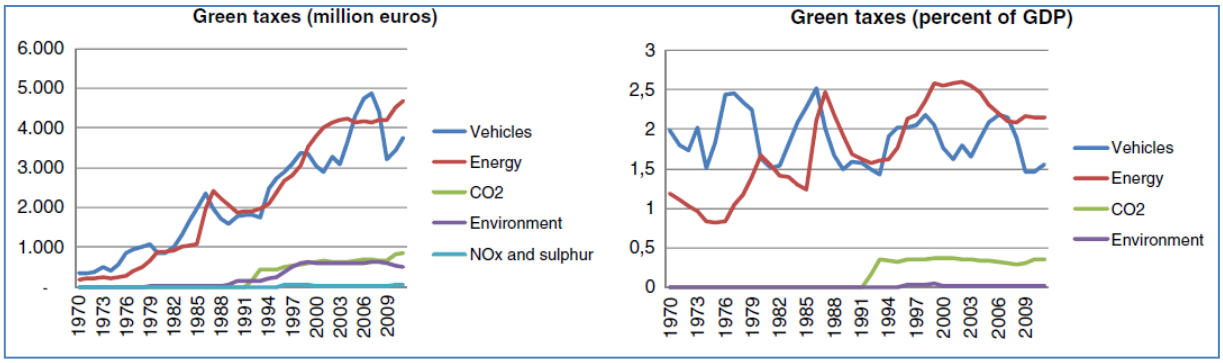

Figure 40: Development in green taxes in million euro and in percent of GDP

Source: Togeby et al (2011)

Indirectly, the variations in new registrations of cars can be seen in the evolution in the total passenger car park.

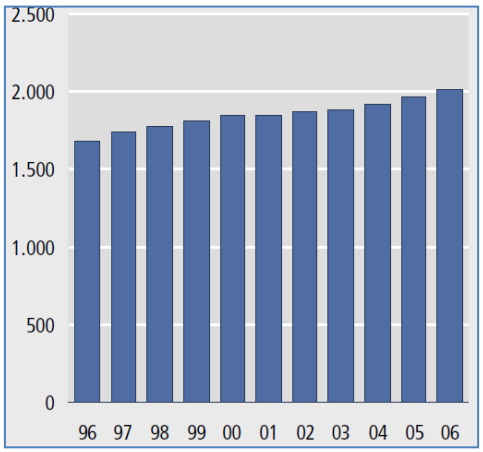

Figure 41: Number of passenger cars 1996-2006

Source: Ministry of Transport (2008)

The impact of the registration tax on EE is debated. It leads to fewer cars per capita in Denmark than in other EU-15 countries with similar GDP per capita.[35] The two-step progression in the tax rate penalizes luxury cars which tend to be bigger and have a specific energy consumption higher than smaller cars; the average size of the car is, therefore, lower than in comparable EU-countries. But the high initial investment into a car also leads to the average car being kept longer years in service than in other EU-15 countries. Since the specific energy consumption of new cars has gone down considerably, the high registration tax slows down the renewal of the car fleet.

In addition, it affects negatively the penetration of hybrid electric – gasoline/diesel cars; since the higher cost of these is reinforced by the high registration fee. This has led to some changes in the registration tax giving green cars a tax rebate; but it only reduces the penalty for these. For electric cars, the government took the decision to remove the registration tax until 2015 in order to facilitate their penetration into the market until the cost of new electric cars has become more competitive with conventional cars.

Another concern is that the use of a car during operation – the choice between car transport and public transport - is not influenced by the original high registration tax: it is determined only by the marginal cost of car transport versus the cost of public transport. This had led to the search for alternative taxation, more linked to the use of the car, rather than its initial investment.[36]

This has led to the proposal by Danish Industry to replace the registration tax by a yearly CO_2 tax of of 3,000 to 100,000 DKK (400 to 13,000 euro), depending on the car's CO_2 emissions. That, however, made the electric car lobby react negatively: fearing it would undermine the improvement in the competitive position of electric cars provided by the elimination of the registration tax for these.

Annual vehicle tax/green tax

A typical middle class car pays 400-500 euro in annual car tax. The theoretical purpose of the annual car tax is to finance the expansion and maintenance of road infrastructure. It used to be called "*weight tax*", as its level was defined by the weight of the car. Since weight of a car is negatively correlated with mileage per liter, the tax assisted the purpose of EE. In 2009, in order to obtain a better correspondence between the level of the tax and its specific energy consumption, the weight tax was replaced by a "*green owner fee*", which depends on the car's CO2-emissions per kilometer, measured by the ECE-norm.

Road pricing

The concept of satellite based road pricing enjoys broad academic and political support. The Council of Economic Advisors estimates that a road price of 25 per cent per km can reduce emissions from transport by 20%. What holds road pricing back is concern about the technical maturity of the technology.

Fuel taxes

Diesel is taxed lower than petrol, but higher than heating gas oil. The tax difference between diesel (gas oil) and petrol is to some extent evened out by a higher annual vehicle tax on diesel vehicles.

[35] The transport researcher Per Homann Jespersen from Roskilde University estimates that an elimination of the registration fee would increase the car park by 20 percent.

[36] The elimination or reduction of the registration tax would have to be made gradually over several years in order to avoid a drop in the value of used cars on the market.

From 1996 to 2001, the taxes per liter on diesel and gasoline fuels were increased gradually from year to year. A general stop of new taxation introduced by Liberal Government taking office in 2001, froze the tax for the following years. The rates were:

Table 20: Petrol and diesel taxes, 2007

Petrol (leaded)	0.62 euro
Petrol (unleaded)	0.54 euro
Diesel	0.40 euro
Diesel (low sulphur)	0,37 euro

In order to avoid border trade problems, petrol and diesel taxes have been set to more or less follow German rates.

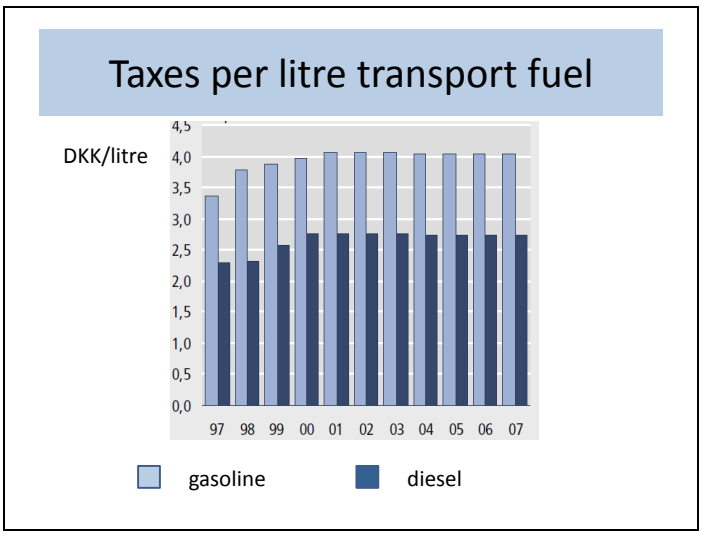

Figure 42: Taxes per litre transport fuel 1997-2007

Source: Ministry of Transport (2008)

Implementation/Costs

n.a.

Monitoring and Evaluation

M&E takes place mainly as the result of recurrent political discussions about the relative weight to be given to the different tax levers.

Achieved Results

Transport researchers assume that the high car registration tax keeps the Danish car fleet at a level about 20 percent lower than in the absence of the tax.

The fuel taxes are only one determinant of consumer prices for transport fuels; the other is the market price of fuels net of taxes. The chart below shows that interaction between green tax policy and developments in the international market prices of diesel and petrol failed to change significantly the relative costs of individual car travel and of public transport. The chart below shows the price indices for the 1996-2006 period for (i) the national consumer price index, (ii) the price of petrol, (iii) the price of bus and train transport.

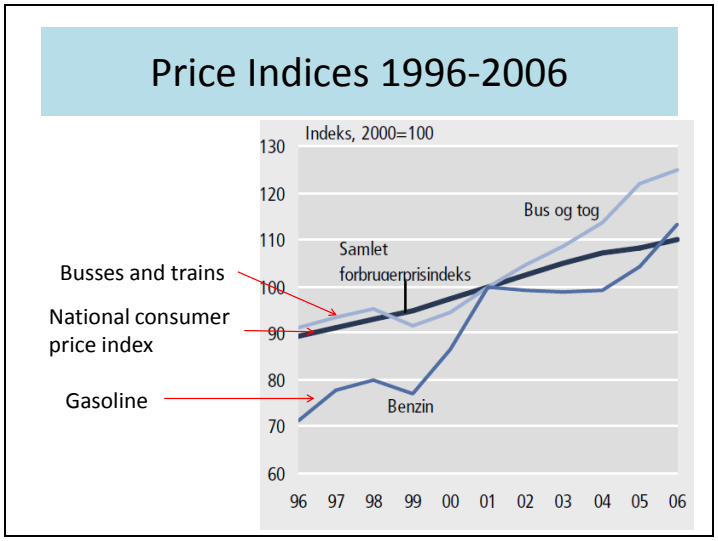

Figure 43: Price Indices for gasoline, trains/buses and general consumer price index 1996-2006

Source: Ministry of Transport (2007)

The chart shows that the green tax policy led to an increase in petrol prices that was faster than the increase in any of the other two indices from 1996 to 2000, whereas petrol prices fell relative to the cost of bus and train transport between 2000 and 2006. The collapse of the international price of crude in 1998/99 off-set the price impact of the 1996 increase in fuel taxation temporarily. But the upward readjustment of crude prices in 1999/2000 enabled the full impact to be felt in year 2000 consumer prices. The tax-stop policy then led to petrol prices evolving slower than the consumer index and much slower than the train and bus index until 2004, when a new boost in international crude prices started to take off.

Impact on Transport Energy Consumption

Information is not available, except the estimate that the own price elasticity of energy demand is -0.2.

Measures for EE Implemented in the Household Sector

Evolution of Energy Demand in the Household Sector

Heating of households accounts for 25 per cent of total Danish final energy demand. That the final consumption of energy for the heating of dwellings has been kept below the 1980-level in spite of a 40 percent expansion in heated dwelling area is **the** success story of Danish EE-policy.

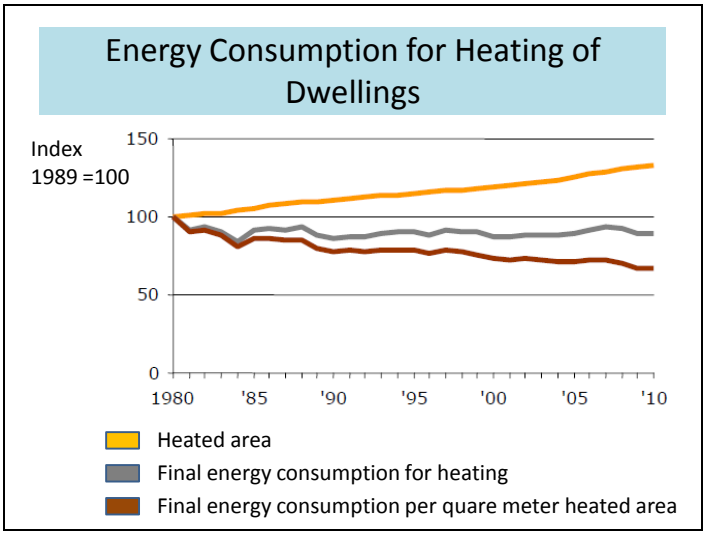

Figure 44: Indices for evolution in final energy concumption for heating of dwellings and total heated area

Source: Energistatistik 2010

From 1990 to 2010, the average energy consumption per household fell 8.4%; although average electricity consumption increased 5.7%, as heating demand dominates household energy consumption; see figure 45.

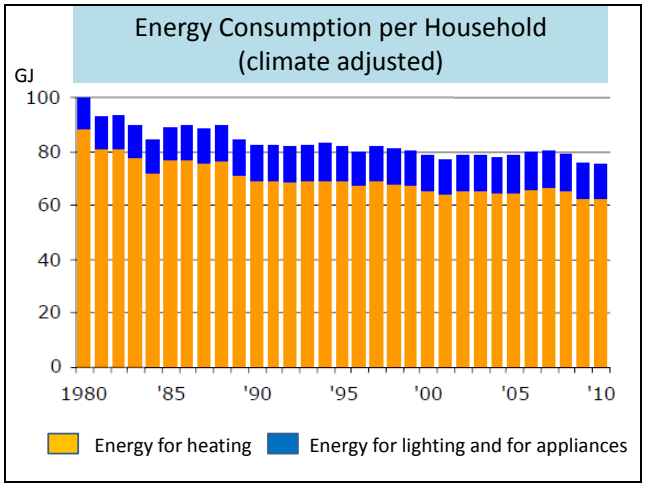

Figure 45: Energy Consumption per Household 1990 to 2010

Source: Energistatistik 2010

Figure 46 presents the information in a different form and for the shorter 1990-2007 period only. The *consumption of energy per dwelling for space heating* fell from 1.98 toe/dw to 1.54 toe/dw equivalent to a decline of 7.1%, while the *consumption per dwelling of electricity for lighting and appliances* increased from 2524 kWh/dw to 3100 kWh/dw equivalent to an increase of 10.5%.

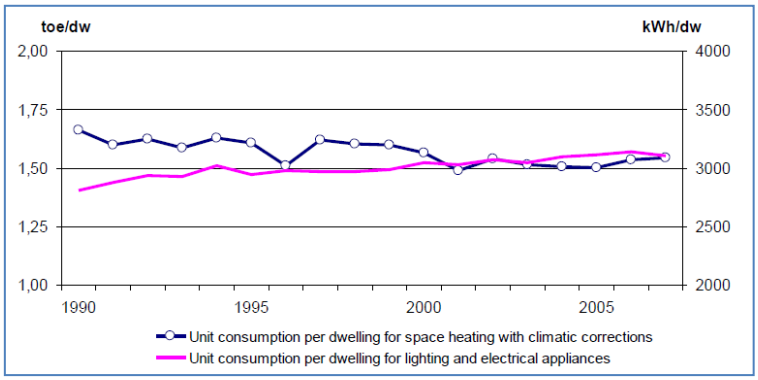

Figure 46: Energy consumption per dwelling for space heating, lighting and electrical appliances 1990 to 2007

Source: DEA / Odyssee

It is seen in figure 46 that the consumption of electricity per dwelling increased steadily throughout the period, while the consumption per dwelling of energy for space heating first fell 11% from 1990 to 2001 and then increased 4% from 2001 to 2007. The development in heating was caused by opposite fuel shift effects during the two periods. During the first period, there was a shift from oil to the more efficient sources natural gas and district heating. The second period included a shift away from the use of electricity for heating towards more use of firewood and wood pellets, renewable fuels with relatively low efficiency.[37]

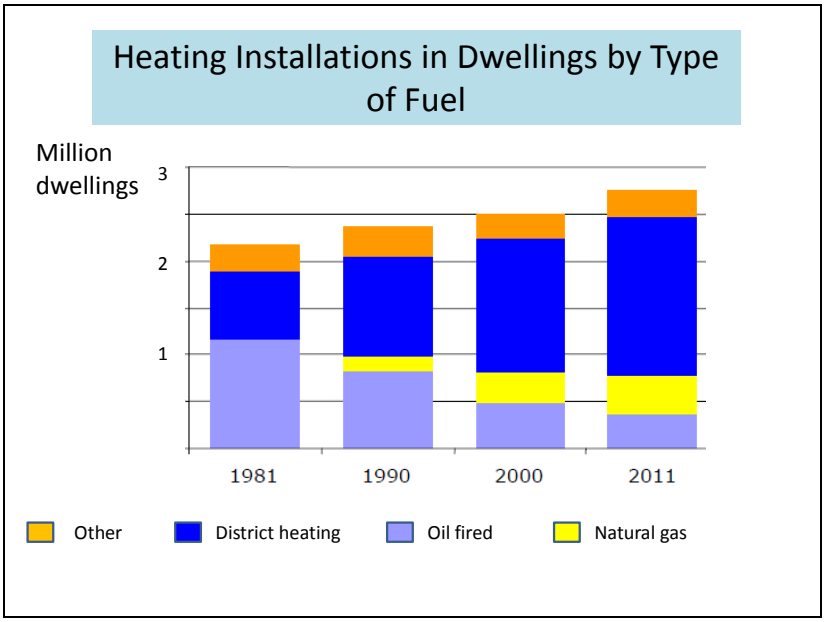

Figure 47: Heating Installations in Dwellings by Type of Fuel 1981 to 2011

Source: Energistatistik 2010

[37] Source: DEA (2011)

Figure 47 illustrates another major policy achievement in household energy: the shift from oil fired heating in 1980 to district heating (63 percent of Danish houses are supplied with district heating) and to natural gas.

The number of electrical appliances in households exhibited a significant increase. The impact of that on electricity consumption was partly offset by lower use of electricity for heating, partly by a general decline in the specific consumption of electrical appliances in the same period. Together the two effects enabled electricity consumption per dwelling (including electricity for space heating) to fall from 4108 kWh/dw to 3900 kWh/dw or by 3.7% from 1990 to 2007.

Stand-alone freezers and washing machines experienced the largest efficiency gains, see figure 48. Their specific consumption fell by 44% and 40% respectively.

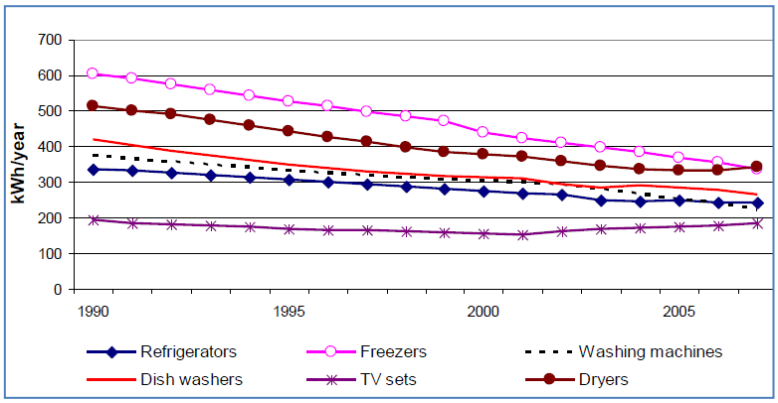

Figure 48: Specific consumption of electrical appliances

Source: DEA/Odyssee

The development in total household EE is captured in the ODEX-indices for space heating, large electrical appliances and total energy consumption, in figure 49.

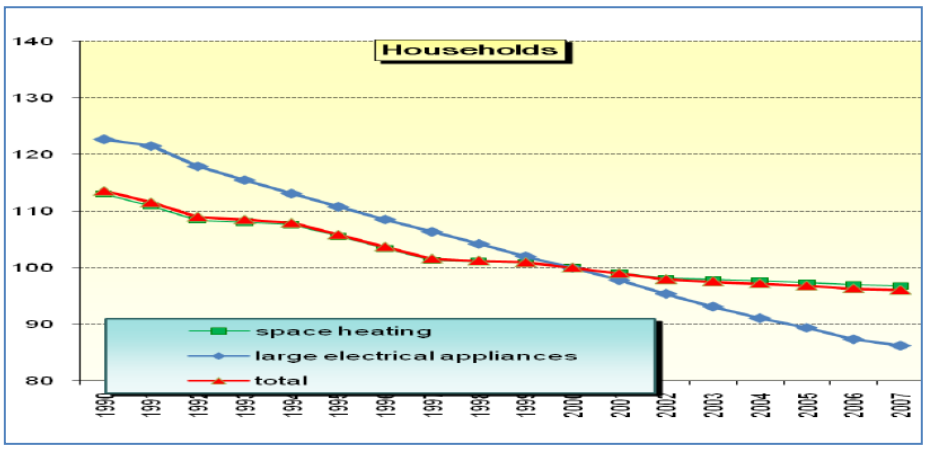

Figure 49: ODEX for household space and heating and electrical appliances 1990-2007

Source: Odyssee

Policy strategy to EE in household sector

High energy and CO_2-taxes on household energy consumption has been the main policy instrument for household EE[38]: taxes make up roughly 50 percent of the household consumer price of natural gas and of heating oil and more than two thirds of the household price of electricity. Next in the order of importance come the EE-obligations imposed by building regulations and then information and awareness activities. Subsidies to household EE have been almost absent; except for short lived campaigns for EE appliances and boilers[39], for social support purposes (investments by pensioners) and for short term boosts to employment in the construction industry.

The Danish Government claims in its energy policy statements that the EE-standards fixed in Danish *Building Regulations* are the stringiest in the world.[40] Recent adjustments include make EE-investments also obligatory for existing buildings when major building renovation is undertaken. In addition, labeling of building components is used as an instrument to improve transparency for investments by dwelling owners in e.g. more efficient windows.

The information provided by *energy labeling* of electrical appliances in accordance with EU-directives was reinforced by *awareness campaigns organized by Electricity Saving Trust*.

Policy measures for Household EE in the MURE data base

The MURE database lists a total of 24 measures that are implemented in the household sector. After leaving out measures which had "low" effect on EE as evaluated by MURE and measures implemented after 2007, six high-impact and seven medium impact measures remain for closer analysis. Below they are grouped by type of instrument:

Investment grants:

- Grant for energy saving measures for pensioners' dwellings (H)

Building regulations

- 1995 Regulations for New Building (M)
- Energy Performance of Buildings EPBD Recast (Directive 2010/31/EU) - Energy Labeling Buildings (H)
- Energy labeling of smaller buildings (M)

Awareness campaigns and information on EE implemented by the Electricity Saving Trust

- Guide for lower electricity consumption (H)
- Cheapest-most expensive campaign focusing on electricity savings (H)
- My house – the intelligent home (H)
- Club1000 - 1000 kWh campaign (M)
- Electricity-saving sockets – Standby Killers (M)
- A-pumps (M)
- The electricity savings label (Elsparemærket) (H)

[38] The promotion of district heating through various means is a policy instrument on the supply side with important EE implications for household energy consumption.

[39] Within the framework of a product-targeted strategy, the DEA together with the natural gas companies has conducted a campaign to promote the utilisation of *energy-efficient condensation boilers.* From the beginning of 1999 to the beginning of 2001, subsidy was granted to the condensation boilers, and their market share has risen from 10-15% to over 50% by 2001. The campaign has resulted in the condensation boilers entering the market in earnest and the installers becoming familiar with them. The Electricity Saving Trust's had a short lived campaign in 1999 where it provided a subsidy for A-rated white goods.

[40] E.g. in Regeringen (2009).

Agreements with industry to market more EE-building materials and equipment

- Agreement on efficient windows (M)

Grid Supplied Heat Planning (M)

The "Grid supplied heat planning" is a revision to the Danish Heat Supply Act (regulating planning for district heating and for natural gas) to ban buildings located within a district heating or natural gas supply network to convert to electric heating. It is an electricity saving measure and not discussed further in this report. The rating "M" for the "Energy labeling of smaller buildings" is an example of misinformation, see the conclusion of the year 2008 portfolio evaluation.

The building regulation is the most important tool for EE in heating and reviewed relatively detailed below. The grant scheme for EE investments by pensioners is of interest, as all countries face the issue of how to alleviate energy poverty problems.

The Electricity Saving Trust is the most important tool to promote savings in the electricity consumption of lighting and appliances. The awareness and information activities implemented by the Trust do provide value for money in the form of energy savings; but, individually, each has too modest an impact on total household energy consumption that it can be detected in the form of discontinuities in the trends established by Odysse data. Therefore, the Trust is reviewed as a measure, with the above seven measures implemented by the Trust being described briefly as activities in the review.

Green taxes on household energy consumption

The structure of the green tax policy implemented in 1996 is described in detail in the chapter on cross-cutting measures. The description makes it clear that the weight of the policy was imposed on household energy consumption. As a result, the prices paid by households for natural gas, heating oil and electricity are the highest in EU-27. The energy prices paid by businesses are EU-average, except when used for heating purposes.

A clear objective of the green taxation policy was to provide consumers with an unequivocal signal about the importance of saving energy. Figure 50 shows that real household energy price for energy peaked in 1981. High taxes on electricity consumption kept the real price for electricity consumption constant throughput the 1980-2010 period; the 2010-price of 2.20 DKK per kWh (= 30 eurocents) made it the highest household consumer price in EU-27. The real prices of heating oil and of natural gas fell until the introduction of the green tax reform in 1996, which by 2001 had brought prices back to their 1981-level. From 2002-2004, the "no-increases-in-taxes" policy of the liberal Government led to a slight fall in the prices of heating oil and of natural gas. The international oil price boom from 2005 then pushed prices beyond the 1981 level. The three energy carriers could be taxed without impacting border trading of fuels with Sweden and Germany. The case gas for petrol and diesel is different; the taxes on transport fuels are always fixed with an eye on the taxation levels in Sweden and in Germany.

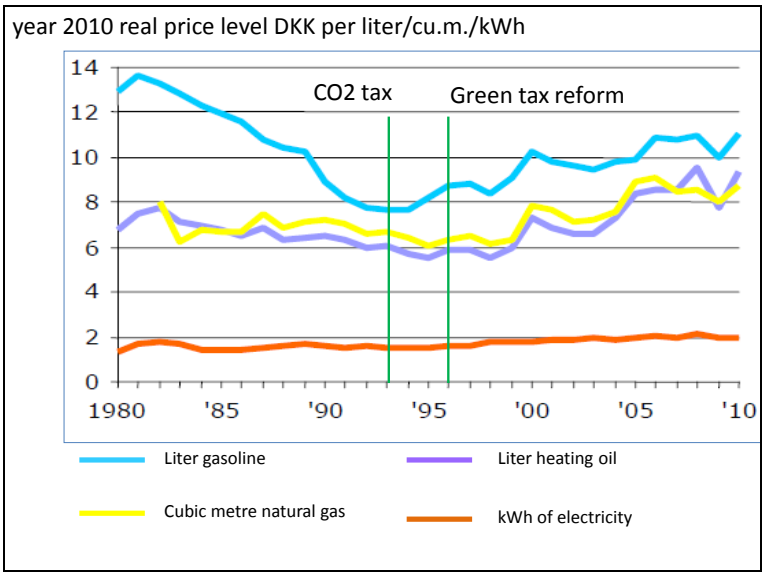

Figure 50: Consumer prices (2010 price level) for household fuels and petrol 1980 to 2010

Source: Energistatistik 2010

Grant for energy saving measures in pensioners' dwellings

Background:
The scheme started in 1993 and ended December 2003. It provided subsidies for energy-saving measures in dwellings occupied by low-income pensioners. The scheme was motivated by the wish to promote energy savings as well as social equity.

Targeted Agents/Coverage
Only pensioners receiving "heating assistance" (income dependent financial support) were eligible for a subsidy. Approximately 285,000 dwellings are occupied by pensioners who receive heating assistance.

Design
The scheme granted subsidies up to 50% of costs for EE-investments covered by the scheme. Subsidy support could be granted several times, but not in excess of a total of Euro 3,334 per dwelling.

Implementation/Costs
The subsidy amount for the scheme was around 9 million euro per year. From 1993 to 1998, approximately Euro 34.67 million were granted in subsidies.

Monitoring and Evaluation
Annual reports based on approved subsidies.

Results
At the end of 1998, subsidies amounting to an average of Euro 1,734 per dwelling had been granted in 24,000 cases, at an estimated average investment of Euro 4,667.

Impact on energy consumption
The energy savings per dwelling are estimated at 35 GJ annually, generally of heating oil.

Awareness campaigns implemented by the Electricity Saving Trust

Background
The Electricity Saving Trust was established in 1996 to promote electricity savings in the public sector and in households. In 2010 it was replaced by a new organization with a broader mandate, comprising savings in

energy consumption in general and not just electricity. The new organization was abolished again in 2012; the DEA took on some of its functions.

Targets/ Expected Outcomes
Reduction of electricity consumption. The target for the Fund was to generate annual electricity savings of 750 to 800 GWh in 2007.

Targeted Agents/Coverage
Electricity consumers in the public sector and in households.

Design
The fund is managed by a board consisting of a chairman and eight other members appointed by the Government. The annual budget of the Trust was financed through a fee on electricity of 0.6 øre per kWh (=0.08 eurocents). The board had full liberty to identify initiatives best capable of fulfilling the objective. The Fund's daily operation was handled by a secretariat with six employees who outsourced many functions to external consultants.

Implementation/Costs
The Trust had an annual budget of approximately 90 million DKK (=12 million euro),

Results/outputs
Min Bolig (My House).
In 2007 the Electricity Saving Trust developed a tool, Min Bolig (My House), for use by consumers to obtain a complete overview of electricity consumption in the home. The tool enables consumers to monitor electricity consumption by electrical appliances and to find out where the largest savings potentials are. The tool builds on plans of the consumer's home in which the consumer can use icons to place electricity-consuming appliances. The tool is web-based and can be accessed through the Electricity Saving Trust's website. With time, the Min Bolig tool will become a technological platform for the intelligent home and it will function as a control centre for appliances and electricity-savings equipment in the home. The website will also include a function to monitor changes in electricity consumption over a day, week and month, once the energy companies have established remote metre reading for ordinary consumers. This is expected in the near future.

A-pumps.
7 out of 10 Danish homeowners have an out-of-date circulation pump which uses too much electricity. The Electricity Saving Trust produced two consumer-oriented TV spots focusing on replacing old circulation pumps. The Trust also contacted the plumbing sector to ensure that they were well informed about the campaign and in a position to offer a good service for customers in parallel with the campaign. The TV campaign was shown on national TV with a parallel banner campaign on a number of websites.

Guide on electricity consumption
In December 2007, the Electricity Saving Trust distributed a guide on electricity consumption to all households in Denmark via the postal service. The 24-page booklet covered the following areas: TV and entertainment, Computers, Refrigerators and freezers, Laundry, Food and drink, Lighting, Indoor climate, Standby consumption, The intelligent home, Set your own savings targets

Cheapest-most expensive campaign focusing on electricity savings (H).
In 2007 the Electricity Saving Trust ran a comprehensive campaign focusing on the fact that energy-saving products may be the most expensive to buy initially, but they are cheaper in the long run through consumption savings. Two advertising spots were produced for the campaign. An A-category light bulb compared with a traditional incandescent light bulb, and A+ and A++ labelled fridge-freezers compared with fridge-freezers with higher energy consumption. In both spots a consumer meets a shop assistant who

explains that the energy-efficient products are cheaper in the long run. The campaign was shown on national TV in 2007 and it is planned to repeat parts of the campaign in 2008.

My house – the intelligent home (H)

In 2007 the Electricity Saving Trust developed a new tool, Min Bolig (My House), for use by consumers to obtain a complete overview of electricity consumption in the home. The tool enables them to monitor electricity consumption by electrical appliances and to find out where the largest savings potentials are. The tool builds on plans of the consumer's home in which the consumer can use icons to place electricity-consuming appliances. The tool is web-based and can be accessed through the Electricity Saving Trust's website. With time, the Min Bolig tool will become a technological platform for the intelligent home and it will function as a control centre for appliances and electricity-savings equipment in the home. The website will also include a function to monitor changes in electricity consumption over a day, week and month, once the energy companies have established remote meter reading for ordinary consumers.

Club1000 - 1000 kWh campaign (M)

Some 15,000 Danes have joined Club1000 on the Electricity Saving Trust's website. The Club provides an overview of electricity consumption by entering readings. Using these readings Club1000 generates a curve from which you can see your consumption compared with the average for Denmark and compared with the recommended consumption of 1000 kWh. Club1000 members receive a monthly target and advice about saving electricity. There has been a short radio campaign on a number of radio stations and there was a campaign on printed media in larger Danish newspapers in November and December 2007. Both campaigns focus on reducing consumption to the recommended 1000 kWh. The plan is to develop the Club1000 website further with member-to-member functionalities, guest writers, etc.

The electricity savings label (Elsparemærket)

In 2006, on the basis of voluntary and free agreements with manufacturers and dealers, the Electricity Saving Trust set up the *Elsparemærket* to help consumers make energy-correct purchases. The *Elsparemærket* is typically used on the most energy efficient 20 per cent of products on the market within their product category. A secretariat for the label has been set up which makes agreements and maintains them. Sample checks are made of the products that carry the label. In 2006 the *Elsparemærket* was introduced for light bulbs; in 2007 on white goods, circulation pumps, electricity-saving sockets, computers and computer screens; in 2008 on televisions, washing-up machines, tumble driers, cordless units and power supply units and appliances.

Electricity-saving sockets – Standby Killers

In 2001, recognising that few people remember to turn off their computer equipment, Peter Karbo, a project manager at the Danish Energy Saving Trust, came up with the idea to develop a special auto-power-off plug bank, in the following denoted as a Standby killer. The Trust contacted the Danish Technological Institute for an assessment. This was the start of a cooperation to develop a functional standby killer that looked exactly like an ordinary plug bank. The special feature of the Standby killer is that it automatically turns off all plugged equipment once the controlling unit (e.g. a computer or TV) is switched off. The first prototype saw the light of day in December 2001. A new generation of standby killers were developed detecting standby power use for any device plugged into the master socket, which means that they can work with all devices as the master, including PCs, notebooks, TVs, audio equipment, etc. At the same time, the energy consumption of new standby killers itself was reduced to almost nothing – in contrast with previous consumption levels of the old TV standby killers, which was 0.5–1.5 Watt. Consumers can typically save 20-25 euro a year by using the electricity-saving socket set. The Trust pushed the market towards launching more products and suppliers. The campaign was launched in autumn 2007 and involved close contact with several major retail chains. These chains were encouraged to offer their customers Standby killers "free of charge", for instance by throwing in a Standby killer with each purchase of a TV or a computer. In return, the Trust ran a TV informational-commercial focusing on the advantages of electricity-saving socket sets and telling consumers which retail chains were offering free Standby killers. The campaign created considerable awareness for standby killers, and soon the retail chains had to sell them separately instead of merely

handing them out with a computer or TV. Total costs for the 2007-08 campaign amounted to around 1.2 million Euro.

Impact on EE
The portfolio evaluation in 2008 (and another, Trust specific evaluation) concluded that the Trust met its EE-objectives. The evaluation estimated the annual savings in 2007 at approximately 1,000 GWh, which is 28 percent above the target.

Agreements on energy efficient windows

Background
The high annual cost of heating makes household consumers pay attention to finding ways of reducing their annual heating bills. Due to many years of information and awareness campaigns most dwelling owners are well aware of the principal means to improve the EE of their buildings: adding extra insulation material under their roofs, cavity insulation of outer walls and installing more EE-windows, the socalled energy-panes. But it requires expert knowledge to visually see a difference between double glazing windows and energy-panes. Within the category of energy panes there are also relatively large differences in U-values and consumers have no way to control the correctness of information about these. In 2003, only 35% of the double glazing sold for use in *existing buildings* were energy-panes. For use in *new buildings* only energy-panes were sold; energy-panes, therefore, accounts for more than 60% of total annual sales.

As a way to achieve market transformation, in 2004, the Danish Ministry of Climate and Energy/DEA signed an agreement with window and glass producers and installers to reduce the use of traditional panes and promote the use of efficient low energy windows and panes.

Targets/ Expected Outcomes
The industry agreed to reduce the market share of traditional thermal panes from 30% in 2003 to less than 10% by 2006.

Targeted Agents/Coverage
The agreement was concluded with the glass industry and all major actors involved in the improvement of windows in new and existing buildings.

Design
This was to be achieved by using two initiatives: 1) By making the energy-pane a standard product in any company's portfolio and working towards a reduction of the price difference and 2) an awareness effort directed at the wholesale market which accounts for the largest portion of the sales of traditional double glazing windows. In addition, the agreement comprised the setting up of a system for labelling of windows and panes. DEA provided grants to finance the setting up of the system for the labelling of windows, information campaigns and assist the development of efficient windows solutions.

Cost of implementation
20 million DKK (2.7 million euro)

Evaluation and monitoring
An evaluation was made for DEA in 2007.[41]

Results
The evaluation was highly critical of the labeling scheme, which it found to be vastly inferior to labeling schemes in other EU countries.

[41] SRC International et al (2007).

The market share of energy-panes had reached the targeted 90 percent.

Impact on energy consumption

Due to absence of relevant good quantitative data, the 2007 evaluation was unable to quantify the impact.

EE-Requirements in Danish Building Regulations

Background

Heating of households accounts for 25 per cent of total Danish final energy demand. In 2009 there were 2,735,000 dwellings in Denmark. Over the past 10 years the rate of addition of new dwelling was 0.7 pct. per year.[42]. Fixing high EE-standards for new building in building regulations (BR) has, therefore, limited impact on total energy consumption for heating. For this reason, BRs in recent years are being expanded to include EE in connection with the renovation of existing buildings.

The first building regulation (BR) to impose requirements on the EE of buildings was introduced in Denmark in 1961. Since then, the EE-requirements have been tightened in new revisions of the BR. Most recently, Denmark revised the BR in order to fulfill the requirements in the Energy Performance of Building Directive (EPBD 2003).

Targets/ Expected Outcomes

Each BR fixed targets for the maximum energy consumption per square meter. Compared to the 1982 BR, the net heat consumption is reduced by 25% by the tightening imposed by BR98.

Targeted Agents/Coverage

New construction of residential and office buildings.

Design

The BR imposes restrictions on heat loss through outer walls, windows, roof and ground deck. Starting with BR79, restrictions were also imposed on the size of the total window area in percent of external walls or the gross floor area of the building. According to BR98, the total window area to external air shall not exceed 22% of the gross floor area of the building and electricity consumption of ventilation systems must not exceed 2,500 J/m³ fresh air.

Table 21 : Selected changes in building component U-values in the Danish Building Regulations

U-values (W/C° m2)	BR61	BR72	BR77 (1979)	BR82	BR85 (1986)	BR98	BR08
Outer walls (>100 kg/m2)	1.1	1.00	0.40	0.40	0.35	0.30	0.30
Outer walls (<100 kg/m2)	0.50	0.60	0.30	0.30	0.30	0.20	0.20
Ceiling	0.40	0.45	0.20	0.20	0.20	0.15	0.15
Floor	0.50	0.60	0.30	0.30	0.30	0.20	0.12
Windows	-	2.90	2.90	2.90	2.90	1.80	1.5

Source: EA Energianalyse (2010)

[42] Source: EA Energianalyse (2010). The information on impacts in this section is taken from that report

The Danish building regulation has moved from being a technology specification (prescribing the standard of the materials used) to a performance specification in BR 98 (prescribing the outcome of the energy saving effort for the whole building). Under BR98 a choice can be made between complying with the reduced building component U-values or the heat loss of the entire building. BR has changed its focus from a net energy frame to a gross energy frame, which implies a choice between insolating and making the building efficient in retaining energy and installing renewable energy systems like solar panels that add energy without GHG emission implications.

Energy requirements for new buildings were later tightened by 25 per cent in 2006, which also introduced a new form of regulation, the *energy framework*: it establishes a comprehensive framework for the building's energy needs, combined with requirements for selected components. Use of RE can also count in fulfillment of the energy frame. This provides greater flexibility and room for innovation, as the developer chooses how the energy framework is to be respected. At the same time, the high minimum requirements for essential building components and installations, ensure that the base housing has a good energy standard.

The energy policy agreement of 2008 decided that the energy consumption in new buildings must be reduced by 25 per cent in 2010, an additional 25 per cent. in 2015 and a further 25 per cent in 2020; thereby achieving a total reduction of at least 75 per cent for new buildings constructed in 2020. To ensure better monitoring and targeting, the agreement decided that energy consumption in buildings is to made more visible by gathering information on energy consumption and energy requirements of each building in the Building and Housing Register (BBR). The BBR Act is to be amended to provide for the collection of the information on energy consumption as it lies with district heating, gas and power companies.

In addition, changes were introduced in the BR to enforce cost effective, energy-saving initiatives in existing buildings. When renovating or changing a building, building owners have the obligation to choose the most energy efficient viable solutions. There is today a requirement that all profitable energy savings must be implemented as part of major renovations , and specific energy requirements when replacing major building components such as boilers, roofs, etc.. Looking forward the Government expects also to require EE-building components for small renovations and maintenance.

Implementation/Costs

n.a.

Monitoring and Evaluation

Several evaluations have been made as part of the preparatory work for new revisions of the BR. In 2010, an evaluation made an econometric analysis of the natural gas consumption in 2003 of a large sample of houses located in two different natural gas supply areas and constructed during different BRs.[43]

Achieved Results

Figure 50, reproduced from the 2010 evaluation, reveals a significant reduction of energy consumption over different construction periods and BRs. Recently constructed houses use almost 50 per cent less natural gas per m2 than houses constructed in 1931-1950, and even the latest change (BR98) covered by the dataset show a significant reduction when comparing houses built before and after 1998. It also shows geographical differences in household energy consumption: MNG customers consume less than HNG customers. The

[43] Ea Energianalyse (2010)

evaluation speculates that lower average household income in the former may explain some of the difference.

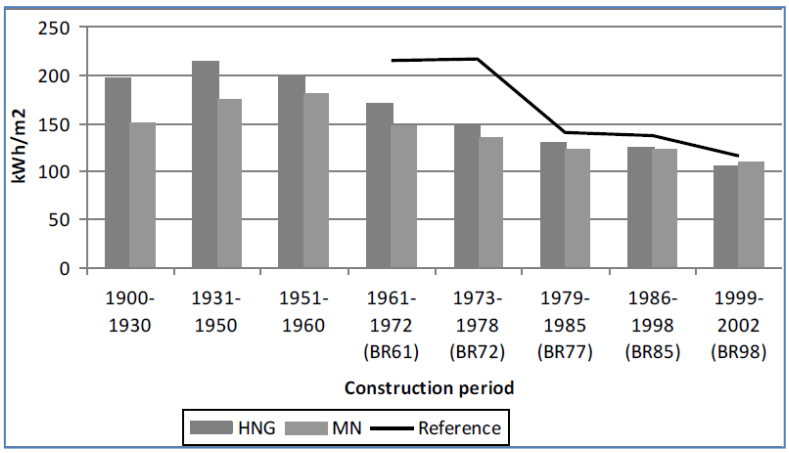

Figure 51: Consumption of gas per m2 by construction period of houses, 2003 data set

Source: Ea Energianalyse (2010)

The figure also shows that owners of pre-1998 buildings have made efforts to improve the EE of their houses. The reference line in figure 49 is calculated as the *level of natural gas that would have been used in a standard 145 m2 house built in different construction periods according to the U-values in the building regulations*.[44] For houses constructed according to the BR61 we see a significant difference between the reference line and the actual average natural gas consumption. For more recent constructed houses the difference between reference line and mean natural gas consumption decreases.

Impact on Energy Consumption

The analysis showed that the tightening of the BR in BR-1998 resulted in a 7 percent reduction in the consumption of natural gas for heating compared to homes built in the period immediately before.

This is lower than the 25% tightening of BR98 compared to BR86 and shows that market forces and awareness campaigns had lifted the EE-standards on the market already beyond the BR-requirement.

[44] The calculations incorporate natural gas used to heat water, heat loss because of ventilation and boiler loss.

EE Improvement Measures Implemented in Tertiary Sector

Energy consumption and EE in the Tertiary Sector

In the year 2000, the tertiary sector with a final energy consumption of about 2 mtoe accounted for 13 percent of total energy consumption: *public service* for 4 percent, *private trade and services* for 9 percent. The energy consumption increased slightly between 1990 and 2007. It was pulled up by growing electricity consumption which by 2007 reached a 50 percent share in the sector's energy consumption.

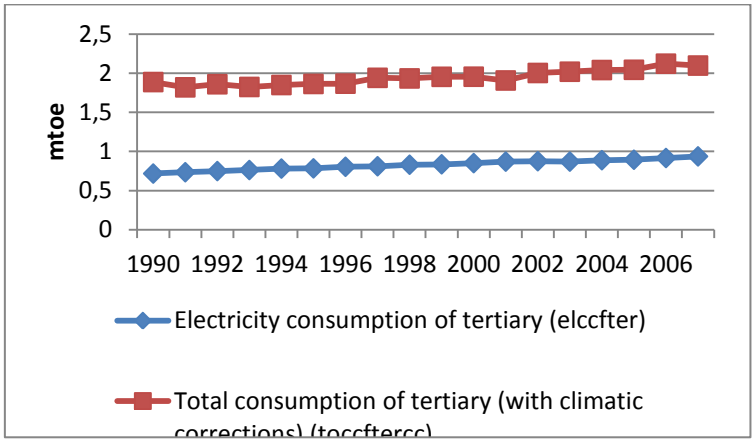

Figure 52: Tertiary Sector energy consumoption and electricity consumption 1990-2007

Source: Odyssee

Figure 53 shows the development in the service sector's energy and electricity intensity from 1990 to 2007. The *energy intensity* - climatically adjusted – fell 27%, the *electricity intensity* 14.6%. The slower decline in electricity intensity reflects the increasing share of electricity in the sector's energy consumption. Energy intensity fell until 2001, the 2001-2007 period saw very little improvement in EE.

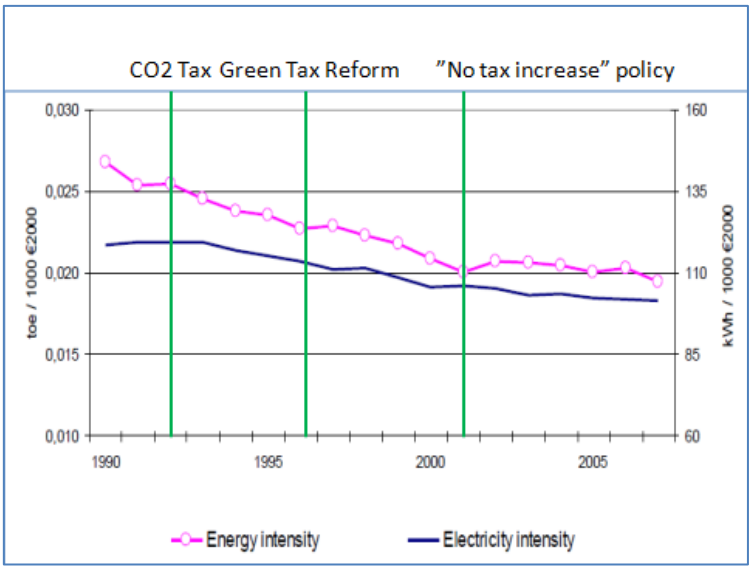

Figure 53: Energy intensity in the service sector 1990-2007, climate adjusted

The energy intensity in the service sector by branch is shown in figure 54. It is highest in *hotels and restaurants* and lowest in *administrations (the public sector)*. During the 1990-2007 period, the energy intensity increased in *hotels and restaurants* and decreased in all other branches, most significantly *trade*, where energy intensity decreased by 44.4%.

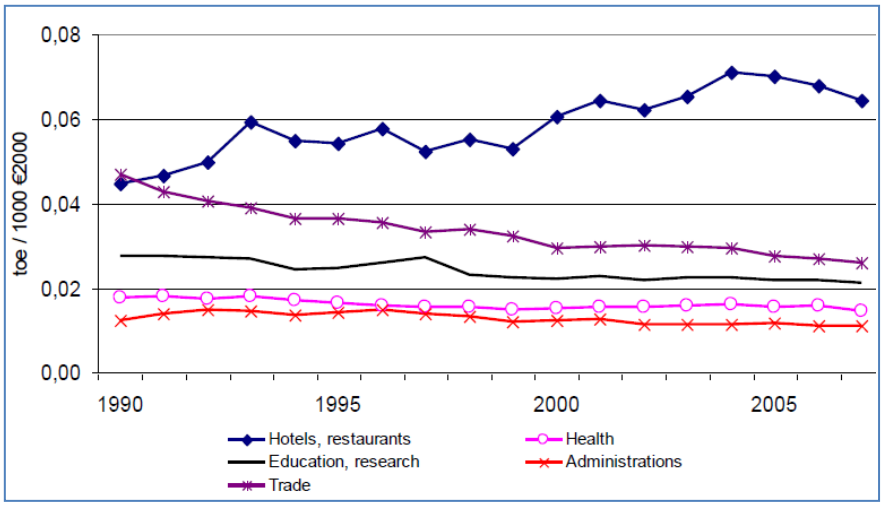

Figure 54: Energy intensity in the service sector by branch 1990-2007

Source: DEA/Odyssee

Despite continued growth in production and in employment, the public sector's annual energy consumption since 1985 had been kept at 25 PJ, see figure 55. Therefore, the public sector's energy intensity fell.

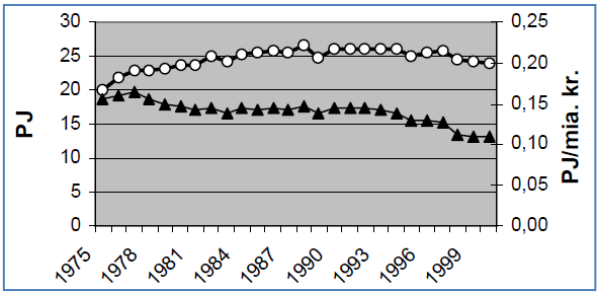

Figure 55: Public Sector energy consumption and energy intensity 1975-2000

Source: Energy Saving Report 2001

Policy strategy for EE in the Tertiary sector

In the sector, the Government faces two substantially different target groups for EE-policy: the public sector and the private business sector. The introduction of a CO_2-tax in 1992 and the increases in energy and CO_2 tax rates in the green tax reform of 1996 were the main policy instrument for EE in the sector. Judging from the discontinuities in EE-performance that can be seen in figure 52, green taxation worked! But whereas public sector institutions, like households, had to pay the full CO_2 tax rates in their energy invoices; the private businesses received some rebates.

The high prices for energy made the cost of energy more visible on the annual budgets of public institutions. Therefore, within a given year, it made sense for public managers to save energy, as it meant that more

money was available for other purposes. In addition, the Government attempted to find ways to allow public institution s to benefit from energy cost savings over several years and not see them evaporate after a year as a new budget for the institution reduced the allocation for energy. Within the public sector, the Government could dictate EE-measures to state institutions by issuing circulars. For municipal institutions, the direct approach was not feasible. Instead, the Government negotiated agreements with the Association of Municipalities that municipal administrations would follow the same EE-policies that were laid down for state institutions. The policy instruments to promote EE in the public sector evolved in the circulars as follows:

- In 2001, a circular imposed onto public institutions the obligation to implement *energy management*.
- In 2005, a circular obliged public institutions to implement *EE-procurement*, to *invest in energy savings with reasonable payback times (up to 5 years)* and to *disclose actual electricity consumption on the Internet*.
- In 2008, a circular assigned state institutions the energy saving target that *energy consumption in 2011 should be 10% lower than in 2006*.

Since the late-2000s, the Government has tried to promote *ESCOs* as a tool for EE in the public sector.

The *Electricity Saving Trust* was a central actor in promoting energy savings in the tertiary sector. It concluded socalled "A"-agreements with private businesses encouraging these to purchase EE- electricity using equipment in exchange for PR and information and reverse-the-trend agreements with municipalities.

In 2001, the Government introduced an official energy saving policy and Parliament adopted a specific Law for Energy Savings. Table 22 shows the business-as-usual scenarios of the policy and the EE-targets by sector. The scenarios saw annual energy consumption of households and of industry to fall during the 2000-decade and increase in the tertiary sector. The EE-policy goal for the tertiary sector was to keep its consumption constant at its year 2000-level, except for a small increase in private trade and services. Considering that the public sector's annual energy consumption had stayed around 25 PJ from 1985 to 2000, keeping the public sector's energy consumption constant was not an overly ambitious EE-target.

Table 22: Sectoral Energy Consumption and EE Targets in 2001 EE Policy

Table 1: Proposals for saving targets for 2008-12 and the saving targets for 2005.

	2000	Scenario without new initiatives		Saving targets, PJ	
	Present final energy consumption	2005	2010	2005	2008-12 proposal
Total, excluding transport	**438**	**425**	**428**	**15**	**20**
Households	188	184	180	8	8
Public service	24	26	27	2	3
Private trade and service	56	56	59	3	4
Industry and agriculture	170	159	161	2	5
Transport	201	219	231	-	7
Total, including transport	**639**	**644**	**659**	-	**27**

Source: Energy Saving Report 2001

Policy measures in the MURE database

The MURE database lists eight measures that were implemented in the tertiary sector. Upon leaving out measures that had "low" or "unknown" effect on EE as evaluated by MURE, three measures are left:

- Heat inspection of small oil heat furnaces
- 1995 Regulations for new Building
- Reverse-the-trend agreements

The most important policy measure is not included in the list: the green tax reform. It is described in detail in the chapter on cross-cutting policies. The section above on EE-policy information about the impact of the green tax policy for tertiary sector EE. The building regulation has been discussed in the household section; and will not be repeated here. The other two measures are described briefly below.

Heat inspection of small oil heat furnaces

Background

n.a.

Targets/ Expected Outcomes

Improved EE of small oil heat furnaces.

Targeted Agents/Coverage

The 700,000 small oil heat furnaces in Denmark are inspected by 2,500 educated consultants.

Design

Statutory annual inspection of small heat furnaces (120 kW or less). The owner has to show the chimney sweeper a contract with an authorised service provider or pay the chimney sweeper for the inspection. The inspection includes measurement of temperature, CO and CO2 content of the smoke and a report including evaluation to the owner. Based on fixed maximum values for these figures, the chimney sweeper can impose the owner to have the oil burner adjusted within 4 weeks.

Implementation/Costs

n.a.

Monitoring and Evaluation

n.a.

Achieved Results

n.a.

Impact on Energy Consumption

The supervision has resulted in improved EE. The average chimney loss has been reduced from 19% to 12-13%.

Reverse-the-trend agreements

Background

The policy of improving EE in the public sector through circulars had not been effective in curbing the growth in energy consumption in the public sector. A statistical analysis of the energy consumption in 100 public buildings, with a total area of 1 million square metres, indicated an increase in energy consumption per square metre area during the period 2000 to 2007 of 4% for heat and 10% for electricity.[45] Electricity consumption by the public sector was growing by one per cent per year. The Electricity Saving Trust set the goal to curb the growth by no later than 2009. A key instrument were ”reverse-the-trend agreements” with municipalities, municipal-, regional-, state institutions and with large private office enterprises under which, the organisations fixed targets for their electricity savings.

In 2010, the Danish Energy Saving Trust replaced the Electricity Saving Trust with a broader energy saving mandate and agreements were expanded to include also heating energy, but not as stand-alone targets in the agreements.[46]

Targets/ Expected Outcomes

Energy savings in the tertiary sector. Specific energy saving targets are fixed in each agreement.

Targeted Agents/Coverage

Municipalities, municipal-/regional-/state institutions and large private office enterprises. Main focus is on public sector institutions.

Design

In the ”reverse-the-trend agreements”, the institutions set targets for their energy savings. E.g. to save two per cent each year from 2008 to 2010 compared with year 2007 electricity consumption. The institutions are obliged to publish their electricity (and, if pertinent, heat consumption) on the website of the Trust so development in consumption and achievement of the targets can be monitored. The institutions also commit themselves to be open and transparent about how their savings are achieved, so others can learn from the experience.

The agreement commits the Trust to provide technical assistance to the institution to help achieve the goal. The Fund offers, among other things: (i) coaching throughout the process by a fixed staff plus a number of specialist experts, (ii) help in implementing EE-procurement, (iii) material to conduct awareness campaigns to staff, (iv) a free “electricity-savings toolbox, (v) ”knowledge exchange presentations at theme meetings, (vi) PR in media.

Implementation/Costs

[45] Source: Togeby et – Portfolio Evaluation (2008)

[46] According to the legislation concerning the Danish Energy Saving Trust, the goal of the Trust is to contribute to the realisation of cost effective energy savings. This goal should be pursued through the use of campaigns, market introductions, dissemination of knowledge, as well as the development and promotion of tools and solutions used to achieve energy savings. In close relation to the stated goal, a central framework for the Trust is that its activities should be coordinated with and support other activities and organisations operating within the field of energy savings, including the energy companies’ activities in relation to their energy saving obligations.

The Trust is financed by a special energy savings charge of DKK 0.006/kWh mainly payable by households and the public sector. Total annual proceeds amount to approximately DKK 90 million (=7.5 million euro) per year. The share of total costs spent on the "turning the tide agreements" is not published.

Monitoring and Evaluation

Each institution with an agreement publishes each year its energy consumption on the website of the Trust, so progress can be monitored.

Achieved Results

More than 130 "turning the tide agreements", some covering electricity savings only, some covering heat energy and electricity, have been signed with: state ministries and agencies, municipal administration and institutions, regional institutions (mainly hospitals), foreign embassies, private firms in the service and trade industry. The energy savings fixed in the agreements range from 2% to 20%.

Impact on Energy Consumption

n.a.

Impact evaluation (methods and results)

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