Adopting the Total Concept Method in Northern European Countries

Local Conditions and Prerequisites

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Introduction

The IEE Project "The Total Concept method for major reduction of energy use in non-residential buildings" aims to demonstrate that large scale energy performance improvements in existing non-residential buildings can satisfy profitability demands set by the building owner/investor and thus become a market driver for major refurbishment towards Nearly Zero-Energy Buildings. The project aims to introduce and adopt the Total Concept method in five Northern European countries so that it will be ready to be implemented by the stakeholders and key actors involved in the energy refurbishment process. These Northern European countries are: Sweden, Norway, Denmark, Finland and Estonia.

The Total Concept is a method for improving energy performance in existing non-residential buildings and applies a refined systematic approach to work with energy issues in the building with the aim to achieve maximum savings in a cost efficient way. The method is based on an action plan comprising a package of measures which meets the profitability conditions stipulated by the property owner. The prerequisite for attaining profitability is that the whole action package is implemented in its entirety.

The Total Concept method is carried out in different steps, involving a number of different working items, e.g. energy auditing, cost estimates, energy calculations, profitability analysis, energy saving package realization, follow up, etc. The prerequisite conditions for carrying out these working items and for adopting the Total Concept method can be somewhat different in the participating countries owing to difference in building codes and existing guidelines regarding for example air exchange rates, indoor climate and other building renovation requirements. It is therefore essential to evaluate the local conditions and prerequisites for adopting Total Concept method in the participating countries in order to guarantee the reliability and comparability of the results.

This study has been carried out with the aim to gather all the necessary information and know-how needed to analyze important differences between the participating five Northern European countries in local conditions and prerequisites for adopting the Total Concept Method.

Scope and method

In this study, the local conditions in five Northern European countries are analyzed, including evaluation of the specific information in the building codes and other requirements, in order to identify important input parameters for adapting the Total Concept method on the national level. The task aims to also provide an input on what competence requirements and trainings are needed for the Total Concept method national applications in the future.

The information was gathered by carrying out interviews and distributing survey questionnaires to different stakeholders in the participating countries. Stakeholders were building owners, building managers, tenant organizations, consultants and energy distributors. Also, two working meetings including discussions on this topic have been held, both prior and after the distribution of the questionnaires.

The survey results are summarized in Appendix 2, were all countries replies to each question could be found. The following review of results and discussions are based on the survey results and the discussions at the working meetings, especially the workshop after the survey, see Appendix 1.

Building codes for major renovations

In principle, building code requirements exist for all countries, which also is a consequence of the EU EPBD. Because of the great variety in buildings, it is very difficult to force strict requirements. Therefore, there are modifications allowed if e.g. the cost-effectiveness is too low, if functional or technical drawbacks exist or if cultural or architectural values are affected negatively.

Requirements on building components (U-values) exists Sweden, Norway, Denmark and as one option in the Finnish regulations. Mostly, the requirement concerns only the replaced parts. There are small differences in required U-values, and it seems like Finland´s option one has the most strict requirements here.

Energy performance requirements at renovation are in place in Sweden and Estonia, and as one option in Finland. As above, modifications are possible, except for Estonia, where there are no modifications if <u>major</u> renovation is performed. Then energy efficiency requirements must be met. If renovation cost is lower than 1/4 of average construction cost of same type of building, then its is not considered a major renovation and energy efficiency requirements do not apply. One other big difference is that the Swedish energy performance values are measured values, while the others are calculated values during standard use of the building.

In principle, requirements for renovations are set with new construction as target, given the modifications according to difficulties in the actual building, as reviewed above.

Differences in energy requirements for renovations between the countries, does not seem to cause any major obstacles when using the Total Concept Method. There will be a variation in performed measures and the efficiency of those, but that variation will also occur nationally between buildings.

Definitions on Energy performance

Energy performance in kWh/m^2 is stipulated in the EU EPBD for the energy certificates. There are, however, differences in the definition of kWh that need to be considered. Even with knowledge of the differences in energy use definitions, it could be difficult to compare numbers, as different components of energy use are included. In Sweden, it is the measured value that should be reported, which differs from the other countries where different calculation schemes are applied. An attempt to compare the energy use definition is given in Table 1.

The borderline between facility and tenant energy use is sometimes difficult to draw. As in e.g. Sweden, where facility energy should be included and the tenants not, it causes problems in buildings when these uses are on the same meter.

Calculation methods for U-values, thermal bridges etc. are similar, and in all countries based on EN standards. In Norway, there is a national umbrella standard that refers to 26 EN standards. However, there might be some small details that differ, because different EN standards are referred to for calculating the same parameter and that some of the EN standards also allow for alternative definitions etc.

Table 1. Comparison of definitions on building energy use.

	Sweden	Norway	Finland	Denmark	Estonia
Heating	Delivered	Net energy	Delivered	Delivered	Delivered
Hot water	Delivered	Net energy	Delivered	Delivered	Delivered
Cooling (AC)	Delivered	Net energy	Delivered	Delivered	Delivered
Facility electr.	Delivered	Net energy	Delivered	Delivered	Delivered
Separate lighting	No, splitted between tenant and facility	Yes, net energy	Yes, delivered	Yes, delivered	Yes, delivered
Tenant energy	Not incl.	Net energy	Delivered	Not incl.	Delivered
Wind electricity	Not incl.		As delivered energy		
Solar PV/Solar heat on the building site	Deducted as used	Delivered	Deducted as used	Deducted as used	
Primary en/CO_2	No weight. Different requirements for electrically heated buildings	No weight	Weight acc. to energy carrier	Weight acc. to energy carrier	Weight acc. to energy carrier
	Only delivered energy		Possible to export on site energy in the balance	Possible to export on site energy in the balance	

Sweden: BBR
Denmark: Calculation procedures specified in SBi guidelines "Bygningers Energibehov".
Norway: Calculation procedures specified in Standard NS-3031 "Beregning av bygninger energiytelse - Metode og data". Today no national primary energy factors are defined.
Finland: According to "Byggnaders energiprestanda: föreskrifter och anvisningar"

Definitions on Energy System Boundaries

System boundaries definitions differ somewhat between the countries. One type of illustration is given in Figure 1 below. The Swedish boundary is the building, i.e. area "E" in Figure 1, where delivered energy to the building enters as electricity, heat/cold, or fuel. Norway presently has net energy demand, which is the energy leaving frame "D" in Figure1. There is a proposal in Norway to change from net energy demand to delivered energy. Denmark's boundaries corresponds to the outer frame, but excluding frame "F". Finland uses the frame "E", as well as Estonia, but they also have a net delivered energy border where exported energy from the building is deducted.

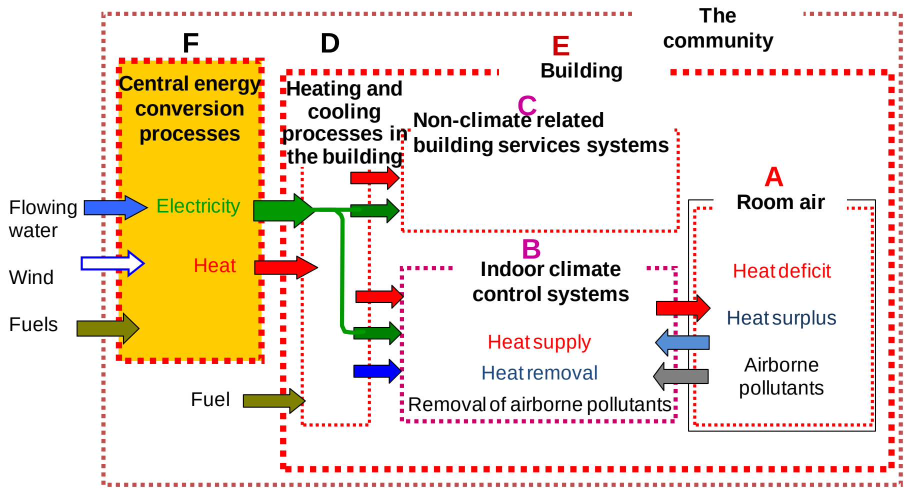


Figure 1. System boundaries that can be applied when analysing the energy behaviour of a building.

Denmark, Finland and Estonia use primary energy factors, i.e. energy carriers have been designated different weight according to how much energy (or CO_2-emissions) that has been used in the production of one kWh of the carrier. Only Estonia express their energy performance requirement in primary energy terms. In Sweden and Norway, primary energy factors are used indirectly, in Sweden by more strict requirement on energy performance for electrically heated buildings, and in Norway by using a real system efficiency factor for the energy supply system.

Although there are different boundaries and perspectives in the countries, this will only have a minor influence on what measures that is performed, because cost savings in purchased (delivered) energy will depend on the price of the energy carrier, and not the recalculated primary energy.

Definitions on Heated Floor Area

In the EPBD, the term conditioned space is used, and the countries have slightly different measurement rules. The common denominator is that floor area is used as the inside of the exterior walls. In Sweden, there are no deductions to this area, and it is not clear from the survey replies if there are any deductions in the other countries. If so, they could not be big.

What are considered as heated area is in Sweden above 10 °C and in Denmark between 5 and 15 °C. There could also be a difference in how garage areas are treated, not included in Sweden independent of temperature, but this is not in the survey replies.

The potential difference in heated area definitions will not affect the adoption of the Total Concept method.

Used methods for energy renovations

The most developed methods covering the whole process, from audit to verified savings are those performed as Energy Performance Contracting (EPC) or by ESCOs (i.e. Energy Service Company) which offers similar services. Different concepts are used, the savings could be guaranteed or shared, the latter is however less and less used, and the investments could be taken by the client or by the ESCO.

The ESCOs have their own methods and tools for selection and calculation of reference year, energy calculation routines, profitability calculations and measurement and verification. This, together with limited transparency for the client, has led to attempts to standardize the energy services, which is in progress now in Sweden, firstly on a voluntary basis.

Other concepts mentioned are methods used at Energy Performance Certification (sometimes also called EPC), as mentioned by Finland and Estonia. However, these certificates do not require the client to execute the measures, only obtaining information on profitable energy conservation measures.

Methods for energy auditing and requirements on auditors (experts), is only in place for the energy performance certificates, which is used in all countries.

Reference (baseline) energy use is of course important when establishing energy savings. When measurements are missing, the baseline could be calculated using e.g. methods described in the Finnish regulations or other energy simulation software. Judging from the survey answers, there seems to be a need for more detailed standardization than present today.

Energy calculations at major renovation are done from simple excel models to dynamic simulation tools. A number of softwares are available. Mentioned in the survey replies are IDA ICE, SIMIEN, VIP Energy, BV2, Energy 10 and IES VE, Riuska, TRNSYS, Energy Plus etc.

For profitability calculations, the most common seem to be a simple pay-back method, however life cycle calculations (LCC) are also used in all countries. Internal return of investment is used by the Total Concept method, presently used only in Sweden.

Different ESCOs methods and tools are used for the same purpose as the Total Concept. However, almost all of these methods are propriety of the ESCOs and not available on the market. There seem to be a need for standardization of baseline energy use and verification by measurement, and possibly also the calculation methods for energy savings and profitability (on a method basis).

The financial requirements on lifespan of the measures taken, required calculation interest rates and future energy price scenarios, are important calculation inputs that will have a great impact on what measures that is profitable to perform. A recommendation of suitable input values could maybe be done to increase the number of energy conservation measures taken.

Measurement and verification procedures

No common verification protocols seem to be used in the countries. The ESCOs probably have company-specific protocols and there might also be some special protocols for specific projects. In Sweden, the Sveby measurement and verification guidelines are used more and more. Sveby, that stands for Standardization and verification of energy use in buildings, is a Swedish trade standard that includes energy calculations, measurements, verification of energy performance and a contract model.

Measurements are mostly used as reading the delivered energy meters for the different energy carriers. Sub metering is used in some cases to follow up individual measures. This and to separate electricity use between tenant and building systems seems to be common in Finland. Of course there are also specific demonstration or research buildings in the countries where a large number of meters are installed and evaluated.

The evaluation period by measurements vary between 1 to 3 years. In Finland, one year of system adjustments and fine-tuning is generally allowed before the verification starts. However, the measurements might be needed to optimize the settings of the control systems.

Different resolutions on the measurement reporting periods are used: Week, month, quarter. The targets are set on a yearly basis. Some projects where building energy management systems are installed, shorter measurement intervals could be used (mostly for fine-tuning purposes).

Climate dependent measurement data are normalized, mostly by national degree-day methods or similar. In Finland, a geographical normalization to the city of Jyväskylä is used for the energy certificates. Adjustments for deviations in building occupancy are rarely done, except for the ESCOs.

Other supplementary measurements as air leakage and sometimes thermography are performed if called for, but not systematically.

More standardized measurement protocols and verification procedures are needed for increasing the precision in the result but also to increase the credibility of the whole project, connecting the earlier performed energy calculations with the measurement results and thus giving feed-back to the calculation consultant. Probably, this is also a topic where training is needed with target on energy consultants and operational personnel.

Comparison of energy prices

It is difficult to make a true comparison of energy prices between the countries, because the price structures are complicated and divided in different parts. Also, substantial local variations are common in Sweden owing to the multiple energy sources used to create electricity, district heating and district cooling. Seasonal prices differences, especially for district heating is common.

When calculating the cost savings for different measures, where savings vary with season, e.g. solar collectors and heat pumps, the price structure becomes very important. However, this is a short-term consideration as the price structure could change overnight.
The national representatives have filled representative energy prices in the summary Table 2, below, but what is included in the prices are not given. Probably, most prices are without VAT, but the inclusion of fixed fees, grid fees, emission taxes, electricity certificates etc. is very difficult to estimate. Price comparisons are probably more valid for the single fuel sources, than district heating and cooling.

The prices that deviates remarkably are the expensive fuel oil in Estonia and regular electricity price in Denmark.

Table 2. Energy prices in € per kWh.

Energy source	Sweden	Norway	Denmark	Finland	Estonia
Electricity, regular	0,065	0,12	0,3	0,11	0,14
Renewable electricity	0,07-0,08	0,12	0,17 The first ten years	0,12	0,14
Fuel oil	0,15	0,08	0,15	0,07	0,088
Natural gas	0,08-0,09	0,09	0,11	0,05	0,055
Wood pellets	0,041-0,058	0,06	0,06	0,06	0,054
Firewood	0,027-0,045	0,12	0,04	0,05	0,031
District heating	0,07	0,13	0,09	0,07	0,075
District cooling	0,044	0,14	0,09 – 0,12	0,11	N/A

Notes and references to Table 2:

Denmark: http://www.byggeriogenergi.dk/media/36821/katalog_installationer_web.pdf
http://www.elforsk.dk/elforskProjects/343-056/343-056_WEB.pdf
Finland: VAT 24 % included.
Estonia: VAT 20 % included.
Sweden: Electricity and district heating according to (Nils Holgersson: http://www.nilsholgersson.nu/rapporter/aktuell-rapport/undersoekning-2014/el/riket/) excl. VAT (20%) and energy taxes.
Renewable energy according to (Telge Energi: http://www.telgeenergi.se/)
*Fuel oil calculated as 13 000/(10000*0,75) where avg. price is 13 000 kr/m^3, 10 000 kWh/m^3, η=0,75*
Natural gas for household customers> 55 000 kWh/year, (SCB, 2014, http://www.scb.se/sv_/Hitta-statistik/Statistik-efter-amne/Energi/Prisutvecklingen-inom-energiomradet/Energipriser-pa-naturgas-och-el/24719/24726/Genomsnittspriser-per-halvar-2007/212955/)
Pellets calculated as 4,9 kWh/kg, prices according to (Energimyndigheten, http://www.energimyndigheten.se/Hushall/Testerresultat/Testresultat/Pelletskvalitet/?tab=2)
*Firewood calculated as price/(1300*0,75) where avg. price is 300-500 kr/m^3, 1300 kWh/m^3, η=0,75*
District cooling according to Fortum. Prices during cooling season excl. load price and bonus (depending on return temperature), (http://www.fortum.com/countries/se/SiteCollectionDocuments/prisavtal-komfort-odaterad-april-2014.pdf)

Implementation of the Total Concept Method

The main benefits using the Total Concept method is that it encourages the property owner to invest more in energy conservation measures with a defined profitability and thus saving more energy than otherwise. It is important to think about what guarantees will be given to the results.

There seem to be no legislative constraints in using the Total Concept method in the countries. The method is competing to some extent with the ESCOs and other special energy conservation projects.

Some points to consider for adaptation in the countries are e.g. that in Finland, there is an official energy calculation method, that probably should be used, the Danish requirement regarding adding insulation irrespective of profitability and the Norwegian problem with low energy prices and high investment costs.

There is a need for improving the know-how of many stakeholders in the process. There are a number of important key actors, all of which are crucial to carrying out the Total Concept method for the best outcome of the energy efficiency measures identified:

- Property owners/clients who will initiate future projects based on the total concept method.
- Property managers, who are responsible for the buildings in question, might play important roles when it comes to investment decisions.
- Energy consultants who are to carry out the work in practice according to the Total Concept method and who will present proposals for the action package.
- Design engineers who carry out the detailed design for the action package in Step 2 in the Total Concept method.
- Contractors who will carry out all the building work according to the consultants' proposals.
- Maintenance staff who are responsible for all the systems in a building and who can directly control the use of energy in the building.

Final Remarks

From perspective of the Total Concept Method and the property owners, the important final result is the verified energy cost savings, which means the differences in purchased energy use before and after performed energy conservation measures. Tenant energy use could be included using some kind of split-incentive ("green") contracts. The energy and economic calculations is the prediction and decision tool for choosing the right combination of measures. Primary energy factors is a way to express the savings in environmental load terms from a societal perspective. Thus the differences in energy definitions will mostly be a bench-marking problem between the countries than an obstacle for adopting the Total Concept Method.

The Total Concept is hopefully one way to change the mindset of the building owners and to inspire them to take an extra step when performing renovation with energy efficiency in focus. Although requirements on return of investment vary, it will be possible to use the Total Concept Method independent of the noted differences in local conditions.

Right now there seem to be no major obstacles in using the Total Concept method in the countries. The methodology is general and allows specific adoptions for special needs of different building owners.

There are many tools and methods available on the market and the advantages with the Total Concept Method needs to be clearly stated.

Appendix 1. Outcomes of the discussions at the Total Concept Working Meeting

Stockholm, 20th of August 2014

Topic 2: Local Conditions and Prerequisites for Adoption

1) Can the same methodology be used in spite of the differences in definitions? Where are the difficulties?

Right now we can´t really see any difficulties with using the Total Concept in other countries. The methodology is general and allows specific adoptions for special needs of different building owners. The main objective with Total Concept is to change the mindset and to inspire building owners to perform renovation with energy efficiency in focus, which will be possible to do independent of differences in local conditions.

2) Conflicts with national schemes and energy certification?

One difficulty might be to evaluate if a specific cost is really belonging to energy efficiency since the law might require that it shall be done during renovation anyway. A long discussion followed about building regulations during renovation in the different northern European countries. It was concluded that the laws are similar in requirements and that it is difficult to judge when it is consider a major renovation (that require more measures for energy efficiency) and how to define economically feasible. It was decided that in the Total Concept we will first concentrate in order to advice the building owner on what measures that are profitable irrespective of if they are compulsory or not. In a second analyse it would be possible to show how costs for compulsory measures will be taken out from the analyse and only additional cost with additional energy efficiency will be added.

3) Which parts need further instructions and tools?

One difficulty is to define the baseline. Especially if the energy performance before renovation is measured for an empty building, a building with inadequate indoor climate or for a building that will change category/activity after renovation (i.e. a kindergarten becomes a primary school). Here recommendations of how to handle the baseline and how to present the baseline for the building owner need to be developed. It is important to show credibility in calculations that clearly explain for the building owner the costs for energy use before renovation, after ordinary renovation including indoor climate improvements, change in building use etc. and after a renovation with total concept including climate improvements, change in building use etc.

Appendix 2. Summary of survey questions and answers from the participating countries

Introduction

Interviews with different stakeholders in Sweden, Norway, Denmark, Finland and Estonia have been performed by the national contact persons during the summer of 2014. Stakeholders were selected having knowledge on national conditions regarding the survey questions. The interviews were made with a sufficient amount of knowledgeable persons to get a good national representation for the answers to the survey questions. Documentation of information sources and countrywide summarized answers is given in the following text. Stakeholders for this survey are experts on national building codes and guidelines, energy consultants, EPC companies, building owners, building managers.

Responsible partners (organizations and persons)

Sweden: Projektengagemang Energi- & Klimatanalys, Dr Per Levin
Norway: SINTEF Building & Infrastructure
Denmark: Danish Building Research Institute / Aalborg University, Alireza Afshari
Finland: Bionova Oy, Tytti Bruce
Estonia: Eesti Kütte- ja Ventilatsiooniinseneride Ühendus (EKVÜ), Kalle Kuusk

Information sources

Sweden:
Diligentia, Lars Pellmark
Fortum, Olle Hansson
www.sveby.org
www.boverket.se

Norway:
[1] Potential- og barrierstudie Energieffektivisering i norske Yrkesbygg (2012)
Interviews:
[2] SHC IEA Task 47 (2013-2014)
[3] DNB Eiendom (2014)
[4] Grønn Byggallianse (2014)
[5] Statsbygg (2014)
[6] SINTEF

Denmark:
Literatures and Interviews with:
Niels Christian Bergsøe, SBi/AAU
Graves K. Simonsen, Danish Association of Construction Clients
Pawel Krawczyk, Rambøll
Nikolaj Haaning, Rambøll

Finland:
Construction Establishment of Defence Administration, Kari Huttunen
Tampere Hall, Marko Koivisto
Real Estate Department, City of Helsinki, Veikko Saukkonen
Real Estate Centre, City of Vantaa, Pasi Salo
Liikelaitos Oulun Tilakeskus, Veikko Kotilainen
Finnish Ministry of Environment, Harri Hakaste
Finnish Construction Industry Association, Ari Ilomäki
The Housing Finance and Development Centre of Finland, Sampo Vallius
Green Building Council Finland, Jessica Karhu
And others.

Estonia:
Eesti Kütte- ja Ventilatsiooniinseneride Ühendus (EKVÜ)
Kalle Kuusk

Survey questions and answers

Questions on building codes and definitions

1. **Exist building code requirements (or other national regulations) that has to be met on major renovations? Which requirements must be fulfilled?**

Sweden: In BBR, the national building code, chapter 9, energy requirements for both new buildings and for major renovations are found. The aim at major renovations, is that the replaced building parts should fulfill the requirements for new construction. However, if the building has architectural, historical or other qualities, or if the measures are unreasonably expensive, exceptions could be made. Renovation should be carried without negatively affecting the energy performance. This is only allowed if the energy performance of the building still meets the requirement for new buildings or if an increase in energy use is necessary to meet other technical demands, such as indoor climate.

In major renovations, the ambition is often to meet the requirements for new buildings. These requirements depend on location, type of energy used for heating and building size. For new non-residential buildings with other than electric heating, the following requirements exists (BBR 21):

Climate zone	I	II	III
The building's specific energy use [kWh per m^2 A_{temp} and year]	120	100	80
+ supplement when the supply air flow for extended hygienic reasons is greater than 0.35 l/s per m^2 in temperature-controlled spaces. Where $q_{average}$ is the average specific flow of supply air during the heating season and no more than 1.00 [l/s per m^2] must be taken into consideration in this calculation.	$110(q_{average}-0.35)$	$90(q_{average}-0.35)$	$70(q_{average}-0.35)$
Average thermal transmittance [W/m^2 K]	0.60	0.60	0.60

For buildings with electric heating, the regulations are more strict:

Climate zone	I	II	III
The building's specific energy use [kWh per m^2 A_{temp} and year]	95	75	55
+ supplement when the supply air flow for extended hygienic reasons is greater than 0.35 l/s per m^2 in temperature-controlled spaces. Where $q_{average}$ is the average specific flow of supply air during the heating season and no more than 1.00 [l/s per m^2] must be taken into consideration in this calculation.	$65(q_{average}-0.35)$	$55(q_{average}-0.35)$	$45(q_{average}-0.35)$
Installed power rating for heating [kW]	5.5	5.0	4.5
+ supplement where A_{temp} is greater than 130 m^2	$0.035(A_{temp} - 130)$	$0.030(A_{temp} - 130)$	$0.025(A_{temp} - 130)$
+ supplement when the supply air flow for extended continuous hygienic reasons is greater than 0.35 l/s per m^2 in temperature-controlled spaces. Where q is the maximum specific flow of supply air at DVUT.	$0.030(q-0.35)A_{temp}$	$0.026(q-0.35)A_{temp}$	$0.022(q-0.35)A_{temp}$
Average thermal transmittance [W/m^2 K]	0.60	0.60	0.60

If the requirements for new buildings are not met, the renovation should aim at the following U-values for the building envelope:

Tabell 9:92 U_i [W/m^{2}K]

U_i	[W/m^{2}K]
U_{tak}	0,13
$U_{vägg}$	0,18
U_{golv}	0,15
$U_{fönster}$	1,2
$U_{ytterdörr}$	1,2

(BFS 2011:26).

Norway: In the original European energy directive a requirement was that cost-effective energy measures should be carried out at major renovation of existing buildings over 1000 m^2. In the revised directive is space limit removed so that all major renovations are covered. With major renovation means that more than 25 percent of the building envelope is upgraded, or that the total cost of the upgrade of the building envelope and building services exceed 25 percent of the value of the building, excluding property value. [1]

In Norway, the current regulation is applicable for existing buildings when it is a change of use or when the renovation, assessed by the municipality, is so extensive that the building is substantially renewed. This is applied for all buildings, regardless of size, but the municipalities have practiced a spacious limit when new regulatory requirements will apply. The Ministry of Local Government and modernisation published a circular letter clarifying the requirements when renovating: "Requirements () is generally limited to () those parts of the structure to which the measure applies". [2] Hence, most small renovation projects falls outside the concept of applying the current regulation on the whole building but according to the guidelines for the current regulations, "measures on existing buildings() shall in principle meet the energy requirements."[3]

Minimum requirements in the Norwegian regulations are stricter than in most other European countries, and also stricter than eg. insulation standard for frame requirement in many countries . Therefore, the minimum requirements as they are designed today, yet also comply with the EU directive, apart from the weak requirement of U-values for windows. Despite this, would these minimum requirements, as only binding guideline for refurbishment, not lead to ambitious upgrading. Moderate component requirements would on the contrary, in many cases, result in an unambitious refurbishment level, which consequently will lead to unprofitable later additional energy upgrades. [6]

[1] EU, 2002

[2] KRD, 2010

[3] TEK 10, 2011

Denmark: Danish Building regulations in accordance to BR 10. For existing buildings there are requirements for individual components. The table provides an overview of the U value requirements. The U value requirements for specific measures apply to conversions, maintenance and replacement. The requirement values in the table apply to conversions with the retro-fit insulation of existing building elements, provided that the work is cost-effective. If the building element is replaced, the table applies regardless of cost-effectiveness.

U value requirements W/m2K	**Change of use and extensions**	**Specific measures**	**Summer house**	**Minimum**	**Cabin**
	Kap. 7.3.2	**Kap. 7.4.2**	**Kap. 7.5**	**Kap. 7.6**	**Bilag 6**
External walls and basement walls in contact with the soil	0.15	0.20	0.25	0.30	0.20
Ground etc.	0.10	0.12	0.15	0.20	0.12
Ceiling and roof structures	0.10	0.15	0.15	0.20	0.15
Windows	1.40	1.65	1.80	1.80	1.50
Rooflights	1.70	1.65	1.80	1.80	1.80
Linear loss – W/(m K)	-	-	-	-	-
Foundations	0.12	0.12	0.15	0.20	0.20
Joint – external wall and window	0.03	0.03	0.03	0.06	0.03

Cost-effective energy improvements to existing buildings are described in Appendix 6 to BR10.

The building must be given an energy efficiency rating of A2 in order to meet the requirements of the Danish Building Regulations. An energy efficiency rating of A1 represents a low energy building. The energy efficiency rating indicates a property's energy consumption and the possibility of achieving savings. Energy consumption is the building's total heat consumption plus the electricity consumption for the operation of the building, plus in large buildings electricity for lighting.

Reference:
http://www.paroc.dk/knowhow/building-regulations/danish-building-regulations-in-accordance-to-br-10?sc_lang=en

Finland: Renovations that are subject to license from public authority have minimum requirements improving energy efficiency. For example, refurbishments, renovations of building envelope, renovations in building technical systems and changes in building use are usually subject to license. However, measures to improve energy efficiency are not required if they are not technically, functionally or financially justified. The law does not provide a method for testing validity of these claims.

Building owner has the power to choose the means to improve energy efficiency. There are three possible ways to meet the energy efficiency requirements:

1. To improve energy efficiency of building envelope structures to prevent the heat conduction from building. The requirements for external walls is the original U-value x 0,5 but maximum 0,17 W/(m2 K). For roof the basic requirement is original U-value x 0,5 but maximum 0,09 W/(m2 K) excluding the cases in which the use of the building changes. Then the maximum is 0,6 W/(m2 K). When the windows and doors are changed to new ones they must have U value better than 1 W/(m2 K).

2. To improve energy efficiency into a certain building type specific level. The indicator is calculatory building operating energy consumption based on standard use of building. The requirements for non-residential buildings are:
    a. Office < 145 kWh/m^2
    b. Educational building < 150 kWh/m^2
    c. Kindergarten < 150kWh/m2
    d. Hotel or other accommodation > 180 kWh/m^2
    e. Retail building < 180 kWh/m^2
    f. Hospital < 370 kWh/m^2
    g. Sports halls except swimming hall and ice hall < 170 kWh/m^2

3. The third option is to improve the E-value e.g calculatory building operating primary energy consumption based on standard use of building. For offices, accommodation buildings and retail buildings the requirement is that E-required is smaller than 0,7 x original E-value. For other building types the requirement is 0,8 x original E-value

In addition to these, building technical systems have their own separate minimum requirements. These are:

- Building air exchange system has to have heat recovery with annual efficiency of 45 %.
- Mechanical input and extract ventilation: characteristic electricity consumption can be maximum 2 kW/(m3/s)

- Mechanical extract ventilation: characteristic electricity consumption can be maximum 1 kW/(m3/s)
- Air exchange system characteristic electricity consumption can be maximum 2,5 kW/(m3/s)

If some requirements cannot be met, it can be compensated by larger improvements in other required measures.

Estonia: Building code ("Minimum requirements for energy performance of buildings" and "Methodology for calculating the energy performance of buildings") sets requirements for primary energy use. Major renovation requirements for primary energy use are for:

- detached houses 210 kWh/(m²a)
- apartment buildings 180 kWh/(m²a)
- office buildings 210 kWh/(m²a)
- commercial buildings 270 kWh/(m²a)
- public buildings 250 kWh/(m²a)
- trading and service buildings 280 kWh/(m²a)
- educational buildings 200 kWh/(m²a)
- kindergartens 240 kWh/(m²a)
- health care facilities 460 kWh/(m²a)

2. Definition on energy performance of the building. What is included in the kWh in the energy performance indicator kWh/m² (e.g. heating, cooling, occupant energy use)

Sweden: The energy performance (specific energy use) is the energy needed for the building to "function" as intended, which means heating, cooling and facility electricity. Energy used by tenants for equipment and lighting etc. is not included in the definition. In the building code, the following definition is used:

"The energy which, in normal use during a reference year, needs to be supplied to a building (often referred to as "purchased energy") for heating, comfort cooling, hot tap water and the building's property energy. If underfloor heating, towel dryers or other devices for heating are installed, their energy use is also included."

Norway: The current regulation on energy performance in Norway is called TEK10 and the energy performance is defined as net energy demand, which is independent of the energy supply system. The total net energy budget aggregates the components heating, hot water, fans and pumps, equipment, lighting and cooling. The components hot water, equipment and lighting* have standardized minimum values, as well as operating time and set temperature for heating and cooling system.[4]

Denmark: 7.2 Energy performance frameworks in new buildings
7.2.1(1) The energy performance framework covers the total requirements of the building for supplied energy for heating, ventilation, cooling, domestic hot water and, where appropriate, lighting.
7.2.3(1) For offices, schools, institutions etc., the total demand of the building for energy supply for heating, ventilation, cooling and domestic hot water and lighting per m² of heated floor area must not exceed 71.3 kWh/m²/year plus 1650 kWh/year divided by the heated floor area.
7.2.3(2) A building heated to more than 5°C and up to 15°C must not have a demand for energy supplied for heating, ventilation, cooling, domestic hot water and lighting per m² of heated floor area in excess of 71.3 kWh/m²/year plus 1650 kWh/year divided by the heated floor area.
7.2.3(3) In the case of buildings or building sections whose requirements include, for example, a high level of lighting, extra ventilation and high consumption of domestic hot water, or which are used for extended periods, or buildings with high ceilings, the energy performance framework
must be increased by the resulting calculated energy consumption. Process energy such as ventilation of fume cabinets is not included in the energy performance framework.

Reference:
http://w2l.dk/file/155699/BR10_ENGLISH.pdf

Finland: The official way to measure the energy performance of buildings (for Finnish energy certificate) is defined in Finnish building regulations (Act on Energy Certificates for Buildings (50/2013)). In these calculations, the included energy flows are: property heating and cooling energy, water heating energy, building ventilation electricity, lighting and occupant energy use.

Estonia: Energy performance indicator includes all the delivered energy (space heating, ventilation, cooling, heating of the domestic hot water, lightning, appliances, plug loads, auxiliary energy).

[4] NS3031, (2011)

3. Definition on energy performance of the building. How is the area defined in the energy performance indicator kWh/m²? What is included in the m²?

Sweden: The area used for energy performance is A_{temp}, which is the heated floor area (above 10 °C) measured from the inside of the building envelope. The building code uses the following definition: "The area enclosed by the inside of the building envelope of all storeys including cellars and attics for temperature-controlled spaces, intended to be heated to more than 10 ºC. The area occupied by interior walls, openings for stairs, shafts, etc., are included. The area for garages, within residential buildings or other building premises other than garages, are not included."

Norway: The area in kWh/m² is called "oppvarmet bruksareal-BRA". This is the heated parts of the building inside the building envelope. The BRA is the net-area, measured from the interior of the wall and do therefore not include the footprint of the facade.[4]

Denmark: 7.2.1(9) "Heated floor area" in 7.2-7.4 means the total floor area of the storeys or parts thereof which are heated. (7.2.1(9)) The heated floor area does not include rooms/spaces which do not fall within the floor area of the building.

Room temperature
All heated rooms/spaces in dwellings, offices, schools, institutions etc. are assumed to be kept at a monthly average temperature of no less than 20°C in all months of the year. Rooms/spaces in such buildings that are heated to between 5°C and 15°C can either be regarded as unheated or heated to no less than 20°C.
Rooms/spaces regarded as unheated are not included in the heated floor area.

Reference:
http://w2l.dk/file/155699/BR10_ENGLISH.pdf

Finland: The area used is heated net surface of the building. This is defined as follows: Heated net surface is the sum of heated gross internal areas per floor (calculated by the internal surfaces of the external floors).

Estonia: Energy performance indicator area is defined as the heated floor area.

4. **Definition on energy performance of the building. How are the system boundaries defined for the building? One example of how the system boundaries can be drawn is shown in Figure 1 below.**

Sweden:

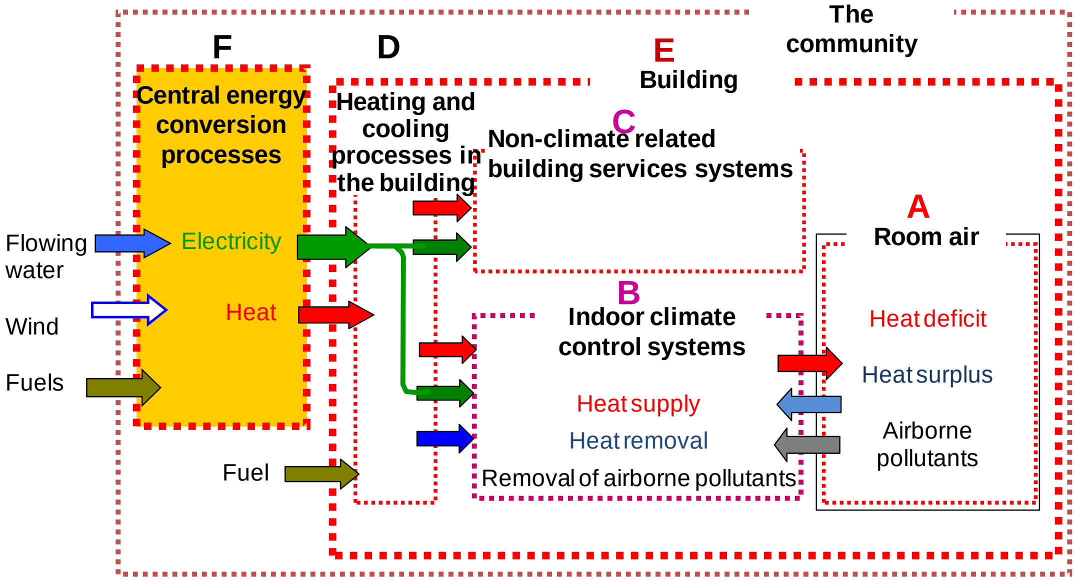
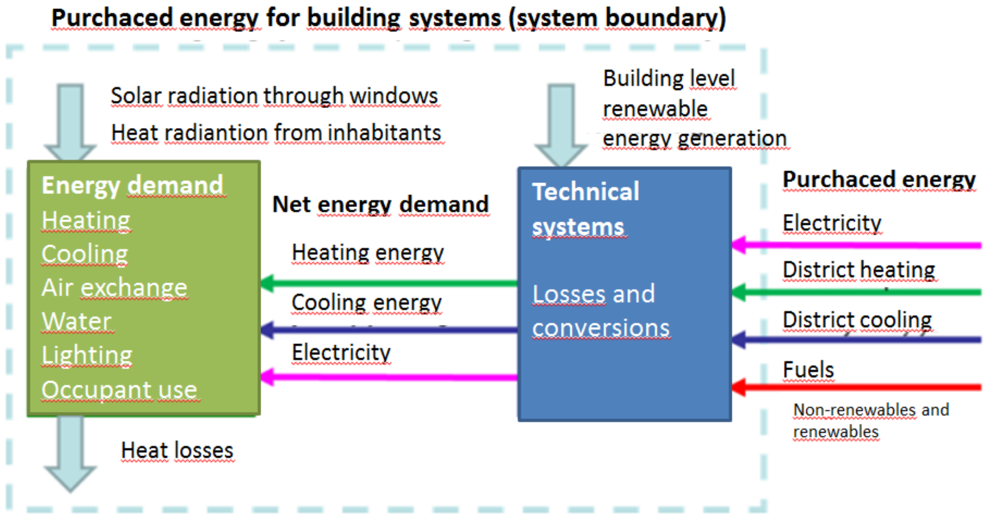


Figure 1. System boundaries that can be applied when analysing the energy behaviour of a building.

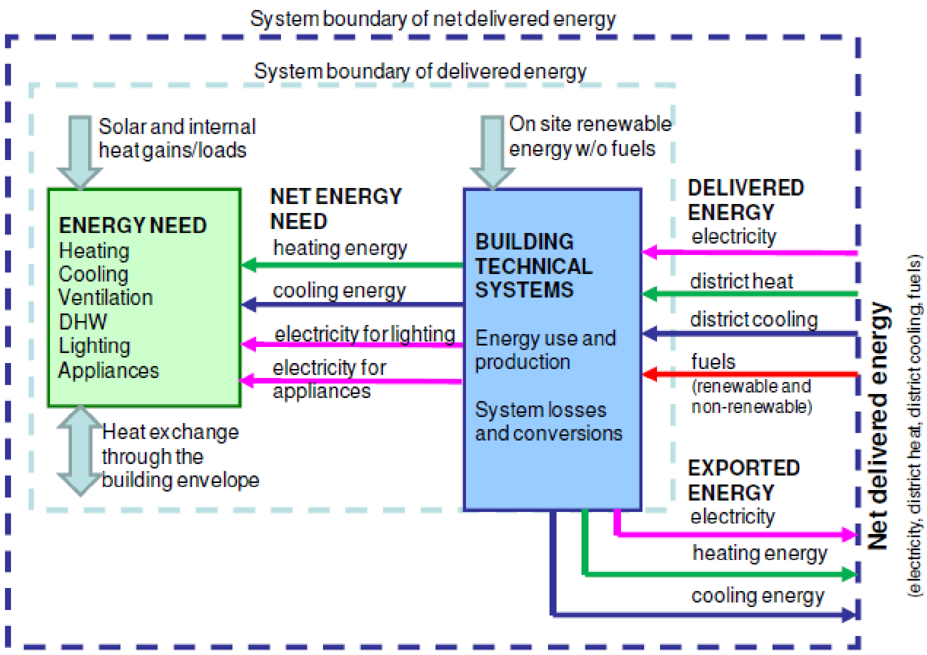
Norway: As described in point 2, the current requirements are defined as net energy demand and do no include the energy supply system. Norway has also implemented the EPBD and use energy performance certificates, where the criteria is for delivered energy, otherwise the same standard, with standardized values is used.
New regulations (TEK15) will come out to hearing, autumn 2014 and it is there proposed to change the requirements from net energy demand to delivered energy.

Denmark: The system boundaries of buildings in Denmark are similar to the boundaries shown in figure 1 excluding system included in F.

Finland: System boundaries that are applied when analysing the energy behaviour of a building according to Finnish building regulations.



Estonia: System boundaries defined for the building energy use are shown in figure.



5. To weight the different energy carriers, are e.g. Primary energy factors used? Which in that case.

Sweden: In BBR primary energy is not considered other than that electrically heated buildings have more strict requirements than those using other heat sources.

Norway: For the Energy Performance Certification, delivered energy is used, here the real system efficiency factor for the energy supply system is used, hence district heating has a poorer efficiency than eg. Direct electricity.
Per today, no national primary energy factors are defined in Norway. It exists a ZEB definition of primary energy factors which is used in some extent.

Denmark: In Denmark most buildings are provided with at least two different types of energy supply. For the assessment of the energy performance frameworks of the buildings, a factor of 2,5 is used to compare electricity with heating.
In connection with class 2015 low energy buildings supplied by district heating, an energy factor of 0,8 applies to district heating for joint assessment with another power supply.

Reference:
http://w2l.dk/file/155699/BR10_ENGLISH.pdf

Finland: Primary energy factors are used. The used factors are:

- Electicity: 1,7
- District heating: 0,7
- District cooling: 0,4
- Fossil fuels: 1
- Renewable fuels: 0,5

Estonia: According to the energy source, primary energy is taken into account with the weighting factors:

- wood, wood-based fuels, and other bio fuels 0,75
- district heating 0,9
- fossil fuel (gas, coal etc.) 1,0
- electricity 2,0

6. What EN standards are applied/referred to on national level when working with energy performance of buildings?

Sweden: In BBR, the average heat transfer coefficient is calculated according to SS-EN ISO 13789:2007. “n-day mean air temperature” is calculated according to SS-EN ISO 15927-5. Method for measurement of air leakage is according to SS-EN 13829.

Norway: For energy performance in buildings a national standard, NS 3031, is used. This standard further refers to 26 other EN standards as e.g.:

- NS EN 13829
- NS EN 15217

- NS EN 15242
- NS EN 15265
- NS EN 15316-1
- NS EN 15603
- NS EN 6946
- NS EN 10077
- NS EN 10211.

Denmark:
(7.2.1(4)) Testing of air changes must be determined on the basis of DS/EN 13829, Thermal performance of buildings – Determination of air permeability of buildings – Fan pressurisation method.

(7.2.1(8)) This provision ensures that the building envelope as a whole has reasonable insulating properties. The design transmission loss must be determined as specified in DS 418, Calculation of heat loss from buildings. For buildings with high ceilings and which are comparable with two storey buildings or buildings with three storeys or more, the corresponding transmission loss must be, respectively, 6 and 7 W/m² of the building envelope. "Windows" includes rooflights and skylight domes.

(7.2.1(10)) This provision requires low energy construction to ensure that the building envelope as a whole has reasonable insulating properties. The design transmission loss must be determined as specified in DS 418, Calculation of heat loss from buildings. For buildings with high ceilings and which are comparable with two-storey buildings or buildings with three storeys or more, the corresponding transmission loss must be, respectively, 5.0 and 6.0 W/m² of the building envelope. "Windows" includes rooflights and skylight domes.

Reference:
http://w2l.dk/file/155699/BR10_ENGLISH.pdf

Finland: Act on Energy Certificates for Buildings (50/2013, in Finnish, Finlex) or related Government Decrees do not directly refer to specific EN standard. However, the calculation instructions mainly follow the standard SFS-EN ISO 13790. Also several other standards are referred for specific calculation needs e.g.:

- SFS-EN ISO 13790 The national calculation instructions mainly follow this standard
- SFS EN 13829 (air tightness)SFS-EN 13141-7 (air handling unit electricity use)
- SFS EN 16147, SFS EN 14511-3 (heat pump electricity consumption)
- SFS EN 14511-2:2007 (heat pump power consumption)

- SFS-EN ISO 14683 (thermal bridges)
- SFS-EN 12464-1 (lighting)
- SFS EN 15316-4-6 (solar electricity)
- SFS-EN 61829 (solar power production)
- SFS-EN 13786 (thermal performance of building components)
- SFS-ISO 13370 (heat losses to ground)

Estonia: Building code ("Methodology for calculating the energy performance of buildings") refers to following EN standards:

- EVS-EN ISO 15927–4:2005 (outdoor climate conditions)
- EVS-EN 12464-1 (lightning)
- EVS-EN 13829 (air tightness)
- EVS-EN ISO 13790 (net energy use)
- EVS-EN ISO 10456:2008, EVS-EN ISO 6946, EVS 908-1 (thermal transmittance of building envelope)
- EVS-EN ISO 13370 (heat losses to ground)
- EVSEN ISO 10211, EVS-EN ISO 10077, EVS-EN ISO 14683 (thermal bridges)
- EVS-EN ISO 10077, EVS-EN ISO 15099 (thermal transmittance of window)
- EVS-EN 13141-7 (air handling unit electricity use)
- EVS-EN 14511-2, EVS-EN14825 (cooling performance)

Questions on methodology

1. What are the existing methodologies used for major renovations on national level? EPC-concepts, Total Concept?

Sweden: The total concept is the method in the survey answers. However, EPC-concepts are applied to some extent.

Norway: There are few EPC-contracts made in Norway per today. The goal is usually a better energy performance certificate. For more ambitious renovations, requirements for passive house or low energy house is set as goal[5]. For major renovation environmental assessment method as BREEAM-Nor BREEAM- In Use or LEED is more frequent applied. Incentives are given for existing buildings achieving passive house level. [3,4,5,6]

Denmark: Energy Performance Contracting is a contractual agreement for an energy efficiency implementation in Denmark. It is done between the beneficiary and the provider (usually an Energy Service Company-ESCO) and the investments are paid back through the energy savings after the efficiency improvement.

[5] NS3701 (2012)

In the ESCO model used in Danish municipalities, the client provides the investment (i.e., no private or third-party financing), and the ESCO-supplier implements the energy retrofitting initiatives, and guarantees the agreed level of energy savings. Energy Performance Contracting would therefore be a more correct term to use, like in Sweden where similar types of contracts are used by the municipalities. As "ESCO" however is used widely in a Danish context, the paper will also use this term. Throughout the paper we will use the term "ESCO-provider" for the ESCO-companies, and "ESCO-contract" for the business model, i.e., the ESCO-contract between the client and the provider.

Practical definitions of ESCO however vary across Europe and the rest of the World. As an alternative, "Energy Savings Performance Contracts" (ESPC) are often used to characterize models for energy services. A major distinction of models is between "Shared savings" and "Guaranteed savings" that concerns different distributions of investments and savings between the client and the ESCO-provider. In short, projects using the shared savings model is based on full financing from the ESCO-provider, who in return get a share of the savings—in contrast, projects using the guaranteed savings model are typically financed by the client, where payments include money for the ESCO-provider to implement and operate solutions, as well as guaranteeing the client a certain level of energy savings over a longer period. The shared savings model is mainly used in developing countries where clients have limited access to capital, whereas in a European context, the guaranteed savings model is predominant.

According to the EU-directive on energy end-use efficiency and energy services an energy service company (ESCO) is defined as: "a natural or legal person that delivers energy services and/or other energy efficiency improvements measures in a users' facility or premises, and accepts some degree of financial risk in doing so. The payment for the service delivered is based (either wholly or in part) on the achievement of energy efficiency improvements and on the meeting of the other agree performance criteria". In an ESCO contract the ESCO-provider takes the risk for achieving defined energy savings instead of the client (e.g., a building owner), making investments in energy savings measures more calculable and thereby attractive for the client.

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Finland: In Finland at least following methods are used:

- PPP (Public-private partnership) and life-cycle models
- EPC - concept
- ESCO

Estonia: Energy Performance Certificate concept is mainly used as building code sets requirements for primary energy use for major renovation.

2. How is the baseline for energy performance established in an existing building? Is this baseline documented e.g. in the contractual agreement with the client?

Sweden: The baseline for energy use is mostly established via energy auditing, and when measured energy use is missing, by simulation. “Sveby” is a trade standard for energy calculation, measurements and verification in buildings. The Sveby “Energiavtal 12” is a standard energy contract between buyer and contractor, that can be applied to ensure that the energy performance target is verified by measurements. Liability is established regarding deviations between contracted and actual energy performance after the refurbishment.
EPC companies may have their own schemes to establish energy performance before measures.

Norway: See question 2-4 on "Questions on building code and definitions"
Total energy is measured and registered. For Statsbygg this is made in for all buildings in the yearly report[5].

Denmark: It depends on the client and budget. It can be simplified to manual calculations in excel, up to advanced and very detailed dynamic simulations.

The European EPBD includes a requirement to display an energy performance certificate in public buildings larger than 1 000 m² and stipulates that the certificate cannot be older than ten years. This is a means of ensuring that public buildings are assessed regularly. Some countries have chosen to extend the regulation to include public buildings less than 1 000 m² and commercial buildings, or to make the certificate valid for less than ten years. Denmark, for example, has made five-year certification mandatory for all buildings (public, commercial and residential) greater than 1 000 m².

Denmark launched its mandatory energy rating systems for commercial and residential buildings in 1992 and 1993, respectively. Denmark is among the countries pursuing very low-energy building; as such, it had strict energy requirements and a certification scheme in place since 1997, before the EPBD was implemented. The Energy Performance Certificate is used for major renovations in Denmark. The Energy Performance Certificates were introduced to Denmark in 1997 predating their introduction through the EPBD and exceeding directive requirements in ambition.

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Finland: When measured information to evaluate the baseline energy consumption is not available, the baseline can be calculated using the calculation method defined in the national regulations (used for Finnish energy certificate). The background documents for these calculations contain standard consumption levels for different types of buildings based on their construction year.

In contract level, the savings are not usually presented as savings but as the actual energy consumption level after the renovation.

Estonia: There is no specific methodology. Usually building owner provides the energy usage data to the energy auditor.

3. Are there specific (or standardised) methods for energy auditing used? What requirements apply for experts carrying out energy audits?

Sweden: The law on energy declaration (2006:985) regulates that energy auditing should be performed, but there is no standardized protocol (BFS 2013:14), and most auditing companies will have their own. These audits are performed only by certified energy experts.

Norway: Mostly only total energy of the different energy suppliers is measured [5,6] When receiving financial support from Enova, it is required to do energy audit (EOS), but it is not required to use the standard NS-EN ISO 50001:2011. When receiving support for heat pump, electricity- and energy measurement is required. The Energy Performance Certificate requires the total energy performance from the last three years from existing buildings.

Denmark: Since May 2011, an Energy Saving Certificate can be issued only by certified companies in Denmark. The certification of a company to issue Energy Saving Certificates in Denmark can be conducted by a Danish accreditation agency (DANAK) or by a corresponding European accreditation agency under the European Accreditation Organization (EA). A certified company must implement an. ISO 9001 QA scheme for its building energy certification system. Two kinds of energy advisers/experts are available. One is energy experts covering single and two-family houses of less than 500 m2 and the other are energy experts covering multifamily houses, public buildings, as well as the trade and service sectors.
Certified companies must carry out their own quality checks according to the DS/EN ISO 9001. The DEA carries out a market surveillance of the companies. These quality checks occur on a regular basis, but may be carried out on the basis of a complaint as well. The DEA has set up a mandatory QA schema. Every Energy Saving Certificate is registered in a central database.

Reference

Implementing the Energy Performance of Buildings Directive (EPBD) – Featuring country reports 2012., ISBN 978-972-8646-27-1, Porto, June 2013. www.epbd-ca.eu

Finland: Finland has an own specific method for energy auditing. The method is supported by Ministry of Employment and Economy which also supports the auditing costs financially. Motiva Oy is responsible for the management of energy audits, and its tasks include the promotion and monitoring of energy auditing activities, the training of auditing personnel, and the quality control of auditing measures. The main aspects of auditing are improvement possibilities of HVAC systems and buildings structures. For each energy audit, two responsible auditors are named and one of them has to be certified by Motiva.

To become a certified auditor the pre-requirement is at least three years basic education in the fields of electrical, HVAC, energy engineering or similar some related work experience or a testimony from the employee of equivalent skills level achieved through many years of work experience. In addition a three day course with an exam must be passed.

Estonia: Building code standardize only residential buildings energy auditing methods. Method for other buildings types energy auditing is provided in buildings energy efficiency expert training. Energy efficiency expert occupational qualification system has four levels:

- energy auditor 6 (only residential buildings)
- energy auditor 6 (residential and public buildings)
- certified energy efficiency expert (residential and public buildings, consultations, energy simulations)
- accredited energy efficiency expert (residential and public buildings, complex buildings, consultations, energy simulations, research and development)

4. How are the energy calculations performed in the major renovation projects? Which computer softwares are used (if any)?

Sweden: Energy performance calculations are mostly performed with established software such as IDA ICE, VIP Energy or BV2. In the "Sveby" guidelines for performing energy calculations, the recommendation for non-residential buildings is to use software that performs dynamic whole-year simulations with at least hourly resolution.

Norway: For the most energy calculations, the norwegian energy program SIMIEN is used. IDA ICE is becoming more and more used for non-residential buildings.[6] External consultants do the energy calculations. It is their choice which program they want to use [5]

Denmark: It depends on the owner. Public institutions tend to use simple methods like Excel or programs like Energy10. Private sector (especially buildings with huge potential of energy savings) would use dynamic simulations, like IES VE where first the baseline is created and afterwards concepts are tested and compared to the baseline.

There are programms available for calculating payback time for single components like pumps (for instance: Grundfoss toolkit) and ventilation air handling units. It can be compared to the values given in "Energistyrelsens Standardværditabel" (standard values of Energy Agency")

The Danish energy calculation tool is described in: "SBi Direction 213: The Energy Demand of Buildings - PC application and guidelines for calculations - Guidelines for Calculations". The PC application includes a calculation core mandatory to be used in relation to calculation of energy demand in new building in relation to the Danish Building Regulations and in relation to energy labeling of new and existing building. The calculation methodology is the same at the one used for proof of compliance in the Danish building code (BR10) for a new building. The methodology is defined in a calculation engine. Any company can create its own energy certification tool, but it must use the same calculation engine in the Danish Building research Institute direction 213 (SBi-Direction 213). The calculation procedure in the BR10 has been updated according to the new requirements, and is described in the SBi-Direction 213. The procedure follows the relevant CEN standards to great extent. This publication also includes the updated PC calculation program Be10. The calculation core of this program is to be used by all other programs for compliance checks and energy certification, to ensure the identical calculation of the EP buildings.

Reference

Implementing the Energy Performance of Buildings Directive (EPBD) – Featuring country reports 2012., ISBN 978-972-8646-27-1, Porto, June 2013. www.epbd-ca.eu.
Søren Aggerholm, Cost-optimal levels of mini-mum energy performance requirements in the Danish Building, SBi 2013:25, SBi/AAU.

Finland: The most commonly used method for calculations is the one required for the Finnish Energy Certificate. In simple cases, this can be done by hand or using a software specifically created for these calculations. If the energy system of the building is more complicated (for instace if cooling is needed) dynamic energy simulation is required. The most commonly used dynamic energy simulation softwares are MagiCAD Comfort and Energy (Riuska), IDA ICE (Indoor Climate and Energy) but also some others may be used.

Estonia: Energy performance of residential buildings without cooling can be calculated with degree days method. Residential buildings with cooling and non-residential buildings energy performance is calculated with dynamic energy simulations.

There are different softwares in use in Estonia (IDA ICE, Riuska, VIP-Energy, TRNSYS, EnergyPlus). Ministry of Economic Affairs and Communications provided freeware (BV^2) for energy calculations for residential buildings without cooling.

5. **What profitability analysis methods/standards are used in the major renovation projects? Are these methods specified by property owners?**

Sweden: Probably, pay-off methods are still the most commonly used method for profitability**.** A number of LCC calculation tools are used, mostly excel-based. Some property owners use the "Total tool" giving the internal return of investment.

Norway: This is specified by the building owner, but external consultants do the LCC. Alternative solutions can be requested for comparing TEK10 and passive house. [5]

Denmark: Appendix 6 in the Danish Building Code contains a summary of measures that are often cost-effective to implement. The appendix also states assumptions that are used in the calculations associated with calculating the energy demands of buildings. Please see Appendix 6 in http://w2l.dk/file/155699/BR10_ENGLISH.pdf

Finland: In some cases the financial calculations are restricted to investment analysis that may be combined with the analysis of profits from the building use. If profitability is analyzed the most commonly used method is payback time. Also life cycle cost analysis may be used with scopes varying form analyzing certain technical investment or structure to entire life cycle cost analysis (for instance according to EN 15643.

Estonia: There is no specific method. Different methods are in use (payback period, global cost, life cycle cost, internal rate of return etc.)

Questions on measurements and verification

1. **Are there any specific measurement and verification protocols used to follow up the energy performance after renovations?**

Sweden: Sveby is a trade standard for measurement, calculation and verification of energy in buildings that is used to some extent.

Norway: Statsbygg has their own system for energy audit, receiving weekly and quarter year reports (ET-curves). But it can also be used for hourly audit. [5]

Denmark: No, there are not any specific measurement and verification protocols used to follow up the energy performance after renovations.

Finland: Any specific measurement and verification protocols are not commonly used to follow up the energy performance. The client may set some indicators that are measured during the period of guarantee to ensure the acceptability.

Estonia: There is no specific method for follow up measurements and verification as building code does not require follow up or verification measurements. If follow up measurements are performed, then the methodology is specified in client and energy auditor agreement.

2. **What measurements are carried out to follow up the savings? Which energy flows are measured? Are effects of individual energy saving measures evaluated/measured separately?**

Sweden: This depends on the building. In some cases the existing energy meters are sufficient to see the difference in energy use and in some cases separate meters have to be installed.

Norway: Mostly only total energy of the different energy suppliers is measured [5,6]
Energy: Water and electricity

Denmark: -

Finland: Improvements in building energy measurements are often included in major renovations. Especially sub-metering for electricity or district heating may be added. Electricity, district heating and district cooling consumption are practically always measured at least at the property level and thus can be used to follow up. Also heating fuel consumption is followed. Electricity consumption may be separated between building technical systems and occupant electricity. The electricity produced by renewable energy production equipment (solar system etc.) may also be measured separately.

Estonia: There is no specific method for follow up measurements and verification as building code does not require follow up or verification measurements. If follow up measurements are performed, then the methodology is specified in client and energy auditor agreement.

3. **Are other evaluation measurements performed? E.g. Air leakage, thermography, etc.**

Sweden: When appropriate, air leakage measurements are performed. Also thermography can be used to evaluate the building envelope.
Norway: Air leakage is normally controlled. Other measures, when needed. Interdisciplinary function tests are performed [5].

Denmark: Blower door test, thermography and performance measurements may be carried out, but it is not a systematic follow-up method.

Finland: The air leakage measurement of the building envelope is sometimes used.

Estonia: There is no specific method for follow up measurements and verification as building code does not require follow up or verification measurements. If follow up measurements are performed, then the methodology is specified in client and energy auditor agreement.

4. How long is commonly the time period for measuring the energy use after renovations in order to verify the savings?

Sweden: Commonly 2 years, but is continually followed up by administrator after the 2-year period. The Sveby Energy contract 12 stipulates three years.

Norway: For eternity. More detailed energy measures, 1-3 years

Denmark: Normally savings are verified yearly. For automatically regulated installations verification may be up to 1-2 years.

Finland: This depends on the client. Generally, the suitable time for verification measurement is considered to be after the building has been used at least for one year because then there has been enough time for needed system adjustments. The verification measurement period is typically at least one entire year.

Estonia: There is no specific method for follow up measurements and verification as building code does not require follow up or verification measurements. If follow up measurements are performed, then the methodology is specified in client and energy auditor agreement.

5. Which resolution is used on measurements (Year/month/week/day/hour/minute)?

Sweden: Different for different projects. In the survey answers, a monthly period is reported.

Norway: There is hourly measurements, but get the statistics weekly and quarter year.
Denmark: Systems without Building management system (BMS) would deliver monthly usage from electricity/heating supplier. Systems with BMS system can deliver any data (also minute based).

Finland: This also depends. If new energy measuring equipment are used (for instance for electricity or district heating) the data resolution is typically an hour.

Old style manual measurements are typically performed monthly. However, energy consumption targets are usually set on yearly basis.

Estonia: There is no specific method for follow up measurements and verification as building code does not require follow up or verification measurements. If follow up measurements are performed, then the methodology is specified in client and energy auditor agreement.

6. **Which adjustments are made on measurement data (and how)? Normalisation of outdoor climate? (e.g. degree day, energy signature) Adjustments for unexpected deviations in occupancy? (e.g. domestic hot water) Other?**

Sweden: Normalization for climate is almost always done according to degree-day, energy index or energy signature methods. The Sveby standard gives the possibility to normalize deviations from expected occupancy, e.g. hot water.

Norway: Climate, degree days. Usually uses Enovas standard values for occupancy
Denmark: Degree days may be used.

Finland: Normalization to outdoor climate commonly used and it is done with degree day method. The data is offered by Finnish Meteorological Institute and the data period that is used in comparison is at the moment 1981-2010. There are two variations of the method. One is adjusting the data only for yearly outdoor climate. The other adjusts the data also to a standard location (that is the city of Jyväskylä). The latter method is used in Finnish energy certificate.

Estonia: Normalisation of outdoor climate with degree day method is used in energy auditing. Adjustments for unexpected deviations in occupancy is normally not used. Standard usage profiles (occupancy, domestic hot water, lighting and appliances electricity usage etc) are used for calculations to prove energy efficiency requirements.

7. Who commonly carries out the follow up work after renovations, e.g. operational personnel, hired consultants, other parties involved?

Sweden: Operational personnel and administrators are usually the people involved. In some cases, external consultants can be hired to do the follow up work. EPC companies usually perform the follow-up in their projects.

Norway: Operational personnel and manager.

Denmark: Operational personnel. During renovation projects an external consultant would be hired. Please see the ESCO method in Denmark.

Finland: Also this depends entirely of the client and the measurements. Some want third party measurements but often the follow up is totally carried out by operational personnel.

Estonia: There is no specific method for follow up measurements and verification as building code does not require follow up or verification measurements. If follow up measurements are performed, then the methodology is specified in client and energy auditor agreement.

Questions on energy market conditions

Representative energy prices in Your country in Euro/kWh ? Fuel oil, Natural gas, Bio-fuel, District heating, Electricity, etc. (fill in applicable prices in table)

Source	Sweden	Norway[6]	Denmark[7]	Finland[8]	Estonia
Electricity, regular	0,08[9]	0,12	0.3	0,11	0,14
Renewable electricity	0,09-0,10[10]	0,12	0.17 For the first ten years	0,12	0,14
Fuel oil	0,19[11]	0,08	0.15	0,07	0,088
Natural gas	0,10-0,11[12]	0,09	0.11	0,05	0,055
Wood pellets	0,051-0,073[13]	0,06	0.06	0,06	0,054
Fire wood	0,034-0,056[14]	0,12	0.04	0,05	0,031
District heating	0,09[9]	0,13	0.09	0,07	0,075
District cooling	0,044[15]	0,14	0.09 – 0.12	0,11	N/A

[6] This is the total energy prices. Most of the energy prices follows the energy price of electricity

[7] **Reference:**
http://www.byggeriogenergi.dk/media/36821/katalog_installationer_web.pdf
http://www.elforsk.dk/elforskProjects/343-056/343-056_WEB.pdf

[8] VAT 24 % included

[9] Nils Holgersson: http://www.nilsholgersson.nu/rapporter/aktuell-rapport/undersoekning-2014/el/riket/ ink. VAT.

[10] Telge Energi: http://www.telgeenergi.se/

[11] Calculated as 13 000/(10000*0,75) where avg. price is 13 000 kr/m^3, 10 000 kWh/m^3, η=0,75

[12] For household customers> 55 000 kWh/year, SCB, 2014, http://www.scb.se/sv_/Hitta-statistik/Statistik-efter-amne/Energi/Prisutvecklingen-inom-energiomradet/Energipriser-pa-naturgas-och-el/24719/24726/Genomsnittspriser-per-halvar-2007/212955/

[13] Calculated as 4,9 kWh/kg, prices according to http://www.energimyndigheten.se/Hushall/Testerresultat/Testresultat/Pelletskvalitet/?tab=2

[14] Calculated as price/(1300*0,75) where avg. price is 300-500 kr/m^3, 1300 kWh/m^3, η=0,75

Questions on Total Concept method implementation

1. **What do you consider to be the main benefits of adapting the Total Concept method in your country?**

Sweden: The system perspective gives opportunities for good installations for a long-term administration. It can motivate property owners to invest more in energy conservation measures.

Norway: -

Finland: The total concept method will offer an alternative perspective compared to investment cost and payback time. The method shows that it is actually possible to achieve higher savings in energy in a financially sustainable way. Having another perspective to the investment cost is especially important for the public sector organizations. Even though public organizations often have set targets for energy savings they are also restricted to certain investment budget and face difficulties to convince the decision-makers that putting in more money to energy savings would actually also be profitable in longer term. On the other hand, private sector has more possibilities to invest only if the measures are considered profitable. For them Total Concept would offer a more comprehensive view of profitable energy saving possibilities.

Another important benefit is that the method involves the stakeholders and thus may bring the energy analysis closer to the design and construction process. Without this kind of procedures, the consultant suggestions about possible energy savings may seem irrelevant to other project stakeholders and on the other hand, some possibilities to save energy may remain unfound. In this kind of cases often only some easy conventional measures to improve energy efficiency are eventually executed.

Also the well-defined follow up process may be very beneficial as there are not ready made concepts for the follow up in Finland at the moment. This may be especially helpful for smaller client organizations that may not have much knowledge of their own.

[15] During cooling season Exkl. load price and bonus, http://www.fortum.com/countries/se/SiteCollectionDocuments/prisavtal-komfort-odaterad-april-2014.pdf

Denmark: When energy efficiency measures are carried out in Danish existing non-residential buildings it is important that they are performed so that:

- The quality of the building and its usefulness is maintained or improved.
- The greatest possible savings are achieved using the allocated resources.

2. What can be the main concerns/issues involved when introducing the Total Concept method in your country? Would there be any legislative constraints that need to be taken into account?

Norway: No problems, for public buildings, it is a good method, thus it is usually the interest rate that is steering

Finland: There is probably not any legislative constraints.

Denmark: When implementing energy saving measures in existing buildings the Danish Building Regulations distinguish between "alteration or maintenance" of a building component and "replacement" of a building component.
In case of alterations and other changes in buildings profitable energy saving measures in terms of insulation of exterior walls, floors, roof constructions and windows as well as changes of installations must be carried out (BR10, kap. 7.4.1, stk. 1).

However, even if an upgrade to today's standard is not profitable, there may be cases where less extensive measures will lead to reduced energy consumption and in that case such measures must be implemented.
E.g. additional interior or exterior insulation of a facade may not be profitable whereas insulation of cavity walls typically is a profitable measure. In that case the latter must be implemented even if the insulating properties of the wall will not meet requirements.

If a building component is replaced, e.g. a roof or a facade section, specific requirements regarding insulation must be met whether it is profitable or not (BR10, kap. 7.4.1, stk. 2).

In some cases it may prove difficult to implement otherwise profitable measures. In that case the lack of profitability must be documented.

An energy-saving measure is considered profitable if the annual saving multiplied by the life time of the measure divided by the investment is greater than 1.33. This equals that the measure must be repaid within 75 percent of the expected lifetime. The Danish Building Regulations contain a list of computational lifetimes.

The reason for the distinction between "alteration or maintenance" of a building component and "replacement" of the building component is that it is often easier to meet the insulation requirements when replacing a building component than when altering a building component.

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Anvisning om Bygningsreglement 2010
Hansen, E. J. D. P. (red.), Stang, B. F. D., Ginnerup, S., Kirkeby, I. M., Buch-Hansen, T. C., Aagaard, N-J., Sørensen, L. S., Bergsøe, N. C., Hoffmeyer, D., Aggerholm, S. & Brandt, E. mar 2013 3. udg. Hørsholm: SBI forlag. 431 s. (SBi-anvisning; Nr. 230, Vol. 2013).
http://w2l.dk/file/155699/BR10_ENGLISH.pdf

3. Would the Total Concept method compete with other similar working methods of energy performance improvements in the buildings? If so, which methods?

Norway: There is not used that many comparable methods on national level

Finland: There are not very similar working methods. Some methods that may compete with this are ESCO projects and PPP/Life Cycle projects that are targeted to energy savings. In some cases also Life cycle cost tool may be used to similar purposes e.g. to evaluate the profitability of different energy saving measures even though this is only an analysis method not an entire project concept.

Denmark: No, it will not compete.
The Total Concept method differs from traditional methods for improving energy efficiency that all the possible energy saving measures are carried out in one single package and that they together meet the property company's/client's profitability requirements. Following up the results of carrying out the improvement measures by registering energy differs from traditional methods.

4. What would be the main points to consider when adapting the Total Concept method to your national conditions? What are the most probable adaption points/changes needed?

Norway: Change of energy prices, investment costs

Finland: One likely adaptation point may be in the energy savings calculation methods. The Finnish energy certificate has its own calculation method that may partially be quite different compared to other countries. Nobody finds it meaningful to do double calculations, so when possible and reasonable, it might be the best to

align the energy evaluation with the Finnish methodology. Also the energy saving measures should also fill the Finnish requirements.
Also there may be some adaptation points in stakeholder involvement procedures and related to contractual issues (depending on the models).

Denmark: The most probable points to take into consideration when adapting the Total Concept method in Denmark are the requirements regarding insulation irrespective of profitability according to the Danish Building Regulations mentioned in question 2 above.

5. **How do you evaluate the current situation with know-how and experience with carrying out major energy retrofitting projects? What are the specified areas where you think the competence needs to be improved and from which side of the party (clients, energy consultants, design engineers, architects, contractors, etc)?**

Norway: See drivers and barriers D2.5

Finland: One clear point in which the competence needs to be improved is the capability to analyze the size of possible energy savings in the design phase. Currently in Finland the savings are very often overestimated. This is a problem especially when the energy saving target is ambitious. The reasons behind this cap is not well known but some suggested reasons are the calculation methods and especially the false assumptions used in the calculations, the overestimated potential of the renewable energy production equipment and the lack of proper adjustments in the commissioning phase after construction. There is also a vivid conversation going on about the possible risks of very energy efficient buildings and the lack of design and construction knowledge related to the new building structures and systems needed.

Also the client organizations have huge differences in knowhow. Some organizations have already gained a lot of experience and knowledge about major energy retrofitting but many are still very restricted in their skills and thus entirely dependent on consultants.

Denmark: There are a number of important key actors, all of which are crucial to carrying out the Total Concept method for the best outcome of the energy efficiency measures identified:

- Property owners/clients who will initiate future projects based on the total concept method

- Property managers, who are responsible for the buildings in question, might play important roles when it comes to investment decisions.
- Energy consultants who are to carry out the work in practice according to the total concept method and who will present proposals for the action package.
- Design engineers who carry out the detailed design for the action package in Step 2 in the total concept method.
- Contractors who will carry out all the building work according to the consultants' proposals.
- Maintenance staff who are responsible for all the systems in a building and who can directly control the use of energy in the building.

All these groups, each in their own particular way, play important roles in the project as a whole.

As end users, the tenants have a significant influence on the energy used in the building and it is therefore essential for the client to keep them well-informed and to be responsive

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