

Development of a 2nd generation energy certificate scheme – Danish experience

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Keywords

EPBD, building stock knowledge, energy certification, energy labelling, energy saving, knowledge extraction, certificate design, certificate secretariat, dwellings, non-residential buildings, asset rating, operational rating

Abstract

Energy certification as described in the European Energy Performance of Buildings Directive (EPBD) will undoubtedly contribute to improving the energy performance of the European building stock. At the same time the Directive offers a unique opportunity to obtain valuable knowledge about the building stock for future surveys of energy saving potentials, compilation of energy saving measures and policy making. However, the knowledge attained will always depend on the quality of the energy certification scheme. Thus, developing energy certificate schemes deserves very careful consideration. This paper describes Danish experience, where mandatory energy certification schemes in operation since 1997 have been updated to accord with the EPBD requirements.

On the basis of Danish experience, this paper will offer some insight about the relationship between data collection, certification procedure and quality control on one hand, and the quality of obtainable knowledge on the other. Also the relationship between the overall quality of the certificate and future possibilities to evaluate the effect of the scheme on the energy performance of the building stock will be discussed.

With this background, lessons learned will be related to the current efforts in Denmark to improve the design of the 2nd generation energy certification scheme. Key issues considered include: How we can change from operational rating to asset rating and how we can ensure the quality of a new certifica-

tion scheme? How can we make an expressive design to ensure transparency, reliability and 'saleability'? And how can we establish an efficient secretariat function?

Introduction

A main objective of the European Energy Performance of Buildings Directive (EPBD) is to improve the energy performance of the European building stock. To achieve this, an energy certificate scheme has become the central element of the Directive, and this will be compulsory for all European Member States from 2009 at the latest. As a consequence, it is possible that knowledge about the energy performance of buildings in all European Member States (MS) will have to be collected in databases. Afterwards, this knowledge might be made available to the building construction and property sectors to promote the energy performance of the buildings. Additionally, the databases might be of high value for future surveys of energy saving potentials, for compiling energy saving measures, for benchmarking buildings and for policy making. In the long run the accumulated knowledge will facilitate more systematic generation of energy savings with a more solid basis, especially if the quality of the building stock knowledge attained by implementing energy certificates is of high quality.

This is exactly what the Danish Energy Authority (DEA) and the Danish Building Research Institute (SBI) have found from a certification scheme launched in 1997. Experience reaped from the 1st generation energy certification scheme was used when the scheme was updated in line with the EPBD. In this 2nd generation energy certification scheme, two methods, one for large buildings and one for small buildings were merged together. At the same time, data collection based on meter readings (op-

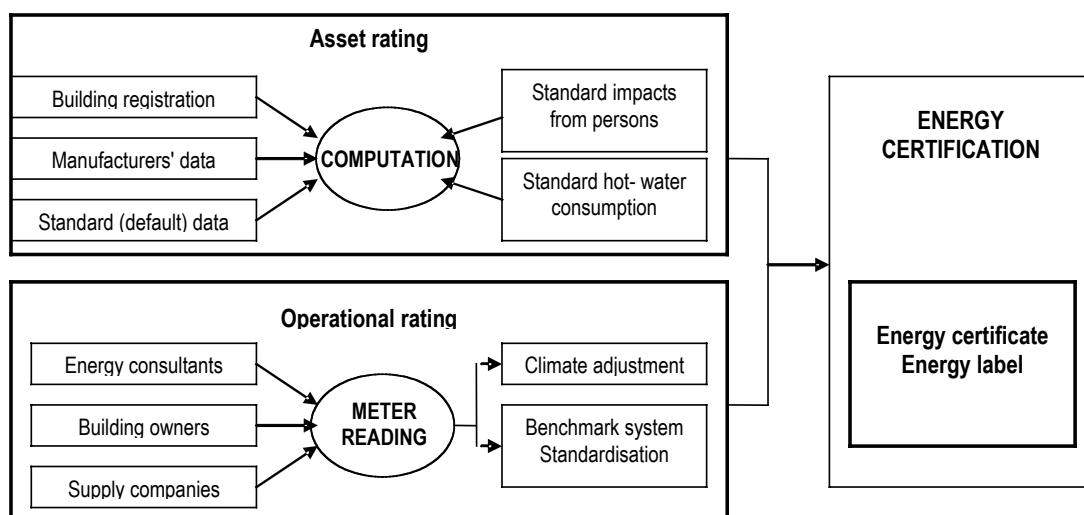


Figure 1. Approaches for energy certification. Possible data flows, based on either asset rating or operational rating, for calculating the energy performance of buildings and for carrying out energy certification of buildings, also known as energy labeling.

erational rating), which was used for large buildings, shifted to data collection based on calculations (asset rating). This shift revealed the advantages and disadvantages of the two types of data collection. Considerations concerning refinement of data arose and all the procedures relating to data input, authorisation of energy consultants, control and transparency of data were reassessed. Moreover, with regard to knowledge extraction, we seriously considered whether the data collected in the new scheme could contribute to surveying potentials, compiling relevant energy saving measures, drawing up benchmarks and evaluating the effects of the energy labelling scheme. Finally all these considerations had to be taken into account in the new, revised scheme.

Obtaining building knowledge

The approach to data collection and data processing is decisive for the quality of the energy certification and for the quality of the analyses it is possible to achieve afterwards. For this reason, there must be serious consideration of whether “a general framework for a calculation of an the integrated energy performance of buildings” (EPBD, article 1,a) should rely on asset rating or operational rating - or on a combination of both. Ideally, calculation of the energy performance using asset rating is the most appropriate, because by definition this approach is independent of building users’ behaviour. From a pragmatic point of view, calculation of the energy performance using the operational rating is the most feasible, because this approach is independent of expert knowledge and it is the easiest method to carry out. In most situations however, a combination of the two approaches seems to be the most suitable, because the advantages of both approaches can then be balanced. See figure 1.

For the asset rating framework, knowledge about the actual building is necessary. Thus computation must rely on losses, loads, generation and distribution systems, and local climate. In addition the computation must include standard loads from persons and appliances, and standard consumption of domestic hot water. In this way asset rating can break down the consumption into single contributions from individual elements of

the energy balance. In addition, it is easy to make adjustments to a standardised use of the building and moreover easy to estimate energy savings. Having said that, it must be emphasised that computation depends on a reliable computation engine and a database with standard, default data on building physics. These data may come from manufacturers or general research, bearing in mind that the data must also relate to old buildings. Finally a realistic calculation cannot be carried out without careful inspection of the building itself. During the inspection, detailed registration and measuring is required. To summarise, the computation approach demands considerable manpower: A corps of well-trained energy consultants. Moreover, an authorised calculation structure is needed which must include a computation tool, an extensive database and a professional secretariat.

The operational rating framework instantly gives a picture of the actual energy consumption. The method is cheap, and it is possible to use automated readings. However, the approach mixes the energy efficiency of a building and the energy behaviour of the building user. Therefore, readings must be related to a standard use of the building and corrections are needed in order to make clear the building performance. Benchmarks can be useful here. Moreover, the meter reading must be adjusted for climate fluctuations. Of course, meter reading depends on meters. Without meters, there is no reading and no certificate to be issued. Data logging and online meter reading can be of great value to estimate a “true” consumption. But still, well-founded correction factors, knowledge about climate adjustment and subtraction of climate independent consumption are all vital within this framework.

Balancing the two approaches will also be a balance between cost and quality. The balance approach can be illustrated as a staircase, with increasing cost and data quality as one approaches the top of the stairs.

Stair 1. The lowest costs level includes only the meter-reading approach. Both the building owner and the utility companies can report on this step.

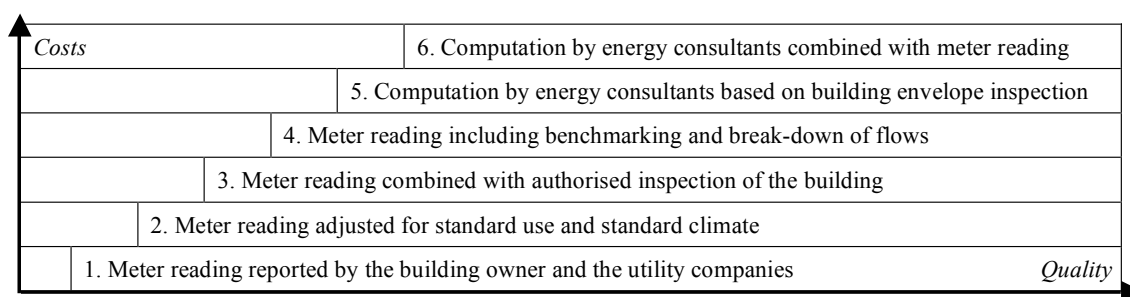


Figure 2. Six stairs of complexity. Six 'stairs' of costs and quality concerning knowledge/data collection for energy certification of buildings. Full operational rating starts from stair 2 and full asset rating from stair 5.

Stair 2. Meter readings are checked by an energy consultant and, using benchmarks, corrected to standard use and standard climate (operational rating).

Stair 3. Meter readings and authorised inspection of the building are combined. During the inspection unreliable meter readings will be corrected and later they will be adjusted using benchmarks and relevant energy saving measures will be identified.

Stair 4. Advanced meter readings are combined with benchmarking and prior knowledge of specific energy uses, e.g. ventilation, lighting, domestic hot water etc. for all types of building. (EU/EP-LABEL, 2007)

Stair 5. Computations (asset rating) performed by an energy consultant based on building envelope inspection. (See EU/EPA-NR, 2007 and (EU/EPA-ED, 2007).

Stair 6. Advanced computation and meter reading are combined to obtain mutual knowledge. Better still, computations based on building envelope inspection and standard, default data are combined with meter readings adjusted for climate and standard use. Combined computations and meter readings are important to enable mutual control and make visible both the user effect and the energy performance of the building.

Certainly, the top-of-the-stairs level implies more manpower, basic building information and calculation facilities and consequently more costs than the bottom stair. Still, given the improved possibilities to generate energy savings from the high quality knowledge of the building stock, the balance between meter reading and calculation is worth serious consideration. In the Danish 2nd generation certification scheme step 5 is being used for small buildings and step 6 for large and commercial buildings.

Refinement of building knowledge

No matter which approach is used to obtain knowledge, the knowledge can be refined afterwards, to a greater or lesser degree, depending of the competence of the authority responsible for the energy certification scheme. Reporting forms and the functionality of computer programmes can be crucial for the quality of knowledge obtained and these must be planned with great forethought. Likewise, the education, qualifications and appointment of the practising energy-consultants as well as their access to high quality, basic knowledge can be vital for the quality of knowledge embedded in the resulting energy certificate. Finally control of the work of the energy consultants, top-down and bottom-up, will influence the refinement

of the energy certificate. There are at least six ways to refine the knowledge obtained from both computations and meter readings as (EU/ENPER-EXIST, 2007 and Thomsen et al 2006). These are:

1. Authority of the energy certification
2. Design of forms and procedures
3. Performance of computer programs
4. Education programmes
5. Handbook for energy consultants
6. Top-down and bottom-up control of data

The following discusses the advantages and disadvantages of each method.

Re 1. A central or local authority (regime) can be responsible for the energy certification procedure as well as the performance of the energy certification scheme. The question of authority, central or local, can be decided by the individual Member States. The starting point however, is the EPBD. This states that the energy performance "should be calculated on the basis of a methodology, which may be differentiated to regional level" (EPBD, 2002, § 10). And "in accordance with the principles of subsidiary and proportionality as set out in Article 5 of the Treaty, general principles providing for a system of energy performance requirements and its objectives should be established at Community level" (EPBD, 2002, § 10). However, "the detailed implementation should be left to Member States, thus allowing the Member States to choose the regime which corresponds best to its particular situation" (EPBD 2002, § 21).

Going beyond the EPBD, there are both advantages and disadvantages concerning the ability of central regimes to manage an energy certification scheme. A central (national/regional) authority can by definition allocate the necessary resources to implement a new certification scheme at all levels of the administrative hierarchy, starting with legislation and general regulation for overall control of the scheme, and continuing with reviews and information to end-users. Thus, a central authority can enforce rapid implementation of the scheme and a fast build-up of a high quality database of building-stock knowledge. However, local authorities can adjust performance and data registration with respect to local building traditions and administrative practices.

Re 2. When an authority is established, reporting forms and computer programs can help to ensure uniform procedures, standard input data and uniform calculation in order to generate the best possible energy certificate. Standards will increase the accessibility, transparency and objectivity of the energy-performance assessment. Furthermore, it is expected that standards for calculation methods and guidelines for inspection of the building envelope and the systems in the building will reduce costs compared with developing and maintaining separate standards and guidelines at regional and national levels.

Nonetheless, it cannot be guaranteed that standards will always generate high-quality reports and high-quality data. It is important that the EPBD standards are flexible enough to allow for necessary national and regional differentiation. If not, the standard forms and standard data-processing will either result in building certification reports that comply with the standards but not with the actual buildings or reports that comply with the actual buildings, but not with the standards.

Re 3. Computer forms are suitable for both inspection and calculation, and they can either be on the Internet or on interactive programs on stand-alone computers. Both types ensure that the consultants follow specific procedures and that they remember all the necessary input data and steps for final certification and final calculation of a label index. In addition, computers can provide a simple check of the validity of the data entered. Likewise, a computer form linked to one single calculation method will ensure uniform results and will facilitate easy administration of the data. Nonetheless, computer forms make demands on the technology. All computer forms require permanent subscription arrangements so that all changes resulting from fault finding or improving the program are communicated instantly and records of changes are kept in a central place.

Re 4. In order to ensure well educated and well trained energy consultants, appointment of energy consultants using an authorisation procedure may be relevant. The authorisation can be linked to education programmes and examinations. The education programmes must relate to different subjects like general building knowledge, energy performance, data registration, data storage, and calculation. Depending on the educational background of the candidate, for example engineer or architect, the education programmes may focus on different subjects. On the other hand, education programmes are expensive in both time and money and education programmes may present a bottleneck for implementation of the EPBD energy certification. Alternatively, on-the-job training-programmes could be considered. In this way energy certification can be initiated from day one, bearing in mind that the quality certification will improve gradually as the number of qualified consultants increases.

Re 5. In addition to authorisation of energy consultants and education programmes, there is a day to day need for knowledge in order to carry out certification in accordance with the EPBD rules and national specifications. For this reason a handbook is an absolute necessity, covering all general rules for certification and all rules decided at national level for carrying out certification, inspection and calculations, and drawing up of the energy certificate. What is more, a handbook can be a central part of an education programme. A handbook can ei-

ther be an Internet version, a printed version, or both. In either case the handbook should be approved by the authority as the official tool.

Re 6. Systematic quality control will continuously raise the quality of data reported and improve data collection. Control prevents sloppy work and unfinished certification reports. At the same time control can be used to identify systematic errors and improvements in the assessment procedure. Several steps of quality control can be identified. These are: automated screening, electronic screening, manual screening, desk control and technical revision.

Automated screening takes place when data are reported. In this way out-of-range data, unlikely data, and missing data can be identified. Electronic screening can be carried out using a computer program that screens the whole database at regular intervals. Manual screening can be performed by statistical analysis, still without inspection in the field. In contrast, a technical audit of labels already issued requires inspection of the property by a second authorised consultant. This auditing, usually based on sample checks, can check data, documentation and proposals for energy saving measures.

As a supplement to a top-down refinement of energy certification data, public access to the energy certificates can also provide a refinement. In the same way as access to information on taxable value of properties, building plans and similar, access to data concerning building energy certification that has been carried out can be utilised to obtain quality control and promote interest in energy certification and the benefits of it. Moreover, if public access is linked to benchmarking, this will highlight the energy performance of the specific building as well as relevant energy saving measures. For new purchasers of a property, benchmarks will be a standard of reference and make it easy to compare houses with regard to their energy performance.

Extraction of building knowledge

Next to direct improvement of the energy performance of buildings, knowledge extraction based on a combination of a number of energy certificates is of high value for research and for policy making. From databases of energy certificates already issued it is possible to extract data to calculate potentials for energy saving and to carry out benchmarking on selected groups of buildings. Finally it is possible to extract data to evaluate the effect of different energy saving policies, energy saving campaigns and the energy certification system itself.

When calculating energy saving potentials, extracts of data related to a specific type of building sorted by use, size, location, age, etc. makes it possible to create a detailed overview of the energy saving potential of different segments of the building stock.

In a Danish study more than 200,000 (Wittchen, 2005) energy certificates from small buildings were analysed and categorised according to the energy rules in the various Danish building codes and recognised changes in the building tradition, starting from 1900 and ending with the building code from 1995. The buildings were divided into seven time-typical periods, each with their typical energy performance. The certificates included information about individual parts of the buildings, their U-value and area, and it was thus possible to

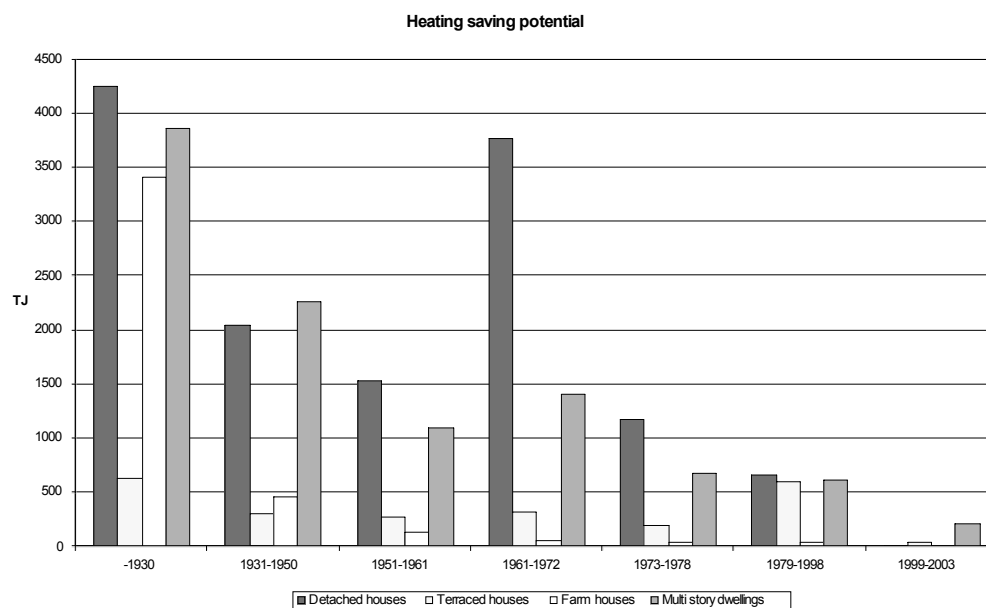


Figure 3. Potential heating savings. Potentials in Danish residential houses, based on a study on more than 200,000 issued energy certificates, and extrapolated to the entire Danish building stock. The savings represent 30 % of the energy consumption for space heating.

identify those constructions with the highest energy saving potential. The energy savings were calculated under three assumptions: 1) Fifty per cent of external walls and floors with the poorest U-values were upgraded to reasonable insulation level, 2) Fifty per cent of all roofs with the poorest U-values were upgraded to today's standard and 3) All windows were upgraded to today's standard.

This study showed that 30 per cent of the energy consumption for space heating in Danish residential houses could be saved. Moreover, the study revealed that there is a large energy saving potential in Danish detached houses built in the period from 1960 to 1972. This is not due to the poor insulation level of these buildings, but rather the fact that a lot of houses were built in this period. Naturally the largest energy saving potential is found in the oldest buildings, but it was also clear that some old buildings have been updated and show a relatively good energy performance. A key question therefore is how to activate incentives to stimulate energy savings in existing buildings.

An intermediate although significant result of the study was an estimate of energy balances of all segments of residential houses in Denmark.

When an energy study, based on issued energy certificates, has been performed, it is possible to couple this information with various geographical information systems, such as GIS (Geographical Information System). In this way it is possible to make the energy saving potential visible on a map, and see if there are regional or local variations that call for special attention or where the most profitable energy savings can be harvested for the least effort.

Extracts of data related to specific-purpose buildings, like schools, hotels and offices can be the key to benchmarking a selected segment of buildings. The idea of benchmarking is that knowledge about the level of energy performance for a specific building can be compared to the energy performance

of the segment as a whole, and this will induce building owners to obtain a better position. The building owner will search for measures to improve the energy performance of the building or will encourage the users of the building to improve their energy behaviour.

In a Danish benchmarking tool for schools, data from all energy certificates issued to for public and private schools was extracted to support a web site aimed at energy officials, school caretakers, teachers, and pupils (Jensen, 2007). Selecting a specific school in this tool makes it possible to compare the energy performance of the school with all other schools in the municipality, the region or the country. Heat, electricity and water consumption are subjects for benchmarking. Moreover the user can select among several units of measurement, for example kWh of heat per square meter per year and kWh of electricity per pupil per day, etc.

When evaluating the effects of the tool it became clear that different extracts could give valuable indications of the effect of different energy saving initiatives. Analyses based on the total number of certificates issued since 1997 clearly indicate that the national building code in Denmark has been successfully implemented. It is evident that the energy performance of buildings constructed in the years after the code was tightened is generally much better than the energy performance of buildings constructed according to the old rules.

Analyses based on the same material make it possible to evaluate the consequences of the energy certification system itself. Such analyses focus on the energy performance of older buildings compared to the energy performance of buildings complying with the building code at the time of their construction.

In continuation of such efforts, it may be possible to carry out more detailed analyses of the effects of specific energy saving campaigns, for instance the effect of a recent campaign in Denmark to encourage people to change their windows to low-energy windows. The quality of such analyses however, very

much depends on the quality and the frequency of the energy certification system.

Implementation of a 2nd generation certificate scheme

The Building Directive (EBPD) has forced the Danish Energy Authority to change the Danish energy certification scheme that came into force in 1997. The Directive corresponds to a large degree to the existing labelling scheme. For this reason the term 'energy labelling' is preferred in Denmark to 'energy certificate' and this term will be used in the remaining part of the paper. Moreover in a Danish context energy labels are already widely used in a wide range of household appliances, light bulbs, refrigerators, vehicles, etc. Like these, the new Danish energy label for buildings also has energy arrows (see Figure 2).

Since 1997 Denmark has had an energy labelling scheme for almost every type of building. The Building Directive (EBPD), which to a large degree corresponds to the existing scheme, has forced the Danish Energy Authority to alter the scheme. The scheme has now been revised to accommodate the requirements of the EPBD and the design of the scheme has been changed to incorporate findings and experience gained during the past years. Since the new scheme came into force, 9,000 detached dwellings have been labelled according to the new scheme, but almost no larger buildings or blocks of flats.

MAIN PLAYERS

The overall administrator of the scheme is the Danish Energy Authority, an Authority under the Ministry of Transport and Energy. Private consultants are involved in a number of activities concerning development and operation of the scheme. All major regulations for the energy labelling scheme are issued by the Danish Energy Authority which is responsible for:

- Legislation
- Setting up general rules for the scheme including a handbook for consultants
- Control of budget and costs
- Overall control of the scheme
- Contracts with the secretariat, technical auditor etc
- Appointment of individual energy consultants
- Setting maximum charges for consultants (small buildings only)
- The political system
- Composition of information for consultants
- Information for consumers/users

The energy regulations in the building code and the rules for energy labelling are linked in several ways. Before official permission to use a new building is given, an energy audit has to be performed to check if the assumptions used when calculating (to obtain a building permit) the energy performance are correct. Furthermore it is mandatory for the public authorities at national level to implement energy saving measures with a

pay-back period of less than five years, as described in the energy label of the buildings.

Responsibility for the calculation tool for both the regulation and the labelling is with the Danish Building Research institute (SBI). Responsibility for daily administration of the energy labelling scheme is with a secretariat hosted by a consortium of two private energy and building consultancy companies. The secretariat carries out operational activities which include:

- Registration of energy consultants
- Education of consultants, new and refresher courses for existing consultants
- Development and maintenance of consultants' handbook
- Registration of energy labels in a database system
- Continuous evaluation of the performance of the scheme
- Collection of statistics to prepare tools
- Collection of statistics for evaluation
- Quality control of the energy labels and the work performed by the consultants
- Operation of the website (www.femsek.dk) and newsletters for consultants.

The secretariat started operation on 1 January 2006 and activities have been developed throughout 2006. The quality of energy labelling and the work performed by the energy consultants is ensured by another energy consulting company, which has been engaged to perform technical audits of the energy labels, e.g. field control of a number of energy labels based on preliminary activities carried out by the secretariat. The quality work commenced during 2006. Responsibility for the Building Code is with the National Agency for Enterprise and Construction.

ACTS AND EXECUTIVE ORDERS

In Denmark the EBPD was followed up by a detailed legislation. Firstly a basic: "Act on promotion of energy savings in buildings", (Act no. 585, 24 June 2005), and secondly a number of executive orders. The executive orders were issued during 2005 in order to enable the labelling scheme to come into force on 1 January 2006. The most important executive orders in force are the: "Executive order on energy labelling of buildings" - edition (No. 1731), issued on 21 December 2006 and "Executive order on inspection of boilers and heating systems in buildings" - edition (No. 881), issued on 18 August 2006.

Together, the legislation describes a rather detailed picture of the energy labelling scheme, leaving only little doubt about how the scheme is designed and the intentions behind it. The detailed legislation is completed with a comprehensive handbook, which describes in detail the work that must be carried out by the energy consultant.

THE LABELLING SCHEME

The Danish energy labelling scheme covers nearly all buildings where energy is used for indoor climate control. Exemptions are buildings used for commercial production and for energy production. In very general terms energy labelling is mandatory in:

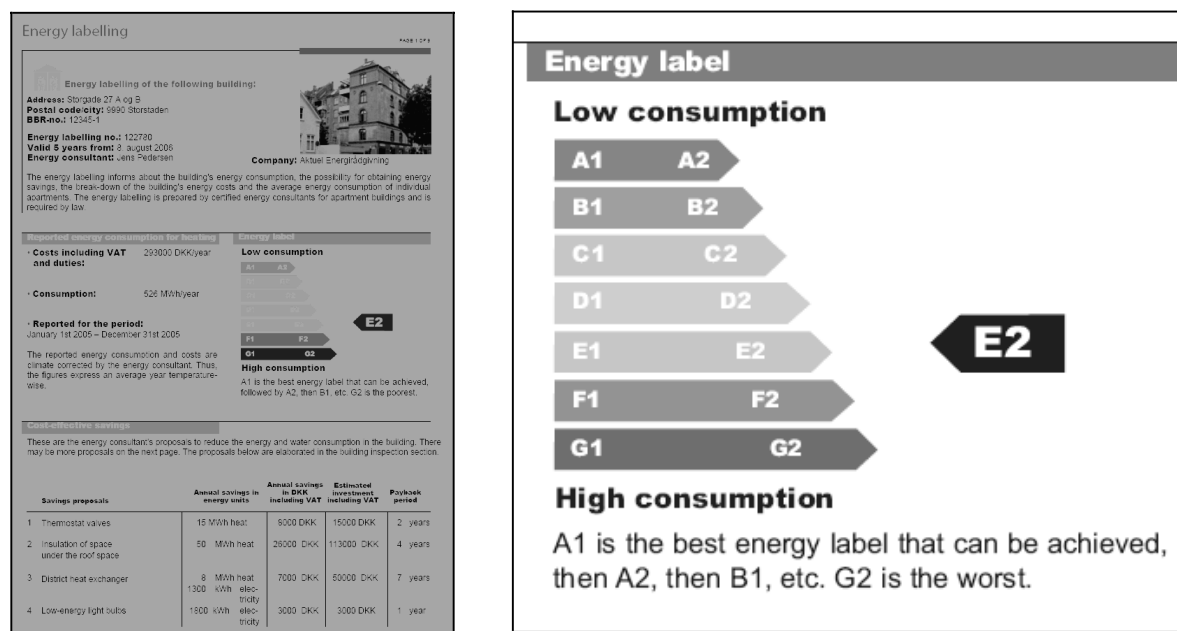


Figure 4. The Danish energy label. In the scheme, energy labelling is performed by use of energy labelling arrows included on the front page of the energy certificate.

- Residential buildings
- Public buildings
- Buildings used for trade and private service
- New and existing buildings

The labelling must be carried out:

- When a building or dwelling is sold or rented out
- Regularly (every 5 years) for buildings larger than 1,000 m²
- Regularly (every 5 years) for all public buildings

The full energy labelling process, which must be completed by an approved and registered energy consultant, covers an energy label, an energy plan, and detailed registration of the whole building (thermal envelope and technical systems). The labelling of a building show the building's energy performance calculated according to a method based on the general framework provisions provided in Annex to the EPBD. In Denmark the method is also used in connection with building regulations to calculate of the energy efficiency of new and renovated buildings. The computer programmes used for the calculation of the energy label are based on a calculation engine developed by the Danish Building Research Institute. However, the design of the user interfaces is open to all market actors. Currently two companies have made such interfaces, which are also used to report the energy labels to a central database system (mandatory).

The energy label includes proposals (an energy plan) on cost effective measures to improve the energy performance of a building. An energy saving measure is cost-effective if the value of the annual saving multiplied by the lifetime of the measure divided by the investment is greater than 1.33. This means that the investment must have a pay-back period of less than three-quarters of its estimated life span.

The energy label is a standardised, documentation of a building's calculated energy performance on the basis of normal building use. For the energy label, energy consumption for heat, domestic hot water, cooling, ventilation and lighting is calculated, as well as the energy consumption of other technical installations, apparatus, etc. Energy labelling is done for an entire building and covers energy labelling of both residential and commercial units. With new buildings, and in other special cases, energy labelling may, however, be done for individual units.

There are 14 classes on the labelling scale from A1 to G2, where A1 is the best. The 14 classes are needed to have a sufficient number of classes to make it possible to improve the label by performing relevant energy saving measures in buildings of different age and energy standard. New buildings must be at least class B1 to get approval for use. Class A1 and A2 are used for low energy buildings. See figure 4.

Energy labelling of new buildings is based on a building inspection, supplemented by material from the building plan and the permit application. The energy consultant ensures that the energy requirements in the Building Regulations have been met. This may include verifying whether the required insulation of technical installations has been done and whether buildings, installations and products in general have the energy efficiency assumed when building permits were applied for. It may also include verifying whether technical installations, etc., have applied a proper control strategy.

The energy labelling scheme is designed to be cost neutral and independent of the Danish tax payers. A fee structure provides the income to cover costs of operating the secretariat, technical auditor, education of consultants etc. The costs of the energy label itself are defrayed by the building owner. For detached single-family dwellings an executive order adjusts the maximum price of an energy label. The price consists of a basic amount and some additional amounts depending on the

specific building, with a maximum price of around € 500. The market for energy labelling of larger buildings is not regulated by the Energy Authority. This could lead to unacceptable high prices for certifying this type of buildings at least in the beginning of a new certification scheme.

APPOINTED ENERGY CONSULTANTS

Individually appointed energy consultants play a very important role in the scheme as the persons who actually carry out the labelling. Two types of appointment are available in the scheme: some consultants cover single family houses and often also perform building inspections (mandatory when a building is sold), while some cover larger residential buildings, public buildings and the trade and service sector. It is possible to be appointed within both types. In order to become an authorised energy consultant, the consultant must be a trained engineer, architect, construction designer or similar and must have at least 3 years of documented, relevant experience in building technology and energy consultancy. The consultants must have compulsory professional indemnity insurance, which must be kept in force at least 5 years after ending as a practicing consultant. Furthermore, they are obliged to take the admission course for the Energy Labelling Scheme and must have passed the final examination. In addition to this, all consultants have to follow an annual one-day follow-up training course, and they receive a newsletter telling about new rules, clarifications, frequently asked questions and general information on the development of the scheme. Information for the consultants is based on experience from the quality control, reported energy labelling, as well as technical research and development. It is essential that the consultant to have a very thorough knowledge of the handbook and the computer programmes.

QUALITY CONTROL

Confidence in the energy label is the most important factor in achieving the main aim of the labelling scheme - energy savings. The user must at all times have confidence in the registrations made, the calculations, the label itself, and especially that the suggested energy saving measures are viable and will result in improved economy. Thus, it is essential to maintain a high level of quality in the energy labelling scheme. If quality is poor, the users will lose confidence in the labels. Quality assessment is essential, as although good consultants might do good work without it, less good consultants will not. Credibility may be lost very fast as a few poor labels can do a lot of damage.

The quality control of the Danish energy labelling scheme takes place at all levels of the scheme. No labelling would be possible if the work were not subject to internal quality management. As mentioned above, active quality management of the labels and the work performed by the consultants is a central part of the labelling scheme. Both the secretariat and the technical auditor have specific quality tasks within the scheme.

At the time of writing the quality management scheme is primarily focussing on ensuring that the consultant is doing exactly as instructed in the handbook. This approach may not in all cases imply that the labels produced are of high quality. Seen in this light, the quality management scheme is currently being further developed in order to focus on a higher degree of quality. The work is aiming at producing clear and publicly available rules and procedures to ensure transparency for the consultant

and the user of the label. In this way the users can help improve quality by demanding quality.

The quality tasks in the existing quality management scheme are outlined below.

- Automatic screening: Every energy label produced must be reported to a central database, including detailed information about the label, information registered, calculation results and energy saving proposals. Prior to entry on the database, labels are automatically screened field by field in order to validate data. The label cannot be sent to the user unless reported to the database. The Danish Energy Authority is responsible for the validation system.
- Electronic screening: Automatic, statistical screening of all data in the database is performed by the secretariat in order to locate statistical outliers.
- Manual screening: Advanced statistical analyses of the development and trends in the reported labels are performed. This task is performed by the Danish Energy Authority.
- Desktop control: Five per cent of all reported labels are taken randomly from the database and checked by the secretariat. This task implies going through the labels and checking whether general information stated about the building is correct and whether the labels fulfil the demands in the handbook. Defective labels are extracted for technical auditing.
- Technical auditing: Field control of half a per cent of all labels is performed by the technical auditor with a visit to the labelled premises. The auditor carries out a new label and compares it with the label being audited. There are three possible outcomes of the audit: 1. no comments, 2. considerable remarks and 3. not acceptable. All consultants of the labels subject to technical auditing are informed and the audit includes a dialogue with the relevant consultant. If a label is assessed "considerable remarks", the consultant will be informed, asked to correct the label and subject to increased quality control. If a label is assessed "not acceptable" the consultant can be warned and may in severe cases be removed from the labelling scheme. In all cases the Energy Authority makes the final decision.

Lessons learned

By implementing a 2nd generation energy labelling scheme in Denmark both the civil servants at Danish Energy Authority and their expert advisers at SBI have gained practical experience.

The two Danish labelling schemes from 1997 have illuminated the two methods by which an energy label accommodates the requirements of the EPBD. These methods are asset rating and operational rating. The label from 1997 for small buildings was based on asset rating, whereas the label designed for large buildings was based on operational rating. In the experience of the label for small buildings, the EPBD occasioned the Danish Energy Authority to implement asset rating for large buildings as well. However, labels made using asset rating do not correspond very well with an annual labelling schedule. It was thus decided that such a comprehensive method only requires re-

labelling every five years. In other words, a minor paradox has appeared: The search for a high quality certificate has reduced the possibility of gaining high quality evaluation and benchmarking, because these activities, important for policy making and energy-saving activities require frequent labelling. At least 10 years, as stated in EPBD as the maximum period between certifications, will require supplementary energy management in large buildings.

The Danish labelling schemes have also highlighted the question of stakeholder acceptance. Until the EPBD, two labels were used, and although there was certain resistance, the labels were widely accepted by energy consultants and building owners. After the EPBD, a redesign of the label for large buildings, primarily to adopt asset rating, has caused much difficulty. The manpower necessary to undertake the task has become overwhelming for planning, design and carrying out the label, as well as for the procedure and the education programme. Moreover, a complete redesign of the handbook to coordinate the principles of the two existing schemes and extension of asset rating to all building types has been a great challenge. Seen from the stakeholders' point of view, asset rating has implied much learning and introduction of a comprehensive procedure, especially when dealing with complicated and mixed buildings. In other words, yet another paradox has appeared: The efforts to create a perfect uniform certification system easy to adopt for all stakeholders has itself complicated the adoption.

However, the overall lesson learned is that all walking the 'Six stairs of complexity' from simple meter reading to integrated operational and asset rating are all fruitful steps. Other things being equal, 'walking upstairs' will always improve the certificate and label and increase the possibilities to obtain building stock knowledge of high quality, for calculating potentials, for benchmarking and for policy making. Nevertheless, in Denmark it has been realised, that the last step taken, from 1st to 2nd generation labelling where asset rating has been fully adopted also for large buildings, is rather a steep incline. Thus in the rear-view mirror, it can be recommended to climb exactly that step with care. By rating large and complicated buildings, a smaller step might be operational rating garnished with calculation of energy-saving measures for selected building components.

Conclusions

Energy certification, as described in the European Energy Performance of Buildings Directive (EPBD), offers a unique opportunity to obtain valuable knowledge about the building stock. However, the knowledge attained will always depend on the quality of the energy certification scheme. Thus, developing energy certificate schemes deserves careful consideration. Based on Danish experience, where certification schemes have been in operation since 1997, it can be stated that:

- A certification scheme may rely on several stairs of complexity, between simple meters reading (operational rating) at the bottom and computation (asset rating) at the top (Figure 2).
- The quality of knowledge possible to extract afterwards for benchmarking and policy making rises with the number of stairs climbed.

- Each step toward the top stair requires more educated consultants and a more developed secretariat to work out and to take care of the labels.
- Climbing the step from combined asset and operational rating to pure asset rating, reaching stair number 5 is rather a step incline, because then advanced investigation programmes and computing systems are required, specially in respect of large buildings.
- At the upper half of the stairs, it must be considered, if one more step is worth climbing, having in mind that each new step represents a higher level of expenses and higher expenses may reduce the frequency of the labelling.

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