QUALICHeCK
Towards better quality and compliance

"Status on the Ground"

Overview of existing surveys on energy performance related quality and compliance

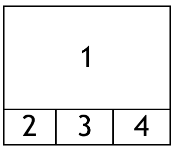
Mikk Maivel, Kalle Kuusk, Raimo Simson, Jarek Kurnitski, Targo Kalamees (Tallinn University of Technology, Estonia)

With contributions from: Samuel Caillou (BBRI, Belgium), Jan-Olof Dalenbäck (Chalmers, Sweden), François Durier (CETIAT, France), Chrysanthi Efthymiou (University of Athens, Greece), Susanne Geissler (OEGNB, Austria), Arnold Janssens (University of Gent, Belgium), Pär Johansson (Chalmers, Sweden), Theoni Karlessi (University of Athens, Greece), Marina Kyprianou Dracou (Cyprus Institute, Cyprus), Xavier Loncour (BBRI, Belgium), Clarisse Mees (BBRI, Belgium), José L. Molina (University of Seville, Spain), Horia Petran (URBAN-INCERC, Romania), Paula Wahlgren (Chalmers, Sweden)

www.qualicheck-platform.eu

Co-funded by the Intelligent Energy Europe Programme of the European Union

IMAGE CREDITS



1. Shutterstock / Ant Clausen
2. Shutterstock / Nonwarit
3. Shutterstock / pryzmat
4. Shutterstock / sergign

Executive summary

This report is part of a series of reports to be produced in the context of the IEE QUALICHeCK project. The primary objective of this report is to gather preliminary information on quality and compliance issues in 9 focus countries (Austria, Belgium, Cyprus, Estonia, France, Greece, Romania, Spain, and Sweden) on the 4 technology areas specifically addressed in the project (transmission characteristics, ventilation and airtightness, sustainable summer comfort technologies, and renewables in multi-energy systems). It is not meant to accurately and exhaustively describe the status of quality and compliance in those countries for those technology areas. This report also includes some information from countries outside the consortium, in particular from the United Kingdom.

The Energy Performance of Buildings Directive recast (EPBD recast) gives ambitious goals for the building sector to reduce energy use as well as greenhouse gas emissions. It requires Member States to engage in the generalisation of Nearly Zero-Energy Buildings (NZEB), both for new and existing buildings. Although experience has shown that such buildings can be realised in practice, there exist many challenges to drive the whole market in this direction. One specific challenge concerns the compliance of buildings to NZEB requirements, in particular how to ensure they actually comply with applicable regulations or programme specifications. Another challenge lies in upgrading the quality of the works to meet NZEB standards at commissioning but also on the longer term.

The IEE QUALICHeCK project addresses these two issues with two main objectives: To set up a series of actions which should result in more attention and practical initiatives for:

1. Actual compliance with the claimed energy performance for new and renovated buildings, i.e., ‘boundary conditions which force people to do what they declare’;
2. Achieving a better quality of the works, i.e., ‘boundary conditions which stimulate and allow the building sector to deliver good quality of the works’.

Chapter 2 of this report describes the overall situation in the 9 focus countries, with specific attention to the status on the quality of input data, the quality of the works and the effectiveness of compliance frameworks. Chapter 3 gives examples of observed performance in daily practice grouped according to the 4 focus technology areas. Chapter 4 briefly presents some examples of interesting schemes, whether already implemented or under development.

Several studies and expert-statements highlight critical issues on the input data used in Energy Performance Certificates (EPC). This seems to arise, at least to a significant extent, from the absence of verification after the works are finished. Compliance frameworks are typically limited to verifications at building permit stage, therefore, not with "as-built" data. Most countries do not have control mechanisms at later stages, including design changes during construction, commissioning, final design/production information, and operation. Therefore, errors due to design modifications compared to the initial EPC submission or poor workmanship (affecting the EPC input data) seem common. In addition, EPC calculations are checked by authorities with very small and seldom random samples. To overcome this problem, several countries or regions (AU (in Salzburg region), BE, FR) have recently introduced interesting schemes to check the consistency of the input data after completion of the works.

Other problems identified on the EPC input data include:

- ✓ unclear procedures;
- ✓ uneasy access to the EPC input data;
- ✓ mistakes or fraud by persons providing the input data;
- ✓ lack of competence of persons providing the input data.

Chapter 3 summarises 31 specific studies addressing specific concerns on performance data from the field, the compliance of the input data, the quality of the works, or the compliance frameworks. Although the situation is contrasted between countries and technologies, this partial information confirms the need to further work on schemes to improve the confidence in the compliance of input values and in the quality of the works. As illustration with regard to transmission characteristics, a Belgian field study conducted in the late 90s on 200 dwellings has shown significant discrepancies between reported and actual insulation levels, with little impact on the requirements supposed to be met. A Swedish study has highlighted challenges for the determination of thermal bridges with an appropriate trade-off between simplicity and accuracy. Regarding ventilation and airtightness, several studies have shown significant deviations

between expected and actual performance (as per EPC rules) and suggest major sources of problems in the design and the quality of the works. There are also interesting examples regarding renewables, e.g., on domestic hot water solar thermal installations in France with, on the one hand, a field campaign on 9 large installations showing an even distribution of very good to very poor results; on the other hand, very good results on 11.817 installations in individual houses audited under a specific certification programme. This chapter also shows the difficulty to define compliance criteria for summer thermal comfort criteria, based on an Estonian field study on 28 apartments buildings, as 65% of the apartments monitored did not comply with the present requirement (less than 150 degree-hours below 27 °C).

In all EU countries, national procedures exist to support the mandatory availability of EPCs for new and renovated buildings. Chapter 4 describes approaches developed or under development to (or potentially interesting to) increase confidence in the compliance of the EPC input data and the quality of the works, and to ease the access to EPC input data. Some approaches are also briefly mentioned in Chapters 2 & 3.

The approaches mentioned or briefly described in this report to increase the confidence the EPC input data include:

- ✓ standard format for documenting the input data and reporting the results of the energy calculations, in order to make the EPC input data and the results documentation transparent (Estonia);
- ✓ automatic checks in the calculation software and/or during upload into the EPC database (Austria, Belgium) ;
- ✓ product data databases to help ensure that correct product data is used (e.g., in Belgium and France);
- ✓ catalogues of construction methods (e.g. thermal bridges catalogues).

As for the quality of the works, the approaches include:

- ✓ voluntary building certification schemes that require measurements and tests (e.g., in Austria and Spain);
- ✓ voluntary certification schemes for construction workers and/or companies (e.g., in Belgium, France, or Romania);
- ✓ mandatory inspection of the building service systems (e.g., in Cyprus, or Sweden).

Overall, although this report does not pretend to give an accurate picture of the quality and compliance status in the 9 focus countries for the 4 technology areas of interest, it suggests that the awareness on those issues, as well as on the measures taken to overcome them range very widely, from little or no field knowledge to in-depth analysis, and from naïve to fairly elaborated schemes. Some very interesting approaches should be analysed in more detail in later phases of the QUALICHeCK project. This report also confirms the need to tackle quality and compliance issues for successful EPBD implementation, both in terms of awareness raising, as well as development of appropriate tools and schemes to increase confidence in the effectiveness of the implementation of the EPBD.

Table of Contents

I. Introduction

The aim of this report is to obtain a state of the art review of the energy performance related quality and compliance situation in 9 focus countries: Austria, Belgium, Cyprus, Estonia, France, Greece, Romania, Spain and Sweden. This report is not looking for all details of this complicated and extensive subject, but provides examples, studies and schemes presenting the current status in respect to quality and compliance frameworks dealing with the quality of the input data used and documented in energy calculations, the quality of construction works and the compliance with the requirements and with the designed performance compared to on-site measurements. Additional references and links are provided to make more detailed information accessible than that provided in this report.

In addition to comprehensive screening in these 9 countries, studies from other European countries have been included based on literature review. All relevant studies were divided into four main themes:

- ✓ Envelope transmission characteristics: this includes opaque components (walls, roofs, …) windows and doors, as well as the handling of e.g. thermal bridges.
- ✓ Ventilation and airtightness: this includes performance of ventilation systems, as well as envelope and ductwork airtightness.
- ✓ Sustainable summer comfort technologies: this includes a wide range of technologies and concepts, e.g. solar control, thermal mass, ventilative cooling strategies, cool roofs, …
- ✓ Renewables in multi-energy systems: this also includes a wide range of energy systems, whereby the common feature is the presence of renewables (heat pumps, solar collectors, biomass, PV, …).

A summary table with relevant classification information, as well as links and references can be found in Annex I.

II. Overall situation at country level

The information in this chapter has been provided by the QUALICHeCK project partners. For each of the 9 countries, there is a description of the status with specific focus on the reliability of input data. It is then followed by a description regarding the quality of the works. Finally, information is given about the compliance framework.

II.1 Austria

II.1.1 Reliable input data

In Austria, Energy Performance Certificates (EPC) are checked as part of the submission procedure to achieve a housing subsidy. The obligation to submit an EPC as part of the housing subsidy submission procedure has been used as a quality control of the EPC. At the beginning, many EPCs were wrong and had to be rejected. During the period 2008-2010 the quality of EPC has improved substantially.

Since many EPC experts have extended their activities from calculating the EPC for housing subsidy submission activities to calculating the EPC for the “selling and renting” market, new challenges have emerged regarding the quality of the EPCs issued for this purpose.

Typically, the EPC is calculated at the moment of the building permit. Even if input data are reliable as such, the EPC could deviate a lot from the actually constructed building: The EPC submission for building permit is often regarded as a “rough draft”, especially in single family housing construction. Decisions upon many details are taken at the site and are also revised (e.g., type and quality of windows, thickness of insulation). Therefore, in the province of Salzburg it is required to update the EPC after completion of the building. However, it is not the usual procedure in other Austrian provinces.

In Austria, there are no published studies having investigated the contribution of reliable input data to the quality of EPCs. However, several theses have investigated associated issues, among others some at the Technical University of Vienna and the Danube University.

II.1.2 Quality of the works

The quality of the works is controlled by the construction site supervisor, which represents the owner and is responsible for the correct implementation of the planned building. After completion the site supervisor confirms to the authority that the building has been completed in compliance with the legal requirements. Then the authority issues the permission to occupy the building. However, in practice there are time and budget limitations. There was a voluntary commissioning procedure for public buildings. However, after privatisation responsibilities and procedures have changed.

In theory there is a quality assurance chain: energy performance certificate and design, construction, monitoring. However, this quality assurance chain is not yet practicised. This is one reason for the difference between calculated energy performance certificates and real energy consumption.

Basically, the status quo of building construction (availability of technologies and know-how) is adequate to meet the requirements of OIB-RL 6 and the respective building legislation. In Austria, the criteria for the housing subsidy are similar compared with what is required by law, but target values are more ambitious, meaning that if the building meets more ambitious energy efficiency criteria – among others – the subsidy amount will be higher (according to Art. 15a V-BVG – Constitutional Law). These more ambitious requirements partly cause problems in building construction.

Based on the BUILD UP Skills Austria (www.buildupskills.at) Roadmap 2013, the following needs have been identified as concerns training related to the “quality of the works”:

- The need to improve the mutual understanding of the different trades regarding the whole building approach with a focus on energy-related issues. Each trade should have a basic understanding of the other involved trades. (Comment: this has been an issue at least since the early 1990ies)
- Specific focus for renovation of historic buildings
- Specific focus for automatic control engineering
- Design of building services systems and technical understanding; focus on hybrid systems

The project “BUILD UP Skills Cross Craft” (http://buildupskills-crosscraft.at) develops training concepts for energy efficient construction, addressing unskilled and skilled workers, and foremen:

- Basic Cross Craft Training - Improving the overall understanding of the trades involved in building construction
- Passive house skilled workers course (compact) – Improving the know-how base required for the construction of Nearly Zero-Energy Buildings
- Quality Coach Training – Training for experienced employees in the construction sector to improve the quality of the works
- Specialisation modules for the renovation of historic buildings and the installation of renewable energy technologies.

The following studies are investigating these aspects in Austria:

- Publicly available:
  - ✓ Build up Skills/Cross Craft
  - ✓ Temporary energy monitoring and the respective reports in the framework of research projects (www.nachhaltigwirtschaften.at)
- Studies / information not publicly available (some of them in the process of being acquired):
  - ✓ Study Wohnfonds Wien
  - ✓ Several field tests: solar thermal systems, heat pumps
  - ✓ Structural Damage Reports of Federal Guild Building Construction (Bauschadensberichte der Bundesinnung Bau)
  - ✓ Evaluations related with energy-related subsidies (e.g. Energieinstitut Vorarlberg, Energiebewusst Kärnten, AEE INTEC, Danube University Krems)
- Relevant initiatives:
  - ✓ ACT – Austrian platform of practice firms, member of Europen which is a non-profit association that was established in October 1997. It is the worldwide network for practice firms. www.act.at/page.asp?id=641

II.1.3 Compliance frameworks

From a governmental point of view, compliance is regulated by building permit and use permits. The overall procedure of compliance is shortly described in Table 1.

Approval procedures in design and construction phases	
Submission of preliminary design to achieve building permit	The building permit is issued by the local authority based on (preliminary) scheme design documentation and EPC.
Design changes	The building owner, or the site supervisor representing the building owner, is responsible to fulfil legal obligations such as the energy performance minimum requirements and, in the case of significant design or component changes, energy calculations have to be revised, but as there is no control mechanism, this is not followed in practice.
Commissioning	Commissioning includes several measurements, but is only required for the housing subsidy scheme and for voluntary building certification (TQB, klima: aktiv, Passivhaus).
Final design/production information; completion announcement and permit of use	Usually there is no official control mechanism for the final design stage and energy calculations are not required to be repeated (exemption forms the province of Salzburg where a design EPC and a completion EPC are required). The building authority issues the permit of use, based on the completion announcement and connected with a site visit, but in fact there is no inspection. With the permit of use the building may be occupied.
Operation phase	New energy certificate after 10 years is mandatory.

Table 1 Usual procedures in Austria

II.2 Belgium

II.2.1 Reliable input data

Probably, the first major study highlighting critical issues on input data was the SENVIVV study (1995-1998), which highlighted that the reported key indicator on energy efficiency used at that time (the average insulation level) was not at all reliable. More studies have been done since then, e.g. various studies on the performances of ventilation systems. As a result, there is among many stakeholders a strong awareness of potential problems with input data and, as a consequence, a strong support for a pragmatic but effective compliance framework. Since 2006, various legislations have been implemented as part of the transposition of the EPBD, whereby specific attention is given to procedures which should result in more reliable input data. In order to come to a better reliability, different types of actions were needed:

- more attention for very clear technical procedures to come to reliable input data;
- for many product families, a whole set of procedures allowing to come to publicly available data (on a voluntary basis) to be used in the context of this legislation (www.epbd.be);
- a robust compliance framework (see 2.1.3).

II.2.2 Quality of the works

Overall, although more recent than for reliable input data, there is a growing awareness that more attention is needed for the quality of the works in relation to building envelope and energy systems performance. It is translated in more interest for training activities but in a number of cases also for third party quality frameworks, sometimes focusing on competence of workers and in other cases on the quality of the works on the building site.

As it often involves liability issues and potential cost increase, it remains a very sensitive issue which requires a careful approach.

II.2.3 Compliance frameworks

In the governmental context, there is in the 3 regions quite a strong support for a sanctioning framework in case the EPC for new buildings is not complying with the requirements. There is a very transparent fine system, which even is included in the software, allowing all parties to see directly the fine in case of non-complying performance or wrong declarations.

Keeping the societal support for such strict compliance framework required a continuous attention for potential bottlenecks and criticism in the market.

A major change with the new regional legislations (as part of the EPBD transposition) is that the proof has now to be provided after the works, whereas in the past the declaration was submitted at the moment of the building permit. Within this new approach, it is still needed to provide information before the start of the works, but it is allowed to make changes during the works as the binding declaration has to be made within 6 months after ending of the works. This latter declaration should correctly describe what has been realised.

II.3 Cyprus

II.3.1 Reliable input data

After the adoption of the Energy Performance of Buildings Directive more attention has been given in Cyprus to the energy efficiency of buildings. Energy performance is one important key factor for the construction sector and in Cyprus is regulated by the Energy Service of the Ministry of Energy, Commerce, Industry and Tourism.

Energy Performance Certificate

In Cyprus EPCs are issued only by qualified building energy assessors who are registered in a register kept by the Energy Service at the Ministry of Energy, Commerce, Industry and Tourism. Assessors qualifications and duties are defined in the relevant regulations. The “Methodology for Calculating the Energy Efficiency of a Building” and the “Building Insulation Guide (2nd Edition)” determine the method of calculating the energy performance of buildings, which must be followed by all the qualified building energy assessors. Also, the SBEMcy software programme is used for calculating the energy performance of a building and issuing the EPC.

The Regulations for the Energy Performance of Buildings (Energy Certification of Buildings) Regulations 2009 (K.D.P.164/2009) establish the legal framework for the energy certification of buildings and the Competent Authority, which is the Energy Service of the Ministry of Energy, Energy, Commerce, Industry and Tourism, keeps for this purpose the following registers:

- Register of Qualified Energy Assessors
- Register of Energy Performance Certificates

The EPC of a new building or a building unit over 1.000m^2 which undergoes major renovation must be submitted as part of its application for building permit and must be accompanied with recommendations for improving the energy efficiency of that building or building unit. Also when selling or renting a building or a building unit, the owner must present to the prospective buyer or tenant the EPC and then deliver it to him. Similarly, when advertising the building or the building unit, the owner must declare in the advertisement the energy efficiency class of the building or building.

This means that:

- In order to secure a building permit for a new building, you must have issued the Energy Performance Certificate (EPC). The EPC is one of the documents to be submitted to the Building Authorities together with the application for the building permit.
- Existing buildings sold or rented must have EPC which must be available by the owner to the prospective buyer or tenant. In law there is no requirement to obtain EPCs for existing buildings which are not sold or rented.

In order to obtain an EPC for the above requirements, the qualified energy assessor of that building or building unit, after completing the calculations for the issuance of the EPC, must first submit two of the archives that are produced by the SBEMcy together with the archive with his recommendations to the competent authority, which is the Energy Service of the Ministry of Energy, Commerce, Industry and Tourism. The Energy Service then checks and processes the data on the submitted archives. In case the Energy Service does not accept the relevant archives, it informs the qualified energy assessor stating the reasons for not accepting them, so that the energy assessor can address those issues. In case the Energy Service accepts the submitted archives, then it registers the EPC and sends it to the qualified energy assessor who issued it, together with its unique number, in order to be submitted as part of the building application. The whole process of checking and data processing from the Energy Service in general takes 3 to 7 days.

II.3.2 Quality of the works

During the construction phase, responsible for monitoring the project in Cyprus is the supervising engineer engaged by the owner. The supervising engineer has a duty to verify that the building is built in accordance with the plans and specifications and also has a duty to verify the good quality of the construction. On governmental view, there is a procedure to check whether the building is constructed in accordance with the approved plans for building permission, but there is no procedure to control energy performance issues related to the quality of the works. However, in November 2011 in the framework of the IEE Build up Skills' initiative, the Project Build Up Skills Cyprus started. The 'Build up Skills' initiative aims to improve the workforce in the construction sector and other related sectors so that the workforce is able to successfully fulfil the requirements arising through the directives and regulations for Nearly Zero -Energy Buildings.

II.3.3 Compliance frameworks

Design phase

The decree from the Minister of Energy, Commerce, Industry and Tourism, which sets the minimum requirements of the energy performance of a building, came into effect for the first time on 21 December 2007. According to the decree, the U-values for the shell and frames in all new buildings and all buildings over 1.000 m^2 that undergo major renovation must not exceed specific U-values, making building insulation essentially mandatory. An important revision of the decree came into effect on 1 January 2010, so as to include the requirements for compliance with the maximum average U-value, for taking the necessary steps regarding providence for systems producing electricity from renewable sources, for the installation of solar panels for producing hot water in residential buildings, and for issuing Energy Performance Certificates with a minimum building's energy efficiency category B. A further important revision of the decree came into effect on 11 December 2013, with the issuance of two new decrees which revised the minimum U-values for the shell and frames of the aforementioned buildings, as well as the appearance and content of the EPC, and the document regarding the qualified energy assessor's recommendations for improving the energy performance of a building.

The EPC is valid for ten years, but it is revised in case of any change in the building that substantially affects its energy efficiency. It must not be altered and it may be cancelled if the competent authority considers it appropriate.

Construction phase

As already mentioned, except from the supervising engineer employed by the owner who has a duty to verify that the building is built in accordance with the plans and specifications and the good quality of the construction, on governmental view there is a procedure to check whether the building is constructed in accordance with the approved plans for building permission, but there is no procedure to control energy performance issues related to the quality of the works. No Energy Audits take place during the construction phase regarding the EPC and the real construction of the building.

II.4 Estonia

II.4.1 Reliable input data

After the adoption of the Energy Performance of Buildings Directive more attention has been paid for the energy us of buildings. . Today the situation has changed and energy performance is a key factor for the construction sector. Energy performance is regulated under the Ministry of Economic Affairs and Communications act no. 63 , "Minimum requirements for energy performance". The Act includes requirements for the energy calculation procedure which need specific reliable input data (Figure 1, Figure 2) that further influence the buildings energy use.

II.4.2 Quality of the works

According to the building regulation, it is possible to inspect construction quality and safety without imposing too burdensome obligations on construction companies. Construction surveillance and issue of building permits and authorisation for the use of buildings are the functions of local governments that will enter the relevant data into the state register of construction works, being also responsible for the authenticity of such data.

As construction is a sector characterised by special requirements, a contract with a specialist and a notice of economic activity to the state register of economic activities will be required to acquire the right to operate in this sector. The state register of economic activities is managed by the Ministry of Economic Affairs and Communications, but in the field of construction the register is kept by the Technical Regulatory Authority.

www.mkm.ee/en/objectives-activities/construction-and-housing-sector/construction

Presentation of input parameters of the energy calculation

Input parameters of the energy calculation

Number of calculation zones	
Type of heating system	
-production of heat and fuel	
-distribution of heat	
Type of ventilation system	
Cooling system (installed/not installed)	

Heat losses through envelope elements					Heat losses through thermal bridges				Heat losses through air leaks	
Envelope element	g -	U_i W/(m² K)	A_i m²	$H_{juhtivu}$ W/K	Thermal bridge	Ψ_i W(m K)	l_i m	$H_{külmasild}$ W/K	Characteristic	Value
Exterior wall 1		0.00	1.0	0.0	Exterior wall-exterior wall	0.00	0.0	0.0	Air leakage q_{50}	0.0
Exterior wall 2		0.00	0.0	0.0	Exterior wall-exterior wall	0.00	0.0	0.0	m³/(h*m²) A_{vp}(envelope), m²	
Warm roof		0.00	0.0	0.0	Warm roof-exterior wall	0.00	0.0	0.0	Number of storeys (integer value)	0.0
Inserted ceiling below attic		0.00	0.0	0.0	Inserted ceiling below attic-exterior wall	0.00	0.0	0.0	V_{inf}, m³/s	0.0000
Floor on ground		0.00	0.0	0.0	Floor on soil -exterior wall	0.00	0.0	0.0		
Floor above aired space		0.00	0.0	0.0	Floor above aired space-exterior wall	0.00	0.0	0.0		
Entry door		0.00	0.0	0.0	Window to wall fixing	0.00	0.0	0.0		
Window (e.g., facing south	0.00	0.00	0.0	0.0	Door to wall fixing	0.00	0.0	0.0		
Window (e.g., facing west)	0.00	0.00	0.0	0.0	Interior wall-exterior wall					
Window (e.g., facing east)	0.00	0.00	0.0	0.0	...					
Window (e.g., facing north)	0.00	0.00	0.0	0.0	...					
...		0.00	0.0	0.0	...					
...		0.00	0.0	0.0	...					
Total:	$H_{juhtivus}$,W/K			0.0	$H_{külmasild}$,W/K			0.0	$H_{õhuleke}$,W/K	0.0

Aggregate specific heat loss of the building envelope	∑H, W,K	0.0
Average thermal transmittance of the building envelope	∑H, A_{vp}	0.0
Heated area of the building	$A_{köetav}$, m²	1.0
Aggregate specific heat loss of the building envelope per square meter of heated area	∑H, $A_{köetav}$, W/(m² K)	**0.00**

Figure 1 Table to present input parameters of energy calculations in Estonia, part 1.

Ventilation system	Pressure rise supply/extract	Fan efficiency supply/extract	Air flow rate supply/extract	System SFP	Temperature ratio of heat recovery	Minimum temperature of exhaust air[1]
	Pa / Pa	% / %	m^3/s / m^3/s	kW/(m^3/s)	%	℃
1 (e.g., ventilation unit 1) 2 (e.g. exhaust fan 1)	/	/	/			

[1]avoiding frost growth on the heat exchanger

Heating system	Efficiency of the heat source -	Efficiency of distribution and emission -	Average coefficient of performance for the heating period[2], -	Electricity consumption of auxiliary devices[3] kWh&(m^2 a)
1 (e.g., heating of rooms) 2 (e.g., ventilation unit) 3 (e.g., hot household water) ...				

[2] to be given in the case of a heat pump system
[3] not given when included as part of a heat pump system

Cooling system	Average cooling season energy efficiency ratio
1 (e.g., central) 2 (e.g., SPLIT) ...	

Local renewable energy systems	Active area of solar collector	Maximum capacity of solar panels	Nominal capacity of wind turbine
	m^2	kW	kW

Internal heat gains	People	Appliances	Lighting	Usage ratio	Use days per week	Use hours per day
	W/m^2	W/m^2	W/m^2	%	d	h

Date	Name	Signature

Figure 2 Table to present input parameters of energy calculations in Estonia, part 2.

The calculated energy use is presented in Figure 3.

Presentation of the results of the energy calculation

Information regarding the building

Address			☐ New building
Year of completion of construction			☐ Major renovation
Heated area		m^2	☐ Renovation
Net area		m^2	☐ Existing building
Energy performance indicator		**kWh/(m^2 a)** (kWh per square meter of heated area)	

Summary of energy use	Purchased fuels amoun t/y	Purchased fuels unit of mass or volume	Delivered energy kWh/y	Delivered energy kWh/(a m^2)	Exported energy kWh/y	Exported energy kWh/(a m^2)	Energy carrier conversion factor -	Weighted energy consumption kWh/(a m^2)
Electricity	-		-				2	
District heating								
Fuel 1								
Fuel 2								
...								
Total	-		-				-	

Total energy use	Electricity kWh/y	Heat kWh/y	Electricity kWh/(a m^2)	Heat kWh/(a m^2)
Heating system	-	-	-	-
Space heating				
Heating of ventilation air				
Heating of household water				
Ventilation system[1]		-		-
Cooling system				
Lighting		-		-
Appliances		-		-
Total (energy use of building technical systems)				

[1] the heating of ventilation air is regarded as part of the heating system

Local renewable and exported energy	Local renewable kWh/y	Local renewable kWh/(a m^2)	Exported kWh/y	Exported kWh/(a m^2)
Heat from solar energy				
Electricity from solar energy				

Net energy need	kWh/y	kWh/(a m^2)
Space heating [2]		
Heating of ventilation air[3]		
Heating of household water		
Cooling		

Figure 3 Table to present results of the energy calculations in Estonia

II.4.3 Compliance frameworks

Approval procedures in design and construction phases are described in Table 2.

Scheme (preliminary) design/ building permit	The building permit is issued by the local authority based on scheme design documentation. This includes energy calculations to show compliance with the minimum energy performance requirements. Based on the energy calculations the EPC is prepared.
Final design/production information	There is no official control mechanism for the final design stage; energy calculations are not required to be repeated. The building owner is responsible to comply with the minimum energy performance requirements and usually a third party assessment of the design package is conducted.
Design changes	The building owner is responsible to fulfil the minimum energy performance requirements and in the case of significant design or component changes, energy calculations have to be revised, but as there is no control mechanism, this is not followed in practice.
Commissioning	Commissioning includes several measurements like measuring ductwork leakage, building leakage rate (not mandatory), balancing of ventilation, heating and cooling systems, ventilation noise measurement. The measurement protocols will be issued.
Building handover	The local authority will make a site visit before issuing the usage permit.
Operation phase	New energy certificate after 10 years is mandatory.

Table 2 Approval procedures in design and construction phases in Estonia

II.5 France

II.5.1 Reliable input data

The calculation procedure (RT 2012) gives a penalty to the products or equipment that do not offer certified performance data.

Therefore, a number of certification schemes by independent certification bodies have been implemented for products, as well as tools to define EPC input data for innovative products (see Figure 4, Figure 5 and Figure 6). They provide reliable data, often measured by an independent accredited laboratory.

In addition, databases with the certified products data have been made available, either by the certification bodies or by professional associations. These databases are often linked to or integrated into the calculation software.

Manufacturers also announce in their documentation the input data needed for the energy performance calculation. In some cases, they have also defined on a voluntary basis a common format to announce those data.

II.5.2 Quality of the works

Several certifications of equipment installers/contractors have been implemented (QUALIBAT, Qualit'EnR, QUALIFELEC, ECO Artisan, Les Pros de la Performance Energétique) to secure the quality of the works. They generally cover quality requirements for the company and for the individual persons that operate the works. They may rely on dedicated training and requirements about the organisation and the working tools/equipment that have to be used by the company.

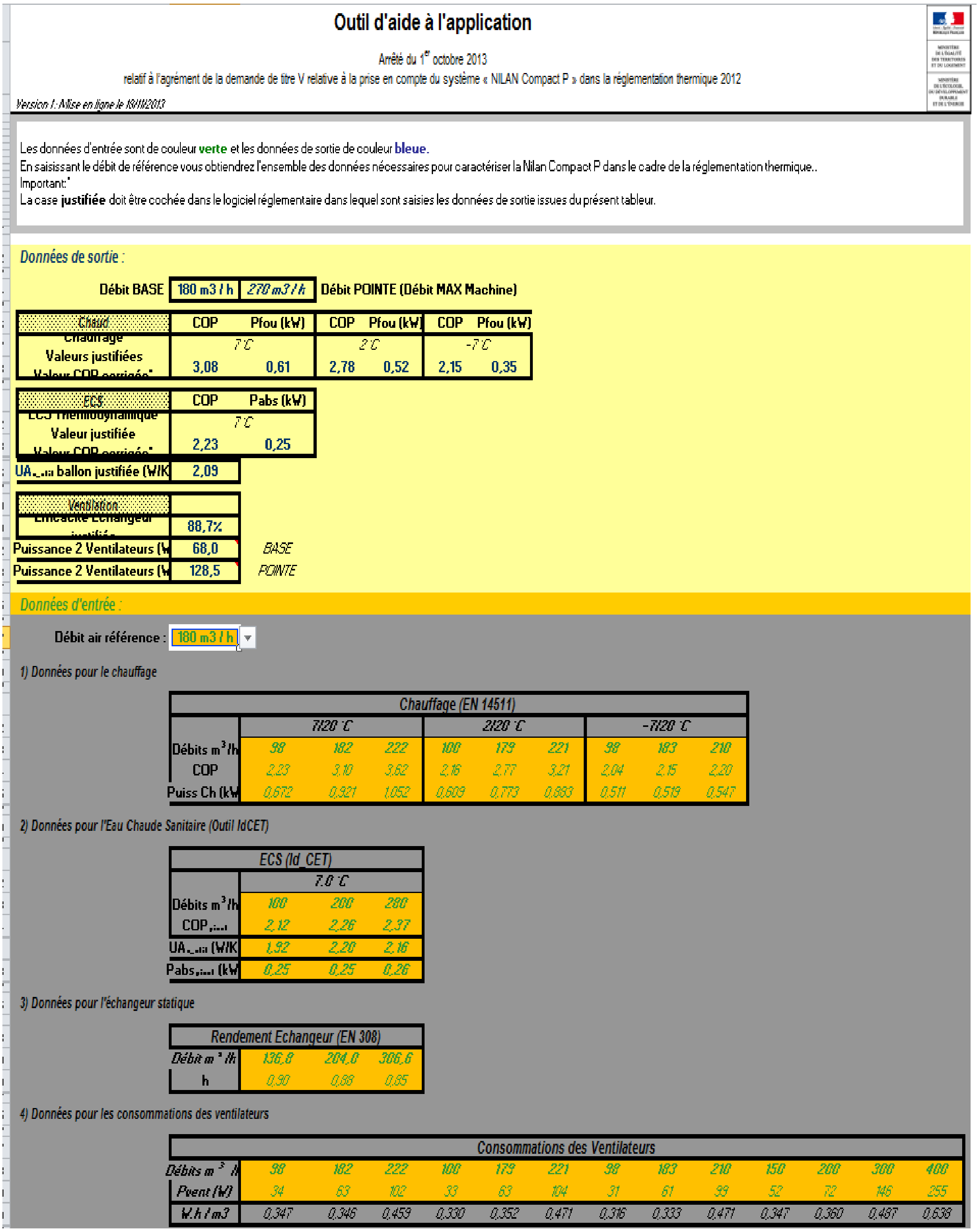
These certifications are voluntary, but they are required in order for the building owner to benefit from public funding or subsidies.

Building companies may also use a certification to improve and demonstrate the quality of their work: NF Maison individuelle (for new single-family houses), NF Maison rénovée (for renovated single-family houses), NF Logement (for multi-family buildings), NF HQE for the energy and environmental impact of new and renovated buildings.

Documents defining the good professional rules are also available: DTUs (Documents Techniques Unifiés), professional rules form the programme "Règles de l'Art Grenelle Environnement 2012 (RAGE 2012)", documents for innovative products (Avis Techniques, Cahiers des Prescriptions Techniques).

Nevertheless, a number of quality issues on the ground still exist. Several surveys have been operated and published to identify them, showing the most frequent weak points, e.g.

- ✓ www.buildupskills.eu/sites/default/files/Livrable_BUS_Francais_fren_1.pdf;
- ✓ www.buildupskills.eu/sites/default/files/Livrable_BUS_Francais_fren_2.pdf;
- ✓ www.buildupskills.eu/sites/default/files/Livrable_BUS_Francais_fren_3.pdf;
- ✓ www.buildupskills.eu/sites/default/files/BUS%20FRANCE_Roadmap%20ENDORSED%20VERSION%20-%2026Nov.pdf.



Outil d'aide à l'application

Arrêté du 1er octobre 2013

relatif à l'agrément de la demande de titre V relative à la prise en compte du système « NILAN Compact P » dans la réglementation thermique 2012

Version 1 : Mise en ligne le 18/11/2013

Les données d'entrée sont de couleur **verte** et les données de sortie de couleur **bleue**.
En saisissant le débit de référence vous obtiendrez l'ensemble des données nécessaires pour caractériser la Nilan Compact P dans le cadre de la réglementation thermique..
Important:*
La case **justifiée** doit être cochée dans le logiciel réglementaire dans lequel sont saisies les données de sortie issues du présent tableur.

Données de sortie :

Débit BASE | 180 m3 / h | *270 m3 / h* | Débit POINTE (Débit MAX Machine)

Chaud	COP	Pfou (kW)	COP	Pfou (kW)	COP	Pfou (kW)
Chauffage Valeurs justifiées Valeur COP corrigée*	7°C		2°C		-7°C	
	3,08	0,61	2,78	0,52	2,15	0,35

ECS	COP	Pabs (kW)
ECS Thermodynamique Valeur justifiée Valeur COP corrigée*	7°C	
	2,23	0,25
UA ballon justifiée (W/K	2,09	

Ventilation		
Efficacité Echangeur justifiée	88,7%	
Puissance 2 Ventilateurs (W	68,0	*BASE*
Puissance 2 Ventilateurs (W	128,5	*POINTE*

Données d'entrée :

Débit air référence : 180 m3 / h

1) Données pour le chauffage

Chauffage (EN 14511)									
	7/20 °C			2/20 °C			-7/20 °C		
Débits m³/h	98	182	222	100	179	221	98	183	210
COP	2,23	3,10	3,62	2,16	2,77	3,21	2,04	2,15	2,20
Puiss Ch (kW	0,672	0,921	1,052	0,609	0,773	0,883	0,511	0,519	0,547

2) Données pour l'Eau Chaude Sanitaire (Outil IdCET)

ECS (Id_CET)			
	7.0 °C		
Débits m³/h	100	200	280
COP	2,12	2,26	2,37
UA (W/K	1,92	2,20	2,16
Pabs (kW	0,25	0,25	0,26

3) Données pour l'échangeur statique

Rendement Echangeur (EN 308)			
Débit m³/h	136,8	204,0	306,6
h	0,90	0,88	0,85

4) Données pour les consommations des ventilateurs

Consommations des Ventilateurs													
Débits m³/h	98	182	222	100	179	221	98	183	210	150	200	300	400
Pvent (W)	34	63	102	33	63	104	31	61	99	52	72	146	255
W.h / m3	0,347	0,346	0,459	0,330	0,352	0,471	0,316	0,333	0,471	0,347	0,360	0,487	0,638

Figure 4. Input data for Compact P-Nilan within the contexte of the French thermal regulation RT2012.

Outil de conversion des résultats d'essais de performance énergétique en mode chauffage selon la norme EN 13141-7 pour utilisation dans le moteur de calcul règlementaire

Utilisation dans le cadre de l'arrêté du 17 décembre 2013

relatif à l'agrément de la demande de titre V relative à la prise en compte des systèmes de ventilation double-flux thermodynamique dans la réglementation thermique 2012

MINISTÈRE DE L'ÉGALITÉ DES TERRITOIRES ET DU LOGEMENT

MINISTÈRE DE L'ÉCOLOGIE, DU DÉVELOPPEMENT DURABLE ET DE L'ÉNERGIE

Version 1 : Mise en ligne le 05/02/2014

Rappel: le présent outil de conversion n'est à utilisé que dans le cas où les essais selon la norme EN 13141-7 porte sur l'ensemble récupérateur statique - pompe à chaleur air extrait/air neuf et/ou le cas où le système fait appel à du recyclage d'air intérieur ou extérieur.

Résultats d'essais à définir par l'utilisateur

Conditions et résultats d'essais selon la norme 13141-7 en mode chauffage

Référence du système (informatif) [ ]

Type de mode chauffage

id_mode Pas de recyclage d'air int./ext.

Statuts des résultats d'essai

id_statut Certifiés

Essais en ventilation seule

qsou (m3/h) [ ] Débit volumique soufflé en ventilation seule

qrep (m3/h) [ ] Débit volumique repris en ventilation seule

Essai en mode chauffage sans recyclage d'air

qsou_modeCH/FR (m3/h) [ ] Débit volumique repris sans recyclage

qrep_modeCH/FR (m3/h) [ ] Débit volumique soufflé sans recyclage

Efficacité d'échangeur disponible (id_source) ? Pour le mode chauffage

εmodeCH (-) [ ] Efficacité de l'échangeur mesurée en mode chauffage

Essai en mode chauffage par recyclage d'air intérieur/extérieur

qrecyclé_CH/FR,int (m3/h) [ ] Débit volumique de recyclage côté air soufflé

qrecyclé_CH/FR,extr (m3/h) [ ] Débit volumique de recyclage côté air extrait

ε(-) [ ] Efficacité de l'échangeur mesurée

Puissance de ventilateurs en mode chauffage

Pvent_sou (W)		Puissance absorbée par le ventilateur de soufflage en mode chauffage pour vaincre les pertes de charge extérieures à la
Pvent_rep (W)		Puissance absorbée par le ventilateur de reprise en mode chauffage pour vaincre les pertes de charge extérieures à la centrale (puissance saisie dans l'extension dynamique

Limites d'utilisation (si indiquée par le fabricant)

θan min (°C)		Température d'air neuf (air extérieur) la plus basse à laquelle

COP mesurée

-

			θair repris(°C)
			20
		Priorité	1
θair neuf(°	**-7**	Option	
	2	Option	
	7	Obl.	

Pabs mesurée

kW

			θair repris(°C)
			20
		Priorité	1
θair neuf(°	**-7**	Option	
	2	Option	
	7	Obl.	

Matrice de performances à pleine charge à saisir dans le générateur thermodynamique de type "2) air extérieur/air recyclé" utilisé

Note: lorsque les résultats d'essais sont déclarés par le fabricant, seule la valeur pivot peut être définie dans la méthode Th-BCE

/!\: Le présent outil n'est pas nécessaire en l'absence d'échangeur ou de débits de recyclage de part et d'autre de de la pompe à chaleur.

COP

-

			Températures amont principales (°C)				
			-15,0	**-7,0**	**2,0**	**7,0**	**20,0**
		Priorité	5	2	3	1	4
Températures aval principales	**5,0**	5					
	10,0	4					
	15,0	2					
	20,0	1					
	25,0	3					

Pabs

kW

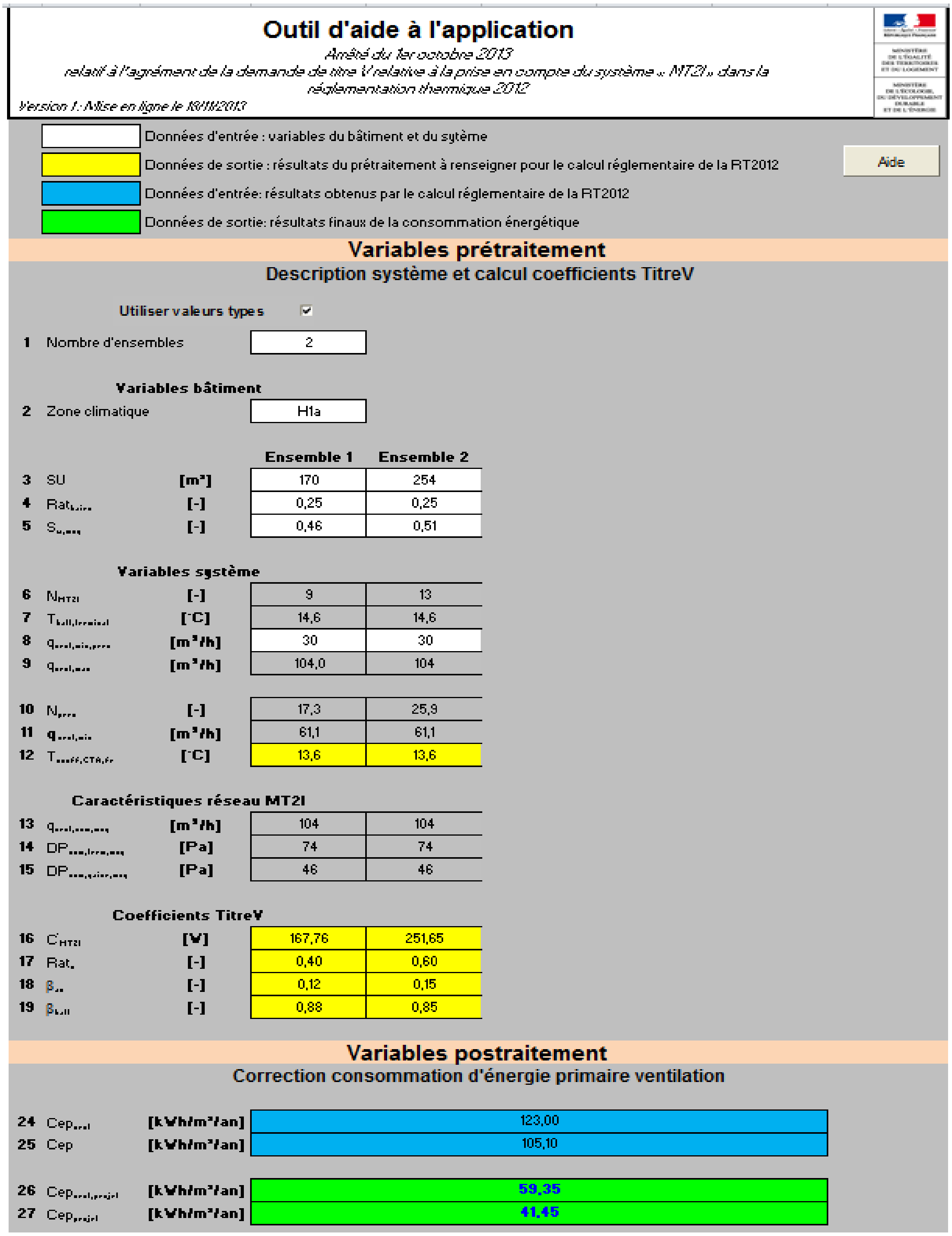
			Températures amont principales (°C)				
			-15,0	**-7,0**	**2,0**	**7,0**	**20,0**
		Priorité	5	2	3	1	4
Températures aval	**5,0**	5					
	10,0	4					
	15,0	2					
	20,0	1					
	25,0	3					

Limites d'utilisation (si renseignées dans les paramètres d'entrée)

Température minimale amont (air extrait) en dessous de laquelle la machine ne peut plus fonctionner

θmin_am	

Figure 5. Input data for dual flow thermodynamic CMV within the context of the French thermal regulation RT2012.



Outil d'aide à l'application

Arrêté du 1er octobre 2013
relatif à l'agrément de la demande de titre V relative à la prise en compte du système « MT2I » dans la réglementation thermique 2012

Version 1 : Mise en ligne le 18/11/2013

(blanc)	Données d'entrée : variables du bâtiment et du sytème
(jaune)	Données de sortie : résultats du prétraitement à renseigner pour le calcul réglementaire de la RT2012
(bleu)	Données d'entrée: résultats obtenus par le calcul réglementaire de la RT2012
(vert)	Données de sortie: résultats finaux de la consommation énergétique

Aide

Variables prétraitement

Description système et calcul coefficients TitreV

Utiliser valeurs types ☑

1	Nombre d'ensembles		2	
	Variables bâtiment			
2	Zone climatique		H1a	
			Ensemble 1	**Ensemble 2**
3	SU	[m²]	170	254
4	Rat	[-]	0,25	0,25
5	S	[-]	0,46	0,51
	Variables système			
6	N_{HT2I}	[-]	9	13
7	T	[°C]	14,6	14,6
8	q	[m³/h]	30	30
9	q	[m³/h]	104,0	104
10	N	[-]	17,3	25,9
11	q	[m³/h]	61,1	61,1
12	$T_{...,CTA,...}$	[°C]	13,6	13,6
	Caractéristiques réseau MT2I			
13	q	[m³/h]	104	104
14	DP	[Pa]	74	74
15	DP	[Pa]	46	46
	Coefficients TitreV			
16	C'_{HT2I}	[W]	167,76	251,65
17	Rat	[-]	0,40	0,60
18	β	[-]	0,12	0,15
19	β	[-]	0,88	0,85

Variables postraitement

Correction consommation d'énergie primaire ventilation

24	Cep	[kWh/m²/an]	123,00
25	Cep	[kWh/m²/an]	105,10
26	Cep	[kWh/m²/an]	59,35
27	Cep	[kWh/m²/an]	41,45

Figure 6. Input data for MT2I system within the context of the French thermal regulation RT2012.

II.5.3 Compliance frameworks

The compliance framework relies on two declarations:

- One is part of the building permit request transmitted to the municipality. It shows the results of the energy performance calculation and attests that the project fulfils the requirements of the regulation.
- The other is part of the declaration that has to be given to the municipality at the end of the construction. It shows some measured values on the finished building (e.g. building envelope air tightness) and certifies that the building has been erected so that it complies with the energy performance regulation, providing the value that has to be used for the energy performance certificate.

The approach to regulatory compliance checks is based on a three-level control. The aim of controls level I is to assess the completeness and conformity of the certificate in consideration of the RT 2012 at the time of the building permit application, or at the end of the construction. In case of inconsistencies, the inspector may decide to establish a control level II, which consists in checking the design, based on plans, specifications, thermal studies to verify proper sizing of installations, performance of products, materials and equipment. The control level III is a complete investigation of compliance with building regulations through site visits.

Compliance checks are operated by governmental bodies on a statistical basis, mainly for dwellings, public and commercial buildings (very few for single-family houses).

II.6 Greece

II.6.1 Reliable input data

The Greek law for the Energy Performance of Buildings (No 4122/2013) harmonises building regulations with the European Directive 2010/31/EC. According to this, the major building works, either new or refurbishments, should meet minimum performance requirements. These requirements are described in the Regulation for the Energy Performance of Buildings (KENAK).

More specifically, the basic process of the Energy Audit is the on-site visit by the inspector and the inspection of the building for recording and cross-referencing as allocated by the owner / manager.

During the energy audit, standard Building Energy Audit forms are filled in, as set in the Directive of Technical Chamber T.O.T.E.E. 20701-4 / 2010, including all the data required for the calculation of the building's energy performance, along with other technical specifications of the building and its electromechanical facilities, which are recorded for statistical purposes and further elaboration by the Hellenic Energy Inspectorate (H.E.I.). The T.O.T.E.E. 20701-4 / 2010, apart from the standard forms for building energy audits, also includes instructions for compiling and verifying the necessary data. Part of the data recorded in the energy audit forms is taken from all the information gathered during the preparation of the inspection.

In the T.O.T.E.E. 20701-1 / 2010 guidelines and explanations are given on the data collection process, relevant data and parameters according to the technical characteristics of the building under consideration, which should be recorded and used to calculate the building energy efficiency. Also, the specific T.O.T.E.E. contains assumptions and alternative values to be used in case there is not enough available data or parameters.

The data from the above mentioned inspection energy forms is entered into the software, which is used for the energy audit of the building. After entering these data, the necessary calculations for both the energy classification of the building and the issue of the Energy Performance Certificate of the building are performed. In case of large surface buildings with complex electromechanical installations beyond the simple recording of data, appropriate equipment for measurement and verification of various parameters that contribute to the accurate representation of buildings and operating conditions may be used.

The measuring equipment may be used for defining the building's geometric characteristics (height, size of openings, brackets, etc.), the quality control of the manufacture of building materials (thermal insulation, surface temperature, etc.), the energy use of the electromechanical systems (for heating, cooling & ventilation, hot water, lighting, etc.), the intensity and voltage, the absorbed electrical or thermal power, the power factor and the quality of the electrical power (harmonics, voltage etc), the lighting levels and the absorbed power of the lighting systems and indoor environmental factors (temperature, humidity, air circulation, etc.).

In addition to recording data on the energy audit form, the inspector should be informed about the scheduled maintenance and identify the necessary energy upgrade interventions which are planned to be applied in the building. The inspector should also be informed by the building manager about the building problems during its operation, and the complaints from the users, if any.

The inspector identifies and confirms the need to upgrade the building and/or maintenance during the inspection. The inspector according to the problems of the building, decides in which sectors is important to intervene (right building maintenance or energy upgrade)

The overall evaluation of the building helps to prioritise the necessary actions for the improvement of the energy performance.

After completing the energy audit and identifying the actual situation of the building, the inspector needs to access the potential interventions that will reduce the required energy consumption and therefore the CO_2 pollutant releases. The inspector, using the proper software, will assess the current energy situation of the building and make the necessary evaluation by applying different scenarios (interventions) for energy upgrade, according to the available technology (energy efficiency study).

Among the results of the selected energy upgrading interventions that can be applied the energy and cost efficient technologies can be found, as well as those that have high energy savings, but a high cost of implementation and can be implemented using available financial tools to become economically attractive.

Apart from the energy rating of buildings with respect to new and radically renovated buildings during the inspection, particularly during the calculations, the inspector should verify that the building meets the minimum requirements as set out in Article 8 of K.EN.A.K.

The issue of the Energy Performance Certificate is the final stage of the energy audit.

According to K.EN.A.K the issue of Energy Performance Certificate is mandatory for all new or radically renovated buildings and for the existing buildings in case of purchase or lease. The final form of the EPC, is given in T.O.T.E.E 20701-4 / 2010, where also editorial guidelines for the inspector are presented.

The EPC is issued after the introduction by the inspector of the file data and the results and after final submission to the Energy Inspectorate (H.E.I.). It then returns electronically (in PDF format) to the inspector, who is obliged to provide a signed and stamped copy to the property owner. The EPC is valid for ten years. However, if a major renovation of the building occurs before the end of the decade; even though the renovation work ends on the expiry of the certificate, the certificate must be reissued.

During the inspection for the issue of the EPC, must be checked whether the building during its construction or renovation met the standards-provisions of the initial energy efficiency study. In case of non-compliance with the study, the current owner / manager of the building must comply within one (1) year from the issue of the EPC, applying measures to improve the energy performance of the building in accordance with the recommendations of the Energy Inspector, referred to in the EPC.

In consistency with the above, before and after construction, there are procedures for recording the energy situation of the building which are included in the energy performance certificate
Within this context, the Ministry of the Environment, Energy and Climate Change (YPEKA), having completed the legal framework on buildings' energy efficiency, has developed a set of financial incentives, with co-financing from the European Union, for the implementation of energy efficiency upgrading interventions in residential buildings, via the "Energy Efficiency at Household Buildings" Program.

The "Energy Efficiency at Household Buildings" Program

- Energy Inspection prior to submitting an application for inclusion in the Energy Efficiency at Household Buildings programme and prepare a proposal for energy upgrade of residence.

The auditor shall, at the invitation of the person concerned, conduct an energy audit to the residence and issue the corresponding Energy Performance Certificate (EPC), which includes Energy upgrade proposals.

Under the proposals of the EPC, the person of interest and the auditor shall jointly select the proposal which will be included in the application form and record detailed related interventions. The proposed interventions should meet specific requirements i.e.:

- ✓ Lead, based on the estimated energy savings, the residence, to at least one energy category higher.
- ✓ The interventions to the construction components and sub-electromechanical systems must meet the minimum requirements as set out in paragraphs 2 and 3 of Article 8 of K.EN.A.K. in agreement with the provisions of the relevant Technical Instructions (T.O.TEE). Excluding the requirement for maximum average U value (Um).

In addition, building materials and electromechanical systems, for which there is an obligation by the legislation, should be CE marked.

Also, the inspector should indicate the specifications and technical and energy performance of building materials and electromechanical systems, all needed to calculate the energy effect and to control the fulfilment of the Programme requirements. The inspector classifies the house to an energy class, the class that would theoretically occur after the implementation of the interventions, and calculates the amount of saved primary energy In addition to the above form, the auditor shall record data on satisfaction of the eligibility criteria of the programme. Especially in the case of a proposed replacement of boiler with a new technology, the satisfaction of the eligibility criteria will be judged based on adequately documented components, along with documentation of the need for change (e.g. boiler suffered irreparable damage) against chemical cleaning or maintenance of the existing one. Advanced documentation will also be required for the proposed internal insulation.

The correct implementation of the above by the inspector is important for the eligibility of the application form, taking into account the fact that the issue of the EPC recommends starting work.

- ➢ Energy Audit after the implementation of the interventions to determine the achievement of the energy objectives set by the first inspection, and recording of implemented interventions that satisfy the requirements of K.EN.A.K.

After the implementation of interventions for the issue of the 2nd Energy Performance Certificate.

Following the implementation of the interventions the beneficiary of the Programme calls for an inspector for the conduction of the new (second) energy audit. The inspector carries out the inspection of the house and issues the corresponding EPC.

With data from the 2nd EPC, the achievement of the energy targets of the project is confirmed based on the relevant decision of upgrading the residence by an energy efficiency class and achieving an energy saving of more than 80% in comparison to the initial EPC calculations.

As part of this inspection, the auditor shall record on the Interventions Record Form the implementation of the interventions carried out and the compliance with the requirements of the programme, their costs and the quantities of materials or systems as indicated in the documents of expenditure, which are submitted by the beneficiary (inventory of the physical and economic object).The corresponding certificates of materials and systems used for the interventions have to be tested by the inspector so as to certify their compatibility with the requirements of K.EN.A.K. and the Programme.

The Ministry of Regional Development and Competitiveness - General Secretariat of Industry as Beneficiary of the Programme shall arrange for sampling control for the proper implementation of the physical and financial progress of the Programme. In this context, the Beneficiary shall develop a methodology for making the necessary sample controls and based on this, cooperates with the Energy Inspectorate (H.E.I.), which, within its competence, checks for verification of the proper implementation of the energy inspections related to the works for the Programme Beneficiaries. The realisation of checks becomes the basis of a relevant cooperation agreement between the two parties.

Validity Controls

In the period until the issuance of the entry decision, the H.E.I. realises systemic checks of the procedures for the issuance of an EPC and makes spot checks, when needed.

To be more clear, the control and monitoring of the process and the quality of the energy audits, the issuance of the energy certificate, the correctness of issued Energy Performance Certificates and the inspection reports for boilers, thermal installations, or air conditioning installations and buildings, the reliable execution of tasks of the Energy Inspectors and the compliance and implementation of the provisions of Law. 3661/2008, as applicable, and the delegated regulations, are carried out by H.E.I.

If, after examination, the Energy Inspector is found to:

a. enter incorrect data or other energy class on the Energy Performance Certificates and / or on the boiler and heating systems and / or air conditioning reports;
b. submit false information and documents;
c. violate the duty of secrecy and confidentiality , the publication of data and information obtained during the performance of his work,
d. use his License inappropriately;
e. fail to fulfil the scientific and professional duties and contractual obligations;
f. violate any other obligation by the provisions of law. 3661/200811, taking as criteria, the importance of the offense, the consequences arising from it, the surface of the certified building etc. Depending on the degree of the offense, the penalties that may be imposed on the energy auditor are the following:
    i. payment of a fine from five hundreds (500) to twenty thousand (20.000) euros
    ii. exclusion of the Energy Inspector from the energy audits for a period of one (1) to three (3) years and
    iii. permanent deletion of the Energy Inspector from the Register of Energy Inspectors.

The fine may be imposed as additional penalty, on top of the penalties of cases (ii) and (iii).

The controls are random or following complaints submitted to H.E.I. on the quality of the carried out energy audits and / or the reliability and accuracy of issued Energy Performance certificates, or upon evidence arising from the control and treatment File Inspection Building, or by order of the Ministry of Environment, Energy and Climate Change (YPEKA).

The energy inspectors carry out controls in order to assure whether the objectives of the preceding paragraph have been met. This verification is occurred in any public or private building, with spot autopsies, tests and measurements and collection of all the necessary dataAfter each check, carried out by the group of Inspectors that conducted the audit, an inspection report is written. In case of any deviation from the results listed in the already issued Building Energy Performance Certificate and / or the inspection report of the boiler and / or installation of heating system and / or installation of air-conditioning, the relative Audit Report is given to the Energy Inspector under investigation via registered call, who is called to a hearing within five (5) days after the submission of the notice to him, in order for him to submit his explanations (orally or in writing) and to provide evidence to document the correctness of the inspection he conducted.

References:

1. Building Energy Inspection, Ministry of Environment, Energy and Climate Change, Athens, January 2011, Version 1.0
2. Government Gazette 132, 5 August 2010
3. Government Gazette 177, 6 October 2010

II.6.2 Quality of the works

During the construction phase, with regard to the Greek reality, responsible for monitoring the project is the supervising engineer engaged by the owner. The supervising engineer has as duty to verify the work so as to anticipated energy requirements as well as the high quality of work. The owner may also control the construction procedures, but usually the lack of knowledge limits his effect. On governmental view, there is no procedure to control energy performance related to the quality of the works.

II.6.3 Compliance frameworks

KENAK provides the incorporation of an integrated energy design of buildings to improve their energy efficiency, energy saving and environmental protection, with specific actions related mainly to:

Design phase: Consultancy Energy Performance of Buildings.

Every building must:

- ✓ meet all minimum requirements;
- ✓ either have a total primary energy consumption less than or equal to the total primary energy consumption of the reference building, or comply with the requirements of the reference building in their entirety

Design and construction phase: Ranking Energy Buildings (Energy Performance Certificate).

The EPC is a document recognised by the ministry, issued by an Energy Inspector (who is admitted into a special registry) and which shows the energy performance of the building. With the EPC, each building is classified in energy efficiency class (there are nine categories, from A + to H), while the Inspector records his recommendations for improving the energy efficiency of the building.

It means that ιn order to secure a building permit for a new building, you must have issued the Energy Performance Certificate (EPC). The EPC is one of the documents to be submitted to the Building Authorities together with the application for building permit.

For any building, the EPC, has a duration of 10 years, provided that no intermediate newest EPC replaces the issued one. In case of a meaningful change occurs in a building that affects it's energy performance, such as change in heating and / or cooling or fuel type used, the EPC becomes invalid and a new EPC should be issued.

Construction phase: Preservation Energy Audits, boilers and heating and air-conditioning.

If the energy audit for the second edition of the certificate proves that the objectives of the first edition have not been fulfilled, appropriate adjustments are required in order to succeed. In case of non-compliance the building never gets the building permit.

II.7 Romania

II.7.1 Reliable input data

Romania has transposed the EPBD by adopting the Law 372/2005 on Energy Performance of Buildings, which was amended in 2013, in order to be in compliance with the recast EPBD. The general framework for EPC and inspection reports verification and sanctions/penalties for non-compliance were introduced. The main responsible body for EPC compliance control is the State Inspectorate in Constructions (SIC). In the effective implementation process this needs to be detailed further by adequate procedures and appointment of relevant independent experts for the actual checks (technical content).

Every energy auditor has to keep a register with all EPCs issued, mentioning the date, the beneficiary, the certified objective address etc. The Romanian law stipulates that the energy auditor is the only responsible for the compliance with requirements of the certification and for the correctness of the energy audit.

The building code requirements for newly constructed buildings concern providing thermal performance indicators, both at component level and at the level of the whole heated space. The building code (C107) contains prescriptive element-based criteria for thermal insulation, as well as a global heat transfer coefficient of the heated volume, G-value (W/m^3K), as an overall minimum requirement, depending on the number of the building floors and the external area per volume ratio (A/V).

There is no minimum energy performance requirement in terms of global indicator, neither for new buildings nor for renovations, except for residential buildings, where there is a maximum allowed heat demand (per total heated volume) that varies from 15 kWh/m^3.year to 37.5 kWh/m^3.year, depending on the external area per volume ratio (A/V). The maximum indicated heat demand is expressed in terms of final energy, without taking into account the system efficiency. Cooling and Domestic Hot Water (DHW) are also not considered.

For new buildings, the thermal regulation was revised in 2005 and 2010 raising the level required in terms of thermal resistance values and maximum allowed heat demand. The type and level of thermal performance requirements for new buildings depend on the building type (dwellings, office buildings, schools etc.) and the building envelope.

The building energy performance is evaluated and presented (in the EPC) based on the approved calculation methodology (MC 001-2006 as amended). Software tools, created according to the Mc 001-2006, are available on the market (software for EPC issued for apartments in collective buildings are subject of compliance verification). The independent control system for energy performance certificates and inspection reports has been defined by the approval of a procedure for State control of the unitary application of legal provisions regarding the energy performance of buildings and inspection of Heating, Ventilation and Air Conditioning (HVAC) systems. The control and compliance check are performed by the State Inspectorate in Constructions (SIC), but first verifications (started early 2014) were limited to formal checks (validity of auditor's certification, identification data, EPC format, if the electronic format was sent to the central database etc.) on the EPCs issued within the national rehabilitation programme (i.e. using public funds). In order to check the technical content of the EPC (i.e., the input data, calculations, and correctness of results) independent qualified experts may be used by SIC, but the procedures to effectively involve external experts are still under development.

To obtain a building permit, house builders must prove that the maximum thermal transmittance and solar heat gain coefficient for the building are respected. The EPC is mandatory at the commissioning phase, but there are no specific requirements such as a maximum energy use or minimum energy class. So, it is theoretically possible to construct an even more energy efficient building if desired, but this remains voluntary and depends on the costs and the level of energy education of the owners.

II.7.2 Quality of the works

Building requirements (including minimum thermal performance of building components and global indicator G) are controlled at the stage of construction authorisation (building permit). In principle, the requirements are respected in the design documentation. Otherwise the construction project does not pass through the authorisation process. However, in practice, the execution of the work is not always undertaken according to the design and can depend on the budget reduction by the investor. In addition the poor execution of details/joints (thermal bridges) can lead to a reduction of the global thermal resistance of the building envelope and usually results in values which do not respect the minimum thermal requirement.

If a construction is built without a permit or infringes its permit, the control authorities may order the demolition of those elements which are not compliant with the permit or were built without a permit. In such cases, the construction works can be suspended. In this case, the administrative fine to be paid by the investor is up to approximately 2.300 € in addition to indemnities for the damage caused.

The intensive programme for energy rehabilitation of block-of-flats and the reinforcement of current building codes require an increased attention to systematic enforcement and compliance controls, together with effective qualification schemes for the workforce involved in these actions. Furthermore, the quality of the works is strongly depending on the level of the workforce education and training, especially regarding the new technologies in the construction sector, related to energy efficient buildings. At this moment a system to ensure the qualification of the building workforce relating to energy efficient technologies or renewable energy systems is under development, with support from the Romanian IEE BUILD UP Skills QualiShell project. The project focuses on the development of qualification schemes for building envelope insulators and insulated window system installers to ensure the execution of high performance building envelopes, while an intensive consultation process is performed in order to develop "qualification engines" (e.g., raising awareness for the need of building owners and investors to have quality, introducing minimum qualification requirements in tendering processes for rehabilitation works and improving compliance framework in the execution of construction works).

II.7.3 Compliance frameworks

The main responsible body for compliance control in construction is the State Inspectorate in Constructions (SIC), a public institution as legal entity, to the Ministry of Regional Development and Public Administration (MDRAP). SIC has a control function over the execution of works. The actual inspection for compliance, after issuing the building permit and authorisation of works, is done by either:

- construction inspectors employed by SIC;
- site inspectors/project supervisors (subject to authorisation by SIC) employed by the beneficiary/building owner;
- technical inspectors (subject to authorisation by MDRAP) employed by the contractor.

Compliance with the energy performance regulation is required during the authorisation phase of construction works. During the final commissioning phase, the realisation of an Energy Performance Certificate (EPC) is required. With the exception of apartments in a block of flats, the EPC also displays the energy performance indicator for a reference (national) building (the same geometry as the actual building, but with the minimum thermal requirements fulfilled). This would be equivalent to the energy performance of the same building respecting the minimum energy performance requirements at component level; however the indicated value is purely informative. No additional checks are made in order to verify compliance with Energy Performance.

The overall procedure of compliance is shortly described in Table 3.

Authorisation design documentation/ building permit	The building permit is issued by the local authority based on design documentation (which is in theory an extract from the complete design documentation). This includes calculations on thermal performance indicators (thermal transmittance and solar heat gain coefficient) to show the compliance with minimum performance requirements. For thermal rehabilitation of existing buildings an EPC and energy audit are usually required.
Final design/production information	The official control mechanism for the final design stage includes authorised experts (by MDRAP) for design verification and quality experts for each essential requirement (Law 10/1995 regarding quality in constructions). Energy calculations are performed by energy auditors for buildings and are included in the EPC and (if the case) energy audit, but they are usually not verified at final design stage.
Design changes	The building owner is responsible to fulfil the minimum energy performance requirements and in the case of significant design or component changes, energy calculations have to be revised, but as there is no control mechanism, this is not followed in practice. All changes should be documented in the ”Building Book” which is kept by the building owner.
Commissioning	Commissioning includes an overall verification and quality checks. It also includes several measurements on heating and cooling systems and ventilation noise measurement (optional), but there are no requirements for measuring ductwork leakage, building airtightness, balancing of ventilation or thermal imaging inspection. The EPC is mandatory at commissioning phase.
Building handover	A local authority representative (inspector) participates in the site visit at final commissioning phase.
Operation phase	The energy performance certificate is valid for maximum 10 years (if no major interventions on the building performance are made).

Table 3 Approval procedures in design and construction phases in Romania

II.8 Spain

II.8.1 Overall situation

The Building Technical Code (Código técnico de la Edificación, CTE), in its basic document on energy savings, recently updated (publication of the update in September 2013, in force since March 2014), sets the maximum amount of non-renewable primary energy that the building is allowed to consume (HE0) and other important minimum requirements that buildings have to fulfil in different sections, such as limitation of the net energy demand (HE1); performance of technical systems (HE2); and energy efficiency of lighting systems (HE3). In addition, it includes two additional documents on the use of renewable energy, minimum solar contribution of Domestic Hot Water (HE4), and minimal photovoltaic contribution of electric power (HE5). With the entry into force of the CTE and the recent update of this Basic Document, DB, of energy savings, one tries to obtain a rational use of energy necessary for the use of the buildings, reducing its consumption to sustainable limits and achieving that a part of this consumption comes from renewable energy sources.

Another key element in these last few years has been the publication of RD 235/2013, for the certification of the energy efficiency of new and existing buildings, , thus completing the transposition of European Directives. This RD establishes, in articles 9 and 10, the regulations for the control and inspection of the energy efficiency certificates. Between its specifications, some aspects are established like competences to the Regional Governments (registration procedures, control and inspection of the certificates). From its publication, the different Regional Energy Agencies (or other organisms, depending on the region) have developed their regional framework to regulate those exercised by state law.

II.8.2 Reliable input data

The regulatory implementation of RD 235/2013 for the certification of the energy efficiency of buildings in Spain, harmonises the national framework of the buildings together with the application of the European Directive 2012/31/EC. This RD 235/2013 establishes the minimum requirements to be met by buildings, both existing and new construction, for the certification of energy efficiency.

The energy efficiency of a building will be determined based on the necessary energy consumption to satisfy the annual energy demand of the building according to normal operating conditions and occupation. It is communicated by a few indicators, ranging from A to G ('A' is the most efficient EPC and 'G' the least efficient). The main energy indicator will be the one that refers to the annual emissions of CO_2, expressed in kg per m^2 of usable surface of the building.

The necessary input data to the EPC are divided in 4 groups of values, as specified below:

- GROUP 1: GENERAL DATA

This group includes data at general level of the building, in reference to its typology (housing, small and medium tertiary building, large tertiary building), climatic zone and location, and other administrative necessary details.

- GROUP 2: CONSTRUCTION AND GEOMETRIC DATA

With respect to the construction characteristics necessary for the determination of the EPC, a different procedure exists for new and existing buildings:

- ✓ In new buildings, the user must identify the details of the building elements, getting the input data from the database referred later, or he can use new materials or products.
- ✓ For existing building, in addition to the procedure allowed for new buildings, the user can use default values. These values were determined in a study by the "Instituto de Ciencias de la Construcción Eduardo Torroja" in relation with the more usual constructive compositions in Spain according to the type of building and the constructive periods based on the year of construction. The selected intervals are in Table 4.

Period	Characteristics
Before 1900	
1901 - 1940	Context of pre-war
1941 - 1960	Context of post-war
1961 - 1980	Entry into force of the regulations MV
1981 - 2006	Entry into force of the regulations CT-79
After 2006	Entry into force of the actual framework CTE

Table 4 Construction periods

With respect to the justification of choices:

- ✓ When the person responsible for the EPC uses default values from the database, it is not possible to modify these data, and no justification of these data is expected by the expert.
- ✓ When the person responsible for the EPC uses other data, it is necessary that there is evidence for these data. Evidence can be delivered by the manufacturer and might be based on CE marking. In general, the user must submit the following input data of materials (Table 5), differentiating characteristics to apply depending on whether the elements belonging to semi-transparent (glazing) or opaque elements:

Semi-transparent element
Thermal transmittance (U in W/m^2·K) for glass +frame , according to CTE-HE1
Solar factor: glass + frame, according to CTE-HE1
Shade factor: winter and summer, according to CTE-HE1
Air permeability of the holes (m^3/h·m^2)

Opaque element
Thickness (m)
Thermal conductivity (W/m·K)
Density (kg/m^3)
Specific heat (J/kg·K)
Thermal resistance (m^2·K/W)
It will be important to indicate the exact position of the enclosure: deck, flooring, exterior façade, enclosure in contact with the ground, interior partition, etc.

Table 5 Input data of materials

With respect to the definition of the geometric characteristics of the building, it is necessary to define in detail the geometry of the building. In this case, the user must provide specific data for each of the spaces in which the building is divided, as it relates to the surfaces of these spaces, as well as the percentage of the window surfaces (glass + frame) existing in each one of the façades. Similarly, the definition of thermal bridges is required.

The orientation of the building must also be given. Data obtained from the Cadastre or another similar source will be considered as reliable.

With respect to the geometry of the building, it will be necessary to identify the elements that give shading on the facade of the building, either by own building obstacles (overhangs and setbacks), or by remote obstacles. It will be necessary to know the skyline that generates shadows on the building, by the determination of the azimuth and solar height for a number of azimuth angles.

➢ GROUP 3: DATA ON AIR CONDITIONING/COOLING SYSTEMS

For air conditioning systems, both default values and values provided by the user exist.

The input data considered by default, or coming from a database, are those belonging to the performance curves of the various equipment included in the building. These data may be considered as by default as long as the user has not got the performance curves provided by the manufacturer of the equipment in question. Similarly to previous cases, these data, when provided by the user, require justification during the control and inspection procedure of the EPC.

Regarding the input data needed to be entered by the user, these will depend on the type of system/equipment concerned. Below (Table 6) is an overall view of the data needed to be entered by the user for each type of system.

System	Parameter	Policy Considerations
Lighting systems	Installed power	Will only apply these considerations in buildings of non-residential type
	Operating hours	
	Lighting control systems by the supply of natural daylight	
Domestic Hot Water (DHW)	Demand for DHW	-
	Power generation system	-
	Percentage of solar coverage	According to the minimum established by the CTE-HE4
Heating systems	Operating conditions	-
	Flow of outside air (ventilation)	-
	Heating system	-
	Cooling system	-

Table 6 System parameters data for the EPC

➢ GROUP 4: DATA ON OPERATIONAL CONDITIONS

In regards to the operational conditions of the building, hourly profiles represent one of the key points in the calculation of the EPC, and vary according to occupation, infiltration, fan operation, set point temperatures, etc. Also, there are two possible scenarios in this case.

The first approach is the use of default profiles, determined according to the type of building, i.e.:

- ✓ Residential buildings: the user will define the type of use that is made of each space, the living conditions, the air flow rates.
- ✓ Non Residential Buildings: in this case the user must enter the parameters considered for residential buildings, with consideration of compliance with the CTE-HS2 for the calculation of the ventilation, and in addition, including the installed lighting power. Based on these parameters three groups of intensity levels of the internal sources are considered, high, medium and low, with four operating profiles: 8, 12, 16 and 24 hours of operation.

In the second case, the user must define the usage profiles of the EPC building that will be taken into account, the occupation input data and other influential variables that the user has taken based on the use and operation of the building. The user, therefore, will establish the usage profile of the building indicating the daily, weekly and annual schedule with all existing exceptions within these types of schedules (feasts, different hours in winter and summer, etc.) All extended information can be found in the following website:

www.minetur.gob.es/energia/desarrollo/EficienciaEnergetica/CertificacionEnergetica/DocumentosReconocidos/Paginas/Normativaymodelosdeutilizaci%C3%B3n.aspx

II.8.3 Quality of the works

In terms of the process of quality control in the works in reference to the verification of the energy efficiency of buildings, the Spanish landscape is marked by the following milestones within the construction process:

a. Start of the works

A compulsory condition for the start of the works will be the presentation at the Town Hall of the EPC project that has to be incorporated into the execution project as a document inside its content.

After having obtained the permissions and necessary licenses, the builder will proceed to the construction of the building.

b. Execution control

The entity control will raise a schedule of visits according to the characteristics of the work. The inspections will coincide with the implementation of certain constructive elements that stand out as milestones, to take into account both the construction process, as well as in regard to the energy efficiency of the building, so that the suitability of the project to the construction executed can be checked on the ground.

Basically the elements to check shall be those relating to the thermal envelope: walls, facade, slabs, roofs, walls in contact with the ground and glazing in the facade; those relating to thermal bridges and finally the facilities: DHW, heating, cooling, lighting and renewable energy sources.

A variable number of visits will be established according to the type, complexity and extension of the building. The visits will follow the procedure of examination that should have been defined and which will be coherent with the Regional framework. After each inspection of work, a written partial report will inform about the results obtained during the inspection, especially of those aspects in which changes should take place and where anomalies were found. The report shall be documented by the photographs and necessary measurements.

A final report will be written with the results of the realised visits. The modifications with regard to the presented project will be reflected so that the above mentioned information could be used in the cross-check of the EPC. The report will be written in accordance with the structure and the format indicated in the technical instructions of the framework.

II.8.4 Compliance frameworks

Compliance with the regulatory framework established by the RD 235/2013 for the EPC in Spain, is split into the following phases. In case of existing buildings, only phases c. and d. are applicable:

a. EPC of the execution project

Will be based on the execution project of the building as well as the documentation required by the Regional Government in what energy efficiency concerns. The document will be signed by the building designer, and may be performed by himself or another technician appointed by him, being incorporated in the execution project document.

b. Verification of the EPC of the execution project

In those cases in which regional rules require it, the verification of the EPC of the execution project will be carried out by a qualified technician of an Entity of Quality Control of the building (ECCE) or by any other organism specially authorised.

c. EPC of the completed building

In this case, the certificate will be signed by the construction manager, responsible of having realised the necessary tasks for securing the EPC, bearing in mind the modifications that the project of the building could have suffered during its construction.

d. Checking of the EPC of the finished building

The control entity will follow the same patterns of control and inspection as in the checking of the EPC of the execution project.

All the modifications that affect to the EPC, which have been gathered in the execution project and in the inspection visits, will be taken into consideration for getting the finished building EPC.

If the final result of the qualification obtained by the entity of control differs from the initially obtained, as a result of differences with the specifications, the promoter or owner will be notified of the reasons that have caused the difference in ratings and a time frame for its amending or, in case of no amending, the initial EPC will be modified. The EPC of the finished building will be included into the certificate of the works as a prerequisite, and will be part of the Book of the Building.

Considerations:

- ✓ The EPC will have a maximum of 10 years validity, and the competent body of each Regional Government will set the specific conditions for its renewal or update.
- ✓ Updating of the EPC will be possible when they deem appropriate within the period of validity of the EPC, or when there are variations in the building that are considered to directly affect the parameters included in the EPC.
- ✓ Establishing a Registry of EPC is the competence of each Regional Government. It includes the EPC of the execution project as well as that of the finished building. The Regional Governments will have the competence to carry out the work of inspection and technical and administrative control stipulated in the RD 235/2013.

II.9 Sweden

II.9.1 Introduction

The Energy Performance Certificate (EPC) in Sweden was implemented in October 2006. The first energy experts were certified in the summer of 2007 and the first EPC was registered in September 2007. Up until June 2014, there are 507.263 EPCs registered in the national database. Contrary to most countries in the EU, the Swedish EPCs are based on the measured energy use. A study (Boverket, 2014) has shown that out of the buildings constructed between 2007 and 2012, only 40% performed according to the prevailing energy regulations. This was based on EPCs from 2.000 buildings. The buildings with the highest non-compliance rate with the energy regulations were built in 2007/2008, whereof 64% did not perform as expected.

II.9.2 Overall situation

In general, the calculated energy use for heating, cooling, operation of Heating, Ventilation and Air Conditioning systems and Domestic Hot Water should be equal to or lower than a defined maximum value in a reference year and in a reference climate zone, assuming a normal use of the building (hot water, indoor temperature, internal loads, ventilation, etc). The recommended maximum average thermal transmittances for the complete building envelope are specified in the building code. Average thermal transmittance of the building envelope should be calculated according to SS-EN ISO 13789:2007 and SS 02 42 30.

The calculated energy use should be verified by measurements of the energy use which are performed during at least 12 and up to 24 consecutive months after commissioning. The measured data should also be corrected to a reference year. The cause for the deviation between the predicted and measured energy use has mainly three causes:

- ✓ errors in the input data (e.g., wrong heated area of the building, changes made to the original design not taken into account);
- ✓ errors in the energy use measurements;
- ✓ differences related to the use of the building; hot water use, indoor temperature, internal loads, ventilation, etc.)

II.9.3 Reliable input data

The input data used for the EPCs are only based on measurements of the energy use in the building during operation. Therefore, the focus will be on the input data used for making the energy use calculations for the building permit.

The calculation procedure for the energy use in buildings is not specified. Designers are free to choose energy simulation programmes and input data. In practice, designers often use a tool, which is developed by the construction and property industry (Sveby, 2009). Some categories are listed in Sveby as standardised occupancy profiles:

- ✓ airing and ventilation;
- ✓ solar control strategies (curtains, awning);
- ✓ household electricity;
- ✓ Domestic Hot Water use.

The indoor temperature should be 21°C for all buildings, except for homes for elderly where 22°C should be used. The temperature used in the calculation can be corrected for deviations found by measuring the temperature in the finished building, as long as the difference is not caused by operational or other errors. Normally, variations in the indoor temperature over the day are not considered. The same applies to the effects by individual temperature measurements because the effect by these are uncertain (Sveby, 2009).

As mentioned above, the validity of calculations is checked by measurements. For new buildings, the measurements of the energy use should not be performed during the first year the building is used, but within 24 months after commissioning.

II.9.4 Quality of the works

In Sweden, the measured energy use is included in the EPC. The quality of the works is dependent on the resolution of the energy metering system within the property. The availability of data increases the accuracy of the EPC. However, most often the energy use for heating and domestic hot water is measured at one location for the complete building complex. The same applies for the electrical energy use in the property, which is divided into facility electricity and household/user electricity.

For the EPCs, the heated area is important for calculating the specific energy use of the building. This area is either measured on the original building plans or measured during a building visit. The measured energy use for heating is corrected according to the degree-days for a typical year. The measured electricity use for building services (e.g., fans and pumps) is added to the total energy use (required energy performance value), while the household electricity (residential) or the user electricity, i.e., energy for lighting and other activities in the building related to the usage, (service buildings) should be excluded (if included in the measurements).

In 2008, a 'competition' was launched by Sveby (2011) where the energy use in a building (kv Kansliet 1) with 117 apartments divided into 10 groups was calculated by a number of energy consultants. The building was designed to comply with the 2006 energy standard and completed in 2008. The 'competition' was divided in two steps; in the first step the participants were given drawings of the building and basic information on the building, in the second step some measured input parameters and more information on the building were provided to improve the energy use calculations.

In the end, 14 consultants handed in 18 contributions to both the first and second step. In the first step, the calculated energy use varied between 67 and 142 kWh/m^2 and in the second step it varied between 70 and 113 kWh/m^2. The average energy use was 86 kWh/m^2 with a standard variation of 10%. There were major differences in the heated area of the building used in the calculations with a spread between 9.500 and 13.000 m^2. It appeared that the variation in competence/experience of the person carrying out the calculation had a bigger impact on the variation of the results than the variation in the accuracy of the input data. At the end, when the calculated energy use was compared to the measured energy use, a number of errors were found in the measured input data given to the participants. Wrong assumptions were found in the input data for domestic hot water, electricity use and the energy efficiency of the ventilation heat recovery. After correcting for these errors, the actual energy use was approximated to 80-85 kWh/m^2 (Sveby, 2011).

From the results of the 'competition', it is evident that better routines and quality assurance are needed for the calculation procedure. It is also important to introduce general schemes for declaring the different parts of the energy balance. Another important finding was the difficulty to get access to reliable measured input data. In this case, there was a lack of energy use loggers to calculate the energy use for lighting in the garden, engine preheaters, heating in external buildings, etc, to exclude these from the EPC for only the building. A major source for the erroneous measured energy use was found to be secondary heat losses in the district heating pipes in the ground outside of the building. These increased the measured energy use by more than 10 kWh/m^2. For the building owner it is important to have knowledge of where the energy paid for is used in order to control that the systems are performing as intended. A proper commissioning that ensure that the building performs throughout the year cannot be stressed enough (Sveby, 2011).

It is clear that the framework for energy use calculations need improvements. In order to reduce the spread among the users, education in how to use the software and certification are needed. The most time consuming part of the work is often to calculate the heated area of the building. Automating this process could help in reducing the spread in the results.

II.9.5 Compliance frameworks

The Swedish EPCs are gathered in a central database where the building owner can get access to the data. It is mandatory to present a summary of the EPC when the building is for sale. The results of the EPCs should also be posted on a prominent common space which is easily accessible for the occupants/users of the building. However, there is no scheme that assesses the quality of the EPCs and the proposed energy efficiency measures (included in the EPCs to make the building owner aware of how to reduce the energy use, e.g., insulate attic floor, install heat exchanger in the ventilation system, etc.).

In the governmental view, the building permit, sent in to the municipalities, regulates the compliance of the building code and the maximum energy use defined in the building code. The overall procedure of compliance is shortly described in Table 7.

Scheme (preliminary) design/ building permit	The municipality issues the building permit based on scheme design documentation. This includes energy calculations to show the compliance with minimum energy performance requirements.
Final design/production information	There is no official control mechanism for the final design stage. It is not mandatory to update the energy calculations. However, the building owner is responsible to comply with the minimum energy performance requirements.
Design changes	The building owner is responsible to fulfil energy performance minimum requirements and in case significant design or component changes, energy calculations have to be revised, but as there is no control mechanism, this is not followed in practice.
Commissioning (or rather inspection, is an mandatory measure between builder and contractor)	Commissioning includes several measurements like measuring ductwork leakage, building leakage rate (not mandatory), balancing of ventilation, heating and cooling systems, noise measurement (if required). The measurement protocols will be issued.
Operation phase	An EPC based on measurements has to be completed no later than 24 months after inspection to verify the energy performance requirements (checked by local authorities, but this is not yet done in practice). New EPC after 10 years is mandatory.

Table 7 Approval procedures in the design and construction phases in Sweden

II.9.6 References

- ✓ Boverket (2014). Skärpta energihushållningskrav – redovisning av regeringens uppdrag att se över och skärpa energireglerna i Boverkets byggregler. Rapport 2014:19. (Tighter demands on energy efficiency – report of governmental mission to review and tighten the energy demands in the Swedish building code). Karlskrona, Sweden: Boverket.
- ✓ Sveby (2009). Brukarindata för energiberäkningar i bostäder. (Input data for energy use calculations in dwellings). Available on: www.sveby.se
- ✓ Sveby (2011). Resultat från energiberäkningstävling för ett flerbostadshus. Projektrapport 2011-10-03. (Results from competition on calculating the energy use in a multi-family dwelling). Available on: www.sveby.se

III. Examples of observed performances in daily practice

III.1.Overview of existing studies

An overview of the studies reported in this chapter is given in Table 8. For each study, the specific relevance/focus is indicated:

- ✓ DATA: the study is of specific relevance with respect to reliability of input DATA
- ✓ QUAL: the study is of specific relevance with respect to the QUALITY of the works
- ✓ COMP: the study is of specific relevance with respect to COMPLIANCE issues

TECHNOLOGY AREA	DATA	QUAL	COMP
Transmission characteristics			
III.2.1 Experiences regarding the average thermal insulation level	X		X
III.2.2 Analysis of different façade solutions for office buildings in Madrid			X
III.2.3 Swedish building stock audit - BETSI			X
III.2.4 Thermal bridges` influence on the calculated energy use	X		
Ventilation and air tightness			
Input data			
III.3.1 Airtightness of building envelope in new apartment buildings	X		X
III.3.2 Ventilation performance in new apartment buildings	X		X
III.3.3 Energy efficiency of retrofitted apartment buildings		X	X
III.3.4 Ventilation airflows in retrofitted apartment buildings		X	X
III.3.5 Ventilation airflows in new apartment buildings		X	
III.3.6 Efficiency of night ventilation technique		X	
III.3.7 Measurements of particulates PM10, PM2.5 and PM1 in Greece		X	
III.3.8 Measurements of indoor pollutants in Athens		X	
III.3.9 Airtightness of windows and building envelope in apartment buildings		X	X
Quality of the works			
III.4.1 Experiences with ventilation performances in practice	X	X	X
III.4.2 Airtightness of building envelope	X	X	X
III.4.3 Quality of ventilation systems in new dwellings		X	
III.4.4 Quality of ventilation systems		X	
III.4.5 Performance and quality of mechanical ventilation in dwellings		X	
III.4.6 Duct leakage in air distribution systems		X	
III.4.7 Experiences with building air tightness in practice		X	
Renewables in multi-energy systems			
III.5.1 Performance of residential PV systems: France	X		
III.5.2 Performance of residential PV systems: Belgium	X		
III.5.3 Performance of domestic small-scale wind turbines: UK	X		
III.5.4 Heating and cooling solutions with efficient systems	X		
III.6.1. Quality of large solar thermal domestic hot water systems		X	
III.6.2 Quality of solar thermal domestic hot water systems in houses		X	
III.6.3 Quality of solar PV installations		X	
III.6.4 Quality of domestic wood boiler installations		X	
III.6.5 Quality of domestic heat pump installations		X	
III.6.6 QualiCert - A common approach for certification or equivalent qualification of installers of small-scale renewable energy systems in buildings	X		
III.6.7 Performance of residential heat pump systems: UK	X	X	X
III.6.8 Performance of residential heat pump systems: Germany	X	X	X
III.6.9 Performance of residential solar water heating systems: UK, Ireland		X	
Sustainable summer comfort			
III.7.1 Summer thermal comfort in new apartment buildings	X		X

Table 8 Overview of existing studies

III.2 Transmission characteristics - Input data

III.2.1 Experiences regarding the average thermal insulation level

Brief description of the study

In the context of the Flemish VLIET-SENVIVV study between 1995 and 1998, 200 randomly selected dwellings were analysed in terms of the average thermal insulation level (Figure 7), whereby the level as calculated by 2 independent experts was compared with the legal requirements:

- 50 dwellings with a building permit when there was no requirement (before September 1 1992)
- 50 dwellings with a building permit when the requirement was K65 (September 1992 – Augustus 1993)
- 100 dwellings with a building permit when the requirement was K55 (starting September 1993)

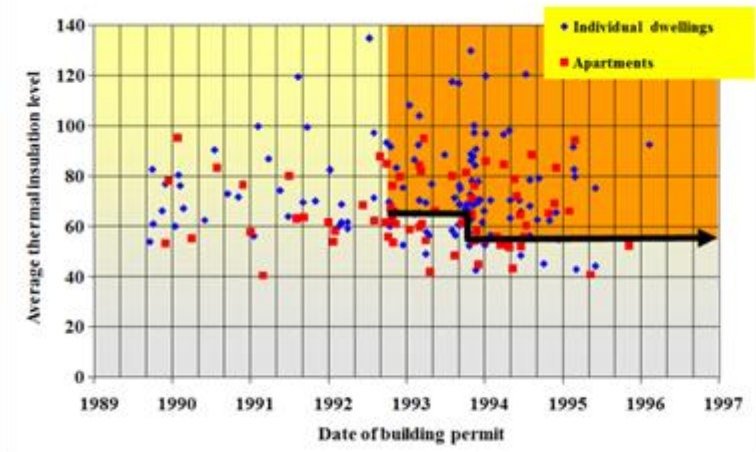


Figure 7 Average thermal insulation level of dwellings

Observed findings

The major findings were that:

- A very large number of the determined average thermal transmittances was substantially above the requirements although all buildings had a declaration which indicated that they met the requirements
- Surprisingly, there was no difference in average insulation level for the 3 periods (Figure 8).

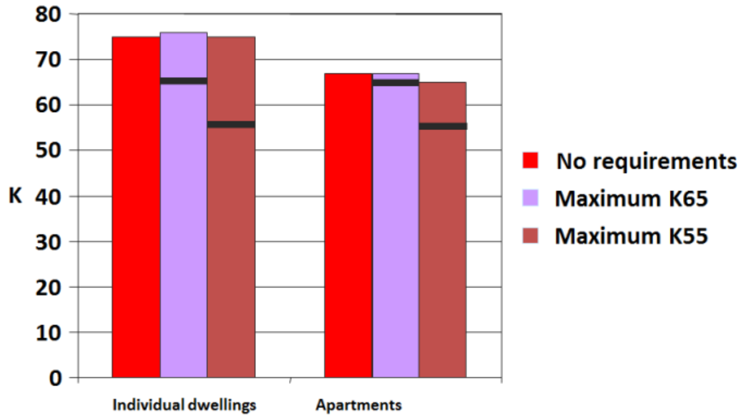


Figure 8 Average insulation levels of analysed dwellings

Lessons to be learned

This study has clearly highlighted that it was in that period in the Flemish context not evident to assume that reporting is done in a reliable way. Moreover, it also showed that, unless the boundary conditions would also change, it had little sense to impose more severe requirements if nothing was done at the level of compliance checks.

Assessment – follow-up actions

The outcome of this study has been a major trigger for awareness raising and achieving societal support for a more strict control framework, whereby the key objective is to create boundary conditions to encourage building professionals to do what they declare.

References and contact information

Documents:
- BBRI report on SENVIVV study

Contact persons:
- Peter Wouters, BBRI

III.2.2 Analysis of different façade solutions for office buildings in Madrid

Brief description of the study

The main target of the TOBEEM project is the determination of the reasonable limits, in both economic and energetic aspects, which can be reached in energy-efficient office buildings in Madrid (D3), as well as the establishment of reliable design criteria to achieve the mentioned consumption limits.

The analysis was established under a specific geographical framework, Madrid, under the current regulatory conditions, and taking into account the specifications in terms of cost-optimal buildings and nearly zero energy buildings design established by the European Directive EU/2010.

The selection of buildings under the study was conducted in consideration to a detailed analysis in real buildings and based on an exercise of synthesis that has allowed showing a larger range of representative office buildings. The following design parameters were established for the calculation:

- Floor building design: two floor plans (standard square floor plan and linear block).
- Identified 10 different typologies of façades, representing over than 50 real-world scenarios.
- % glazing: variation between 30 and 84% of openings in façades, according to the skin type.
- Type of glass: up to 10 different types of glass were considered, with specific treatments (low-emission and solar blocking) and types of chamber components (air and argon).
- Shade elements: 10 different situations, considering fixed and moving elements, as well as the urban setting of the buildings (skyline, remote obstacles).
- Identified 8 possible orientations, according to The Building Technical Code.
- Distinction between light and heavy frameworks, consistent with the types of façades described.
- Internal loads: 2 definitions of typical domestic loads on equipment, occupancy and lighting of spaces.
- Infiltration: 2 definitions of the infiltration, based on theoretical and real cases of construction pathologies or defective construction works.
- Generation systems: assessment of 4 energy generating systems, boiler and cooler, electric heat pump, Variable Refrigerant Flow (VRF) with alternative thermal motor, and district heating and cooling (DHC) based on a cogeneration machine and chiller.
- Climate-control systems: 2 systems, convective type (fan-coils) and radiant (radiant floor and ceiling).
- Ventilation: 2 ventilation systems, fixed or variable flow rates.
- Climate, 2 scenarios representative of high-rise climate, and urban microclimates.

A representative sampling of office buildings was created by a combination of the previous parameters divided into four main groups according to the number of floors (low or high) and the floor plan layout (square or linear block).

Observed findings

It is truly feasible and highly profitable to build energy-efficient and cost-effective office buildings, under the current context, according to sector capabilities, expertise and technology available in the current market conditions.

This is, considering that the office buildings built in recent years have higher associated consumption, about 150 kWh/m^2 per year, which can be reduced to around 60 kWh/m^2 per year, for buildings with a range of costs between 1.100 and 1.200 € /m^2. These values could be reduced even further in the detailed design of a specific building, depending on the architectural and constructive solutions, as well as the use of efficient and renewable systems adapted to each building.

Building energy-efficient and cost-optimal office buildings is less expensive, considering not only the global cost of the entire life-cycle but also the investment costs. Actually, the difference between a high-consumption building to those others, in the range of 50 to 100 kWh/m^2 per year consumption, shows savings of more than 4 % of the initial investment, without considering the savings on the electricity bills or other life-cycle items.

The foregoing highlights that:

- The architectural and constructive design as well as the operation of the building over its service life are the main elements to be considered in energy and cost-effective buildings. An efficient operation of the building is almost three times more important than architectural and constructive design and nearly nine times more important than the proposed energy system, as far as energy consumption is concerned.
- Transparent facade buildings (high proportions of openings and/or curtain walls and double skin facades) are significantly more expensive and are associated with higher consumption levels than conventional buildings that are opaque, inertial and protected from the elements. This fact is particularly relevant in the case of double skin buildings. Indeed, transparent buildings facades are associated with additional costs, about more than 300 €/m2 and an increase in primary energy consumption of more than 25 kWh/m2 per year. Both, the investment in operation and maintenance, of transparent facade buildings are neither economic nor energy efficient profitable. These conclusions are independent to the geographical orientation due to their regulatory standardisation.
- High rise buildings (unrated special towers) are more expensive and less energy-efficient than normal urban buildings. This is mainly due to the architectural and constructive constraints, but also for the environmental conditions, the ones become more significant when there are pathologies associated with the work.

The results of the study can be carried out from multiple analysis. Some of the most relevant ones are:

<u>Results according to regulation conditions</u>.

Those results of total cost and primary energy consumption are under regulatory conditions of reference.

The graph shows three scenarios:

- The scenarios to the right of the red line represent buildings that are not CTE compliant.
- The scenarios between black and red line represent buildings that are compliant with the regulatory requirements.
- The scenarios to the left of the black line represent buildings with A or B EPC rating.

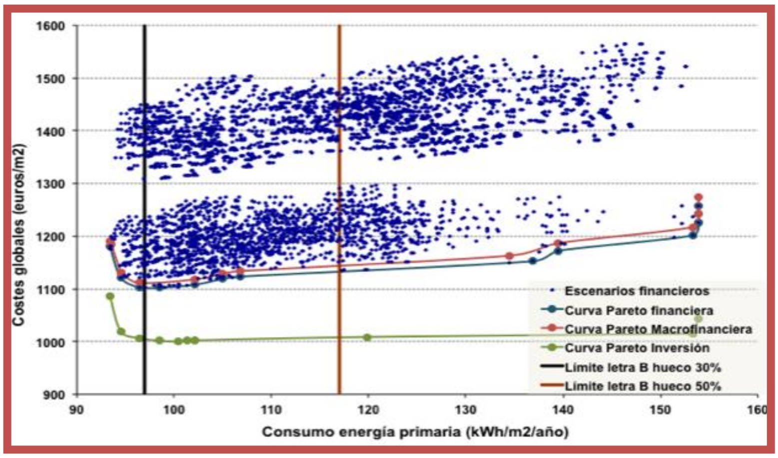


Figure 9 Primary energy consumption and global cost under regulatory conditions

Results according to real and optimised conditions.

The results of total cost and primary energy consumption calculations are under other operating conditions and optimising elements that are neither constructive nor architectural. These are the real and optimised conditions.

The graph shows three scenarios:

- The scenarios to the right of the red line represent buildings that take real conditions into account. In this cases, measures have been implemented during monitoring and infiltration test in relation to occupancy, infiltration and the operating orders.
- The scenarios between black and red line represent buildings that are compliant with the regulatory requirements.
- The scenarios to the left of the black line represent buildings with optimised conditions. These opmitised conditions refer to the ones that allow improvements in the consumption associated with the buildings.

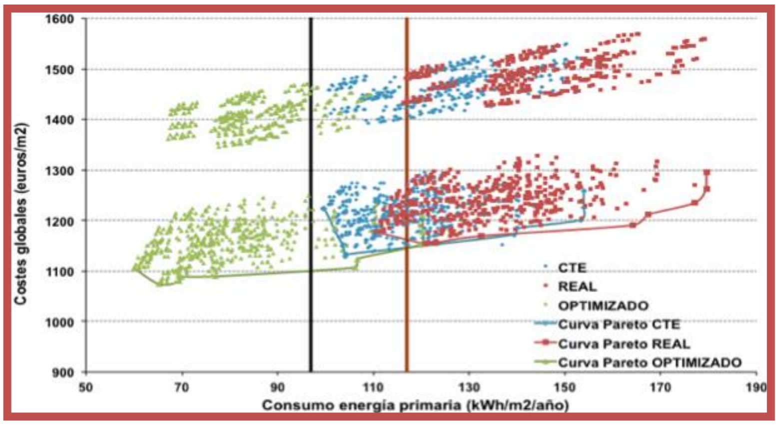


Figure 10 Primary energy consumption and global cost under real conditions

Evolution of energy prices and discount rates. This specific analysis shows that the different energy price evolution scenarios have a residual impact in comparison with the significance of the discount rate.

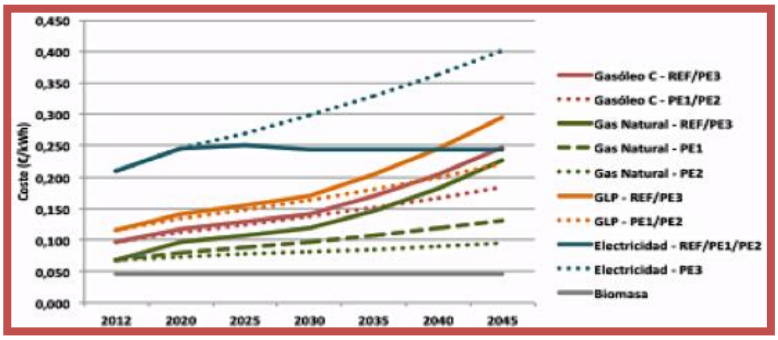


Figure 11 Evolution of energy prices and discount rates

Lessons to be learned

The complete analysis of the study, evidences as main conclusion that it is possible to build efficient office buildings (considering energy and economic aspects), being perfectly viable and highly profitable in the current context.

Assessment – follow-up actions

The TOBEEM project demonstrates the need for a substantial review of the predominant urban planning in the tertiary national service.

An in-depth analysis (detailed enhancements), with a higher geographical scope (other climatic zones), would provide a holistic overview of the approaches above and allow us an advance in the leadership of bringing the NZEB near to the cost-effective ranks.

Also, the study offers, in its assorted documents, multiple specific conclusions that deserve, in a detailed analysis of the results, to be applied in other sectorial studies, for example, extensive databases of prices, settings of dynamic simulations and the skills of cloud computing technologies, between others.

References and contact information

Documents:

- Executive summary of TOBEEM Project, integral energy guidelines of office building in Madrid. Feasibility of the current design of office buildings in Madrid with minimum cost and energy consumption in the Horizon 2020. Published on the web pages listed below.

Contact persons:

- Pascual, J.
- Expósito, C.

Website, links:

- http://aiguasol.coop/2014/02/17/proyecto-tobeem/
- www.alia-es.com/alia/Trabajos/ProyectosModule/displayProyecto/f5d9b91f843d9ebbcb867c7862c14f8e

III.2.3 Swedish building stock audit - BETSI

Brief description of the study

There have been numerous studies on the technical properties in the Swedish Building stock in the past. In 1991, the STIL study was performed for non-residential buildings and in 1992, the ELIB study was performed for single and multi-family dwellings.

In 2006, Boverket was commissioned by the government to perform a larger study on the building stock to improve and update the previous studies (ELIB/STIL). The objective was to describe the technical characteristics of the buildings by inspection, measurements, questionnaires, interviews, etc., with regard to energy use, indoor climate and the condition of materials and constructions of the buildings and the building services systems. The study is abbreviated BETSI (Building's Energy, Technical Status and Indoor environment). Experts investigated approximately 1.800 buildings, statistically chosen to represent the entire building stock. The first results were presented in 2009, and more extensive results in 2010. Four reports are summarising the results from the studies of the building stock, moisture and mould growth, energy and chemicals in the indoor environment.

Observed findings

The major findings were that:

- The average U-value of single family houses is 0,36 W/(m2K) which is better than for multi-family dwellings with 0,44 W/(m2K) and commercial and public buildings with 0,43 W/(m2K). A comparison with the previous survey (ELIB/STIL) shows that the average U-value has improved in the building stock as a whole for the different years of construction.
- The average U-values for windows in single family houses and multi-family dwellings are 2,2 and 2,1 W/(m2K), respectively. In commercial and public buildings it is 2,3 W/(m2K).
- Natural ventilation is the most common ventilation system in single-family houses constructed before 1975. In newer buildings mechanical ventilation dominates. About 60 % of the single-family houses erected between 1986 and 1995 have heat recovery of the exhaust air ventilation.
- The ventilation air exchange rate is 0,4 1/h and 0.5 1/h in single-family houses and multi-family dwellings respectively. Among the single-family houses, 80% has a lower air exchange than 0,35 l/(s•m2) which is the requirement for new buildings. Of the multi-family buildings, 60% are below the requirement.
- Only 40% of the schools and kindergartens has an OVK (mandatory ventilation inspection) without complaints and 40% has failed the OVK. However, of the schools and kindergartens built after 1980, almost all have an OVK without complaints.
- Overall, nearly 60% of the buildings in the category 'other premises' reported an OVK without complaints. The proportion of OVK without complaints varied between 29% for public, cultural, swimming and sports facilities and 72% for healthcare buildings.

Lessons to be learned

There are rather large variations regarding energy use in the Swedish building stock depending on the year of construction and type of building.

Assessment – follow-up actions

The study is used in numerous research projects concerning potential energy savings in the Swedish building stock.

References and contact information

Documents:

- A number of reports issued by Boverket in Swedish (Main report: 'Så mår våra hus - redovisning av regeringsuppdrag beträffande byggnaders tekniska utformning m.m.')
- Hjortsberg, M. (2011). Description of the Swedish building stock using material from a Swedish Statistical Survey of 1800 buildings. In proceedings of the SB11 Helsinki World Sustainable Building Conference, 18-21 October, 2011, Helsinki, Finland.
- Mattsson, B. (2011). Costs for reducing the energy demand in the Swedish building stock according to national energy targets. In proceedings of the SB11 Helsinki World Sustainable Building Conference, 18-21 October, 2011, Helsinki, Finland.

Contact persons:

- Nikolaj Tolstoy, Swedish National Board of Building, Housing and Planning (Boverket), nikolaj.tolstoy@boverket.se

Website, links, …

- www.boverket.se/betsistudy

III.2.4 Thermal bridges` influence on the calculated energy use

Brief description of the study

Calculations of U-values follow SS-EN ISO 6946:2007 and SS-EN ISO 13370:2007. Thermal bridges may be defined as a part of the building envelope penetrated by materials with different thermal conductivity and/or with changed thickness/amount of materials used and/or with difference between internal and external areas, according to SS EN ISO 10211:2007. Calculations of thermal bridges must be carried out in a correct and standardised way to ensure a properly sized heating system and a good indoor climate. There is today a risk of misunderstanding and inconsistent use of the methodology when transmission heat transfer is calculated. To investigate the state of knowledge among Swedish consultants a survey was conducted regarding thermal bridges and calculations of transmission heat transfer. Furthermore, the impact of thermal bridges was studied by comparative calculations for a case study building with different building systems and different amounts of insulation.

Observed findings

The study shows that the relevant standards and the building code in Sweden are interpreted in many different ways regarding calculation of heat transfer transmission and energy performance. There is a lack of understanding regarding the impact of different measuring methods on thermal bridges and the guidelines in Boverket's Building Regulations allow a simplified estimation of the influence of thermal bridges by a proportional increase of the U-values.

Lessons to be learned

When more insulation is used the relative impact of thermal bridges increases.

It is not suitable to use a single predefined percentage factor, increasing the transmission heat transfer through building elements, to account for the effect of thermal bridges.

No clear practice/norm can be identified regarding which measuring method is usually applied. A need for clearer building regulations, for the development of guidelines on how to use the available international standards and for education/training of engineers and architects has been identified.

Assessment – follow-up actions

Apply a simplified estimation of the influence of thermal bridges with an absolute value as in the German guidelines.

References and contact information

Documents:

- Berggren, B. and Wall, M. (2013). Calculation of thermal bridges in (Nordic) building envelopes – Risk of performance failure due to inconsistent use of methodology, Energy and Buildings 65 (October 2013), 331-339, ISSN 0378-7788

Contact persons:

- Björn Berggren, Lund University, bjorn.berggren@ebd.lth.se, +46 46 222 73 56

Website, links, …

- http://dx.doi.org/10.1016/j.enbuild.2013.06.021

III.3 Ventilation and air tightness – Input data

III.3.1 Airtightness of building envelope in new apartment buildings - Estonian housing stock technical condition - apartment buildings built during the period 1990-2010

Brief description of the study

Indoor climate was analysed in the 28 apartment buildings constructed between 1990 and 2010 and studied in the context of the Estonian housing stock technical condition study. Airtightness of the building envelope was measured in 23 apartment buildings (26 apartments).

Observed findings

The major findings were that:

The average air leakage rate @ 50 Pa:

- q50 1,7 m3/(h·m2) (0,8…4,6 m3/(h·m2)
- n50 2,3 h-1 (0,9…6,6 h-1)

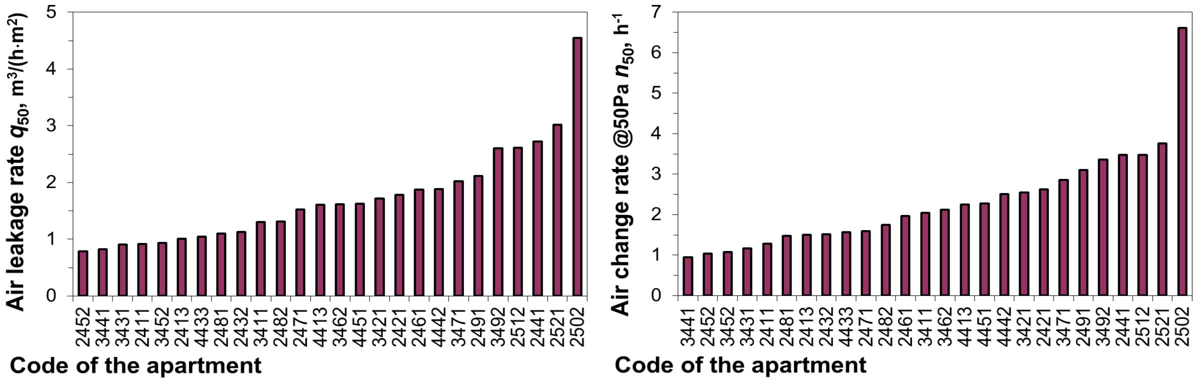


Figure 12 Air leakage rate (left) and air change rate (right) of measured apartments

Lessons to be learned

The design value of air leakage rate for new apartment buildings is q50 = 3 m3/(hm2) is on the safe side compared with measured (base) value of q_{50} = 2,5 m^3/(hm^2).

Assessment - follow-up actions?

There were no specific follow-up actions.

References and contact information

Documents:

- Study report (in Estonian)

Contact persons:

- Targo Kalamees, Tallinn University of Technology

Website, links:

- www.kredex.ee/public/Uuringud/Uute_korterelamute_uuring_2012.pdf

III.3.2 Ventilation performance in new apartment buildings - Estonian housing stock technical condition - apartment buildings built during the period 1990-2010

Brief description of the study

The indoor climate was analysed in the 28 apartment buildings constructed between 1990 and 2010 that were studied in the context of the Estonian housing stock technical condition study. Ventilation airflow was measured in 23 apartments.

Observed findings

The major findings were that:

General airflow in apartments:

- ventilation airflow rates in apartments were low in general;
- only few apartments correspond with the requirement of indoor climate category II: 0,42 l/(s·m2);
- the average 0,3 l/(s m2) was also below the requirement of indoor climate category III: 0,35 l/(s·m2)

Results are presented in Figure 13.

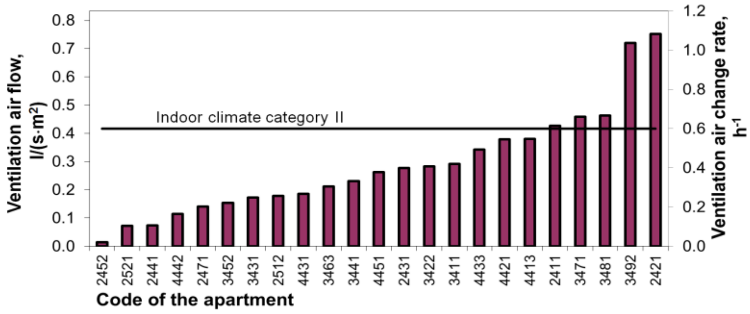


Figure 13 Ventilation airflow and ventilation air change rate of measured apartments

Ventilation airflow rates in two-person bedrooms

- average 10 l/s (st.dev. 5 l/s)
- 26% correspond to indoor climate category II requirements (14 l/s)

Results are presented in Figure 14.

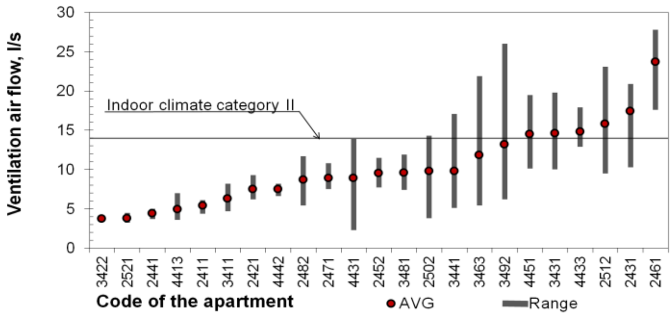


Figure 14 Ventilation airflow in two-person bedrooms

Lessons to be learned

Ventilation airflow in new apartment buildings often does not meet the indoor climate category II requirements.

Assessment – follow-up actions

There were no specific follow-up actions.

References and contact information

Documents:
- Study report (in Estonian)

Contact persons:
- Targo Kalamees, Tallinn University of Technology

Website, links:
- www.kredex.ee/public/Uuringud/Uute_korterelamute_uuring_2012.pdf

III.3.3 Energy efficiency of retrofitted apartment buildings - Indoor climate and energy efficiency of retrofitted apartment buildings and analysis of their compliance with the standards and energy audits

Brief description of the study

Expected and measured energy usage after the renovation was analysed in 20 apartment buildings in Estonia.

Observed findings

The major findings were that (Figure 15):

- expected reduction of heating energy consumption is comparable to the measured one only in few buildings;
- energy savings in calculations of energy audits are often too optimistic;
- considering the fact that the majority of the buildings were under ventilated, the real reduction of the energy consumption should be lower.

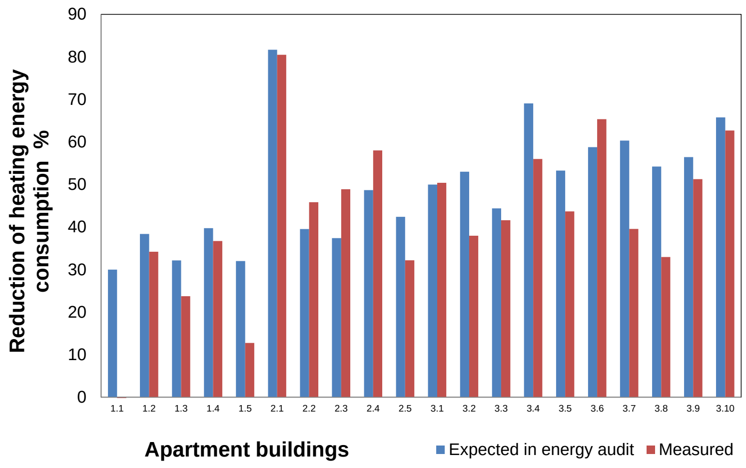


Figure 15 Measured and expected reduction of heating energy consumption

Lessons to be learned

Reasonably good heating energy savings occurred at much lower ventilation rate than designed.

Assessment - follow-up actions

The outcome of this study changed the procedure of proving energy efficiency for renovation grants application.

References and contact information

Documents:

- Study report (in Estonian)

Contact persons:

- Anti Hamburg, Tallinn University of Technology

Website, links:

- http://www.kredex.ee/public/Uuringud/Rekonstrueeritud_korterelamute_uuring.pdf

III.3.4 Ventilation airflows in retrofitted apartment buildings - Indoor climate and energy efficiency of retrofitted apartment buildings and analysis of their compliance with the standards and energy audits

Brief description of the study

Ventilation airflow after renovation was measured in 20 apartment buildings with different ventilation systems.

Observed findings

The major findings were that (Figure 16):

- ventilation airflow meets the indoor climate class II requirements only in apartment buildings with mechanical supply-exhaust ventilation system with heat recovery.

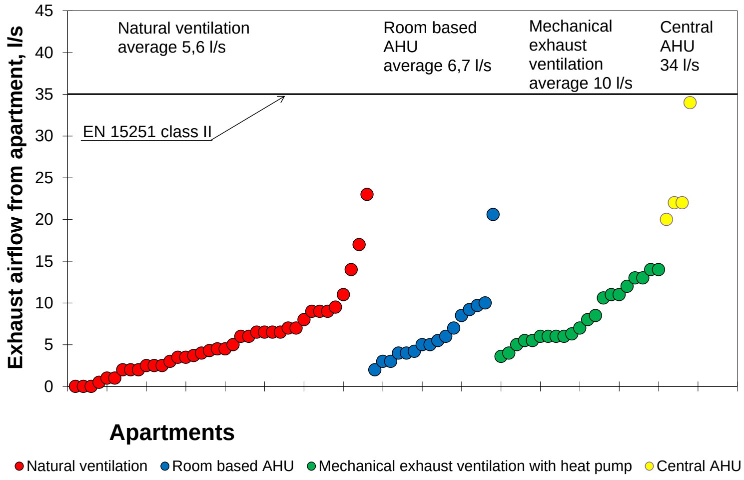


Figure 16 Exhaust airflow from apartments

Lessons to be learned

Renovated apartment buildings are often under ventilated (possible reasons: noise, energy saving, draft).

Assessment - follow-up actions?

The outcome of this study changed the procedure of proving indoor climate assurance for renovation grants application.

References and contact information

Documents:
- Study report (in Estonian)

Contact persons:
- Tallinn University of Technology

Website, links:
- www.kredex.ee/public/Uuringud/Rekonstrueeritud_korterelamute_uuring.pdf

III.3.5 Ventilation airflows in new apartment buildings

Brief description of the study

One of the goals of this work is to describe the situation of the first apartments built in Spain under the Technical Building Code (CTE, 2007) requirement on ventilation. To do this the measured ventilation flow in each of the rooms of the tested apartments were compared with the required ventilation airflow rate. In the event of not achieving these minimum flows the other main goal has been to try to determine the source of the problem and ameliorate the ventilation system performance. Measurements presented in this paper were obtained using tracer gas techniques based on the concentration decay method. From these data it is concluded that there are few dwellings that comply with the requirement of minimum ventilation. The rooms with the greatest problems are the living room and bedrooms where the air intakes are located.

Observed findings

- There is a great deviation between the measured flows and the required ventilation according to the Technical Building Code (CTE). It is also observed that a large percentage of the rooms do not meet the CTE requirements, as the ventilation is insufficient (Figure 17).
- The required ventilation rate of air entering in the apartments is according to the regulations, but this air does not enter through the supply rooms.
- The minimum airflow rates that are considered necessary for proper indoor air quality are not achieved in supply rooms.

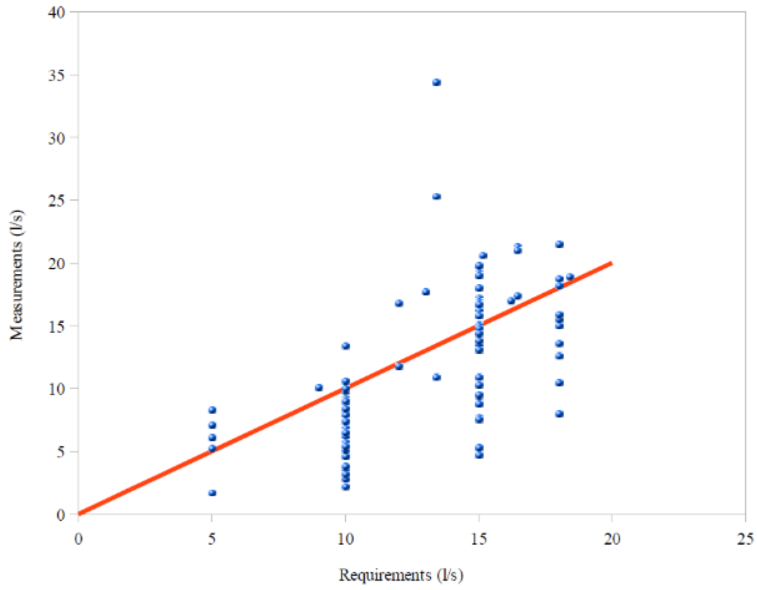


Figure 17 Airflow rate measurements versus minimum required ventilation rate according to CTE. Measurements below the line are lower than minimum.

Lessons to be learned

- It is necessary to establish a criterion for the ventilation airflow rate and control its compliance

References and contact information

Documents:

- Analysis of Ventilation of Dwellings in Spain in Relation to Technical Building Code Using Tracer Gas Techniques. International Journal of Ventilation. ISSN 1473-3315, Volume 11, No 3 December 2012.

Contact persons:

- M. Odriozola Maritorena, J.M. Lizarraga Sala, K. Martin Escudero, C. García-Gáfaro, C. Escudero Revilla

Website, links:

- www.ijovent.org/doi/pdf/10.5555/2044-4044-11.3.271

III.3.6 Efficiency of night ventilation technique

Brief description of the study

Two hundred fourteen residential buildings have been selected among data included in a data base involving more than 800 night ventilated residential and commercial buildings in Greece. Projects are selected to present common characteristics and a wide spectrum of specific cooling needs and night air flow rates. In particular, all buildings are mechanically air conditioned, present a quite high thermal mass level, and are located in zones of similar climatic conditions. All cases are single houses, and their surface ranges between 55 and 480 m^2. The buildings present the whole spectrum of cooling load levels, from very low (5k $Wh/m^2/y$) to very high (90 $kWh/m^2/y$), while the applied air changes per hour vary between 2 and 30. The considered buildings are typical residential constructions insulated with 5 - 10 cm of insulation materials. Insulation is usually put in the middle of the walls and at the exterior of the roof. In most case, glazing is limited up to 20% of the total building surface. Almost all windows are solar protected and internal gains are quite similar. The thermal capacity per unit of surface is of the same order of magnitude for most of the buildings. Typical constructions consist of: Cavity walls with 5 - 10 cm of insulation. The interior part consists of plaster plus bricks of 9 cm with a thermal capacity of 0,84 J g^{-1} K^{-1}, and a U value close to 0,5 $W/m^2/K$. Roofs are insulated from the exterior and consist of plaster plus exposed concrete of 20 cm with a U value close to 0,4 $W/m^2/K$.

Observed findings

It has been found that night ventilation applied to residential buildings may decrease the cooling load up to 40 $kWh/m^2/y$ with an average contribution close to 12 $kWh/m^2/y$. Given that the utilisability of the energy offered by night ventilation techniques increases as a function of the initial cooling needs of the buildings, those with high cooling loads benefit a much higher absolute contribution than buildings presenting a low cooling demand. The correlation between the cooling needs of the buildings and the energy contribution of night ventilation is found to be almost linear.

Lessons to be learned

The whole analysis permits to better understand and evaluate the expected energy contribution of night cooling techniques

References and contact information

Documents:
- On the efficiency of night ventilation techniques applied to residential buildings
- Published paper in Energy and Buildings 42 (2010) 1309-1313

Contact persons:
- Santamouris, M., Sfakianaki, A., Pavlou, K.

Website, links:
- www.elsevier.com/locate/enbuild

III.3.7 Measurements of particulates PM10, PM2.5 and PM1 in Greece

Brief description of the study

Measurements of particulate matter (PM), PM10, PM2.5 and PM1 have been performed in residential buildings, schools, Universities, Sport Centres, Airports, Hospitals and Clinics, Museums, Offices and Night Bars. The size of these particles is subdivided into several groups depending on their diameter. If the particle diameter is less than 10 μm, it is called PM10, if the particle diameter is less than 2.5 μm, it is called PM2.5, etc. Measurements have been performed by various research groups in Athens, Salonica and some other major cities in the country. The aim of this study is to report in a comparative way the actual situation in the country and propose the necessary measures to improve indoor environmental quality.

Observed findings

The indoor concentration of PM10 varies as a function of the concentration of the outdoor environment, the processes in the building and the ventilation rate.

In the developed world, indoor concentration varies between 20-150 μg/m^3, while in the developing world, the concentration is much higher and may rise up to 15.000 μg/m^3.

The indoor concentration of PM10 has been measured in 52 residences in Athens. The concentration depends highly on the presence of smokers in the space. In environmental tobacco smoke (ETS) free buildings the concentration of PM10 is around 50 μg/m^3, while when ETS is present the average concentration may rise up to 200 μg/m^3 (Figure 18).

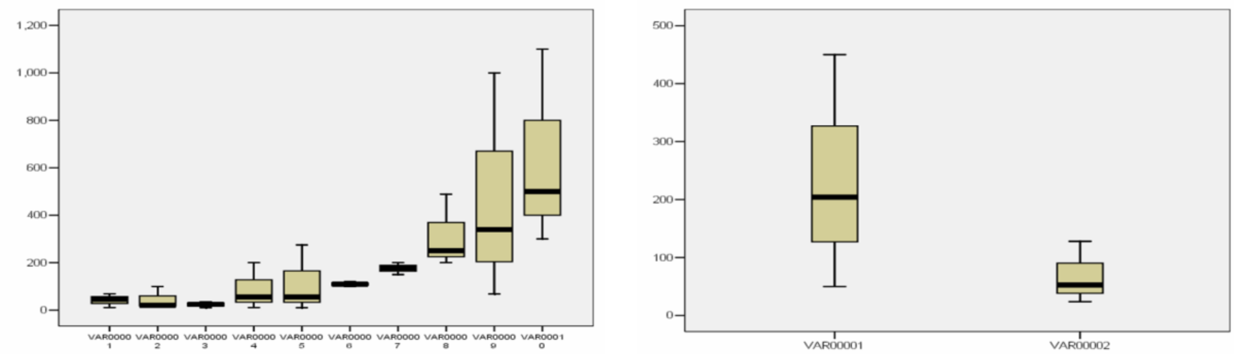


Figure 18 Concentration of PM10 in Residences, (μg/m3) (left) and concentration of PM10 in buildings in Athens, (μg/m3) (right).

In parallel, in the developed world, indoor concentration of PM2.5 varies between 20-50 μg/m^3, while in the developing world, the concentration is much higher and may rise up to 8.000 μg/m^3, especially when biomass is used.

The indoor concentration of PM2.5 has been measured in many residences in Greece. The concentration depends highly on the presence of smokers in the space. In ETS free residences the concentration of PM2.5 is around 20-40 μg/m^3, while when ETS is present the average concentration may rise up to 100 μg/m^3.

Lessons to be learned

The aim of this study is to report in a comparative way the actual situation in the country and propose the necessary measures to improve indoor environmental quality.

References and contact information

Documents:

- Indoor Particulates Pollution In Greece

Contact persons:

- Santamouris, M.

III.3.8 Measurements of indoor pollutants in Athens

Brief description of the study

Measurements of indoor pollutants have been performed in 50 residences in Athens. The concentration of CO_2, CO, TVOC's and PM2.5, PM10 has been monitored together with indoor temperature and humidity. Previous research of indoor air quality problems in Greece, has shown that the selected pollutants are the most important ones. The ventilation rate has been estimated using continuous CO2 measurements. |Almost the totality of residential buildings in Greece is naturally ventilated. During the measurements period, all openings remained closed and ventilation was achieved only through infiltration. This is the standard procedure followed in residential buildings during the winter period. Infiltration rate of dwellings in Athens varies between 0,5 to 1,5 ach as a function of the quality of the envelope. Measurements have been performed during the winter period of 2004 and in particular between December 2003 and April 2004.

Observed findings

The maximum indoor concentration of indoor pollutants varied between 400 to 1.800 ppm.

In almost 70 % of the houses the maximum concentration exceeded 600 ppm, while in 25 % of the dwellings exceeded 1.000 ppm. The mean air flow rate was close to 1,1 ach. Almost 95 % of the dwellings presented a flow rate below 2 ach. (Figure 19)

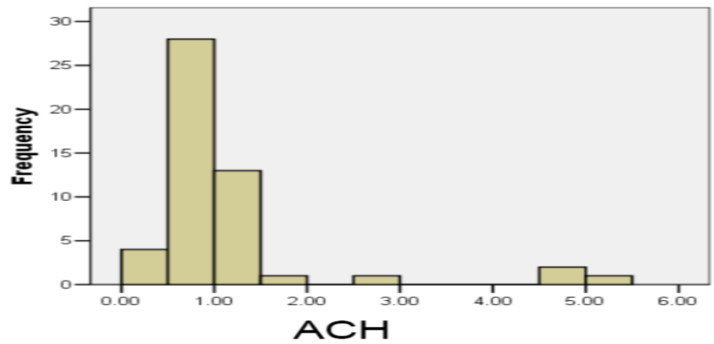


Figure 19 Air flow's frequency

Lessons to be learned

It is evident, that indoor pollution is a major problem for dwellings in Athens. Given that a very clear correlation between the indoor pollutants and the ventilation rate has been found, increased ventilation rates may contribute highly to improve indoor environmental quality of households.

References and contact information

Documents:

- Indoor Air Quality In Fifty Residences In Greece

Contact persons:

- Santamouris, M., Argiroudis, K., Georgiou, M., Pavlou, K., Assimakopoulos, M., Sfakianaki, A.

III.3.9 Airtightness of windows (on the market) and building envelope in apartment buildings

Brief description of the study

The study ("Ensuring thermal and physiological comfort in occupied spaces with reduced energy consumption") included a documentary analysis and experimental research performed "in vitro" and "in situ" focused on the effective performance of windows existing in the Romanian market and on the airtightness of existing buildings including various window types (1 individual house and 5 apartments in collective buildings).

The studies were reported in the research contracted by the National Building Research Institute (INCERC Bucharest) with the Ministry of Regional Development and Tourism (2008-2010).

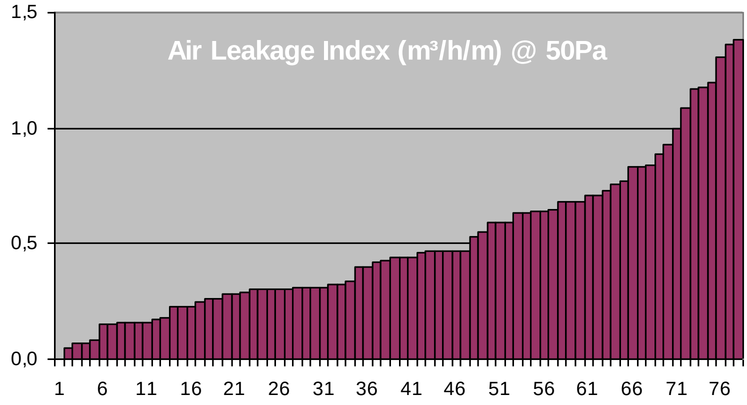


Figure 20 Air leakage index of windows

Observed findings

Tests performed on 79 windows in the Laboratory for Thermal Protection of Buildings within INCERC Bucharest, showed a large variation of "air leakage index", but limited to 1,35 $m^3/h/m$ @ 50Pa. The average is around 0,50 $m^3/h/m$ @ 50Pa and the results are characteristic for the current insulating windows market.

Other tests performed this time on whole living units (1 individual house + 5 apartments) showed the following characteristics related to:

- Windows: air permeability of 9,0 to 27 $m^3/h/m^2$ @ 50Pa
- Envelope: air permeability of 3,2 to 6,8 $m^3/h/m^2$ @ 50Pa

and the air change rate (na @ 50Pa) of 5,1 to 6,8, with a high value of 12,4 h-1 for a small one room apartment.

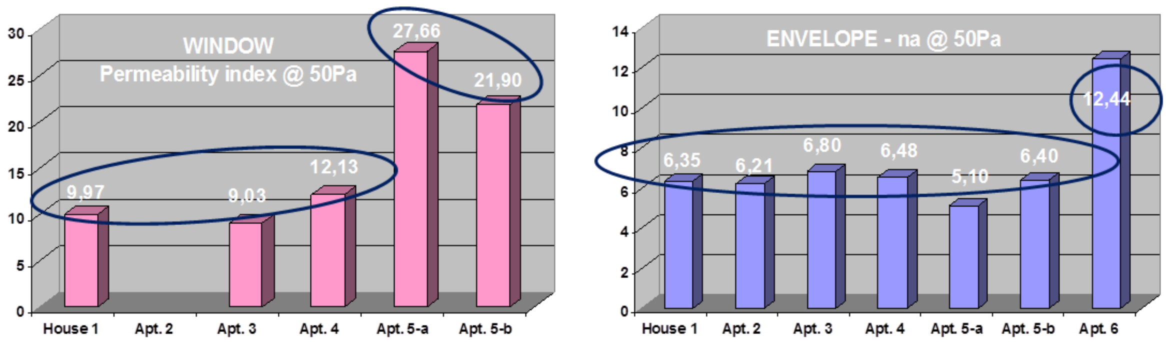


Figure 21 Air permeability index of windows (left) and envelope air change rate (right)

The study analysed also the problems related to indoor air quality in educational buildings.

Without any experimental work performed, the research addressed the ventilation practices for occupied spaces in schools or public buildings, which differ from those for residential buildings. Many studies on indoor air quality, ventilation and building-related health problems in schools has shown that ventilation is inadequate in many classrooms and was considered to be the main cause of health symptoms.

Moreover, the research showed that poor indoor air quality in school buildings can cause a reduction in the students' performance; whereas good air quality in classrooms can enhance children's concentration and also teachers' productivity. Therefore the ventilation requirements for are focused on minimum air flow per person. Ventilation needs are much higher because of people concentrated in closed spaces over extended periods of time, and the required ventilation rate has to be assessed.

Theoretical and experimental studies focused to Romanian schools showed that direct and natural ventilation is not effective for adequate indoor air quality.

Concerning the major rehabilitation programme for schools, the result is not in favour of indoor environment, the refurbishment works resulted in increased air tightness, but no controlled ventilation system installed.

The evaluation of energy performance of buildings within the EP certification scheme denotes in many cases an error in considering the ventilation strategy used in educational buildings. Basically, if no mechanical ventilation system exists in the building, then the value for residential spaces is used in EPC calculations, which can artificially "improve" the energy performance of the certified building, while the reality is that the indoor air quality is not acceptable.

Thus, a correct evaluation is to be done by considering the minimum ventilation rate for occupancy hours and low ventilation for long breaks, while providing a penalty value in the rated energy value for the inadequate ventilation system.

This is related both to the quality of the EPC issued for education buildings and to the requirements to ensure a good quality of indoor environment at design and implementation phases.

References and contact information

Documents:

- Ensuring thermal and physiological comfort in occupied spaces with reduced energy consumption, Contract nr. 342 / 2008 (INCERC Bucharest)

Contact persons:

- Dan Constantinescu, Horia Petran – INCD URBAN-INCERC

III.4 Ventilation and air tightness - Quality of the works

III.4.1 Experiences with ventilation performances in practice

Brief description of the study

The project OPTIVENT, carried out between 2010 and 2013, aimed to point out ventilation problems and solve them. In this context, a bunch of 50 dwellings were tested. Most of these dwellings were recently built and had to respect the EPB regulation (the regulations give the required air flows via the norm NBN D 50-001). In terms of ventilation, they had mechanical ventilation systems, type C (natural supply and mechanical exhaust) or D (balanced mechanical ventilation).

The measurements concern the airflow rates, the noise level, the electric consumption of the fan(s) and the air quality (microbiological aspects). In addition, a qualitative assessment was done.

NB: In the following points, we focus on the airflow rates, however interesting conclusions could be made on the others aspects such as electricity consumption.

Observed findings

In more than 50% of the tested spaces, the measured installed airflow rates were below the required airflow rates. However, on average for the whole tested sample, the airflow rates in these spaces are not far from the required ones. Moreover, in most of the dwellings, the total of the measured airflow rates is not far from the total of the required airflow rates. The reason is that, in a given dwelling, the balancing of the air flow between different rooms is poor with as result that some airflow rates are too low and others too high.

Lessons to be learned

The main lesson learned is that the ventilation installations are too often incorrectly adjusted: too high flow rates in some spaces and too low in other ones. Recommendations and tools for installers are needed.

Assessment – follow-up actions

Guidelines and tools are now available on the website www.optivent.be. This tool enables the sizing of the ducts, the selection of the fans and describes also a set procedure. In addition, guidelines for airflow rate measurements are proposed (type of methods, conditions of measurement, etc.) in order to support installers in the compliance checking.

References and contact information

Documents:
- See website

Contact persons:
- Samuel Caillou, BBRI

III.4.2 Airtightness of building envelope

Brief description of the study

Air tightness of 20 single-family buildings was measured under natural conditions and under a 50 Pa pressure difference between indoor and outdoor environment. The buildings were rated according to their measured air tightness.

Observed findings

Results of the study showed that 25% of the buildings correspond to high level, 45% to medium level and 30% to low level.

Air change rate (h^{-1}) at 50 Pa	Ventilation rate ((h^{-1}) for naturally ventilated single family houses	Envelope tightness level
10	1,5	Low
4-10	0,8	Medium
4	0,5	High

Table 9 Air tightness levels for natural ventilated, non-shielded single-family buildings

According to a statistical evaluation, the samples of buildings that belong to the ‘‘low air tightness level’’ category are statistically homogeneous. The samples of buildings that belong to the ‘‘medium/high air tightness level’’ categories are statistical uneven.

References and contact information

Documents:

- Air tightness measurements of residential houses in Athens, Greece
- Building and Environment 43 (2008) 398–405

Contact persons:

- Sfakianaki, A., Pavlou, K., Santamouris, M., Livada, I., Assimakopoulos, M.-N., Mantas, P., Christakopoulos, A.

Website, links, …

- www.sciencedirect.com/science/article/pii/S0360132307000091

III.4.3 Quality of ventilation systems in new dwellings

Brief description of the study

This analysis, based on French regulatory compliance controls and performed only on ventilation regulation (among 7 other regulations including energy performance), gives clear information about ventilation dysfunctions localisation and qualification. Up to now, only 1.287 dwellings have been analysed through 373 control reports performed between 2008 and 2011. Nearly all dwellings of the sample are equipped with simple exhaust mechanical ventilation. Humidity demand-controlled ventilation accounts for 74% of the sample. Balanced ventilation is found only in 10 single-family dwellings. The statistical analysis of this sample reveals that 604 dwellings out of 1.287, that is 47% of the sample, do not comply with the ventilation regulation. It also means that 47% of the sample present at least one non-compliance remark. The non-compliance rate is 68% for single-family dwellings, and 44% for multi-family dwellings.

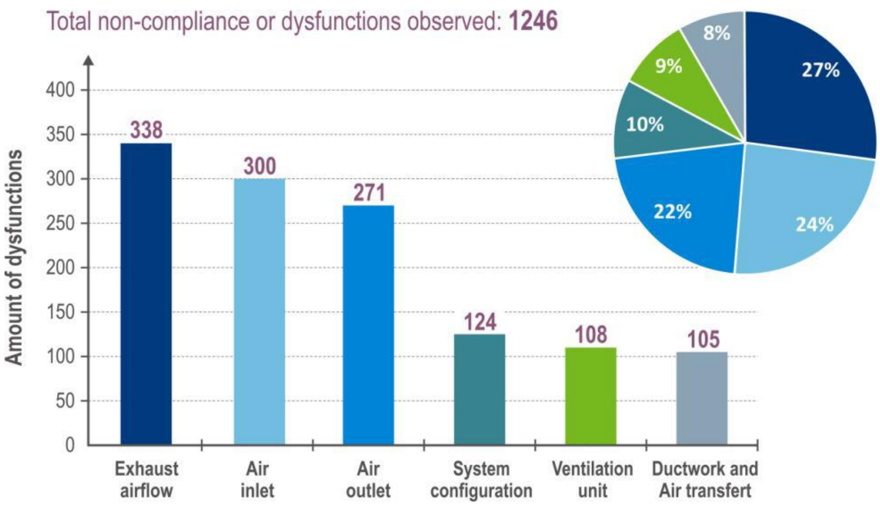


Figure 22 Ventilation dysfunctions

Observed findings

- ventilation installation verification is rarely planned during the construction phase;
- ventilation system commissioning control is not systematic or is incomplete;
- in-site ventilation system mounting is often far from the expected quality;
- even if adapted industrial solutions are available, ventilation system dysfunctions are very frequently observed

Lessons to be learned

- Ventilation commissioning is an absolutely necessary step to ensure a well working installation upon receipt, with an in-use performance corresponding to the planned one.
- Many dysfunctions could be avoided through the implementation of quality management tools.

Assessment - follow-up actions

- The on-going "VIA-Qualité" project will go further on reasons and solutions to improve ventilation systems quality once these are installed.
- The French Effinergie+ label plans to reinforce ventilation controls, introducing ventilation airflows and duct leakage measurements at commissioning.

References and contact information

Documents:

- Detailed analysis of regulatory compliance controls of 1287 dwellings ventilation systems. Proceedings of the 34th AIVC - 3rd TightVent - 2nd Cool Roofs' - 1st venticool Conference , 25-26 September, Athens 2013

Contact persons:

- Romuald Jobert, Gaëlle Guyot, gaelle.guyot@developpement-durable.gouv.fr

Website, links:

- www.aivc.org/sites/default/files/140.1367584004.full_.pdf

III.4.4 Quality of ventilation systems

Brief description of the study

In late 2011 The Building Services Research and Information Association (BSRIA) undertook a small independent study on 40 random properties constructed by different builders, with various ventilation systems employed to the requirements contained in the 2010 version of the Building Regulations to assess their performance characteristics. It found that that 95% of everything initially evaluated failed to meet the requirements of the Building Regulations with some installations having a number of failure modes.

Observed findings

Value	Description
33 (82.5%)	Ductwork incorrectly fitted (kinked / bent / poor joints / excessive length)
10 (25%)	Undersized fans to meet the minimum ventilation requirement
6 (15%)	Insufficient fans or terminal outlets for dwelling type
3	No boost function
3	Incorrect installation data
2	Missing ductwork
1	Blocked ductwork

Table 10 Ventilation system failure modes in a study of 40 dwellings

The ventilation systems design was regularly compromised with inadequate installation, inspection and commissioning, along with the instrumentation used providing data that was wholly incorrect.

Lessons to be learned

- Only firm implementation of the existing Regulations by the Building Control officers are likely to have a significant change on the overall quality of the construction works.

Assessment - follow-up actions?

- Steps in the right direction are currently being made, with for example the production of a freely available flow measurement guide

References and contact information

Documents:

- Quality of ventilation systems in residential buildings: status and perspectives in the UK. Air Infiltration and Ventilation Centre (AIVC) International Workshop Proceedings 18-19 March 2013

Contact persons:

- Alan Gilbert, alan.gilbert@bsria.co.uk; Chris Knights, chris.knights@bsria.co.uk

Website, links:

- www.aivc.org/

III.4.5 Performance and quality of mechanical ventilation in dwellings

Brief description of the study

Presented are the results of a Dutch national study into performance of mechanical ventilation systems. Ventilation systems with natural supply and mechanical exhaust ventilation (MEV) and balanced mechanical supply and exhaust systems with heat recovery (MVHR) were investigated. Surveys were performed in 299 homes, which included visual inspections and measurements of ventilation rates per room and installation noise levels. An additional survey regarding perceived indoor air quality and self-reported health was completed per household.

Observed findings

- In 48% of the dwellings with balanced mechanical ventilation the total air supply rate was insufficient (<0,7litre/s/m2), while the air supply rate in 85% of dwellings was insufficient in one or more rooms in comparison with the Dutch Building Code.
- Total air exhaust rates were insufficient in 55% of the dwellings with balanced ventilation and in 69% of the dwellings with mechanical exhaust.
- The exhaust rates in one or more rooms did not comply with the standards in 80% (MVHR) and 76% (MEV) of the dwellings.
- Noise levels are higher than 30 dB(A) in one or more bedrooms in 86% of homes with MVHR in the setting in which the ventilation system is providing a sufficient ventilation rate (>0,7litre/s) in many dwellings (or in the highest setting if the ventilation rate is insufficient).
- High noise levels are in part caused by incorrect placement of (flexible) ductwork, for example sharp bends.
- In most cases, the ventilation unit is placed at position that will increase the chances of ventilation noise (53% of MVHR and 67% of MEV).
- Silencers are not properly installed on either air supply or exhaust duct (66 of MVHR).
- Ductwork is not properly installed (48 of MVHR and 40 % of MEV).

Lessons to be learned

In many instances where mechanical ventilation systems show problems, the installer, the contractor, the developer, the architect and the end-user are all to blame. The underlying problems seem to be improper design requirements, a lack of quality assurance, lack of inspection and enforcement of the building code and a too small budget. Another potential factor is the lack of coordination between the design team, the engineer and the installer, leading to contradictions on site that result in compromised installations.

Assessment – follow-up actions

- Process-related recommendations to guarantee better performance of mechanical ventilation systems are presented in the article.

References and contact information

Documents:

- Mechanical ventilation in recently built Dutch homes: technical shortcomings, possibilities for improvement, perceived indoor environment and health effects, Architectural Science Review, 55:1, 4-14

Contact persons:

- Jaap Balvers , Rik Bogers , Rob Jongeneel , Irene van Kamp , Atze Boerstra & Froukje van Dijken

Website, links:

- http://dx.doi.org/10.1080/00038628.2011.641736

III.4.6 Duct leakage in air distribution systems

Brief description of the study

To investigate the implications of duct leakage, a field study was performed on 42 duct systems in Belgium and France. The measurement data confirm the findings of the few earlier experimental investigations on these matters in Europe. In this sample, the leakage rate appears to be typically three times greater than the maximum permitted leakage adopted in EUROVENT 2/2 (Class A). The advantages of tight ducts are illustrated with a theoretical case study on a balanced ventilation system with heat recovery. It indicates that the overall effectiveness of the system reduces drastically if the ducts are leaky. The savings potential of an airtight duct policy at the European level is calculated (a) based on estimates of the number of buildings equipped with mechanical ventilation systems, and (b) assuming market penetration scenarios of rehabilitation techniques.

Observed findings

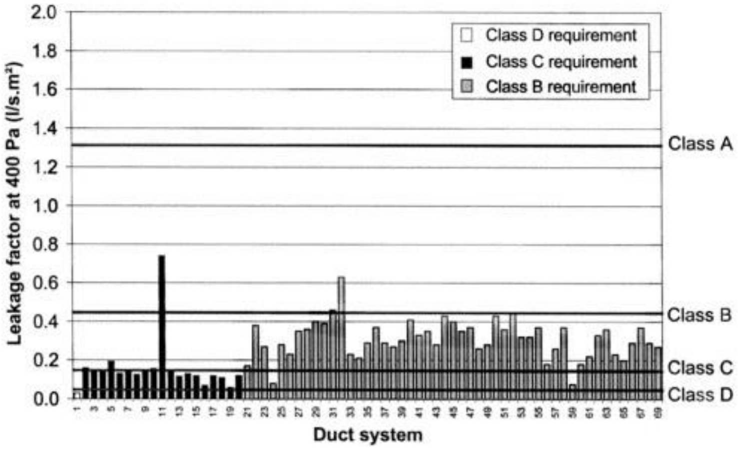


Figure 23 Leakage factor at 100 Pa for the investigated systems in Belgium.

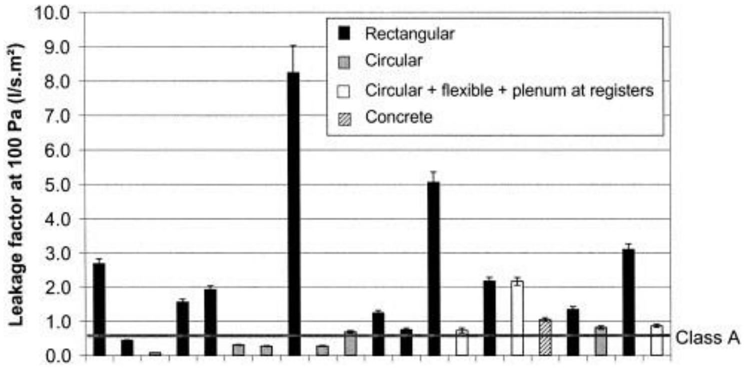


Figure 24 Leakage factor at 100 Pa for the investigated systems in France.

- The tested duct systems are in general very leaky (typically three times leakier than Eurovent Class A). The reason for such poor performances seems to lie in the lack of attention paid to these systems and the technologies adopted. In fact, in these countries, installation is most often done using conventional in situ sealing techniques (e.g. tape or mastic). Therefore, the ductwork airtightness is very much dependent upon the workers' skills.
- Duct leakage can have a severe impact on the ventilation rates and energy consumption of a building.

Lessons to be learned

- A major barrier towards tighter systems lies in cost issues.
- Additional investment cost (if any) for quality-products should be looked at along with the potential savings on labour cost. In addition, significant energy savings can be achieved with tight ducts, which will have a positive effect on the Life Cycle Cost of the system.
- The analyses presented in this paper show that ventilation and energy use implications of leaky ducts in European buildings are also very large and merit further examination.

References and contact information

Documents:

- Energy saving potential in Europe, Duct leakage in European buildings: status and perspectives, Energy and Buildings 32 (2000)

Contact persons

- François Rémi Carrié, Alain Bossaer, Johnny V. Andersson, Peter Wouters, Martin W. Liddament

Website, links

- www.sciencedirect.com/science/article/pii/S0378778800000499#
- http://dx.doi.org/10.1016/S0378-7788(00)00049-9

III.4.7 Experiences with building air tightness in practice

Brief description of the study

The study was performed by Ghent University in order to study the evolution of achieved air tightness in building practice as a function of construction date, and in order to study the difference between 'mainstream' workmanship and results obtained by the 'engaged' market. The study is based on airtightness measurements in 44 randomly selected, standard new built single family houses in Belgium ('group 1' in Figure 25). The results are compared with those from a previous study in the early 1990's (SENVIVV), with a database that was compiled with results from 161 air tightness reports executed on newly built dwellings by private party consultants ('group 2'), and with the entries in the governmental EPBD-database (1884 measurements).

Observed findings

The results show that the mean leakage rate is about 6 ACH50 for the randomly selected houses ('group 1') and 3 ACH50 for the houses in the databases (EPBD and 'group 2'). The houses in the databases are tested upon the initiative of the owner and are a reference for dwellings that are intended to be airtight. Therefore, the attention to airtight workmanship is substantially higher for these cases than in the randomly selected houses. However, compared to the situation in the 1990's the results show that the airtightness achieved in current construction practice has improved in general.

Lessons to be learned?

The results demonstrate the substantial difference between the air tightness achieved by 'mainstream' workmanship and results obtained by the 'engaged' market. Since a large portion of the leakage can be attributed to differences in design and workmanship measures are needed to improve the quality of both and further improve airtightness of buildings. The results further show that when a pressurisation test is required by the owner, the designer and contractor improve the workmanship, even when no airtightness requirement is imposed.

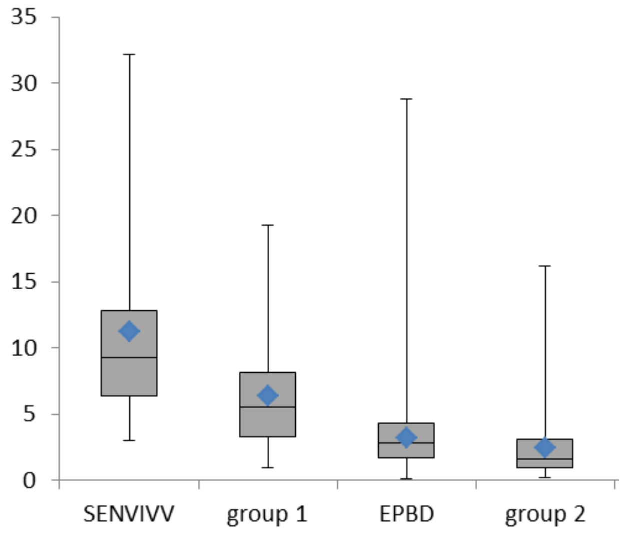


Figure 25 Air leakage rate in single family houses

Assessment – follow-up actions?

One of the Belgian regions is considering the possibility to relate the systematic measurement of building airtightness to requirements for Nearly Zero Energy Buildings.

References and contact information

Documents:

- Airtightness assessment of single family houses in Belgium, Jelle Laverge, Marc Delghust, Nathan Van Den Bossche and Arnold Janssens (UGent), (2014) INTERNATIONAL JOURNAL OF VENTILATION. 12. p.379-390

Contact persons:

- Arnold Janssens, Jelle Laverge, Ghent University

III.5 Renewables - Input data

III.5.1 Performance of residential PV systems: France

Brief description of the study

The main objective of this paper is to review the state of the art of residential PV systems in France. This is done through analysing the operational data of 6.868 installations.

Observed findings

- After a mean exposure time of 2 years, the mean value of Performance Ratio (PR) is 76% and the mean Performance Index (PI) is 85%, which implies that the typical real PV system produces 15% less than a reference PV system.
- On average, the real power of the PV modules falls 4.9% below their corresponding nominal power announced on the manufacturer's datasheet.
- A brief analysis by PV modules technology has led to relevant observations for two technologies. On the one hand, the PV systems equipped with HIT (Heterojunction with Intrinsic Thin layer) modules show performances higher than average. On the other hand, the systems equipped with the CIS (chalcopyrite) modules show a real power that is 16% lower than the nominal value.

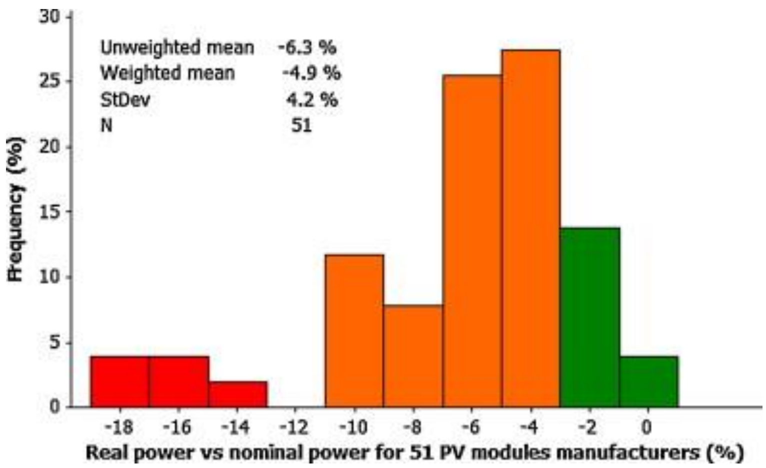


Figure 26 Histogram of the deviation of the real power of the PV modules respect to their nominal power. On average, the PV modules real power falls 4.9% below their corresponding nominal power.

References and contact information

Documents:

- J Leloux, L Narvarte, D Trebosc. Review of the performance of residential PV systems in France Renewable and Sustainable Energy Reviews 16 (2), 1369-1376

Contact persons:

- Jonathan Leloux, Luis Narvarte, David Trebosc

Website, links:

- www.sciencedirect.com/science/article/pii/S136403211100517X

III.5.2 Performance of residential PV systems: Belgium

Brief description of the study

The main objective of this paper is to review the state of the art of residential PV systems in Belgium by the analysis of the operational data of 993 installations. For that, three main questions are posed: how much energy do they produce? What level of performance is associated to their production? Which are the key parameters that most influence their quality?

Observed findings

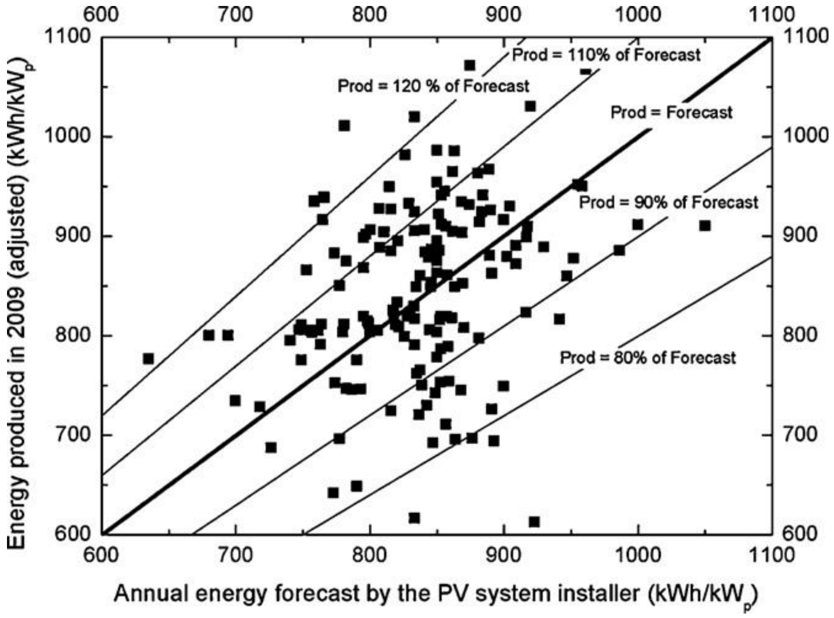


Figure 27 Regression analysis between the energy produced in 2009 by the PV systems and the corresponding production expected by the PV system owner. No significant correlation is visible

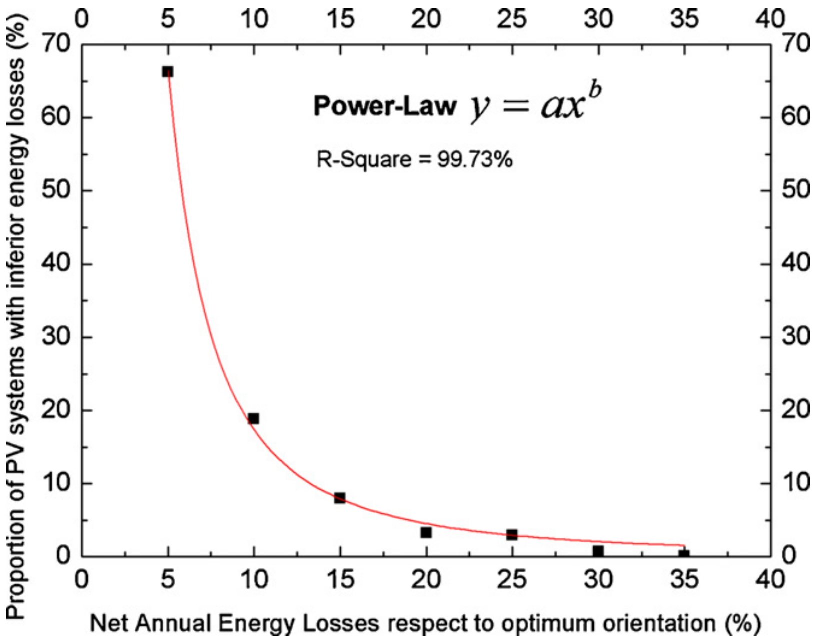


Figure 28 Proportion of PV systems (in percent) oriented so that they lose less than a given percentage of net annual energy respect to the optimum orientation. Almost 70% of the PV systems lose less than 5% of annual energy due to their orientation, and less than one fifth lose more than 10%.

- The quality of the PV systems is quantified using the performance ratio, and the performance index. After a mean exposure time of 2 years, the mean value of performance ratio is 78% and the mean performance index of the PV systems is 85%, which implies that the typical real PV system produces 15% less than a very high quality PV system (or reference PV system).
- A middling commercial PV system, optimally oriented, produces a mean annual energy of 892 kWh/kWp.
- The mean performance ratio is 78% and the mean performance index is 85%.
- The energy produced by a typical PV system in Belgium is 15% inferior to the energy produced by a very high quality PV system.
- On average, the real power of the PV modules falls 5% below its corresponding nominal power announced on the manufacturer’s datasheet.
- Differences between real and nominal power of up to 16% have been detected.

References and contact information

Documents:
- Leloux, J., Narvarte, L., Trebosc, D. Review of the performance of residential PV systems in Belgium. Renewable & Sustainable Energy Reviews. 2012, 16(1), 178-184.

Contact persons:
- Leloux, J., Narvarte, L., Trebosc, D.

Website, links:
- www.sciencedirect.com/science/article/pii/S1364032111003923

III.5.3 Performance of domestic small-scale wind turbines: UK

Brief description of the study

Energy Saving Trust's field trial report on domestic wind turbine illustrates the technical factors that impact the performance of domestic small-scale wind turbines, including installation and proper siting. The field trial was developed and launched in January 2007. In total 38 building mounted turbines and 19 free standing turbines were investigated. Field trial sites included urban, suburban and residential areas; agricultural farms and remote community schemes.

Observed findings

- The building mounted turbines did not approach the commonly quoted load factors of 10 %.
- No urban or suburban building mounted sites generated more than 200 kWh per annum, corresponding to load factors of 3 % or less.
- In some cases, installations were found to be net consumers of electricity due to the inverter taking its power from the main supply when a turbine was not generating.
- Lower than anticipated performance figures were primarily due to inappropriate installations, both in terms of locations with a poor wind resource and positioning.
- The performance of free standing turbines frequently exceeded commonly quoted annual load factors of 17 %.
- Free standing turbines sited in built up areas did not perform as well, again due to the insufficient wind resource.
- Accurate wind speed data is not readily available for many potential customers of domestic small-scale wind turbines, especially those in urban locations.

Lessons to be learned

- Wind turbines do work but only when installed properly in an appropriate location.
- Average annual wind speed of the site should be at least 5 m/s.

Assessment - follow-up actions?

- The Microgeneration Certification Scheme (MCS) will aim to provide customers with the highest level of assurance in terms of product and installers.
- The Energy Saving Trust has consulted with relevant stakeholders to discuss these improvements and identify future actions to provide better information to potential consumers.

References and contact information

Documents:
- Location, location, location: Domestic small-scale wind field trial report. 2009

Contact persons:
- Simon Green
- Jaryn Bradford

Website, links:
- www.energysavingtrust.org.uk/sites/default/files/reports/Location_Location_Location_field_trial_small-scale_wind_report%20%282%29.pdf

III.5.4 Heating and cooling solutions with efficient systems

Brief description of the study

The study was aimed for the analysis of the variation in rates of energy efficiency and EPC rates, in tertiary building of hotel use, through the simulation of various energy scenarios to implement them in different heating and cooling solutions based on efficient equipment.

54 simulations were implemented in real tertiary buildings of hotel use, with different dimensions (hotels of 35, 71 and 120 rooms) and in different climatic zones (B3, C2, C3, D2, D3, E1), covering a wide range of solutions and possibilities to be able to extrapolate the findings obtained from the study.

The study compares the current situation (using standard systems available in the market), with more efficient solutions for heating and cooling, as listed below:

	Current Situation	Improved Situation	Hotels	Climatic zones
Solution 1	Gas boiler	Condensing gas boiler	35, 71, 120 rooms	D2, D3, E1
Solution 2	Heat pump (over 10 years, low energy performance and poorly maintained)	Efficient heat pump (DHW, heating and cooling)	35, 71, 120 rooms	B3, C3, D3
Solution 3	Cooling system (over 10 years, low energy performance and poorly maintained)	Efficient cooling system (just cooling)	35, 71, 120 rooms	B3, C2, C3

Table 11 Simulation variants

The different combinations were analysed by means of a simulation of the energy needs and the energy consumption of each one of them, both in winter and summer, with the facilities simulated in every situation in order to cancel its effect on the change of the EPC.

Observed findings

For each of the solutions scenarios in study, the results are analysed based on the CO_2 emission ($kgCO_2/m^2$), the primary energy consumption, the final energy consumption, calculating the savings between both situations. The obtained results are featured in Table 12.

Climatic zones in Spain are identified by a combination of letters for winter and numbers for summer, being A the less cold and E the coldest, 1 the less hot and 4 the hottest. For instance Madrid is D3 Cold in winter and Hot in summer.

	SOLUTION 1				SOLUTION 2				SOLUTION 3			
	Gas boiler VS Condensing gas boiler				Heat pump (over 10 years) VS Efficient heat pump				Cooling system (over 10 years) VS Efficient cooling system			
SAVINGS	Climatic zone	Total emissions	Primary energy consumption	Final energy consumption	Climatic zone	Total emissions	Primary energy consumption	Final energy consumption	Climatic zone	Total emissions	Primary energy consumption	Final energy consumption
HOTEL		%	%	€/m²		%	%	€/m²		%	%	€/m²
35 ROOMS	D2	45,9	28,69	9,05	B3	15,23	15,22	1,92	B3	14,43	14,40	1,32
	D3	44,5	32,45	7,78	C3	18,25	18,32	2,75	C2	14,22	14,34	1,14
	E1	46,9	32,45	10,68	D3	18,97	18,99	2,93	C3	12,98	13,15	1,09
71 ROOMS	D2	44,2	32,42	7,28	B3	14,76	14,85	1,08	B3	10,75	10,84	0,37
	D3	10,48	30,43	5,67	C3	16,01	16,01	1,36	C2	7,36	7,33	0,23
	E1	45,4	33,21	8,65	D3	16,35	16,41	1,43	C3	9,83	9,96	0,31
120 ROOMS	D2	42,25	30,78	5,87	B3	12,2	12,27	1,13	B3	19,54	19,67	1,26
	D3	41,15	29,77	5,29	C3	13,2	13,06	1,5	C2	18,36	18,53	1,04
	E1	43,47	31,75	6,90	D3	15,2	15,08	1,62	C3	17,74	17,56	1,06

Table 12 Summary results

Lessons to be learned

After the energy simulation of the models, different energy ratios were obtained and are used to compare the energy consumption obtained and to determine the achievable energy savings, as well as to analyse the variation of the EPC ratings (partial/global). In each situation, the following aspects have been studied in relation to the base case:

- energy savings obtained (primary/final energy);
- CO2 emissions avoided;
- variation of the EPC rating of the building;
- economic equivalent savings.

The conclusions obtained from this study are summarised in Table 13. In general, we can say that in any of the solutions scenarios the replacement by more efficient systems is an improvement, not only in annual savings, but also in a change of the EPC rating, and therefore an improvement of the energy efficiency index. In addition, it can be proved that the percentage of annual savings is set to be in a similar range as other buildings regardless to the size of the hotel and the different climatic zones in which it has been analysed. In the case of replacement of the gas boiler by a condensing gas boiler, we obtain savings between 35,80 and 36,90 %. In case of replacement of the heat pump (over 10 years) by an efficient heat pump, the percentage range of savings is extended between 19,09 and 26,50 %. Finally, in the case of replacement of a cooling system (over 10 years) by an efficient chiller, the saving varies between 35,30 and 45,30 %.

	SOLUTION 1				SOLUTION 2				SOLUTION 3			
	Gas boiler VS Condensing gas boiler				Heat pump (over 10 years) VS Efficient heat pump				Cooling system (over 10 years) VS Efficient cooling system			
SAVINGS	Climatic zone	Annual saving	Initial EPC	Final EPC	Climatic zone	Annual saving	Initial EPC	Final EPC	Climatic zone	Annual saving	Initial EPC	Final EPC
HOTEL		%	Emissions rate			%	Emissions rate			%	Emissions rate	
35 ROOMS	D2	36,82	D (1,14)	B (0,62)	B3	22,48	E (1,31)	D (1,11)	B3	35,65	F (1,70)	E (1,45)
	D3	35,92	D (1,02)	B (0,57)	C3	25,60	E (1,55)	D (1,27)	C2	40,34	F (1,67)	E (1,43)
	E1	36,81	D (1,28)	C (0,68)	D3	26,50	F (1,62)	E (1,31)	C3	35,38	F (1.72)	E (1,49)
71 ROOMS	D2	36,81	E (1,53)	C (0,85)	B3	23,45	E (1,37)	D (1,17)	B3	44,54	D (1,12)	C (1,00)
	D3	36,12	E (1,31)	C (0,76)	C3	23,91	E (1,54)	D (1,29)	C2	42,76	D (1,08)	C (1,00)
	E1	36,39	F (1,70)	C (0,93)	D3	24,15	E (1,53)	D (1.28)	C3	45,30	D (1,11)	C (1,00)
120 ROOMS	D2	36,22	C (0,97)	B (0,56)	B3	19,09	D (1,11)	C (0,97)	B3	42,99	E (1,31)	D (1,05)
	D3	35,82	C (0,90)	B (0,53)	C3	21,59	E (1,37)	D (1,19)	C2	44,65	D (1,21)	C (0,99)
	E1	36,20	D (1,08)	B (0,61)	D3	22,56	E (1,37)	D (1,16)	C3	42,53	E (1,31)	D (1,08)

Table 13 Summary conclusions

Assessment - follow-up actions

A detailed analysis of this study suggests that the installation of efficient heating/cooling systems with higher energy performance has a direct bearing on a substantial improvement of the saving, as well as of the index of energy efficiency.

References and contact information

Documents:

- Analysis and energy simulation of different scenarios of efficient systems in tertiary buildings of hotel use. Analysis of the change in the index of energy efficient and the EPC through the implementation of efficient heating and cooling systems solutions. Studio non-published, commissioned by Gas Natural Fenosa to Applus Norcontrol, S.L.U., Energy Services & Energy Efficiency Unit.

Contact persons:

- Castaño Alarcón, E. elisa.castano@applus.com
- Rodríguez Cuadrado, L.F. luisa.rodriguez@applus.com

III.6 Renewables - Quality of the works

III.6.1 Quality of large solar thermal domestic hot water systems

Brief description of the study

Fifteen large solar thermal hot water systems have been audited (2013) by IZUBA energies in the French region Provence-Alpes-Côte d'Azur, on behalf of regional authorities and ADEME.

These systems are used for dwellings, hotels or residences for elderly people.

A slide presentation available at the link below provides a synthesis of these audits.

Observed findings

Numerous problems are identified on the audited installations:

- wrong dimensioning or design;
- low thermal insulation of piping;
- low insulation of the water storage tanks;
- errors or weak points in the design and installation of the hydronic circuits;
- no technical documentation available, lack of maintenance;
- no measurement devices to check the performance.

Lessons to be learned

Energy performance results are available for 9 installations: 3 of them have a high performance, 3 have a good performance and 3 a low performance.

Assessment - follow-up actions

The presentation proposes among others the following actions that should improve the situation:

- training;
- quality insurance procedures;
- systematic commissioning and maintenance;
- continuous measurements to know and follow the performance.

References and contact information

Website, links, …

- www.solaire-collectif.fr/upload/data/Resultats%20audits%20PACA%2010avril2013.pdf

III.6.2 Quality of solar thermal domestic hot water systems in houses

Brief description of the study

French installation companies of solar thermal systems can apply for the qualification QualiSol, in order to show to customers their skills for installing these systems.

The quality label Qualisol is managed by the French association Qualit'EnR.

Each certified company is submitted to an audit by Qualit'EnR, at least once every three years. The audit consists in looking at the actual quality of an installation.

Between 2007 and 2012, 11.817 installations with a solar thermal domestic hot water system have been audited.

A press release of Qualit'EnR provides some statistical results.

Observed findings

The results of the audits operated in 2012 on solar thermal domestic hot water systems (their number is not indicated) show that:

- 93% of the audited installations have an excellent (70%) or good quality (23%);
- the quality is insufficient for 6% of the audited installations (orange);
- 1,5% of the audits show a failing installation.

The following picture shows how the quality has been improved since 2007.

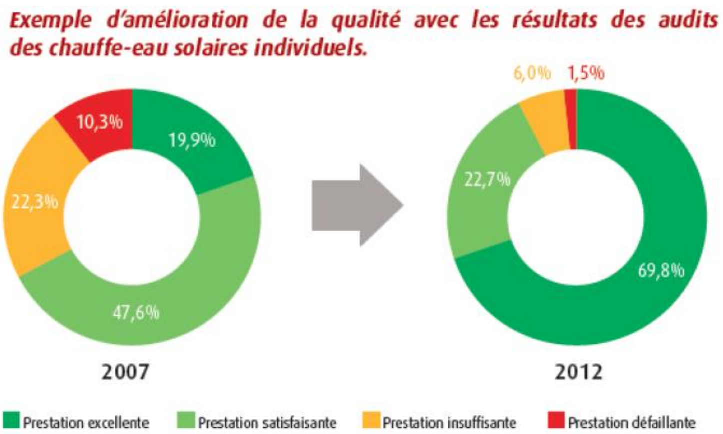


Figure 29 Results of the audits operated in the years 2007 and 2012 by Qualit'EnR on solar thermal domestic hot water systems under the quality label Qualisol. (dark green: excellent, light green: good, orange: insufficient, red: failing)

Lessons to be learned

The most frequent failures are:

- no indication of the trademark and type of the antifreeze liquid used;
- safety valve not fitted to the container;
- container under safety valve not empty or not marked.

Assessment – follow-up actions

Qualit'EnR has developed check-up files that help the installer to control the quality of his own work.

A help line is also available for technical advice.

The journal "Qualit'EnR infos" regularly includes reminders about good practice, based on the failures that have been found during the audits.

References and contact information

Documents:
- Qualit'EnR – Dossier de presse 2013

Website, links, …
- www.qualit-enr.org/presse/
- www.qualit-enr.org/professionnels/audit/Qualisol

III.6.3 Quality of solar PV installations

Brief description of the study

French installation companies of solar photovoltaic systems can apply for the qualification QualiPV, in order to show to customers their skills for installing these systems.

The quality label QualiPV is managed by the French association Qualit'EnR.

Each certified company is submitted to an audit by Qualit'EnR, at least once every three years. The audit consists in looking at the actual quality of an installation.

In the year 2012, 294 installations with a solar photovoltaic system have been audited.

A page of Qualit'EnR website provides their statistical results.

Observed findings

The results of these 294 audits of solar photovoltaic installations show that:

- 77% of the audited installations have an excellent (41%) or good quality (36%);
- the quality is insufficient in 15% of the audited installations (orange);
- 7% of the audits show a failing installation.

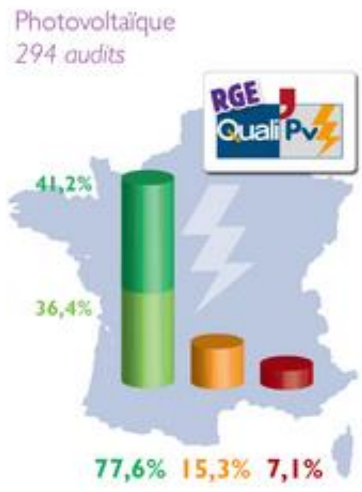


Figure 30 Results of the audits operated in the year 2012 by Qualit'EnR on 294 solar photovoltaic installations under the quality label QualiPV. (dark green: excellent, light green: good, orange: insufficient, red: failing)

Lessons to be learned

The most frequent failures concern the electrical installation and safety aspects:

- signalling not present or not complete;
- equipotential bonding not correctly achieved;
- no or incomplete mechanical protection on the accessible wires.

Assessment – follow-up actions

Qualit'EnR has developed check-up files that help the installer to control the quality of his own work.

A help line is also available for technical advice.

The journal "Qualit'EnR infos" regularly includes reminders about good practice, based on the failures that have been found during the audits.

References and contact information

Website, links, …

- www.qualit-enr.org/professionnels/audit/QualiPV

III.6.4 Quality of domestic wood boiler installations

Brief description of the study

French installation companies of wood boilers can apply for the qualification Qualibois, in order to show to customers their skills for installing these appliances.

The quality label Qualibois is managed by the French association Qualit'EnR. It applies to wood boilers but also to independent wood heating appliances (fireplaces, stoves).

Each certified company is submitted to an audit by Qualit'EnR, at least once every three years. The audit consists in looking at the actual quality of an installation.

In the year 2012, 208 installations with a domestic wood boiler have been audited.

A page of Qualit'EnR website provides their statistical results.

Observed findings

The results of these 208 audits of domestic wood boiler installations show that:

- 97% of the audited installations have an excellent (61%) or good quality (36%);
- the quality is insufficient in 3% of the audited installations (orange);
- there is no failing installation.

Figure 31 Results of the audits operated in the year 2012 by Qualit'EnR on 208 domestic wood boiler installations under the quality label Qualibois. (dark green: excellent, light green: good, orange: insufficient, red: failing)

Lessons to be learned

The most frequent failures are:

- no disconnecting device on the water filling circuit;
- draught moderator on the flue gases exhaust not correctly installed
- incorrect ventilation openings for the room in which the boiler is installed.

Assessment - follow-up actions

Qualit'EnR has developed check-up files that help the installer to control the quality of his own work.

A help line is also available for technical advice.

The journal "Qualit'EnR infos" regularly includes reminders about good practice, based on the failures that have been found during the audits.

References and contact information

Website, links, …

- www.qualit-enr.org/professionnels/audit/Qualibois

III.6.5 Quality of domestic heat pump installations

Brief description of the study

French installation companies of heat pumps can apply for the qualification QualiPAC, in order to show to customers their skills for installing these appliances.

The quality label QualiPAC is managed by the French association Qualit'EnR.

Each certified company is submitted to an audit by Qualit'EnR, at least twice every three years. The audit consists in looking at the actual quality of an installation.

In the year 2012, 319 installations have been audited.

A page of Qualit'EnR website provides their statistical results.

Observed findings

The results of these 319 audits of domestic heat pump installations show that:

- 74% of the audited installations have an excellent (61%) or good quality (13%);
- the quality is insufficient in 19% of the audited installations (orange);
- almost 7% of the audits show a failing installation.

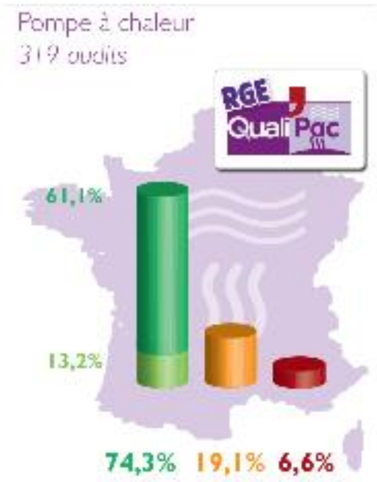


Figure 32 Results of the audits operated in the year 2012 by Qualit'EnR on 319 heat pump installations under the quality label QualiPAC. (dark green: excellent, light green: good, orange: insufficient, red: failing)

Lessons to be learned

The most frequent failures are:

- no completion check report available;
- no commissioning report available;
- no thermal insulation for pipes and fittings in unheated spaces.

Assessment – follow-up actions

Qualit'EnR has developed check-up files that help the installer to control the quality of his own work.

A help line is also available for technical advice.

The journal "Qualit'EnR infos" regularly includes reminders about good practice, based on the failures that have been found during the audits.

References and contact information

Website, links, …

- www.qualit-enr.org/professionnels/audit/QualiPAC

III.6.6 QualiCert - A common approach for certification or equivalent qualification of installers of small-scale renewable energy systems in buildings

Brief description of the study

QualiCert stands for “Common approach for certification or equivalent qualification of installers of small-scale renewable energy systems in buildings”. The QualiCert project has contributed to the development of a European set of common “key success criteria” for certification or equivalent qualification schemes for installers of building-integrated biomass stoves and boilers, shallow geothermal energy systems, heat pumps, photovoltaics and solar thermal systems so that they can be mutually recognisable.

Observed findings

QualiCert’s objective is to come up with a list of key success criteria for the successful design and implementation of a scheme. This conclusion is intended to serve as inspiration for Member States when designing their certification (or equivalent qualification) system, while at the same time allowing them to adapt their system to the existing national situation and ensuring a high quality of RES installations, with the ultimate goal of fostering market penetration of renewable energy.

References and contact information

- www.qualicert-project.eu/fileadmin/Qualicert_Docs/Docs/Manual/QualiCert_Manual_NEWv2.pdf
- www.qualicert-project.eu/746.0.html

III.6.7 Performance of residential heat pump systems: UK

Brief description of the study

The Energy Saving Trust's (EST) heat pump field trial, conducted at two phases between 2008 and 2013, presents reliable data on the in-situ performance of both air and ground-source heat pumps in UK homes. Comprehensive monitoring was carried out at 83 households for Phase I. For Phase II of the trial, 38 of the heat pumps from Phase I were selected for a range of interventions, from major (for example, re-sizing the heat pump) to minor (for example altering control parameters).

Observed findings

Figure 33 shows the heating system efficiency as per the Phase I system boundary, which includes heat pumps, electric backup and top-up heaters, if used. For the Seasonal Performance Factor calculation in Phase II (Figure 34), a different system boundary is used. The Seasonal Performance Factor assesses the performance of only the heat pump unit and the equipment (fan or pump) required to make the source energy available to the heat pump. Therefore, for heat pumps with an integral electric backup heater, consumption of this heater was subtracted from the overall electricity supply to the heat pump.

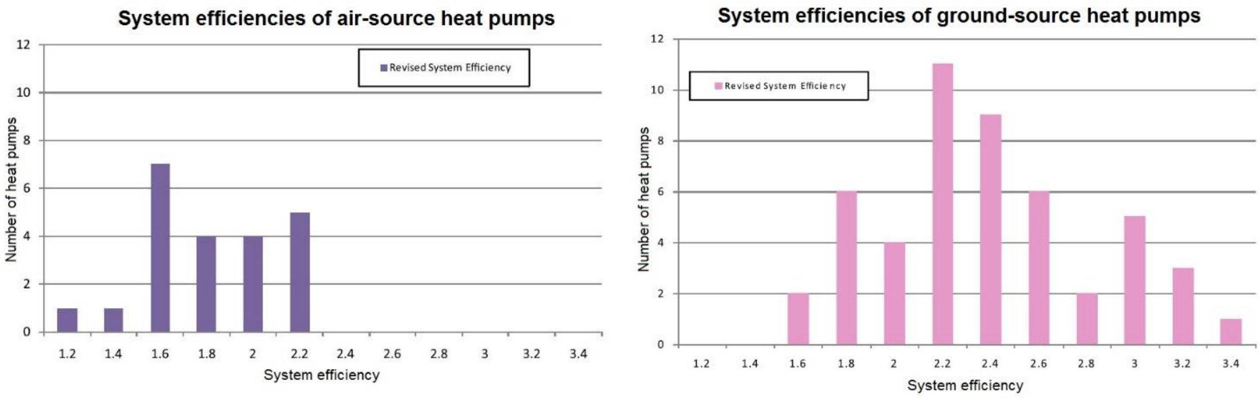


Figure 33 Summary of the revised estimates of system efficiency for the first year of the heat pump field trials (Phase I).

The European Commission states that the minimum level Seasonal coefficient of performance for a heat pump to be considered renewable is 2,5 – the system boundaries for this calculation are those of Seasonal Performance Factor (system boundary H2). From Figure 34, we can see that 9 of the 15 air-source heat pumps and 20 of the 21 ground-source heat pumps would be considered renewable under this definition.

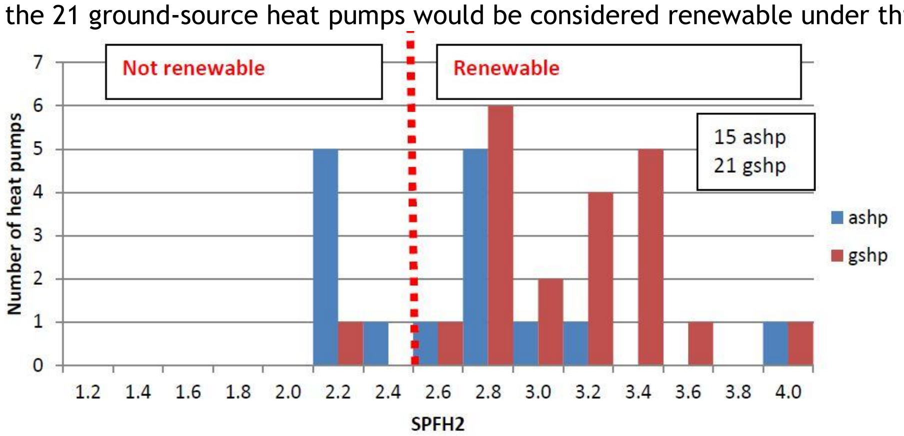


Figure 34 Seasonal coefficient of performance SPFH2 for air-source (ashp) and ground-source (gshp) heat pump systems. Only values above 2,5 are considered to be renewable.

Table 14 shows the factors divided into two categories: design and installation or commissioning.

Category	Factor	Estimated potential loss of performance as measured by system efficiency
Design	Under-sizing of heat pump	Up to 1,5
	Under-sizing of borehole/ground loop	Up to 0,7
	Insufficient insulation of pipework and hot water cylinders	0,3-0,6
	Under-sizing of hot water cylinder	Up to 0,4
	Too many circulation pumps	0,1-0,3
	Over-sizing/control strategy results in overuse of back-up heating	<0,1
Installation/ commissioning	Central heating flow temperature too high: radiators	0,2-0,4
	Central heating flow temperature too high: under-floor heating	0,1-0,3
	Circulation pumps always on	

Table 14 Factors influencing heat pump performance.

- The sample of ground source heat pumps had slightly higher measured system efficiencies than the air source heat pumps. The 'mid-range' ground source system efficiencies were between 2,3 and 2,5, with the highest figures above 3,0.
- Heat pump performance is sensitive to installation and commissioning practices.

Lessons to be learned

- The field trial findings categorically show that the simplest system designs achieve the best efficiencies.
- If a heat pump is installed even slightly wrong, the outcome for the householder may be very wrong.

Assessment - follow-up actions?

- Microgeneration Certification Scheme is a prerequisite for access to grants and incentives through the Low Carbon Buildings Programme (LCBP), and has been suggested as a prerequisite for the proposed Renewable Heat Incentive (RHI).
- The Energy Saving Trust will work with the UK government and industry to re-assess appropriate training for installers.

References and contact information

Documents:
- "Getting warmer: a field trial of heat pumps"
- "Detailed analysis from the first phase of the Energy Saving Trust's heat pump field trial"
- "Detailed analysis from the second phase of the Energy Saving Trust's heat pump field trial"

Contact persons:
- Simon Green, Project Director
- Jaryn Bradford, Project Manager

Website, links:
- Getting warmer: a field trial of heat pumps: www.heatpumps.org.uk/PdfFiles/TheEnergySavingTrust-GettingWarmerAFieldTrialOfHeatPumps.pdf
- Detailed analysis from the first phase of the Energy Saving Trust's heat pump field trial: www.gov.uk/government/uploads/system/uploads/attachment_data/file/48327/5045-heat-pump-field-trials.pdf
- Detailed analysis from the second phase of the Energy Saving Trust's heat pump field trial: www.gov.uk/government/uploads/system/uploads/attachment_data/file/225825/analysis_data_second_phase_est_heat_pump_field_trials.pdf

III.6.8 Performance of residential heat pump systems: Germany

Brief description of the study

The project “HP Efficiency“ was conducted from October 2005 to September 2010 in Germany. The main objective was the independent determination of the efficiency of heat pump systems. About 110 heat pumps were evaluated. Within the anonymous evaluation 56 ground source, 18 outside air and 3 water source heat pumps were taken into account. The majority of the installed heat distribution systems were underfloor heating systems.

Observed findings

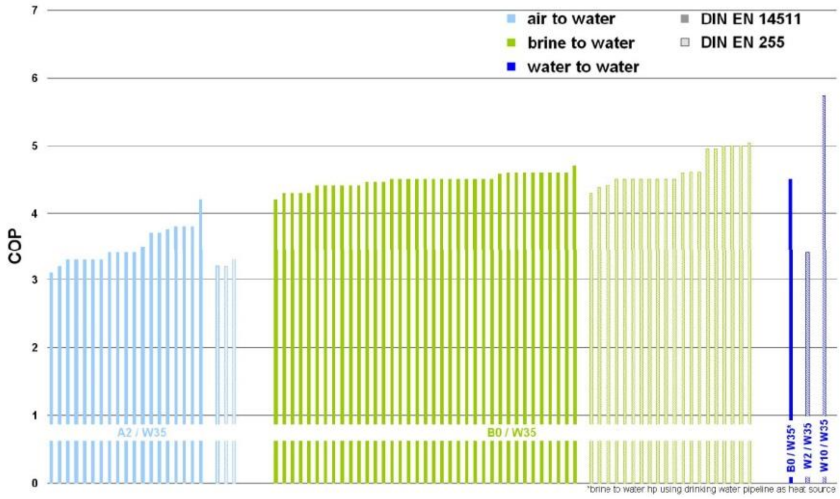


Figure 35 Coefficients of performance (COPs) of the evaluated heat pumps displaying the heat sources and the underlying certification standard

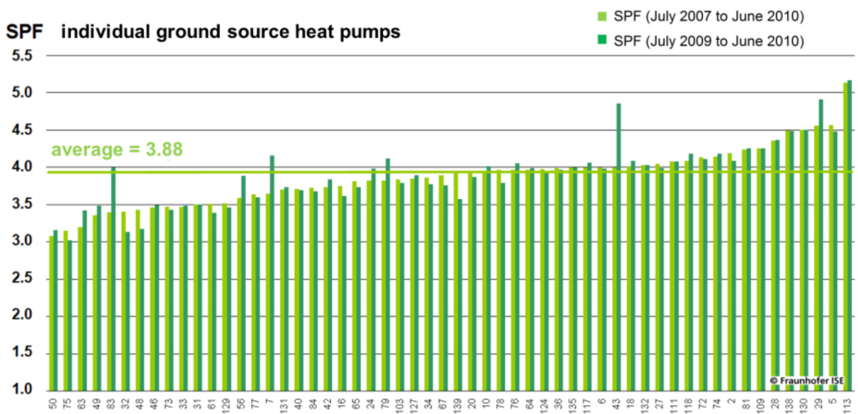


Figure 36 SPFs of ground source heat pumps for July 2007 to June 2010 and July 2009 to June 2010; the labelling corresponds to ID numbers known to manufacturers

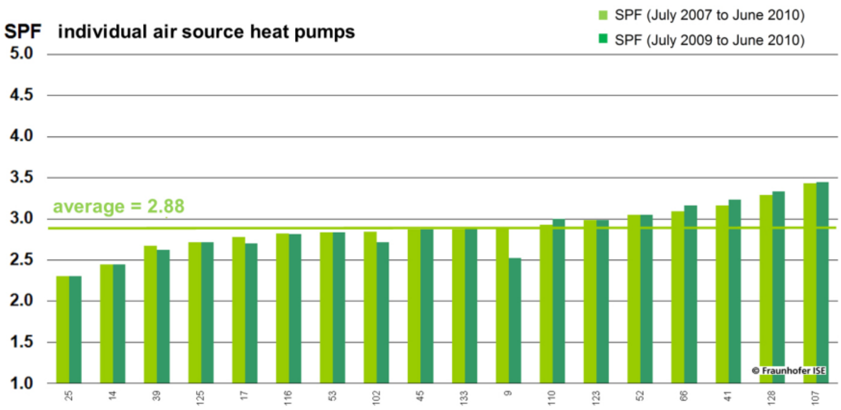


Figure 37 SPFs of air source heat pumps for July 2007 to June 2010 and July 2009 to June 2010 respectively; the labelling corresponds to ID numbers known to manufacturers.

- The entire evaluation period lasted from July 2007 to June 2010. Within this period ground source heat pumps reached an average seasonal performance factor (SPF) of 3,9 and air source heat pumps a SPF of 2,9. Within the second phase of the project an average SPF of 4,1 was reached by ground source heat pumps and 3,0 by air source heat pumps. The SPF of three evaluated water source heat pumps was determined at 3,7.
- Heat pump systems with combined buffer storage (space heating and DHW) reached lower SPF values compared to other storage concepts.
- The decrease of the energetic quality of the building influences the SPF positively up to a space energy usage of about 70 kWh/m², whereas higher values influence the SPFs negatively.

Lessons to be learned

- As main outcome of the project it was detected that carefully planned and correctly installed heat pump systems reach efficiencies which enable ecological and economic advantages compared to fossil heating systems. However, the variety of aspects concerning planning, installation and operation led to a large range of results.
- Correctly designed ground source heat pumps do not require an electrical back-up heater.
- Heat pumps with solar thermal systems are widely balanced by a system seasonal performance factor (SSPF). Hereby, it became clear that an increasing cover ratio of the solar thermal system influences the SSPF positively.

References and contact information

Documents:
- Heat Pump Efficiency. Analysis and Evaluation of Heat Pump Efficiency in Real-life Conditions.

Contact persons:
- Marek Miara, marek.miara@ise.fraunhofer.de

Website, links:
- http://wp-effizienz.ise.fraunhofer.de/download/final_report_wp_effizienz_en.pdf

III.6.9 Performance of residential solar water heating systems: UK, Ireland

Brief description of the study

The study provides results from an independent trial of solar water heating systems carried out in the UK and the Republic of Ireland. Monitoring of 88 sites took place over twelve months from April 2010 to April 2011: 54 flat-plate and 34 evacuated-tube collectors were monitored and examined.

Observed findings

- Solar water heating systems have the potential to work well in the UK and the Republic of Ireland when installed properly and controlled adequately by the user.
- Well-installed and properly used systems provided around 60 % of a household's hot water.
- The trial also found examples where systems were not properly configured or used, and where the contribution from solar was as low as 9 %.
- There was little difference between the total solar energy yield of those installations that used flat-plate solar collectors and those that used evacuated-tube solar collectors.

Lessons to be learned

- Insufficient insulation installed on hot water storage cylinders and pipes significantly reduced the proportion of hot water their solar water heating systems provided.

References and contact information

Documents:
- Here comes the sun: a field trial of solar water heating systems.

Contact persons:
- Jaryn Bradford, Frances Bean

Website, links:
- www.energysavingtrust.org.uk/content/download/29047/348320/version/2/file/Here+comes+the+sun+-+solar+hot+water+report.pdf

III.7 Summer thermal comfort - Input data

III.7.1 Estonian housing stock technical condition - apartment buildings built during the period 1990-2010 - Summer thermal comfort

Brief description of the study

Indoor climate was analysed in 28 apartment buildings constructed between 1990 and 2010 and studied in the context of the Estonian housing stock technical condition study. Indoor temperature was measured in the 28 apartments buildings (in 61 apartments).

Observed findings

- indoor temperature is higher than the requirement in 65% of the measured apartments.

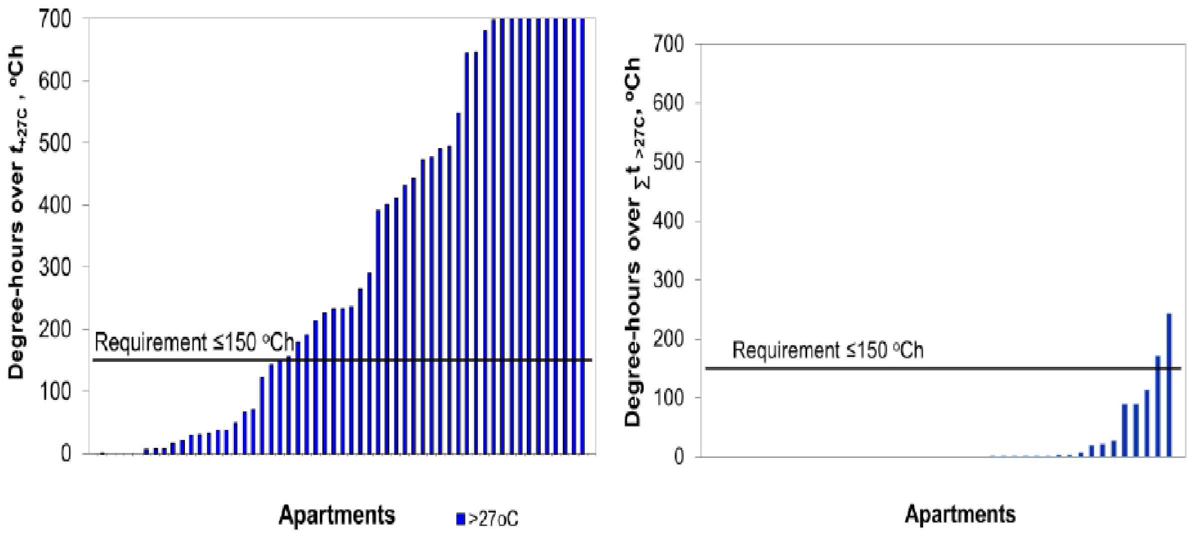


Figure 38 Indoor temperature in measured apartments

Lessons to be learned

Summer indoor temperature is allowed to be 150 degree hours over 27 ^{0}C. Measurements showed that indoor temperature is higher in 65% of the measured apartments.

Assessment - follow-up actions?

There were no specific follow-up actions.

References and contact information

Documents:

- Study report (in Estonian)

Contact persons:

- Targo Kalamees, Tallinn University of Technology

Website, links, …

- http://www.kredex.ee/public/Uuringud/Uute_korterelamute_uuring_2012.pdf
- Maivel, M.; Kurnitski, J.; Kalamees, T. (2014). Summer Thermal Comfort in New and Old Apartment Buildings. In: Proceedings of 8th Windsor Conference: Counting the Cost of Comfort in a Changing World: 8th Windsor Conference, International Conference held 10th - 13th Aprill 2014, Windsor UK. (Toim.) Prof. F. Nicol; Prof S. Roaf; Dr L. Brotas; Prof Rev M. Humphreys. NCEUB 2014: Network for Comfort and Energy Use in Buildings, 2014, 42 - 50.

IV. Examples of potentially interesting schemes (existing or under development)

IV.1 Austria

IV.1.1 Schemes / mechanisms for quality assurance of input data

EPC databases and control schemes are in place in some of the Austrian provinces::

- Automatic checks in the calculation software and during upload into the EPC database are in place but improvement is still needed, and further development is on-going.
- There is a random check of selected EPC reports including detailed control based on drawings etc., carried out by the responsible authority.
- There is a periodical newsletter addressing the energy experts calculating EPC, describing the most frequent errors and offering adequate solutions.

There is one Austrian province without automatic checks included in the EPC database. Regular checks which are done for the housing subsidy scheme could be extended to all buildings; these checks are successful and educate energy experts calculating the EPC, as well as building designers and building owners.

Mandatory commissioning should be introduced in general, not only for housing subsidy schemes and voluntary building certification.

Energy monitoring of the buildings should become business as usual (will be solved with the introduction of smart meters in the course of smart grid developments).

Mandatory on-site inspection of building is requested, including photo documentation of building components. This is partly implemented by the new Viennese building code (updated version): documentation of building components for future maintenance planning.

The simplified calculation procedure should be abandoned because it is just a rough estimation.

IV.1.2 Schemes / mechanisms for improving the quality of the works

Voluntary building certification schemes requiring measurements and tests and energy monitoring:

- TQB (most comprehensive building assessment scheme: Total Quality Building TQB operated by ÖGNB; other similar schemes such as BREEAM, LEED, DGNB)
- Klima:aktiv declaration (part of TQB and representing the building part of the Austrian climate protection programme)
- ÖKOPASS (part of TQB and focusing on residential buildings, energy and indoor air quality)
- Passive house certification according to Passivhaus Institut Darmstadt

Training of individuals and certification: certified heat pump installer, certified PV installer, certified biomass installer, certified solar thermal installer.

E.g. www.ait.ac.at/research-services/research-services-energy/training-education/?L=1.

There is no adequate training for building owners and/or their representatives.

In the province Carinthia, it is in the framework of the housing subsidy mandatory to get energy advice from a qualified expert. There is a grant available for this service but only if registered energy advisors are consulted. These experts help with the submission of proposals for funding (e.g. renewable energy systems), compare tenders and check executed works. A few years ago the province Lower Austria funded also consulting services during building construction as part of the housing subsidy scheme, but this was abandoned due to the lack of finance, which has been the same in all provinces.

The province Vorarlberg gives financial support of 1.200 € for the development of comprehensive renovations concepts, to make sure that renovation work is carried out in the correct sequence if the works are executed step by step due to the lack of finance.

On site focus:

- It is necessary to train all workers, not only the foremen; each trade must receive a briefing at the construction site, because if workers understand the importance of e.g. airtightness, they will work more carefully.
- Site foreman's plans must contain all details.
- Site supervision needs more time and budget.

To improve the situation on site, the regional energy agency "Energie Tirol" offers construction supervision called EQ programme which is part of the klima:aktiv declaration.

IV.2 Belgium

IV.2.1 Quality framework - EPBD database

Context/Starting point for the scheme

The EPBD as implemented in the three regions of Belgium, has set as a major point of attention to create boundary conditions that stimulate/enforce people to 'do what they declare' and by this approach increase the reliability of EPC declarations for new buildings.

Within this approach, there is a strict compliance framework. In order to minimise the risk of discussions regarding the input data used in the EPC, there was a wide consensus that "easy access to reliable input data" is important.

Objectives

The objectives can be summarised as follows:

- To clarify as much as possible, and after consultation with the relevant sectors, the procedures to be used for coming to reliable input data (whereby maximum use is made of CEN procedures).
- To have a framework which meets all relevant national and European requirements, in particular the Construction Product Regulation.
- To have an easy access to the data by having a public website.

Present status

The website (www.epbd.be) is operational.

It is an evolutive process, in terms of type of product families included in the data base as well as in terms of amount of data by product family. The website is now recognised by the 3 regions as a reliable source of input data. However, it is NOT mandatory to be included in this database.

Coupling with the EPBD software tools is operational.

Future

No major further developments are foreseen, except some improvements in user friendliness.

Analysis - synthesis

Overall, we have the impression that this scheme is highly appreciated by the market. This is reflected by the number of consultations of the database.

Ideally, such scheme should not be developed at national level but at a supra-national level.

References and contact information

Documents:

- Several documents available on www.epbd.be

Contact persons:

- Peter Wouters, BBRI

Website, links, …

- www.epbd.be

IV.2.2 Quality of the works – Insulation of existing cavity walls

Context/Starting point for the scheme

The market share of insulation of existing cavity walls is growing in Belgium. Due to the impossibility of a visual control, the quality of the works is crucial. Thus, a quality scheme was established. This scheme is based on the STS 71.1. (STS: Spécifications Techniques - Technische specificaties) and a technical agreement and is supported by financial incentives for the end-customer.

Objectives

The main objectives are:

- to ensure the quality of the used products by product controls (in the plant and on-site);
- to improve the competence of the installers by training and quality checks on-site.

Present status

The scheme is operational in one region since the beginning of 2013. It assures the training of installers and the quality of the chosen products. The incentives are given if the work is realised according to this framework. Controls are organised in the product's plant and also on-site. These continuous controls and their periodicity are described in the technical agreement.

Future

Currently, the framework is fully functional in one of the three Belgian regions. The implementation in the two others is scheduled.

Analysis - synthesis

Driven by incentives, the scheme goes well.

References and contact information

Documents:

- STS 71.1 : Post-isolation des murs creux par remplissage in situ de la coulisse ayant une largeur nominale d'au moins 50 mm
- STS 71.1 : Na-isolatie van spouwmuren door insitu vullen van de luchtspouw met een nominale breedte van ten minste 50 mm
- NIT 246 : Post-isolation des murs creux par remplissage de la coulisse
- TV 246 : Na-isolatie van spouwmuren door het opvullen van de luchtspouw

Contact persons:

- Peter Wouters, BBRI

Website, links, …:

- www.ubatc.be

IV.2.3 Quality of the works – Quality framework in relation to performances of ventilation systems

Context/Starting point for the scheme

Currently, the quality of the ventilation systems is sometimes very poor in Belgium (low flow rates, high electricity consumption, acoustical problems, etc.). There are also problems of non-compliance with the regulation.

A few years ago, the first idea to improve the quality of the ventilation systems was to develop a voluntary framework to certify/recognise installers. This framework is based on a set of performance criteria with a relatively high quality level (largely above the legal requirements and largely above the current practice). But the very limited success of such a voluntary quality framework in foreign countries (NL, FR, etc.) underlined the disadvantages and limitations of such an approach: voluntary + high quality criteria → risk of poor market penetration because of the gap between the current practice and the higher quality foreseen.

Based on this, a new approach was investigated, which focuses on a report of the performances of the ventilation system after installation, and on the reliability of this report by certifying/recognising the person responsible for this report.

Objectives

The aim is to develop a framework to ensure a reliable report of the performance of ventilation systems after installation, as summarised as follows.

- This report is based on a set of various quality criteria (flow rates, acoustical comfort, electrical consumption, etc.).
- The reliability of this report is ensured by certifying/recognising the persons responsible for the report.
- This reliable report is a powerful tool to objectively evaluate/identify the quality of a given ventilation system, for the customer, for the authorities, etc.
- The conformity with the high level of quality criteria is not obligatory as such, but some of these criteria can be required in different specific contexts, for instance in the EP regulation, and also for private quality labels, for specific incentives, in the specifications, etc.

Certification scheme

In principle, several categories of persons could become certified as ventilation reporters in this framework. This could be the installer itself, an architect, the person responsible for the EP declaration/calculation, etc.

To become certified/recognised, a first evaluation must demonstrate the skills of the person to carry out these ventilation controls, thanks to a training and an examination. Examples of evaluated skills are: the ability to measure airflow rates and electricity consumption, the knowledge of the quality criteria, basic knowledge on ventilation, etc.

Moreover, the certified/recognised persons are regularly and randomly controlled by a third party organisation to ensure that the delivered ventilation report is correct, reliable and of good quality. For example, the certified/recognised persons would be controlled for around 10% of their reports.

Use of this ventilation report

First of all, this reliable report can be a powerful tool to clarify the customer expectations before the installation works, and the quality of the execution after the works. It is not obligatory to meet all the quality criteria as such, but this set of criteria could be used by customers and designers to choose what criteria are important for them and what they are ready to pay for.

Secondly, some of these quality criteria and this reliable report could be used in different contexts, such as private contexts (quality labels, contracts, etc.) or in regulation, such as EP regulation.

Finally, this ventilation report includes also some input data for EPC calculation. In Belgium, besides product EP input data, the EP calculation uses also some “as built” measurements, such as mechanical flow rates, airtightness of the ductwork, etc. This reliable report can then also be useful in the context of EP input data, by giving reliable input data for the installed system.

Present status

Currently, the set of quality criteria has been developed in a reference document (“STS” in Belgium), within a working group involving the ventilation sector.

The organisation of the certification/recognition of the ventilation reporters is under development.

At least one of the 3 Regions in Belgium is highly interested to couple this quality scheme with the EP regulation: in the future, all the input data used in EP calculation will be obligatory coming from the reliable reports in this framework. Moreover, some of the criteria will be obligatory in the context of this regulation (for example: measurement of the airflow rates).

Future

This quality framework must still be launched in practice.

One can expect that the 2 other Regions in Belgium will also be interested to couple their EP regulation with this framework.

Analysis – synthesis

The main advantage of this scheme is the possibility to combine the freedom of a voluntary approach with the incentives of an obligatory one:

- the reporting of the performance of the installed system is obligatory (or can be easily obligatory in different contexts: regulation, etc.);
- but the fulfilment of the performance criteria is quite voluntary, to be chosen by the designers and the customers themselves (who will have to pay for higher quality).

For the designers and customers:

In comparison with a voluntary label with high quality requirements, they can choose what they want and what they will pay for, between no requirements (and low quality) and all the requirements (and high quality).

For the authorities:

In comparison to an obligatory scheme with quality requirements, they could let the market evolve step by step, by possibly increasing the level of the requirement in time in a transparent set of performance criteria.

This scheme could then allow the market to evolve progressively from the currently low quality in practice to higher quality in the future.

Moreover, the reporting by a certified/recognised person in this scheme can also be useful to ensure the reliability of EPC input data at the level of the installed system.

References and contact information

Documents:

- Securing the quality of ventilation systems in residential buildings: existing approaches in various countries, Van Den Bossche Paul, Janssens Arnold and Saelens Dirk (2013) AIVC Conference Proceedings. p.288-296

Contact persons:

- Peter Wouters, Paul Van den Bossche, Samuel Caillou (BBRI)

IV.2.4 Compliance – Flemish approach

Context/Starting point for the scheme

In Belgium, the implementation of the EPBD is the responsibility of the regions.

In the Flemish thermal insulation regulation preceding the new EPB regulation, control by the authorities heavily focused on the calculations submitted as part of the demand for building permit. Little on-site control during/after the construction phase was performed, and any non-compliance observed at that stage usually ended up unpunished because of the cumbersome juridical sanctioning system.

The SENVIVV study, which was performed at that time, showed that compliance was very poor, at least during the first few years of application of the regulation. Other studies realised at the same period have shown very poor compliance with the requirements regarding the installation of ventilation systems.

On the basis of the evidence produced by these studies, as part of the new EPB-regulations there has been a shift of focus to the as-built situation when it comes to control of compliance. A system of nearly-automatic administrative financial fines has been instituted. The as-built evaluation also allows to promote the real product characteristics of the materials and systems that have been applied, thus creating an extra drive for high performance products and the precise characterisation of their properties.

In Flanders the full electronic EPB-declaration must be uploaded on a central server for computerised processing and archiving. Any non-respect of an EP-requirement is automatically detected and fined. In 2008 about 6% of the EPB-declarations have reported non-compliance with 1 or more EP-requirements. This situation has improved in the following years.

A specific software, the 'EPB back office', was developed on the energy performance database, so that Flemish Energy Agency can check compliance with procedures and requirements, and to perform quality assurance checks for new buildings.

The amount of building declarations not fulfilling the requirements was higher for building permits in 2006 (9%) than in the more recent years (5% in 2008).

Based on the information contained in the central database, the Flemish Energy Agency regularly produces statistics showing information regarding the compliance rate (Figure 39). On this figure, the thresholds of the required energy performance as well as the minimum level for incentives can be seen. The non-compliances can also be seen (e.g. until 2010, the required E-level was E100)

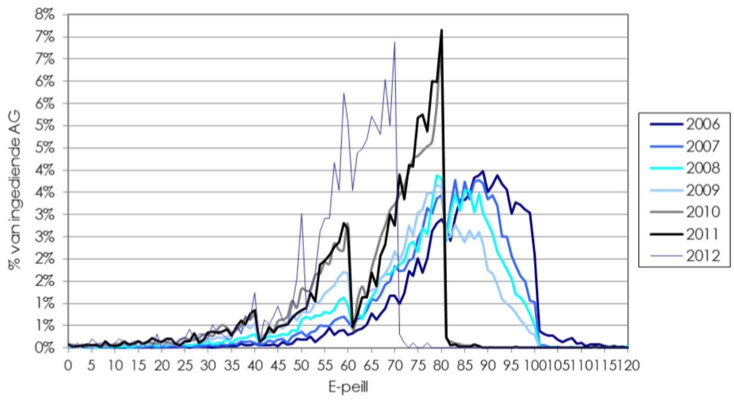


Figure 39: Distribution of the EP-indicator (E-level) according to the building permit's year of delivery

Objectives

The objective for the Flemish energy agency was to improve the enforcement of the regulation. This objective is obtained by implementing tools that allow having a view on the compliance rate and deciding, if necessary, to develop the necessary measures to improve the situation. An affective system of sanctioning is part of this process.

Present status

The enforcement of the regulation is a crucial attention point for every adaptation made. Statistics regarding the compliance rate are regularly produced. Based on this information, specific actions can be undertaken.

Future

The Energy Performance regulation is regularly adapted to respond to the requirements of the European directives (EPBD, EED, RED). New parts to the regulation are regularly introduced/adapted. The next steps are for instance a sharpening of the requirements for new buildings (NZEB requirement). The possibility to enforce the regulation is one of the first attention points when developing the regulation. This aspects remain valid for the new developments.

Analysis – synthesis

- Effectiveness of the regulation has become a top priority. Unclear or non-controllable elements will not be introduced in the regulation.
- An effective sanctioning system is in place. The administration must not judge who has made the error, the fine system is quite automatic.
- There are clear procedures on acceptable input data.
- The result of the control (e.g. statistics on compliance rate) are regularly communicated.
- The different actors are aware of the control and fine system.
- Regular stakeholder meetings are organised to make the regulation a living process. In 2012, this kind of process has been organised to assess the opportunity to introduce a specific requirement of the building airtightness.

References and contact information

Documents:

- SENVIVV, "Insulation, ventilation, and heating in new dwellings. Results of a survey.". BBRI-report #4, March 19998 (available in Dutch and French).
- ASIEPI Information Paper - P174 - Belgium: Impact, compliance and control of legislation – March 2009. From the book "Stimulating increased energy efficiency and better building ventilation" – March 2010 - ISBN 2-930471-31-X

- Overview of 8-year experience with the EP regulation in the Flemish Region - Cijferrapport energieprestatieregelgeving - Procedures, resultaten en energetische karakteristieken van het Vlaamse gebouwenbestand - periode 2006 – 2013. In Dutch. Available on www.vlaanderen.be/economie/energiesparen/epb/doc/EPBincijfers-2006-2013.pdf

Website:
- Flemish energy Agency (VEA) – www.energiesparen.be (in dutch)
- EPBD Concerted Action (country report) – www.epbd-ca.eu

IV.3 Cyprus

IV.3.1 Quality of the works – Quality framework in relation to Build Up Skills

Context/Starting point for the scheme

In November 2011 in the framework of ''Intelligent Energy for Europe'' and ''Build up Skills'' initiative the Project Build Up Skills Cyprus started. The ''Build up Skills'' initiative aims to improve the workforce in the construction sector and other related sectors so that the workforce is able to successfully fulfil the requirements arising through the directives and regulations for nearly zero energy Buildings.

The initiative ''Build up Skills'' is the result of policies and objectives promoted by the European Union such as the ''20-20-20'' targets and the target for reducing greenhouse gas emissions by 80-95% by 2050. The EU has undertaken studies on the readiness of all disciplines to meet the emerging needs. From these studies it was concluded that in the Construction Sector and related industries, 2,5 million workers need further improvement of their skills.

The European initiative ''Build Up Skills" is part of the European "Intelligent Energy Europe" programme and is co-financed by the European Executive Agency for Competitiveness and Innovation (EACI).

Objectives

The ''Build Up Skills'' initiative aims at the continuing vocational education and training of employees in technical occupations in the construction sector, as well as other related sectors, which relate to the installation and maintenance of energy efficiency, energy saving and renewable energy systems in buildings. The main goal is the acquisition by these people of the necessary knowledge, skills and attitude, in order to render both the Construction sector, as well as other related sectors, capable of meeting the relevant targets of the ''Europe 2020'' strategy, such as buildings with nearly zero energy consumption.

Future

The workforce in the construction sector and other related sectors will be more knowledgeable and better qualified so that it will be able to successfully fulfil the requirements arising through the instructions and regulations for buildings with nearly zero energy, and the quality of works will improve significantly.

Analysis - synthesis

It will be an extremely useful educational tool for the workforce in the construction sector.

References and contact information

Documents:
- BUILD UP Skills – Cyprus National Roadmap
- BUILD UP Skills – Cyprus Analysis of the National Status Quo

Contact persons:
- Cyprus Energy Agency, Cyprus Productivity Centre, Cyprus Organisation for Standardisation, Human Resource Development Authority of Cyprus, Cyprus Institute of Energy, Technical Chamber of Cyprus

Website, links, …
- www.cea.org.cy/we_qualify/
- www.buildupskills.org.cy

IV.3.2 Quality of the works – Review of air conditioning and heating systems

Context/Starting point for the scheme

The inspection of air conditioning and heating systems aims to reduce energy consumption and carbon emissions. This inspection applies to air conditioners with a rated output greater than 12 kW or cumulatively in a building more than 50 kW and heating systems boiler nominal output of 20 kW and above.

Accessible parts of systems used for heating buildings with a boiler nominal output power beyond 20 kW qualify for regulation, control and inspection at regular intervals. The frequency of these inspections in Cyprus is specified in the decrees K.D.P.148/2013 and K.D.P.149/2013.

The inspection of air conditioning systems in Cyprus is carried out only by inspectors whose qualifications are specified in regulations. For this reason the relevant authority, which is the Energy Service of the Ministry of Energy, Commerce, Industry and Tourism, keeps a database of inspectors for the air conditioning units. The frequency of the inspections differs depending on the power of the air conditioning system and is specified in the relevant decree which is issued by the Minister.

For the purpose of implementing the provisions of the Law the Energy Service, as the competent authority, has prepared the Energy Performance of Buildings Control Regulations (Inspection of Heating Systems with Boilers and Inspection of Air Conditioning Systems) Regulations 2014, which require, inter alia, that the inspection will be carried out in accordance with the procedure described in the Guide of Inspection of the Heating Systems with Boilers and the Guide of Inspection of the Air Conditioning Systems, which are based on European standards.

The competent authority may issue a certificate of registration and may register inspectors of heating systems with boilers and air conditioning systems in accordance with the aforementioned Regulations. Moreover, the decrees provide that no person shall carry out such inspection work unless holding a certificate of registration in the register of inspectors, which must be shown to the owner of a heating system or a representative thereof, before carrying out the work involved. Before the inspection, inspectors are required to inform the competent authority of the date and place of the inspection and the name of the owner of the system which will be inspected. For each work carried out by the inspector, the inspector must maintain records with various information and data. The competent authority may suspend or terminate the registration of such an inspector.

Objectives

The inspection of air conditioning and heating systems aims to reduce energy consumption and reduce carbon emissions. Within reasonable time after the conclusion of the inspection a report must be delivered to the owner with inspection results and suggestions for the improvement or the upgrade of the system. The relevant authority may request to see the report at any time.

Present status

The scheme is under operation.

Future

The scheme of inspection of air conditioning and heating systems will continue in order to reduce energy consumption and reduce carbon emissions of those systems.

Analysis – synthesis

It is a greatly appreciated scheme as it contributes not only to the reduction of energy consumption and carbon emissions of those systems, but also to assurance regarding health and safety issues regarding the aforementioned systems.

References and contact information

Contact persons:

- Energy Service at the Ministry of Energy, Commerce, Industry and Tourism.

Website, links, …

- www.mcit.gov.cy/mcit/mcit.nsf/All/DA87F1F89C94B0F7C2257625004867C2?OpenDocument
- www.mcit.gov.cy/mcit/mcit.nsf/All/DDE87E9DF110F6F1C22575AD002C5549?OpenDocument

IV.4 Greece

IV.4.1 Input data – Quality framework - EPC database

Context/Starting point for the scheme

Energy performance contracting (EPC) is when an energy service company (ESCO) is engaged to improve the energy efficiency of a facility, with the guaranteed energy savings paying for the capital investment required to implement improvements. Under a performance contract for energy saving, the ESCO examines a facility, evaluates the level of energy savings that could be achieved, and then offers to implement the project and guarantee those savings over an agreed term. Energy Performance Contracting allows facility owners and managers to upgrade ageing and inefficient assets while recovering capital required for the upgrade directly from the energy savings guaranteed by the ESCO. The ESCO takes the technical risk and guarantees the savings. ESCO market in Greece is just taking off the ground. According to JRC-IE 2010 report, it has been stalled for years due to the absence of EPC-related specifications in public tendering, tender evaluation, contract monitoring and repayment, and the vague definition of Energy Performance Contracting (EPC) and Third Party Financing (TPF) actors. A number of favourable legislative changes (such as a new law on Public-Private- Partnerships (PPP)) have in the last years enabled the creation of an ESCO market. The energy service companies (ESCO) Registry, has been established very recently and is maintained by the Department of Efficient Energy Use and Conservation of the General Secretariat for Energy and Climate Change, Ministry of Environment, Energy and Climate Change (YPEKA, www.ypeka.gr), in the context of the Ministerial Decision 13280/07.06.2011 "Energy service companies. Operation, Registry, Code of Conduct and similar provisions". Till now ESCOs or companies that had the potential to become an ESCO were collected in an association of a related field, such as the Hellenic Association of Solar Industries. (Latest Developments of ESCO industry across EUROPE).

Objectives

Identify barriers and success factors for the implementation of EPC projects.

Future

Development of EPC Markets

Analysis - synthesis

Overall, we have the impression that this scheme is highly appreciated by the market.

References and contact information

Documents:

- D2.4 Country Report on Identified Barriers and Success Factors for EPC Project Implementation, Greece. This document has been conducted within the framework of project "Transparense – Increasing Transparency of Energy Service Markets" supported by the EU programme "Intelligent Energy Europe", www.transparense.eu

Contact persons:

- Dr. Kostas Konstantinou kostas@anatoliki.gr

IV.4.2 Quality of the works – Quality framework in relation to energy efficiency

Context/Starting point for the scheme

The energy performance of buildings directive (EPBD) (91/2002/EU) opened the way for member states of European Union to create and apply a holistic approach on buildings' energy performance. In 2011, the residential sector in Europe accounted 24,7% of the final energy consumption (European Environment Agency 2013). As a matter of fact, during 2005-2010 final energy consumption of EU households per person has decreased by 6%, while in Greece around 12% (Climate and Energy Country Profiles 2013). In particular, Greek household primary energy consumption was calculated as 27,9% of the total one in 2011, while energy dependency was recorded at 72,9% in 2008.

In parallel, Greek building stock accounts around 4 million dwelling (Hellenic Statistical Authority), where only 28% were constructed after the implementation of the first Greek Insulation Law (TIR) (Official Gazette of the Hellenic Republic 1979). Thus, approximately 3 million dwellings are lacking insulation in the building envelope. In this direction, Greece has recently put into force a new law 2661/2008 on energy consumption (Official Gazette of the Hellenic Republic 2010, Technical Chamber of Greece 2010a, 2010b, 2010c, 2010d) harmonised with the European Directive 91/2002.

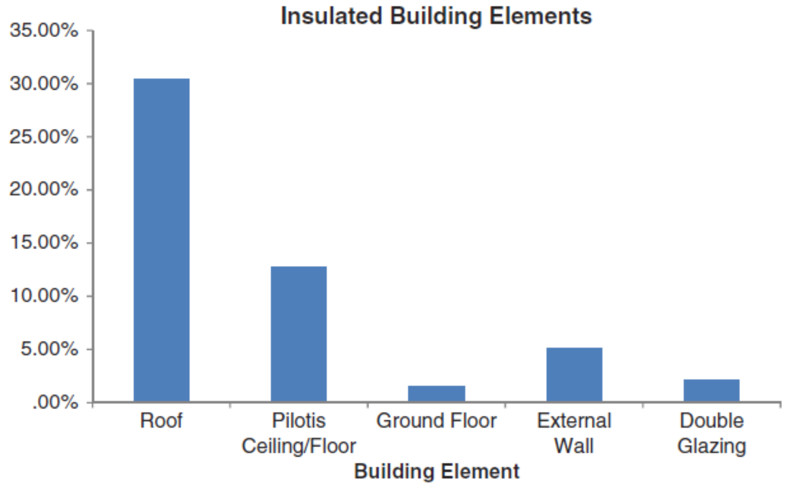


Figure 40 Percentage of insulated building elements of the existing building stock

Objectives

The importance of the reduction of the energy consumption and the independence of the fossil fuels is well documented. Buildings are still by far the main producer of CO_2 emissions. Thus, we need to exhaust all the possibilities in order to find solutions for their improved energy behaviour. Within this scope, a research started in the area of Greece collecting and analysing energy data from almost 610 apartments constructed from 1960 up to 2005. The methodology followed and presented in this chapter had as main target the implementation of insulation scenarios and the study of their contribution towards:

- the amelioration of U value and
- the mitigation of the heat balance and consequent reduction of the buildings' thermal losses.

References and contact information

Documents:
- Field survey on multi-family buildings in order to depict their energy characteristics
- Published paper in International Journal of Sustainable Energy, 2014

Contact persons:
- Chadiarakou, S. & Santamouris, M.

Website, links, …
- http://dx.doi.org/10.1080/14786451.2014.883626

IV.5 Romania

IV.5.1 Input data – Quality framework - EPC database

Context/Starting point for the scheme

Since 2009 a central EPC DataBase was substantiated within URBAN-INCERC, by developing the structure and defining the requirements for an electronic format of issued EPCs. The starting point was the analysis of potential benefits of having the central EPC register: building stock data, information for database for EPC issuing methodology improvement, facilitate EPC control system application, improving the quality of EPC elaboration by providing feed-back to energy auditors for buildings.

Objectives

- To develop procedures for elaborating the electronic format of EPC based on the information contained in the actual EPC document.

- To structure the information in a central database and to develop practical tools for the input of EPC data.
- To structure the information from energy audit reports and from the inspection reports (HVAC systems) in order to further develop the central database to include more relevant information.
- To prepare the development of an online system to register the electronic format of EPC in the database.
- To develop tools for the plausibility and quality checks of relevant data from EPCs, energy audits and inspection reports.
- To support the building energy auditors in their activity.

Present status

The central database is running within URBAN-INCERC since 2008, when energy auditors for buildings started to send the electronic version of issued EPCs, according to the provisions of methodological norms for the application of Law 325/2005 on energy performance of buildings. The amended Law 325/2005 (republished in 2013) provided that the central database is under the responsibility of MDRAP where EPCs (electronic format) should be sent.

EPCs continue to be sent by energy auditors for buildings to URBAN-INCERC. The electronic format of the EPC (structured XML file) was defined in 2010 (when the database was structured), but until now it was not formalised by a legal act. Currently the EPCs are sent in various formats and are received in order to manually introduce the EP data in the database at a later stage.

By the end of April 2014, more than 150.000 EPCs in (various) electronic format have been received in the database of URBAN-INCERC, while only approx. 31.000 EPCs have been processed by manually introducing key EP data in the system.

Future

The further development of a central database in order to introduce automatic transmission and receiving/processing of EPC data (as a transition to an online system) is planned, but it lacks financing. Furthermore, it depends on the modified version of the EPC, which is under discussions / revision for some years now.

Should a financing opportunity be identified, the development of the intended system could be done in 1 year.

Analysis – synthesis

Overall the database is running and is managed with voluntary effort, being ready to be developed further towards automatic functionality.

The potential benefits from a centralised EPC database are great, while further developments could be explored (e.g. connecting with other databases and use in real estate publicity).

References and contact information

- INCD URBAN-INCERC, INCERC Bucharest Branch, Centre for Energy Performance of Buildings – Horia Petran, Head of Centre

IV.5.2 Quality of the works – Certification System for Construction Companies

Context/Starting point for the scheme

Currently, there is no legal procedure in Romania for the certification of companies in the construction sector or the systems/installations sector respectively.

The preparation of a certification scheme for professional qualification of construction companies has been under discussion in the last 10 years based on the initiative of social partners in the construction sector. Several actors were involved in the development of the scheme (ARACO – the Romanian Association of Construction Entrepreneurs, which is a professional, governmental and non-political association of employers, with the support of PSC – the Ownership of Construction Companies) and the scheme is running on a voluntary basis, under the leadership of ARACO, the last revision being published in June 2010.

Objectives

The main objective is to ensure a neutral, competent and recognised evaluation and certification system for professional qualification of construction companies. After the evaluation process, the construction companies can prove their professional capability when required, e.g. in construction works tendering process.

Present status

ARACO, along with PSC and the relevant professional associations in constructions and installations/building services have issued since 2009 a proposal for a unitary framework on the certification of the technical-vocational qualification of construction operators so as to acknowledge their capacity to carry out constructions compliant with the main requirements, as per the provisions of Law no. 10/1995 regarding quality in constructions (as amended), as well as the procedures regarding the monitoring of the certification activity. So far, this proposal did not lead to an actual legal act. ARACO is evaluating upon request the companies in constructions (mainly the members of the association). After the assessment it issues certificates to confirm the existence of the experience and technical capacity of the said, as per the provisions of a regulation, the certification system being voluntary.

Future

The adoption of a legal act to implement the certification scheme at national level is under discussion starting from 2009, between the Government (MDRAP) and a stakeholders consortium (ARACO, PSC and relevant professional associations).

Moreover, the need for a certification scheme and body was also underlined in the consultation process with key stakeholders within the National Qualification Platform and included in the Roadmap developed under BUILD UP Skills Romania Initiative. In this respect, one of the proposed measures referred to the need to delegate competences / appoint a national body/ institute for the certification of the vocational qualification of operators in constructions as starting point for assuring the certification of the workforce qualification within construction companies.

The consultation process is ongoing and reached the political level, waiting for a decision.

Analysis – synthesis

The scheme for the professional qualification of construction companies is a very good initiative in the context of ensuring adequate quality and performance, especially in relation to the realisation of buildings with high energy performance.

In order to have an effective impact it should be supported either by transformation in a mandatory system (by adoption in legal act) or by ensuring a coherent regulatory framework to recognise the investments made by some construction companies in raising the quality of construction works (e.g. specific requirements in tendering process of public funded projects, increasing quality compliance in construction sector).

References and contact information

Documents:

- REGULATION (voluntary) for the certification of the professional qualification of construction companies (in Romanian) - updated June 2010
- Draft Decision on certification of technical and professional qualifications of the construction operators (in Romanian)

Contact persons:

- Laurențiu Plosceanu, President ARACO
- Tiberiu Andrioaiei, Vice-president PSC

Website, links, …

- www.araco.org/certificare/2010/certificare%20capabilitate/REGULAMENT%20modificat%2006.2010.pdf (in Romanian)
- www.araco.org/certificare/2011/HOTARARE%20%20certificare%20completa%20in%2021%20feb.%202011.pdf (in Romanian)

IV.6 Spain

IV.6.1 The application of PassiveHaus standard to the Spanish climate for refurbishing of existing buildings. PASSIVE HOUSE RETROFIT KIT PROJECT

Context/Starting point for the scheme

The aim of the project is to develop a web-based tool-kit for passive house retrofitting (PHR) applied to social housing comprising the elements of:

- general guidelines based on best practice;
- examples of passive house retrofittings applied to social housing;
- catalogue of passive house retrofitting building components;
- methodology for making own solutions.

The tool-kit has been developed for Austria, Denmark, Lithuania, Spain and The Netherlands. For each country there is a number of building types and for each of these there is information about: actual state (photo, general information about the building, U-values, building materials, etc., heating system and energy need), energy savings, retrofitting measures, energy costs and energy consumption with incomplete Passive House Retrofitting.

The passive house concept comprises a building with an extremely low energy need for space heating (less than 15 $kWh/m^2 \cdot a$). In very cold climates, key elements are a high thermal insulation of the building envelope (walls, windows, etc.), air tightness of the envelope and heat recovery in the ventilation system. In warmer climates, control strategies against overheating (awnings, night ventilation, etc.). have become more important. Depending on the building type, energy savings vary between 80 and 95%. The specific heating demand is typically reduced from values between 150 and 280 $kWh/m^2 \cdot a$ to less than 30 $kWh/m^2 \cdot a$.

Objectives

The main target of the web-tool for building refurbishment according to passive house standard is a method that helps housing companies decide which of their buildings qualify for passive house retrofit and how this can be done most economically. The tool provides general information about PHR principles and advantages, about measures, costs and economic feasibility. Its main instrument is a typology, presenting energy concepts for different building types from various construction periods.

Present status

The buildings under study provided by Spain for the analysis and the economic feasibility of the application of the standard Passive House match to three different construction periods: before 1960, between 1960 and1979, and post 1979. Also the buildings fit to three different residential building typologies: large residential block (more than 4 floors), small residential block (4 or less floors) and terraced housing. Below is the example of one of the buildings analysed by Spain, in which you can observe the PHR measures implemented and the obtained results.

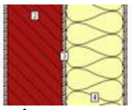
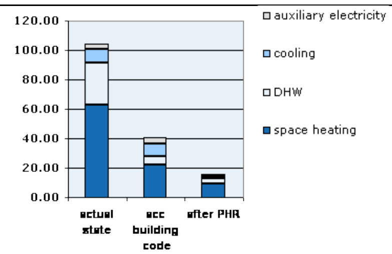
LARGE RESIDENTIAL BLOCK: build before 1960	
	GENERAL DATA OF THE BUILDING Situation: Andalucía Number of floors: 5-12 Volume: 6.000-14.400 m^3 Heated area: 2.000-4.800m^2 Heating system: ➢ Old boiler with poor maintenance and 60% of annual yield Energy demand ➢ Heating: 30 – 45 kWh/m2a, 115.200 – 172.800 kWh/a ➢ Cooling: 10 – 25 kWh/m2a Building characteristics: ➢ U façade: 2,27 W/(m2K) ➢ U deck: 2,10 W/(m2K) ➢ U floor: 2,06 W/(m2K) ➢ U window: 5,70 W/(m2K) ➢ Lack of: night ventilation system, solar collectors for DHW, sunscreens on windows
PHR MEASURES	**SUMMARY OF RESULTS**
U façade: 0,30 W/(m^2K) Composition: brick (26cm), plaster (1cm), and exterior insulation (10cm) 	 Performing a refurbishment according to the standards of the PHR, the final energy consumption can be reduced from 105 to 16 kWh/m^2·a. The same building refurbished according to the CTE has a final energy consumption of 42 kWh/m^2·a. Performing a complete refurbishment according to the standards of the PHR, the total energy invoice of the building is reduced from 30.453 EUR/a to 5.105 EUR/a, taking into account current energy prices. The comeback period of the investment is around 15 years, but can be reduced in some cases if we consider regional or state incentives.

Table 15 Analysed large residential building

Future

This tool allows certain advantages in regard to the application of the PHR standard. Below, we describe some of these advantages:

- ➢ Reduction of energy cost.
- ➢ Improvement of thermal comfort. The main objective of the PHR standard is energy savings, coupled with an increase in thermal comfort.
- ➢ Increase the quality of indoor air. The constant air renewal provides for very good indoor air quality.
- ➢ Improved possibilities to be let or rented. Allows better options in the rental of dwellings. PHR improves the quality and ease of achieving rental housing.
- ➢ Over-protecting the envelope of the building. Due to the thermal insulation, the skin of the building is protected from condensation and increases its durability. The minimisation of thermal bridges and the improvement of the sealing also reduce the structural damage.
- ➢ Improves the acceptance and increases the development of sustainable buildings.

- Improvement of the conservation of energy resources, collaborating in the reduction of climate change. Greenhouse gas emissions are reduced to less than 10% in comparison with the initial situation.
- Urbanistic revaluation. As examples demonstrate, whole settlements can be revaluated, when PHR is combined with urbanistic measures.

Analysis - synthesis

This web-tool for building refurbishment according to PHR standard is based on the following technical foundations in respect to the energy performance of buildings.

Minimised transmission losses	Heat, which is kept inside the house, needs not be replaced by using energy - this is the most important PH principle. For this reason the building envelope has a very high standard of insulation - typical thicknesses for wall and roof are around 20 to 40 cm. Typical windows will be triple-glazed. Specific building details will reduce thermal bridges to practically zero.
Minimised ventilation losses	Heat recovery in the ventilation system will reduce losses by about 80% while increasing both thermal comfort and air quality. A precondition for heat recovery is a high level of air tightness of the building envelope, minimising losses from warm air leaking through cracks and crevices.
Passive and active solar	The lower the heat losses, the higher the contribution of internal heat gains (from people, lights, electrical equipment etc.) and solar radiation to the heating demand. In addition to passive solar gains, active systems like thermal collectors or PV-systems can be used.
Efficient energy supply	Efficient systems like special heat pumps, high efficiency gas boilers or wood pellet burners.
Overheating control	Mainly passive measures like overhangs, shading devices,(e.g. awnings) are used.

Table 16 PHR principles for building refurbishments

The energy measures proposed for the different building categories are the typical Passive House Retrofitting-measures:

- external insulation + plaster;
- insulation of flat roof on top of new sealing;
- high efficiency double glazing;
- solar collectors for HDW;
- high efficiency gas fired boilers;
- reducing solar radiation by design;
- night ventilation;
- efficient active cooling systems.

The results in terms of heating/cooling energy savings and energy consumption for heating after Passive House Retrofitting for best (biggest energy savings), poorest (smallest energy savings) and average (of building categories) are the following:

Rating	Building type	Heating/cooling consumption, kWh/m²·year		
		Before PHR	After PHR	Savings
Best, un-typical due to very high savings	1960 typical terrace house, compact	87	15	72
2nd best - included because "Best" is unusual	1960 typical Multifamily house ≤ 4 floors, compact	60	14	46
Poorest	1979 typical terrace house, compact	27	5	22
Average of the 9 building categories	-	49	12	37

Table 17 Energy consumption before and after PHR

The results in terms of energy costs for heating/cooling after Passive House Retrofitting for best (biggest energy savings), poorest (smallest energy savings) and average (of building categories) are the following:

Rating	Building type	Energy costs per year, EURO (per apartment)		
		Before PHR	After PHR	Savings
Best, un-typical due to very high savings	1960 typical terrace house, compact	1.052	140	912
2nd best - included because "Best" is unusual	1960 typical Multifamily house ≤ 4 floors, compact	670	111	559
Poorest	1979 typical Multifamily house ≤ 4 floors, compact	470	104	366
Average of the 9 building categories	-	606	90	516

Table 18 Energy costs before and after PHR

In comparison with buildings adapted to the CTE, significant energy savings of up to 80% can be achieved in some cases. But PH does not only save energy; as shown by the measures taken in hundreds of "passive houses", both the thermal comfort and indoor air quality are much better than in a “typical” housing. For both energy savings for heating and cooling and for energy costs the oldest buildings included have the highest potential for savings due to bad energy standard before retrofitting. The poorest result on both energy savings for heating and cooling and for energy costs reductions is for more new compact buildings.

Costs of the works required for PHR is a serious concern.

References and contact information

Documents:

- www.energieinstitut.at/retrofit/Dateien/Startseite/E-RETROFIT-Popular.pdf
- www.energieinstitut.at/retrofit/Dateien/Startseite/E-RETROFIT-KIT-Publishable-Report.pdf

Contact persons:

- D. José Luis Molina Félix (jlmolina@us.es)

Website, links, …

- www.energieinstitut.at/retrofit/?to=0&forward=LAND_SPRACHE0&id=dd75d0c3cadf41302864ed81146558d3&dmy=cfb5492fd1738dc9ecca17ff97f7fd0d

IV.6.2 PRECOSTS&E. Assessment of construction cost and energy consumption derived from the housing EPC rating

Context/Starting point for the scheme

This study has been promoted by the Asprima Foundation and its partners and has been prepared by an independent institution, the Universidad Politécnica de Madrid (Technical University of Madrid). The study is conceived under the interest of conveying the message that the commitment to improve the energy efficiency is not only a question of responsibility and commitment to sustainability and the environment, but must also be an excellent investment.

This assessment allows knowing that the commitment of promoters, auxiliary industry and users, in addition to responsible is economically viable and must be raised not as a cost, but as an investment that improves substantially the energy efficiency of housing. The study has been carried out by analysing the energy management system in homes located in Madrid (climatic zone D3 according to the CTE).

Objectives

This study has two objectives: on the one hand, to analyse the cost of implementation of energy efficiency and, on the other, to analyse the savings in consumption being produced by these measures and which have a direct impact on the improvement of the environment and the economic saving that the end user entails living in a more efficient housing.

Present status

The study has been conducted based on building finished prior to the regulatory requirements established by the DB-HE of the CTE. A building of 143 controlled-price social housing (PPV-SPT) was chosen for the following reasons:

- Orientation of each house.
- The same type of housing can be found in all four orientations.
- Low EPC rating of the building.

Within the working hypothesis that have been considered in the study, it is important to mention the following ones:

- The selection of heating/cooling systems has considered climate factors represented in the different climatic areas, Madrid in this first phase, and Valencia, Sevilla, Oviedo, and Barcelona in a second phase.
- Measures and actions considered have been the most common and appropriate for a residential building located in Madrid.
- Economic valuations and prices refer to the original budgets of the existing building.

Future

In a second phase, this same analysis is being done in other climate zones, in particular in Valencia, Sevilla, Oviedo, and Barcelona. Once this phase is developed, it will be possible to established detailed national and regional conclusions that evaluate the construction costs associated with improvement measures needed for an improvement of the EPC rating of homes nationwide.

It may establish behavioural as well as zonal hypotheses according to the most relevant features of the building and with direct influence in its energy performance.

Analysis – synthesis

Once the EPC rating of the building has been obtained, the analysis was performed for a total of 14 proposals for improvements to the original project. As it is a project prior to the entry into force of the CTE, it is necessary to implement certain measures so that the building meets the minimum requirements established in the document HE1 (limitation of energy demand), assuming there will be an increase in the budget of a 1,8%.

The results are based on the implementation of a set of measurements, existing in three key areas:

- Design and orientation of the building. This approach is essential to obtain a good EPC rating. It is not possible to obtain a EPC rating greater than C, without limiting the surface of gaps in the north façade and place shade devices in east, west and south orientations.

- Envelope. The reduction of the thermal transmittance values represents an important improvement in the EPC rating, considering equal terms of design and heating/cooling systems.
- Energy management systems.
  - It is possible to affirm that the choice of a collective or individualised system does not influence the EPC rating of the building, as well as the cost of the project. The results obtained in both cases are similar.
  - There is a clear improvement in the EPC rating When substituting the standard by a condensation boiler, both at individual and collective level and with an estimated costs of less than 0,8% of the budget.
  - As in the previous case, an underfloor heating system, on equal terms of design and envelope, means an improvement in the EPC rating of the building.

It can be said, therefore, that energy efficiency does not depend on both the economic investment as well as the joint of design and balanced conception of the possible actions. A design that combines compactness, orientation, percentage of holes, solar protection and insulation, together with efficient heating systems with condensing boilers (low temperature) or by underfloor heating and natural gas fuel systems, will result in efficient buildings workable in both features: energy and economy.

References and contact information

Documents:

- PRECOST&E Project (www.asprima.es/Data/images/Folleto-Calificacion-def-web.pdf)

Contact persons:

- Asociación de Promotores Inmobiliarios de Madrid (Real Estate Association of Madrid) asprima@asprima.es

Website, links, …

- www.asprima.es/Noticias/Publicaciones/Estudios/Estudio-PRECOSTE/Primera-fase-de-PRECOSTE-Estudio-completo,24763

IV.7 Sweden

IV.7.1 Compliance framework – The Swedish use of EPC and performance evaluation

Context/Starting point for the scheme

The Swedish EPCs are gathered in a central database where the building owner can get access to the data. It is mandatory to present a summary of the EPC when the building is for sale. The results of the EPCs should also be posted on a prominent common space which is easily accessible for the occupants/users of the building. By using the address, property number or the EPC ID number, anyone can get basic information on the energy performance of a building with an EPC. It is also mandatory to propose energy efficiency measures in the EPCs to make the building owner aware of how to reduce the energy (e.g. insulate attic floor, install heat exchanger in the ventilation system, etc.).

Objectives

To compare the energy use between buildings to challenge the owner to perform energy efficiency measures. The EPC is regarded as an informative steering scheme.

Present status

There is no scheme that assesses the quality of the EPCs and the proposed energy efficiency measures. The energy efficiency measures are of a simpler kind (e.g., better control on the indoor air temperature and measures for reduced hot water consumption). Many building owners (80%) state that they were aware of the energy efficiency measures already before the EPC was issued. However, of the 67% of the owners that got energy efficiency measures with the EPC, 60% states they will perform one or several of the energy efficiency measures during the coming years.

Future

There is an ongoing discussion to improve the quality and the use of the EPCs as the local authorities (presently responsible for the control) have neither the competence nor the means to fulfil their present obligations.

Analysis - synthesis

The present procedure with calculations of requirements for building permission and verification of requirements by EPC based on measurements is good in theory, but is not fully implemented in practice.

References and contact information

Documents:

- Boverket (2009). Utvärdering av systemet med energideklarationer. Uppdrag nr 12 Uppföljning av energideklarationer enligt regleringsbrev för budgetåret 2009 avseende Boverket. M2008/4791/A. (Evaluation of the system with energy performance certificates). Karlskrona, Sweden: Boverket.

Website, links, …

- www.boverket.se/Bygga--forvalta/Energideklaration/
- www.boverket.se/Bygga--forvalta/Energideklaration/Sok-och-bestall-energideklaration/Bestall-energideklaration/
- www.boverket.se/sv/om-boverket/publicerat-av-boverket/publikationer/2010/utvardering-av-systemet-med-energideklarationer/

IV.7.2 Input data and compliance framework – SVEBY

Context/Starting point for the scheme

SVEBY (Standardise and verify the energy performance in buildings) is a voluntary national programme involving major actors in the Swedish building sector in order to comply with the new energy performance requirements in buildings (EPBD).

Objectives

The energy performance of buildings as described in BBR (Swedish building code) is supposed to be valid for “normal” use. The objective of SVEBY is to provide standardised input data for energy calculations and recommendations regarding verification of (compliance with) the required energy performance of buildings, thus providing a necessary complement to the more general recommendations in BBR.

Present status

The scheme includes (so far) recommended input data regarding residential building and offices, as well as guidelines how to measure and verify the energy performance.

Future

The programme is supposed to continue and be developed along with the developments of the energy performance requirements in BBR.

Analysis - synthesis

The calculation and verification of the energy performance in buildings is a cumbersome process. The use of SVEBY guidelines is increasing among professional builders, but it is far from used in all building projects.

References and contact information

Website, links, …

- www.sveby.org

IV.7.3 Compliance framework – Mandatory ventilation inspection – OVK

Context/Starting point for the scheme

Due to the serious situation with poor indoor environment in many buildings and premises in Sweden, regulations on the operation of the ventilation system (OVK) were enforced and legislated by the parliament in 1991.

Objectives

Indoor air quality affects human health. Air quality is influenced by a variety of factors such as: the level of particulate matters, gaseous pollutants, temperature and humidity. The aim of OVK (mandatory ventilation inspection) is to ensure that satisfactory indoor climate requirements in the building are met, as well as to verify that the ventilation system and its properties are in line with the requirements in force when the system was first used.

Present status

Existing buildings (except single and twin-family buildings) should be controlled and checked at regular intervals as follows:

- Inspection intervals of 3 years for: kindergartens, schools, health care facilities and similar, regardless of the type of ventilation system, as well as apartment buildings, office buildings and the like, with the FT (supply and exhaust) and FTX ventilation (supply and exhaust with heat recovery).
- Inspection intervals of 6 years for: apartment buildings, office buildings and the like with F (exhaust), FX (exhaust with heat recovery) and S-ventilation (natural ventilation).

At the periodic inspection an approved expert (inspector) should check that:

- the function and properties of the ventilation system follow the regulations in force when the system was operational;
- the ventilation system does not contain contaminants that can spread in the building;
- the instructions and maintenance instructions are readily available;
- the ventilation system in general works in the way that is intended.

To have an idea on how the ventilation system works, it might be useful to get the opinions of operational staff, residents and other users of the building. Those comments can be taken into consideration while selecting both measurement points and control methods.

The expert shall also examine steps/measures, which can be taken to improve energy efficiency of the ventilation system and does not cause a worse indoor climate.

If errors are discovered during the OVK inspection, the inspector rejects the ventilation system. The error must be corrected by the property owner at the scheduled time decided by the inspector and the municipal building department may impose a fine if problems related to OVK are not addressed.

Here, current regulations refer to both the regulations that apply when the building was built and the ventilation system was commissioned, as well as the arrangements in force at a later installation or substantial modification of the ventilation system in an existing building.

Future

Having a proper indoor environment is part of the national goal “A Good Built Environment” where the ventilation control plays an important role. “By 2020, a building and its properties shall not affect its occupants health negatively. Therefore, it shall be ensured that by the year 2015 all buildings where people stay often or longer have documented operational ventilation”.

Analysis – synthesis

The scheme has improved the situation a lot, but we are still far from reaching the national goal as described above.

The BETSI study reveals that just over 100.000, corresponding to 60% of the apartment buildings, have an OVK without complaint.

The Swedish Energy Agency and Boverket study STIL 2 has concluded that schools and kindergartens, built after 1980, have mostly approved OVK. In total, for schools and kindergartens, barely 40 % of the stock has OVK without complaint and approximately 40 % of all schools and kindergartens have failed OVK.

In the category of other premises, tested within BETSI, the proportion of OVK status without comments varies between 29 % for public, cultural, swimming and sports buildings and 72 % for healthcare buildings. Nearly 60 % of these facilities reported completed OVK without remark.

References and contact information

Document:

- Boverket (2012). Regelsamling för funktionskontroll av ventilationssystem, OVK. (Rules and regulations for inspection of ventilation systems). Karlskrona, Sweden: Boverket.

Website, links, …

- www.boverket.se

IV.7.4 Quality framework – Requirements in building projects – AMA

Context/Starting point for the scheme

AMA (General material and workmanship specifications) is a reference framework (series of books) that describes requirements on materials, work and result related to all types of building projects.

AMA also includes administrative rules and recommendations, for call for tenders, as well as contracts, can be based on references to AMA to a large extent.

AMA is managed by Svensk Byggtjänst AB, a service company with as aim to coordinate, inform and support the building sector with the appropriate framework material.

Objectives

The objective of AMA is to provide the building sector with a framework with requirements based on what is regarded as good praxis, accepted quality, proven technology and good workmanship.

Present status

The scheme was initiated in 1945 and the first reference books ByggAMA (building construction) and RörAMA (pipe work) came in 1950. At present there are more than 10 reference books covering different subjects related to building projects. The AMA scheme also provides educational material related to AMA for the building sector.

Future

New editions are planned for every 3rd year.

Analysis - synthesis

The scheme governs all major Swedish building projects since a long time.

References and contact information

Documents:

- E.g. AMA AF (rules, regulations); AMA Anläggning (site/plant); AMA EL (electricity); AMA HUS (building design/construction); AMA VVS & Kyl (heating, ventilation, air conditioning, cooling, sanitation, etc.)

Website, links, …

- http://byggtjanst.se/bokhandel/ama/

IV.7.5 Quality framework – ByggaE (BuildE - Energy efficient)

Context/Starting point for the scheme

The buildings of today are more optimised and complicated than before. Therefore, they are more sensitive to errors and problems such as built in moisture and air leakages. Building with high demands on energy efficiency tends to require technical solutions that may influence other aspects of the building's performance. A clear definition of functional demands and a quality assured building process lead to good conditions for the sustainable construction of an energy efficient building with good indoor environment.

Objectives

The purpose of the scheme is to guarantee that the building fulfils the defined functions.

Present status

ByggaE (BuildE - Energy efficient) is not designed to be a quality assurance programme ready to be used in individual building projects, but is designed to be used as a guide to establish quality routines and control points. ByggaE should be used together with ByggaF (moisture control) and ByggaL (air tightness).

Future

The scheme may be connected closer to the work done within SVEBY. Continued development with case studies of the model is needed to streamline the scheme to make it easier to implement throughout the building process.

Analysis – synthesis

The scheme is under development. There is a need in the industry of a standardised process and ByggaE could be that common process. More education and motivation of using the scheme is needed.

References and contact information

Documents:

- Thorbjörn Gustavsson, Svein Ruud, Anna-Lena Lane, Enar Andersson (2013). ByggaE - Metod för kvalitetssäkring av Energieffektiva byggnader. SP Rapport 2013:09. (ByggaE – Method for Quality Assurance of Energy Efficient Buildings). Borås, Sweden: SP Technical Research Institute of Sweden.

Contact persons:

- Thorbjörn Gustavsson

Website, links, …

- www.byggae.se

IV.7.6 Quality framework – LÅGAN

Context/Starting point for the scheme

LÅGAN (Program för byggnader med LÅG energiANvändning) is the National programme for low energy buildings hosted by Sveriges Byggindustrier (The Swedish Construction Federation) with support from the Swedish Energy Agency.

A board comprising major actors governs the programme. The programme runs for 5 years from 2010 to 2014. The total budget is 54 million SEK, where the Energy Agency covers 40% and participating actors contribute with 60% own funding.

Objectives

A national platform with the objective to collect and disseminate knowledge about low energy buildings. The programme’s focus is on new buildings and completely renovated buildings.

From a QUIALICHeCK perspective the LÅGAN programme supports improved and unified input data for (energy performance) calculations, improved work practice, improved project evaluation and improved energy performance certificates (EPC). The results from evaluated projects, including comparisons between energy performance calculations and measured energy performance, as well as experiences from construction work and inspection (and commissioning) procedures, will be disseminated with the intention to improve the compliance of future projects.

The platform coordinates and administrates a programme comprising of:

- Communication - Main focus on dissemination of the work performed within the programme towards target groups (builders, contractors, consultants, etc.).
- Demonstration – Financial support to evaluation of and information about building projects that meet the programme criteria.
- National cooperation – Coordination of regional projects. Support enabling regional projects to take part in national knowledge enhancement.
- Implementation support – Participating building actors develop different tools (education, models, procedures, etc.) to support implementation on their own funding.

Programme criteria: New building projects are eligible for support if the ‘energy performance’ is 50% below the national requirements (BBR 16). Renovation projects are eligible for support if the ‘energy performance’ is reduced by 50% or 40% below the national requirements (BBR 16), or if the ‘energy performance’ is reduced by 75%.

Measureable goals:

- 8 demonstration projects of different types in different geographical regions;

- evaluation of at least 4 projects in operation for 4 years;
- 5 regional/local cooperation projects with at least 8 activities;
- at least 12 projects comprising implementation support carried out by at least 5 actors.

Present status

One of the main outcomes is a web-based database with low energy building projects. It contains good examples to support market development and shows which actors are involved in which regions.

For the time being there are 13 ongoing demonstration projects, 5 ongoing cooperation projects and 7 ongoing implementation projects.

References and contact information

Contact persons:

- Åsa Wahlström, CIT Energy Management

Website, links, …

- www.laganbygg.se

V. Conclusions

This report gives a preliminary overview of the situation regarding the quality and compliance mostly in the 9 focus countries represented in the QUALICHeCK consortium (Austria, Belgium, Cyprus, Estonia, France, Greece, Romania, Spain, and Sweden) on 4 technology areas (transmission characteristics, ventilation and air tightness, sustainable summer comfort technologies, renewables in multi-energy systems).

Although this report is not intended to give an accurate picture of the situation, the information collected suggests several critical sources of errors in the input data used in Energy Performance Calculations, including: absence of consistency check based on "as-built" data; unclear procedures; uneasy access to input data; mistakes or fraud by persons providing the input data; lack of competence of persons providing the input data.

In addition, partial information based on the analysis of 31 studies and selected schemes developed to overcome problems identified on the compliance of EPC input data or the quality of the works, suggests that the state of awareness and maturity of the schemes is very diverse depending on country and technology, ranging from very limited field knowledge to in-depth understanding, and from naïve to fairly elaborated schemes.

The approaches mentioned or briefly described in this report to increase the confidence in the EPC input data include:

- standard format to document the input data and to report the results of energy calculations, to make the EPC input data and results documentation transparent (Estonia);
- automatic checks in the calculation software and/or during upload into the EPC database (Austria, Belgium) ;
- product data databases to help ensure that correct product data is used (e.g., in Belgium and France);
- catalogues of construction methods (e.g. thermal bridge catalogues).

As for the quality of the works, the approaches include:

- voluntary building certification schemes that require measurements and tests (e.g., in Austria and Spain);
- voluntary certification schemes for construction workers and/or companies (e.g., in Belgium, France, or Romania);
- mandatory inspection of the building service systems (e.g., in Cyprus or Sweden).

Future work within QUALICHeCK will focus on further identification of problems based on field studies performed by consortium members in the 9 focus countries. This will allow a refinement of the understanding of the sources of errors in EPC input data and quality of the works. In parallel, the consortium will examine the reasons behind those sources of errors and will further investigate the relevance of specific schemes to reduce those errors.

These analyses will benefit from significant interaction with stakeholders foreseen through workshops, roadshows, national consultation platforms as well as the QUALICHeCK platform.

The ultimate goal is to produce and share information on how to tackle quality and compliance issues to help effective implementation of the EPBD recast in the Member States.

Annex I

Overview of relevant studies

		12	26	6	18	24	28	26
		TECHNOLOGIES				ASPECTS		
Country	**Description**	**INS**	**V&A**	**SUM**	**REN**	**DATA**	**QUAL**	**COMP**
Belgium	Ventilation: measurements versus requirements		X	X		X	X	
Belgium	III.2.1 Experiences with average insulation level	X				X		X
Belgium	Easy access to reliable input data	X	X	X		X		X
Belgium	Quality frameworks for post cavity insulation	X					X	X
Belgium	III.4.1 Experiences with ventilation performances in practice		X			X	X	X
Belgium	Compliance framework	X	X	X	X	X		X
Belgium	III.4.6 Duct leakage in air distribution systems		X				X	
Belgium	Legal framework for innovative systems - which technologies		X			X		X
Belgium	Handling of thermal bridges - theory and practice	X				X		X
Belgium	Quality framework for PV systems				x		X	X
Belgium	III.5.2 Performance of residential PV systems: Belgium				X	X		
Belgium	III.4.7 Experiences with building air tightness in practice		x				x	
Estonia	III.3.1 Estonian housing stock technical condition - apartment buildings built during the period 1990-2010 Airtightness of building envelope in new apartment buildings		X			X		X
Estonia	III.3.2 Estonian housing stock technical condition - apartment buildings built during the period 1990-2010 Ventilation performance in new apartment buildings		X			X		X
Estonia	III.7.1 Estonian housing stock technical condition - apartment buildings built during the period 1990-2010 Summer thermal comfort			X		X		X
Estonia	III.3.3 Indoor climate and energy efficiency of the retrofitted apartment buildings and analysis of their compliance with the standards and energy audits Energy efficiency of retrofitted apartment buildings		x				x	x

		12	26	6	18	24	28	26
		TECHNOLOGIES				ASPECTS		
Country	**Description**	**INS**	**V&A**	**SUM**	**REN**	**DATA**	**QUAL**	**COMP**
Estonia	III.3.4 Monitoring of the indoor climate and energy efficiency of retrofitted apartment buildings and analysis of their compliance with the standards and energy audits Ventilation airflows in retrofitted apartment buildings		x				x	x
Estonia	Investigations of heating cost determination by heat allocators in apartment buildings		x				x	x
Europe	Quality checks in passive house approaches					X		X
Europe	III.6.6 QualiCert - A common approach for certification or equivalent qualification of installers of small-scale renewable energy systems in buildings				X	X		
France	III.4.2 Airtightness of building envelope		X			X	X	X
France	III.4.3 Quality of ventilation systems in new dwellings		X				X	
France	Legal framework for innovative systems - which technologies	X	X	X	X	X		X
France	III.6.2 Quality of solar thermal domestic hot water systems in houses				x		x	
France	III.6.1 Quality of large solar thermal domestic hot water systems				x		x	
France	III.6.3 Quality of solar PV installations				x		x	
France	III.6.4 Quality of domestic wood boiler installations				x		x	
France	III.6.5 Quality of domestic heat pump installations				x		x	
France	III.5.1 Performance of residential PV systems: France				x	x		
Germany	Handling of thermal bridges - theory and practice	X	X			X		X
Germany	III.6.8 Performance of residential heat pump systems: Germany				X	X	X	X
Greece	III.3.6 Efficiency of night ventilation technique		x				x	
Greece	III.3.7 Measurements of particulates PM10, PM2.5 and PM1 in Greece		x				x	
Greece	III.3.8 Measurements of indoor pollutants in Athens		x				x	
Netherlands	III.4.5 Performance and quality of mechanical ventilation in dwellings		X				X	

		12	26	6	18	24	28	26
		TECHNOLOGIES				ASPECTS		
Country	**Description**	**INS**	**V&A**	**SUM**	**REN**	**DATA**	**QUAL**	**COMP**
Netherlands	Legal framework for innovative systems - which technologies	X	X	X	X	X		X
Romania	III.3.9 Airtightness of windows (on the market) and building envelope in apartment buildings		x				x	x
Spain	III.2.2 Analysis of different facade solutions for office buildings in Madrid	x						x
Spain	III.3.5 Ventilation airflows in new apartment buildings		x				x	
Spain	III.5.4 Heating and cooling solutions with efficient systems				x			
Sweden	III.2.3 Swedish building stock audit - BETSI	X	X					X
Sweden	III.2.4 Thermal bridges` influence on the calculated energy use	X				X		
UK	Quality framework for post cavity insulation	X					X	X
UK	Quality framework for airtightness		X			X		X
UK	III.5.3 Performance of domestic small-scale wind turbines: UK				X	X		
UK	III.6.7 Performance of residential heat pump systems: UK				X	X	X	X
UK	Performance of residential solar water heating systems				X	X	X	
UK	III.4.4 Quality of ventilation system		x				x	
UK	III.6.9 Performance of residential solar water heating systems: UK, Ireland				x		x	

Annex II

Data collection template for existing data

1. Introduction

The aim of this document is to obtain a more or less clear picture of the situation in your country/sector. We are not looking for a fully 100% accurate picture.

The information collected through this document is CONFIDENTIAL and in its present form not aimed for external distribution outside QUALICHeCK. Therefore, we hope that you will provide relevant information.

In a later phase:

Some of the information collected in this document might be included in a report aimed for public distribution BUT only after your approval;

More detailed information might be asked for, in particular in relation to compliant and available data, quality of works or compliance frameworks.

2. Overall situation

In this paragraph, we like to see your overall assessment of the situation in your country. In §3, practical examples are expected regarding field experience (good or bad), whereas in §4 we expect examples of approaches in your country regarding . As indicated above, the information will be treated confidential.

2.1. Reliable input data

Give a brief description of the situation in your country regarding information about te status on the ground on input data as well a interesting schemes (whether or not successful)

2.2. Quality of the works

Give a brief description of the situation in your country regarding information about te status on the ground on the quality of the works as well a interesting schemes (whether or not successful)

2.3. Compliance frameworks

Give a brief description of the situation in your country regarding information about te status on the ground regarding compliance activities as well a interesting schemes (whether or not successful)

3. Examples of observed performances in daily practice

In this section, we look for collected information regarding the situation on the ground. It can be field studies showing positive outcomes as well as field studies showing very critical outcomes. If possible, a brief assessment why the results are as they are might be very useful.

3.1. Input data / Quality of the works

Brief description of the study

Observed findings

Lessons to be learned

Assessment – follow-up actions

References and contact information

Documents:

Contact persons:

Website, links, …

4. Examples of interesting schemes (existing or under development)

In this paragraph, we invite you to briefly present interesting schemes related to one of the 3 areas of interest (reliable input data / quality of the works / compliance). It can be (very) successful schemes as well as schemes which in practice are not working well. In both cases, it is interesting to have a brief description of the context of the scheme, objectives, status, future expectations as well as an indication of the reasons for success and/or issues of concern. As indicated before, this information will be treated confidentially.

4.1. Input data / Quality of the works

Context/Starting point for the scheme

If possible, give an indication of the context in which this schemes was developed

Objectives

If possible, give a brief description of the objectives of this scheme

Present status

Briefly describe the present status of the scheme

Future

If possible, give a brief indication of envisaged further developments and/or useful improvements.

Analysis – synthesis

If possible, give a brief description of your overall assessment of the scheme.

References and contact information

Documents:

Contact persons:

Website, links, …

5. Synthesis - Conclusions

Give a brief overall assessment of the situation in your country

5.1. Awareness aspects

5.2. Engagement level

5.3. What could QUALICHeCK contribute?

5.4. What could we contribute to QUALICHeCK?

5.5. Other issues

QUALICheCK

Project Partners