State of the Art of Energy Renovations of Buildings in Denmark

Jensen, Per Anker

Publication date:
2011

Document Version
Publisher's PDF, also known as Version of record

CENTER FOR FACILITIES MANAGEMENT
CFM
REALDANIA FORSKNING

DTU

ACES-project

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in Denmark

Per Anker Jensen

November 2011

CONTENT

Page

1. INTRODUCTION

The purpose of this document is to provide an overview of the current state of energy renovation in Denmark as an input to the partners in the ACES project and as a basis for further work on the project. This includes particularly a contribution to WP1 'Visions and possibilities for building renovation' (KTH main responsible) and a basis for WP2 'Evaluation of economic and environmental benefits for restoration' (DTU main responsible).

The overview mainly includes short summaries and references to a number of publications written in Danish. This document provides an English presentation of these publications and in most cases also links to web-sites, where the publications can be accessed.

A 'white book' on building renovation has recently been published with an overview of existing knowledge and the most important studies of the effects of renovation in Denmark (BiD and GI, 2011). This includes a chapter particularly about energy renovation of buildings and this has been an important basis for this document.

I thank senior researcher Jesper Ole Jensen, The Danish Building Research Institute, for comments to a draft version of the documents. Jesper Ole Jensen is involved in CFM's project on ESCO in municipalities mentioned in section 4.2.

Contact has been made to senior researcher Kim B. Wittchen, The Danish Building Research Institute, who is responsible for the Danish part of the Nordic project MECOREN (Methods and Concepts for sustainable Renovation). The project also involves KTH from Sweden and partners from Norway and Finland. A first draft report has been produced on "Building typologies in the Nordic countries" (Wittchen et al., 2011). The report includes overview of available information in the four countries on development in building and energy regulation, building stock, energy certification, energy performance and building typologies. The draft report in English is available at the ACES projectweb. Another report by the MECOREN project with cases studies should be nearly finished.

The rest of the document is structured in three main sections. Section 2 informs about energy renovation measures in general and in relation to different types of building. Section 3 focuses on barriers and incentives for energy renovation as well as stakeholder aspects. Section 4 presents some specific tools and methods in relation to energy renovations, which seems of particular relevance for the ACES project.

Besides a list of references with links to web addresses, there is also at the end a separate annotated list of Danish web-sites related to the topic.

2. ENERGY RENOVATION MEASURES

2.1 General measures

The civil engineering department at DTU has produced an idea catalogue of general measures for energy renovation of all building types (DTU-BYG, 2010). It includes the following 48 measures divided in 7 areas:

1. Insulation of the building fabric
    1. Added insulation of flat roofs
    2. Added insulation of moderate sloping roofs
    3. Added insulation of high sloping roofs
    4. External insulation of outer walls
    5. Internal insulation of outer walls
    6. Added insulation of floor on ground level
    7. Added insulation of low cellars
    8. Added insulation of high cellar
    9. Insulation of thermal bridges
    10. Air tightening of the building fabric

2. Windows
    1. Renovation with double glazing
    2. Renovation by replacing thermo glass with energy glass
    3. Replacing façade windows with energy windows
    4. Replacing façade windows with plus windows
    5. Replacing façade windows with ventilation windows
    6. Replace/establish windows in sloping roofs
    7. Replace/establish windows in flat roofs

3. Glass facades, incl. sun shading, and lighting
    1. Added insulation with glass facades in contrete building
    2. Efficient sun shading for regulation of sunshine and daylight
    3. Establishing sun walls
    4. Closing in balconies
    5. Renovation of lighting systems in larger buildings

4. Installations – water born heating and cooling
    1. Change to low temperature heating and high temperature cooling with thermo active building components
    2. Change to low temperature heating with radiators
    3. Technical insulation
    4. Automatic control of water born heating and cooling system

5. Installations – air born heating, ventilation and cooling
    1. Preheating of ventilation underground – also cooling
    2. Ventilation with heat regain: Natural, hybrid and mechanical
    3. De-central ventilation with heat regain
    4. New efficient ventilation units
    5. Utilisation of free cooling
    6. Utilisation of materials with phase shifts

6. Energy supply
    1. Water supply, including de-central
    2. Replace district heating installation
    3. Replace oil based heating unit
    4. Replace gas based heating unit
    5. Replace circulation pumps in heating and air-condition system
    6. Sun panels for water heating
    7. Combined sun heating system for air and water
    8. Establishing sun panels on roofs
    9. Establishing air-water heat pumps
    10. Establishing air-air heat pumps
    11. Establishing underground heating
    12. Micro power and heating plant
    13. Renovation of cooling system for room ventilation and cooling

7. Building operation
    1. Commissioning
    2. Monitoring and energy management
    3. User behavior and management

Each measure is described based on a common template, including among other things principle drawings, references, cost estimates and energy saving.

The report also refers to the web-site www.energikoncept.dk, which includes a reference catalogue with a gross catalogue of energy saving measures.

The Danish Building Research Institute has made a report about potential energy reductions in existing buildings (SBi, 2009a). It establishes scenarios until 2050 for energy reductions based on increased heat insulation of outer walls, roofs, floors and windows and improvements in technical installations for the Danish building stock.

The Danish Council for Ecology has produced a report for an industry association on building integrated energy production (Det Økologiske Råd, 2011). It provides an overview of products on the Danish market mostly on electricity production by solar cells (Photo Voltaic) and heat production from water based solar panels. The report indicates that a change is taking place towards increasing use of building integrated energy production partly due to

new incentives in public regulation but also because of quite drastic price reductions for solar cells. It is now economical advantageous for private house owners to invest in solar cells. An important precondition for this is, that the public regulation in Denmark allows owners of solar cells to deliver electricity to the general electricity network and have the delivered electricity fully deducted in the annual electricity consumption of the household. As major part of the consumer price of electricity is energy taxes and V.A.T. etc., this implies a considerable indirect state support to electricity produced by solar cells.

2.2 Measures for different building types

The Danish Building Research Institute has made a report about the need for maintenance and renovation in private rented housing with focus on motives, strategy and economy (SBi, 2008a). The Danish green think tank CONCITO has produced a report with a proposal to solve the so-called paradox problem in private rented housing further mentioned in section 3.2. Their report also presents model calculations for energy renovation of a private rented housing estate from 1935 (CONCITO, 2011). It includes a basic but economically sound renovation including insulation of floor over entrance gate, walls towards unheated rooms, floor over basement and heat and water pipes. It also includes a more ambitious renovation which in addition has added insulation of massive outer walls and replacing windows and doors in external walls.

The Danish Building Research Institute has made a report about renovation of social housing based on studies of 10 estates in 2004 before renovation and in 2007 after renovation (SBi, 2008b).

The civil engineering department at DTU has produced a report about energy reductions in public buildings. The measures resemble the earlier mentioned general measures and a university building is used as case. More interesting in this context in the reports presentation of methods for economical assessments of energy reductions as mentioned in section 4.1 (DTU-BYG, 2008)

The consulting engineering company COWI has produced a report about reduction in CO_2 in municipal buildings using data from the national Energy Labeling system (BiD and GI, 2011).

The Palaces and Property Agency's homepage has an idea catalogue of energy optimization measures in state buildings: ses.dk/da/Energi/Saadan%20sparer%20du/Idevaerktoej.aspx. They have also published a report about energy optimization of listed buildings (SES, 2009). An example project for renovation of a listed building has also been made based on a preliminary study (Realea, 2009).

3. BARRIERS AND INCENTIVES

3.1 General barriers and incentives

Even though there is a lot of focus on energy renovation of buildings, the development in practice is not going very fast according to the 'white book' (BiD and GI, 2011). A stakeholder analysis has been made as part of the work on the 'white book', and this summarizes the main barriers as follows (Advice A/S, 2011):

1. Too little political consciousness about the value creation by renovation
2. Weak economical incentive structures – including the paradox problem
3. Lack of life cycle cost perspective
4. Lack of standard solutions/concepts
5. Clear 'hen and egg' problem – lack of demand causing lack of development causing lack of demand
6. Overview and common direction is lacking among the actors
7. No overview of potential and priority
8. Renovation has an image problem compared to new building activities

The Danish Building Research Institute has listed a number of barriers divided in internal barriers, which cover the inertia among building owners, and external barriers covering lack of knowledge, resources and solutions (SBi, 2009b). The Danish Council of Technology has also listed a number of barriers, including lack of requirements, knowledge and experience, and frontrunner projects for both private and public buildings (Teknologirådet, 2008).

One of the main incentives is supposed to be the Energy Labeling system (EMO). The regulation varies for different buildings types. For housing EMO is mandatory for buildings over 60 m^2. For rented out buildings for business purpose it is mandatory for buildings over 1.000 m^2. The system includes that a certified consultant makes an EMO report for each building before it is sold and/or by regular intervals. The EMO report should include recommended measures to reduce energy within a specified payback time.

A report made for the Danish Energy Agency has investigated the effect of nine different energy actions aimed at reducing energy – not just in relation to buildings but in general (EA et al. 2009). One of the conclusions was that the Energy Labeling system is not cost effective.

For public buildings it is compulsory to implement all the measures in the Energy Label report with up to 5 years payback time. The earlier mentioned report from the civil engineering department at DTU about energy reductions in public building criticizes that this means that many economical sound measures with longer payback time is not implemented (DTU-BYG, 2008).

A new report from about the Energy Labeling in Europe from The Danish Building Research Institute concludes that the label is not being utilized by Danish building owners (Gram-Hanssen & Haunstrup Christensen, 2011).

The above mentioned stakeholder analysis points at the following ways forward (Advice A/S, 2011):

1. Political consciousness and will to act
2. Economical incentives, for instance energy differentiated property tax, financial support and support of life cycle cost perspective
3. Productivity development
4. Make it easier to start renovation by one-stop delivery packages, tools to visualize measures and effect and a choice between a number of standard solutions
5. Better coordination and collaboration
6. Easier access to consulting
7. Solving the paradox problem

The stakeholder analysis identifies a large number of different stakeholders with different interests in energy renovation of buildings, but except for the paradox problem the stakeholders do not have contradictory interests.

3.2 The paradox problem in private own rented buildings

The paradox problem is known internationally and is also called the landlord-tenant dilemma or a principal-agent problem. The International Energy Agency has produced a report about the problem (IEA, 2007) referred to in the Danish report by CONCITO (2011), which also mentions initiatives in different countries.

The paradox is that energy renovation of private owned rented building in principle should be of interest for to owners and tenants, but they are seldom implemented due to the contradictory economical interests for the owners in high rent income and tenants in low rent cost. Furthermore, the owner has to pay for the investment and the tenants will obtain the cost savings due to energy reductions. The owners' possibility to increase the rent due to energy renovation is limited in the present regulation of rented housing in private owned buildings in Denmark, which increases this problem considerably.

CONCITO's proposal for a solution is called "Green Town Renewal", which refers to town renewal programs in Denmark in the 1990´s, where the normal regulation of rented housing was abandoned and the housing improvements with large public financial support were agreed between the private owners and the tenants in each estate. Changes in legislation are seen as necessary as well as financial support. CONCITO suggest that the funding is provided by the energy supply companies by increasing their existing duty to ensure energy re-

ductions. The proposal has been negotiated with several organizations, but the Danish tenants association has reservations in relation to how much the rent must be increased (CONCITO, 2011).

The former Danish Ministry of Welfare has produced a report about barriers and incentives for energy reduction in rented housing covering both social and private owned housing. The report also mentions the barriers in the present regulation of private owned rented housing, but they do not make any suggestions for a solution (Velfærdsministeriet, 2009).

The new Danish government from October 2011 has announced an initiative to change the regulation for private owned rented housing with the aim to overcome the paradox problem.

3.3 The paradox problem and incentives in public buildings

In the Danish state there has since year 2001 with the introduction of the so-called SEA reform of state property and building administration been a division of ownership and use of space with formal rental contracts except for the defense area. This has created a similar paradox problem as for private owned rented buildings with contradictory interests between landlords and tenants, although there is no legal regulation prohibiting increases in rent to cover investments in energy improvements. It also creates divisions in who is responsible for different parts of buildings and thereby for implementing energy improvements. In the regions and municipalities there are also typically divisions between central property units and the user institutions, but there usually are no formal rent arrangements.

The Palaces and Property Agency has had a consulting company to produce a report about incentives for energy reductions in state buildings (PÖYRY, 2009). The report recommends an incentive model with penalties and bonuses in Public-Private Partnership project and a similar model for other new state building projects. In state owned rentals the report distinguish between smaller improvements, where a temporary rent increase until the investments is covered is recommended, and more expensive projects with reduction in energy for heating, where it is recommended to include the heat cost in the rent for as long a period as needed to cover the investment. The latter proposal may require a revision of the rent regulation for state property (the SEA guidelines). A similar model is recommended when the state has space rented in private owned buildings.

In the earlier mentioned report produced by the Palaces and Property Agency concerning energy optimization of listed buildings is mentioned, that it is considered to introduce a model for state organizations renting space in state property, where the tenant is compensated relatively for covering investment cost of energy improvements, if they leave within 5-10 years after the improvement (SES, 2009).

4. TOOLS AND METHODS

4.1 Economical assessments

The report mentioned in section 2.2 about energy reductions in public buildings from the civil engineering department at DTU includes a chapter about economical assessments (DTU-BYG, 2008). It distinguishes between private and societal economical assessments. The later are based on a guideline from the Danish Energy Agency and will not be mentioned further here.

The report takes a starting point in the method Simple Payback Time, which is very commonly used, but the report points out that it neither takes the service life nor inflation into account. There is a common misleading practice to compare the payback time of measures with different lifetimes equally. It is recommended that simple payback time is only used for measures with a short service life and not for instance for insulation with typical service life of 30-100 years. The report recommends the method Cost of Conserved Energy (CCE) or Cost of Saved Energy (CSE) – in Danish called 'Energisparepris' (ESP), which is a measure of the price of saving one kWh. The report from 2008 presents this method in a quite advanced form based on net present value calculations. The method also includes the degree of renovation as the relation between the age of a component and the service life as percentage (DTU-BYG, 2008).

In the other report from the civil engineering department at DTU with the idea catalogue from 2010 the method is used in a more simple form without including net present value calculations, finance cost, inflation and other future economical conditions. The degree of renovation is replaced by an energy renovation factor between zero and 1 defined as the degree of the investment in a renovation project that is related to energy renovation. CCE is simply calculated as the investment cost divided by energy cost saving over the service life and adjusted according to the energy renovation factor, if the building renovation covers more than energy renovation (DTU-BYG, 2010).

The Property and Palaces Agency (SES) has on their homepage a tool for calculating the profitability of energy investments. It is included in an Excel spreadsheet and the calculations are based on net present value with a formula used by the Agency of Economy. The discount rate is 5% p.a. determined by the Danish Ministry of Finance and the annual increase in energy prices exclusive of inflation is 0.92% based on prognoses from the Danish Energy Agency. The calculation requires the following input data:

- Service life expectancy
- Annual savings from the investment in DKK
- The initial investment

The tool also includes some typical examples of service life expectancies. It can be downloaded at: www.ses.dk/Home/Energi/Beregn%20rentabiliteten.aspx.

4.2 ESCO contracts

In recent years we have seen a fast development in use of Energy Performance Contracts (EPC), where a building owner arrange a partnership with an external provider, who conduct an energy renovation and optimization of the building over a period. Often the provider promise guaranteed energy savings and is paid by a part of the savings over a number of years. Some providers also finance the necessary investment and are called ESCO's (Energy Service Companies), but there is a variety of contract forms. The term ESCO has become commonplace in Denmark and is used in the following as an umbrella term.

There are other European countries like Sweden and Austria with much more experience with ESCO than Denmark (BiD and GI, 2011).

Until now it has mostly been Danish municipalities, who have been active in making ESCO contracts, but the market seems to be developing fast. At CFM we have over the last 2 years carried out a research project about ESCO in Danish municipalities and two conference papers has been published (Jensen et al., 2010, 2011a, 2011b and 2012).

Three of the pioneering municipalities (Middelfart, Kalundborg and Gribskov) are collaborating on a development and demonstration project on ESCO supported by EU, see: http://www.escommuner.dk/index.php?option=com_content&view=article&id=277&Itemid=144. This website includes a tool for calculation of key figures for ESCO.

There is also another website with more general information about ESCO: www.goenergi.dk/offentlig/vaerktoejer-og-beregnere/esco

There are some municipalities (including Middelfart, Høje Taastrup and Roskilde), that have established initiatives to engage private house owners in collaboration on ESCO.

A first ESCO contract has been made by a social housing association. This project for the estate Bæk-/Fosgården is expected to reduce the rent by Euro 10-15 pr. Month. It is arranged with a temporary increase in the rent but a similar reduction in heating cost in four years. In this period the total cost is neutral for the tenants and after the 4 years the rent is reduced again and the tenants gain all savings from the energy reductions. The contract is regarded as a pilot test for the social housing sector (BiD and GI, 2011). The contract is on the ACES project web.

In 2009 the former Danish government launched a strategy for energy reductions in buildings, which included initiatives to enhance ESCO.

The first ESCO project in ministry buildings (the buildings of the Danish Nature Agency) was signed in 2011. Here, the Ministry of Environment has invested EUR 267,000 in 40 buildings, with the aim of reducing the energy use in the building stock by 25% in 2013. In 2011, three ESCO projects in university buildings were sent to tender, and other projects are in preparation (Jensen et al., 2012).

The new Danish Minister for Climate, Energy and Buildings from October 2011 has in an interview mentioned that ESCO in private housing could be a possible way to finance energy reductions (Licitationen, 28 October 2011).

There does not seem to be any examples from Denmark, where ECSO like models have been implemented as a way to solve the paradox problem in private owned rented buildings, but this seems an interesting possibility to investigate.

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WEB-SITES

www.bo-energi.net
Homepage about renovation of rented out housing following a conference and an action plan by collaborating associations.

www.byggeriogenergi.dk
Homepage for Knowledge centre for energy reductions in buildings (Videncenter for vedvarende energi) placed at the Danish Technological Institute.

www.concito.dk
Homepage of the Danish green thinktank CONCITO. Includes various reports on climate issues.

www.energikoncept.dk
Tool for renovation of multi-storey housing estates with BIM-configuration. Includes a reference catalogue of energy saving measures.

www.ecocouncil.dk
Homepage of the Danish Ecological Council (Det Økologiske Råd). Includes various reports on climate issues.

www.energiforumdanmark.dk/
Homepage of the association Energy Forum Denmark (Energiforum Danmark) with a knowledge bank and a development forum. Includes the information tool: www.energiwiki.dk

www.escommuner.dk/index.php?option=com_content&view=article&id=277&Itemid=144.
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Homepage of Centre for Renewable Energy (Center for Vedvarende Energi) – an independent public organization. Includes information on ESCO in public organizations:
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Website about energy in state buildings at the homepage of the Palaces and Property Agency. Includes idea catalogue: ses.dk/da/Energi/Saadan%20sparer%20du/Idevaerktoej.aspx and tool for profitability calculations:
www.ses.dk/Home/Energi/Beregn%20rentabiliteten.aspx