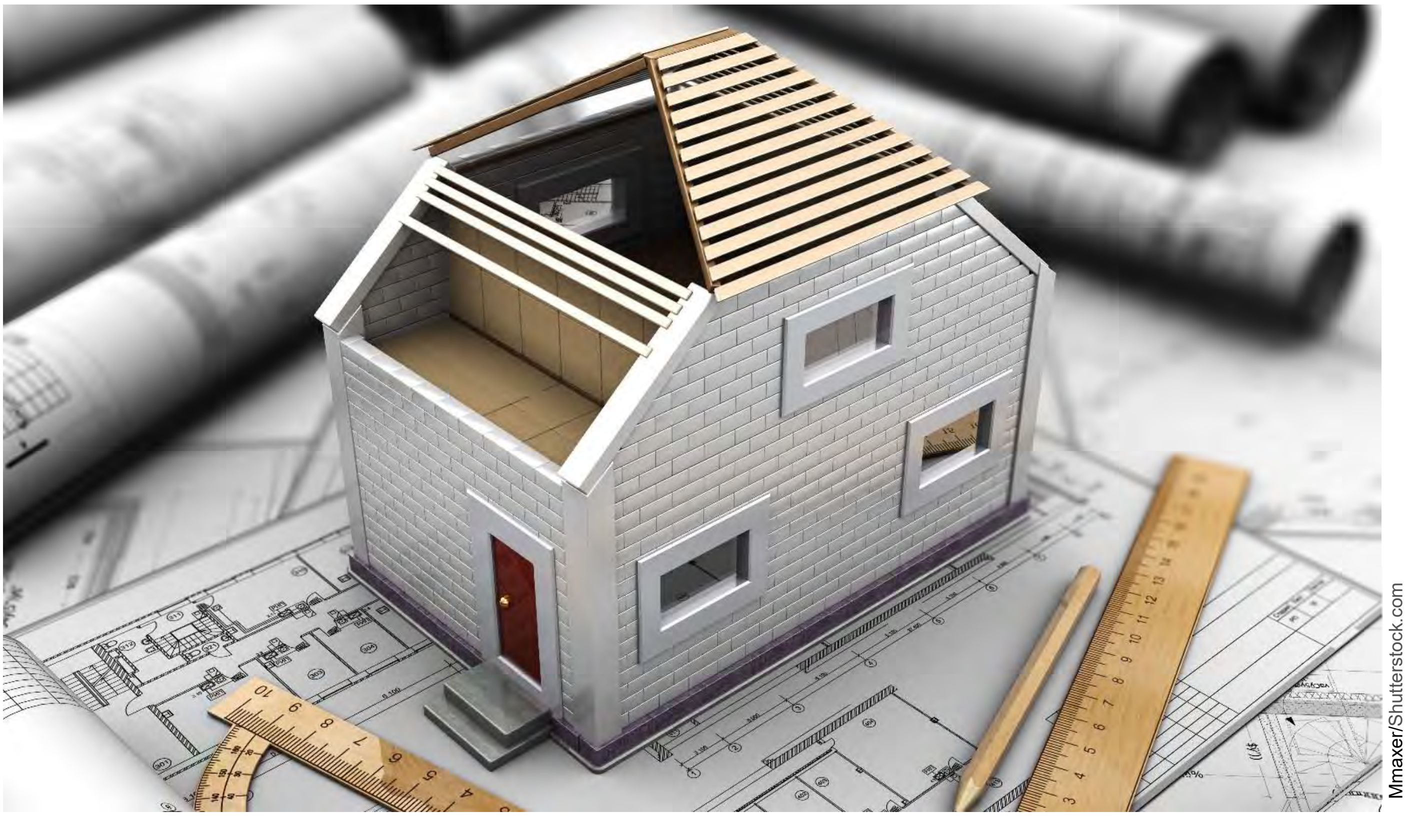
International Energy Agency

Towards compliant building airtightness and ventilation systems
AIVC Contributed Report 16

Energy in Buildings and Communities Programme
June 2017



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EBC is a programme of the International Energy Agency (IEA)

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Preface

The International Energy Agency

The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme. A basic aim of the IEA is to foster international co-operation among the 29 IEA participating countries and to increase energy security through energy research, development and demonstration in the fields of technologies for energy efficiency and renewable energy sources.

The IEA Energy in Buildings and Communities Programme

The IEA co-ordinates international energy research and development (R&D) activities through a comprehensive portfolio of Technology Collaboration Programmes. The mission of the Energy in Buildings and Communities (EBC) Programme is to develop and facilitate the integration of technologies and processes for energy efficiency and conservation into healthy, low emission, and sustainable buildings and communities, through innovation and research. (Until March 2013, the IEA-EBC Programme was known as the Energy in Buildings and Community Systems Programme, ECBCS.)

The research and development strategies of the IEA-EBC Programme are derived from research drivers, national programmes within IEA countries, and the IEA Future Buildings Forum Think Tank Workshops. The research and development (R&D) strategies of IEA-EBC aim to exploit technological opportunities to save energy in the buildings sector, and to remove technical obstacles to market penetration of new energy efficient technologies. The R&D strategies apply to residential, commercial, office buildings and community systems, and will impact the building industry in five focus areas for R&D activities:

- Integrated planning and building design
- Building energy systems
- Building envelope
- Community scale methods
- Real building energy use

The Executive Committee

Overall control of the IEA-EBC Programme is maintained by an Executive Committee, which not only monitors existing projects, but also identifies new strategic areas in which collaborative efforts may be beneficial. As the Programme is based on a contract with the IEA, the projects are legally established as Annexes to the IEA-EBC Implementing Agreement. At the present time, the following projects have been initiated by the IEA-EBC Executive Committee, with completed projects identified by (*):

Annex 1: Load Energy Determination of Buildings (*)
Annex 2: Ekistics and Advanced Community Energy Systems (*)
Annex 3: Energy Conservation in Residential Buildings (*)
Annex 4: Glasgow Commercial Building Monitoring (*)
Annex 5: Air Infiltration and Ventilation Centre
Annex 6: Energy Systems and Design of Communities (*)
Annex 7: Local Government Energy Planning (*)
Annex 8: Inhabitants Behaviour with Regard to Ventilation (*)
Annex 9: Minimum Ventilation Rates (*)
Annex 10: Building HVAC System Simulation (*)
Annex 11: Energy Auditing (*)
Annex 12: Windows and Fenestration (*)
Annex 13: Energy Management in Hospitals (*)
Annex 14: Condensation and Energy (*)
Annex 15: Energy Efficiency in Schools (*)

Annex 16: BEMS 1- User Interfaces and System Integration (*)
Annex 17: BEMS 2- Evaluation and Emulation Techniques (*)
Annex 18: Demand Controlled Ventilation Systems (*)
Annex 19: Low Slope Roof Systems (*)
Annex 20: Air Flow Patterns within Buildings (*)
Annex 21: Thermal Modelling (*)
Annex 22: Energy Efficient Communities (*)
Annex 23: Multi Zone Air Flow Modelling (COMIS) (*)
Annex 24: Heat, Air and Moisture Transfer in Envelopes (*)
Annex 25: Real time HVAC Simulation (*)
Annex 26: Energy Efficient Ventilation of Large Enclosures (*)
Annex 27: Evaluation and Demonstration of Domestic Ventilation Systems (*)
Annex 28: Low Energy Cooling Systems (*)
Annex 29: Daylight in Buildings (*)
Annex 30: Bringing Simulation to Application (*)
Annex 31: Energy-Related Environmental Impact of Buildings (*)
Annex 32: Integral Building Envelope Performance Assessment (*)
Annex 33: Advanced Local Energy Planning (*)
Annex 34: Computer-Aided Evaluation of HVAC System Performance (*)
Annex 35: Design of Energy Efficient Hybrid Ventilation (HYBVENT) (*)
Annex 36: Retrofitting of Educational Buildings (*)
Annex 37: Low Exergy Systems for Heating and Cooling of Buildings (LowEx) (*)
Annex 38: Solar Sustainable Housing (*)
Annex 39: High Performance Insulation Systems (*)
Annex 40: Building Commissioning to Improve Energy Performance (*)
Annex 41: Whole Building Heat, Air and Moisture Response (MOIST-ENG) (*)
Annex 42: The Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems (FC+COGEN-SIM) (*)
Annex 43: Testing and Validation of Building Energy Simulation Tools (*)
Annex 44: Integrating Environmentally Responsive Elements in Buildings (*)
Annex 45: Energy Efficient Electric Lighting for Buildings (*)
Annex 46: Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo) (*)
Annex 47: Cost-Effective Commissioning for Existing and Low Energy Buildings (*)
Annex 48: Heat Pumping and Reversible Air Conditioning (*)
Annex 49: Low Exergy Systems for High Performance Buildings and Communities (*)
Annex 50: Prefabricated Systems for Low Energy Renovation of Residential Buildings (*)
Annex 51: Energy Efficient Communities (*)
Annex 52: Towards Net Zero Energy Solar Buildings (*)
Annex 53: Total Energy Use in Buildings: Analysis & Evaluation Methods (*)
Annex 54: Integration of Micro-Generation & Related Energy Technologies in Buildings (*)
Annex 55: Reliability of Energy Efficient Building Retrofitting - Probability Assessment of Performance & Cost (RAP-RETRO) (*)
Annex 56: Cost Effective Energy & CO2 Emissions Optimization in Building Renovation
Annex 57: Evaluation of Embodied Energy & CO2 Equivalent Emissions for Building Construction
Annex 58: Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurements (*)
Annex 59: High Temperature Cooling & Low Temperature Heating in Buildings
Annex 60: New Generation Computational Tools for Building & Community Energy Systems
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Annex 73: Towards Net Zero Energy Public Communities
Annex 74: Energy Endeavour
Annex 75: Cost-effective Building Renovation at District Level Combining Energy Efficiency & Renewables

Working Group - Energy Efficiency in Educational Buildings (*)
Working Group - Indicators of Energy Efficiency in Cold Climate Buildings (*)
Working Group - Annex 36 Extension: The Energy Concept Adviser (*)
Working Group - Survey on HVAC Energy Calculation Methodologies for Non-residential Buildings

Foreword

Because buildings are responsible for 40% of energy use and 36% of Greenhouse Gas (GHG) emissions in the EU, energy efficiency in buildings has become a priority to drastically reduce the energy use in buildings. Consequently, a number of policy measures have been implemented in European Member States to drive the market towards Nearly Zero-Energy Buildings, including the Energy Performance of Buildings Certificates (EPCs), which are the most visible instrument of the Energy Performance of Buildings Directive (EPBD). Nevertheless, the boundary conditions that are necessary for these measures to be effective have rarely been carefully addressed. In this respect, two specific concerns lie in the compliance of Energy Performance of Buildings Certificates (EPCs) and in the quality of building works.

The IEE QUALICHeCK project's goal was to raise awareness and trigger initiatives to improve the compliance of Energy Performance Certificates and the quality of buildings works in order to decrease the actual energy use of buildings. In other words, QUALICHeCK urges building professionals to "do what they declare" since otherwise, it discredits the overall approach already engaged since a number of years in European countries with energy conservation regulations and incentives in the building sector.

This goal entailed 3 specific objectives:

1. To confirm the concern for non-compliant EPCs and quality of buildings works. Although there were some unstructured market feedback and studies pointing out this problem, further understanding of the status on the ground and the extent to which non-compliance could jeopardize the effectiveness of policies was necessary.
2. To show the benefits of existing approaches. There exist several voluntary or regulatory schemes that have been developed in many European countries to contain non-compliance of EPCs and of the quality of building works. QUALICHeCK's objective was to disseminate information on these schemes to inspire other bodies facing similar challenges.
3. To give the key steps to set up compliance frameworks. Because the development of a compliance framework can appear somewhat chaotic for an external observer—for instance because of feedback loops with stakeholders—the consortium came up with a summary of key issues that should be addressed for a sound foundation of the framework.

Based on a literature review and 10 specific field studies in 9 countries, each on samples of 25+ buildings, the EU QUALICHeCK project has confirmed this concern for non-compliant EPCs and quality of buildings works by showing that insufficient quality assurance measures increase the risk of discrepancies between claimed or expected and actual performance. Speaking about ventilation and airtightness, this could consist in the absence of controls of the building or ductwork airtightness values reported in the EPCs; this could also be the ambiguity left for the EPC expert to choose the appropriate input data for a specific ventilation system.

The good news is that there are also interesting approaches that have been developed to contain some of the issues reported in the field campaigns. In the area of ventilation and airtightness, these approaches include competent tester schemes for building airtightness or ventilation system performance checks, or databases developed to ease unambiguous EPC input data selection and control.

QUALICHeCK ended in February 2017. The consortium has archived its key findings in several reports and 59 factsheets which are short 2- to 10-page documents highlighting specific results. All public deliverables are available on the QUALICHeCK website (http://qualicheck-platform.eu/).

To ease the dissemination of these results in the ventilation and infiltration community, this report collates 23 factsheets specifically related to ventilation and airtightness issues, field data, and solutions. We hope you will find this information useful. Buildings are responsible for a major share of energy use and have been a special target in the global actions for climate change mitigation, with measures that aim at improving their energy efficiency, reduce carbon emissions and increase renewable energy use.

Peter Wouters, Rémi Carrié

QUALICHeCK project coordination

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Technology	Aspect	Country
Ventilation and airtightness	Quality of the works	France

BUILDING REGULATIONS CAN FOSTER QUALITY MANAGEMENT: THE FRENCH EXAMPLE ON BUILDING AIRTIGHTNESS

The French regulation includes an alternative route to systematic building airtightness testing to justify for a given airtightness level. This route was developed to push professionals to revisit their methods for implementing building airtightness solutions and to include specific quality requirements. At the end of 2014, 81 such quality management approaches have been approved representing a production of about 15.500 buildings per year.

Residential buildings ☑	Non-residential buildings ☑	Specific buildings: ……
New buildings ☑	Existing buildings ☐	

Context

There exists a significant body of literature showing the negative impacts of air leaks in building envelopes as well as the benefits of good building airtightness with appropriate provisions for ventilation, whether natural or mechanical. This explains why the French regulation has taken into account building airtightness since over 30 years, unfortunately with little success until about 2006. That year, a new regulation (RT 2005) came into force, with a benefit of about 7% on the calculated energy use for better airtightness on single-family houses. This regulation also introduced a new scheme (Annex VII of the regulation) to justify for the target airtightness level based on quality management (QM) principles.

Objectives and problems addressed

The QM scheme was initially developed considering the difficulties building professionals had to achieve good airtightness and the hope that cost abatements due to allowance for non-systematic testing could encourage building professionals to engage in a QM approach for building airtightness. The major problems addressed with this approach include:

- ✓ Poor training of designers and workers
- ✓ Recurrent poor treatment of envelope leakage sites
- ✓ Absence of self-checks on site
- ✓ Cost for systematic airtightness testing

This scheme is applicable to all new buildings. Because of its limited market potential for non-residential buildings, it will be restricted to residential buildings as of July 2015 (Annex VII, 2014).

Approach to overcome identified problems

Regulatory background

The 2012 French regulation introduced a minimum requirement for the building airtightness of all residential buildings, including mandatory justification of the airtightness levels mentioned in Table 1. For non-residential buildings, default values apply depending on the building types; if a value better than the default value is used in the calculation, mandatory justification applies as well.

In all cases where justification is necessary, the building airtightness level must be justified either:

- ✓ with an airtightness test by a certified tester of each building; or
- ✓ with a certified quality management approach that allows non-systematic testing.

The reference text for this QM approach is in the Ministry order of the energy performance regulation itself (RT 2005 and RT 2012). It allows the applicant not to perform an airtightness test systematically, but requires the organisation to set up a quality management approach for the whole building process that has to be approved by a specific national committee. In its 2012 version (Annex VII of RT 2012), successful applicants can use air permeability at 4 Pa in multiples of 0,1 $m^3/h/m^2$:

- ✓ in the range of 0,3-0,6 m^3/h/m2 (depending on the results they submitted in their application) for single-family buildings (this range corresponds to about 1,6-3,2 m^3/h/m2 at 50 Pa);
- ✓ in the range of 0,3-1,0 $m^3/h/m^2$ (depending on the results they submitted in their application) for multiple-family buildings;
- ✓ greater than 0,3 $m^3/h/m^2$ and smaller than the default value for other types of buildings (no longer applicable as of July 2015).

	Minimum requirement	Possible values in case of QM approach (multiples of 0,1 $m^3/h/m^2$	Default value
Single-family buildings	0,6 (3,2)	0,3-0,6 (1,6-3,2)	
Multi-family buildings	1,0 (5,4)	0,3-1,0 (1,6-5,4)	
Non-residential buildings (no longer applicable as of July 2015)		0,3-1,7 (1,6-9,2) or 0,3-3,0 (1,6-16,2) depending on building type	1,7 (9,2) or 3,0 (16,2) depending on building type

Table 1: Airtightness levels in the 2012 French regulation in m^3/h per m^2 of cold surface area at 4 Pa. Approximate corresponding values at 50 Pa are shown in parenthesis.

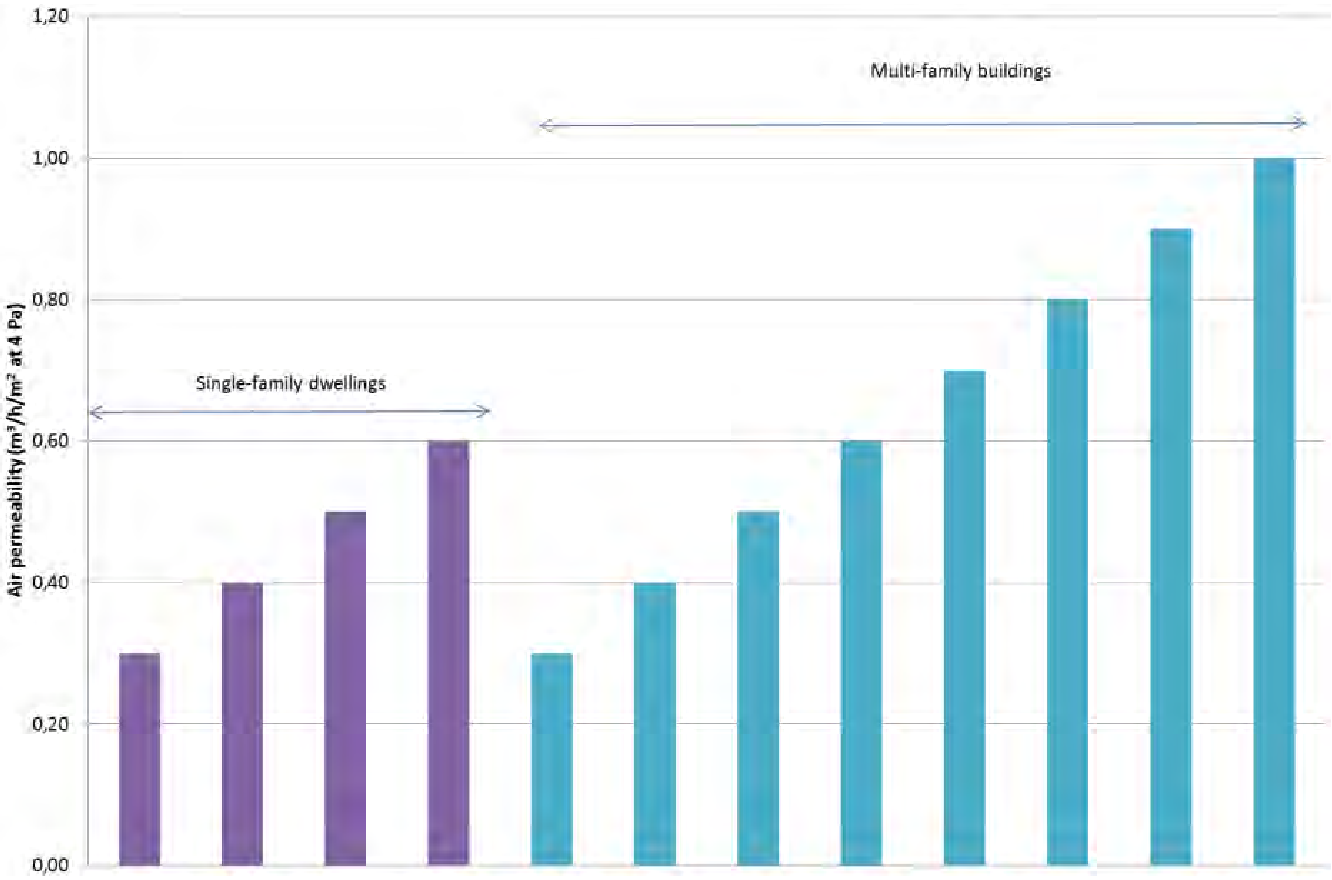


Figure 1: Possible values of maximum air permeability guaranteed by the applicant in single-family dwellings and multi-family buildings.

Eligibility and application

In principle, any building owner can apply for a certified QM approach but in practice, this option is mostly used by builders of single-family dwellings.

Basic requirements

The basic requirements for the 2012 quality management approach to be approved can be summarised as follows:

- ✓ identify the scope of the approach regarding the types of buildings concerned;
- ✓ identify "who-does-what" and when;
- ✓ show the involvement and training the workers internal to the company or sub-contracted;
- ✓ trace each step of the approach;
- ✓ show site supervision documents;
- ✓ show how remedial actions are implemented and traced;
- ✓ prove that the approach is effective based on measurements on a sample;
- ✓ propose a scheme to ensure that the approach will remain effective with time, based on measurements on a sample. The application must include a bar chart of airtightness measured values; and
- ✓ have the system audited according to ISO 19001 by an independent ISO 9001 certified organisation.

Successful applicants are not required to perform tests systematically but only on samples (typically 5% to 10% of their production for single-family dwellings, see Table 2) to comply with the justification for the air tightness level used in energy performance calculation. They have to send to a yearly report to the ministry including measurement results. If their report does not comply with regulation (poor application of QM approach, bad airtightness test results), the applicants can be de-certified.

Type of buildings	Production	Sample size
Single-family dwellings	Nprod ≤ 500 Nprod > 500	Ntests = 5 +10 % Nprod Ntests = 55 + 5 % (Nprod - 500)
Other buildings	Nprod ≤ 50 Nprod > 50	Ntests = 30 % Nprod Ntests = 15 +15 % (Nprod - 50)

Table 2: Minimum sample size for the QM approach in the 2012 French regulation

Submission process and foreseen changes with certification bodies

Candidates submit their application to the ministry in charge of construction explaining the steps they have implemented to plan airtightness, build according to the specifications, check and remedy if deviations are observed, in conformity with the ministry order. They have to show based on measurement on samples that their approach was effective. Because some applicants had difficulties giving the right amount of information, leading sometimes to heavy applications difficult to examine by the commission, a public webpage managed by the ministry[1] gives additional information for applicants, including the evaluation grid which is used by the commission and hints on what is expected by the commission.

To cope with the increasing number of applications, the ministry has revised the order to have the applications processed by accredited certification bodies under contract with the government starting July 2015. The requirements remain the same but the approach is restricted to residential buildings and applicants are charged.

Evaluation of the applications

A committee of 12 experts set up by the ministry in charge of construction meets about 10 times a year to evaluate the applications.

The experts analyse the applications with an evaluation grid which is a detailed transposition of the requirements of the order of the ministry including fields to be filled by the expert such as the documents examined to evaluate each criterion and the expert's opinion.

With the transfer to certification bodies as of July 2015, the evaluation process will remain the same in principle, but the evaluation committees will be set up by the certification bodies themselves.

[1] http://www.rt-batiment.fr/batiments-neufs/etancheite-a-lair/demarche-qualite-annexe-vii.html

Market acceptance of the approach

Several key market actors were sceptical about the uptake in the market given the methods and organisational changes it implies for building professionals. In fact, because the benefit can be substantial for builders of single-family houses with a production greater than 50-100 houses per year, once a few pioneers implemented this process with the support of consultants, many others have followed.

At the end of 2014, 81 QM approaches have been approved. The corresponding number of buildings produced in accordance with a QM approach is about *15.500 buildings per year*, i.e., around 10% of the national residential building production.

In case of replication in another context, one important pre-requisite clearly lies in the benefit for applicants in terms of assessment of the energy performance.

Pros and cons of possible options

This paper describes one specific scheme applicable when the airtightness level reported in the EP certificate has to be justified, either because a minimum requirement must be justified or because the value reported differs from a default value. Of course, many options could be discussed for a similar scheme if replicated in a different context. Nevertheless, for a given issue, whether one option is appropriate or not has to be appreciated in a given context. Therefore, the sections below do not give definite answers on the relevance of choices that could be made but point out pros and cons that should be considered when choosing options. These are summarised in Table 3.

Non-systematic versus systematic tests – Size of sample

The allowance for non-systematic tests has been a strong driver for the market acceptance of the approach. This requires boundary conditions to avoid adverse effects, namely in the French case, the obligation to set up a quality framework to secure the claimed airtightness level and to perform tests on a samples of a minimum size (Table 2). Therefore, the cost abatement thanks to sampling are partly counter-balanced by investments in the development and operation of the QM approach. The distribution of builders according to their production suggests that it remains interesting for builders producing over 50 houses per year, the trade-off being somewhere in the range of 20-50 houses per year (Figure 1).

In other contexts, the sample size should be set considering the target users, in particular, the typical production that may be concerned. It may result that allowance for non-systematic testing is not relevant in another context. If the objective is to foster QM approaches to improve the treatment of air leakage sites and encourage self-checks without allowances for non-systematic testing, favourable calculation factors when such approaches are implemented could be considered.

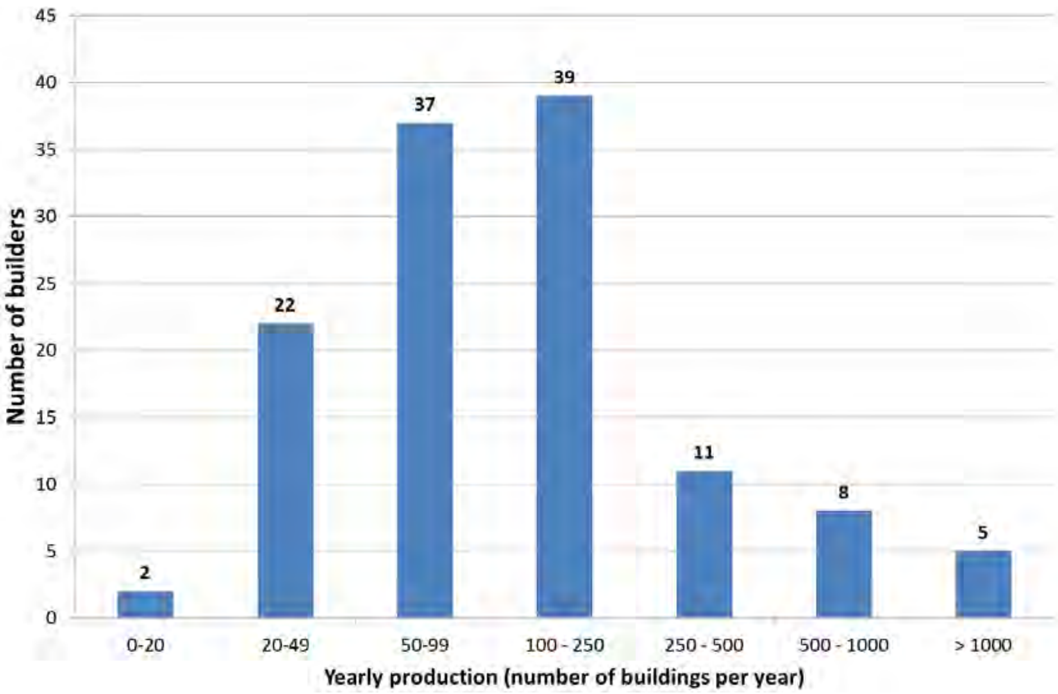


Figure 1: Distribution of builders applying the approach according to their yearly production

Safety margin for the level guaranteed

Because tests are performed on samples only and the difficulty to reach extreme airtightness levels, the present approach is not applicable to justify for airtightness levels below 0,3 $m^3/h/m^2$ at 4 Pa (about 1.6 $m^3/h/m^2$ at 50 Pa). In other words, if one needs to justify an airtightness level below 0,3 $m^3/h/m^2$ for a specific building, he has to perform an airtightness test whether a QM approach is implemented or not. Another safety margins which may be envisioned would be a safety factor between the maximum permeability measured on the samples and the level guaranteed. In the French context, this is applied voluntarily by several builders (e.g., who aim for an airtightness value around 0,1 $m^3/h/m^2$ under their official target), so as to be sure to comply with their official target. When builders apply such process, they hardly ever exceed the official target value.

Such safety margins seem relevant although there is little feedback on their effectiveness.

Independent tests versus self-tests for the samples

Unlike the 2005 version, the 2012 version of the scheme requires tests reported to the ministry to be performed by independent testers. Concerns for competition distortion and confidence in the results together with the pressure of independent testers are partly responsible for this change. Note however that this requirement can be by-passed by creating a testing company which is legally independent, although under the authority of the same person(s) in reality. In addition, it implies extra costs and assumes enough independent testers available to match the demand. Finally, experience has shown that builders have considerably improved their methods by doing tests themselves, which explains why some continue to perform many tests themselves although not required to.

Certification via a private body versus a committee managed by state of local authority

Since its origin in 2006, the present approach has been fully handled by the ministry in charge of construction. The advantage is that it has allowed the processes to progressively step up in a non-competitive environment for the evaluation committee, and to tune the quality requirements for the evaluation of the procedures to the satisfaction of the ministry. One downside lies in the number of applications overflowing the committee's capacity, probably magnified by the exemption from payment for applicants as well as the handling of poor or incomplete applications (although procedures have been set up to speed up the handling of such applications as mentioned above).

Consequently, as of July 2015, the applications will be processed by certification bodies. This required another set of procedures to be defined by the ministry to specify the requirements to the candidate certification bodies. Because applicants will be charged, this may help improve the quality of the applications and thereby speed up the evaluation process. The transition is expected to be smooth now that the system is mature.

QM versus results-based approach or application of standard drawings

Pushing professionals to engage in quality management for building airtightness was a primary motivation for setting up this approach in France. It was preferred to simpler approaches for builders that could be based uniquely on proofs of results achieved on a sample (showing results below a given level of permeability) or the application of standard drawings.

These alternatives may be appropriate for a different context but they do not directly push professionals to plan airtightness, implement adequate solutions, check their implementation on site and correct in case of deviations. These are precisely the core elements of a QM approach. Without integrating these aspects, the risk of deviation is likely significant, in particular when only applying standard drawings without performing some tests.

Option	Pros	Cons
✓ Non-systematic versus systematic testing - Sample size	✓ Cost abatement for non-systematic testing can be a major market driver if it covers the cost for developing and operating the scheme	✓ Market potentially concerned may be marginal due to minimum sample sizes ✓ Market distortion if QM requirements to secure level are insufficient
✓ Safety margin for the level guaranteed	✓ Confidence in values reported by the applicants	
✓ Independent tests versus self-tests for the samples	✓ Confidence in values reported by the applicants ✓ Confidence in values used in EP certificates	✓ Cost for the builder ✓ Builders also learn by performing tests themselves ✓ Need to have a matching number of independent testers available ✓ Testers may be independent on paper but not in practice
✓ Certification via a private body versus a committee managed by state or local authority	✓ Cost for state authority ✓ Better quality applications (due to fee)	✓ Need to write specifications for certification bodies ✓ Need to follow up effectiveness of the certification bodies ✓ Cost for applicants

Table 3: Pros and cons of various options

Compliance concerns related to EP regulation and to the QM approach

No reporting ☐	Wrong reporting ☑	Not meeting the performance requirements ☑

Compliance concerns related to EP certificates (see QUALICHeCK terms and definitions)

Lessons learnt from state controls

Because of the limits of a documentary analysis, the ministry decided to implement yearly control campaigns to better assess builders' approaches, including their effectiveness in terms of actual airtightness. These control campaigns consist in in-situ audits and tests performed by independent controllers (State controllers).

Thus, the approach allows the ministry to monitor the progress of the applicants year by year and overall, a set of options progressively modified or introduced has brought more confidence in the values declared by the applicants. Analysis of the yearly reports has shown that on average between 2008 and 2011, the builders have made progress to build airtight envelopes (see Figure 3). It has also shown much better results than those obtained in field campaigns conducted about 10-15 years ago (Litvak et al., 2000; Litvak et al., 2005; Guillot and Litvak, 2000).

Independent in situ controls of the scheme performed by the state since 2011 have shown some positive results but also raised several concerns (Charrier et al., 2014):

- ✓ First, quantitative requirements are generally met (Figure 3); however, in several cases, the measured airtightness did not meet the level claimed by the applicant;
- ✓ Second, several weaknesses in the actual implementation of the approaches were found although the quantitative requirements may have been met (see Figure 4).

These results call for pursuing in situ independent controls by the scheme holder with both in situ measurements and checks of the correct implementation of the QM procedures.

Nevertheless, this approach encourages applicants to secure a minimum airtightness level. This statement is supported by Figure 5 which shows that both the median value of the airtightness levels and the spread of the distribution are significantly smaller for buildings subjected to a QM approach. Thereby, it contains the risk of degrading the EPC with poor airtightness or not meeting a minimum airtightness requirement if applicable.

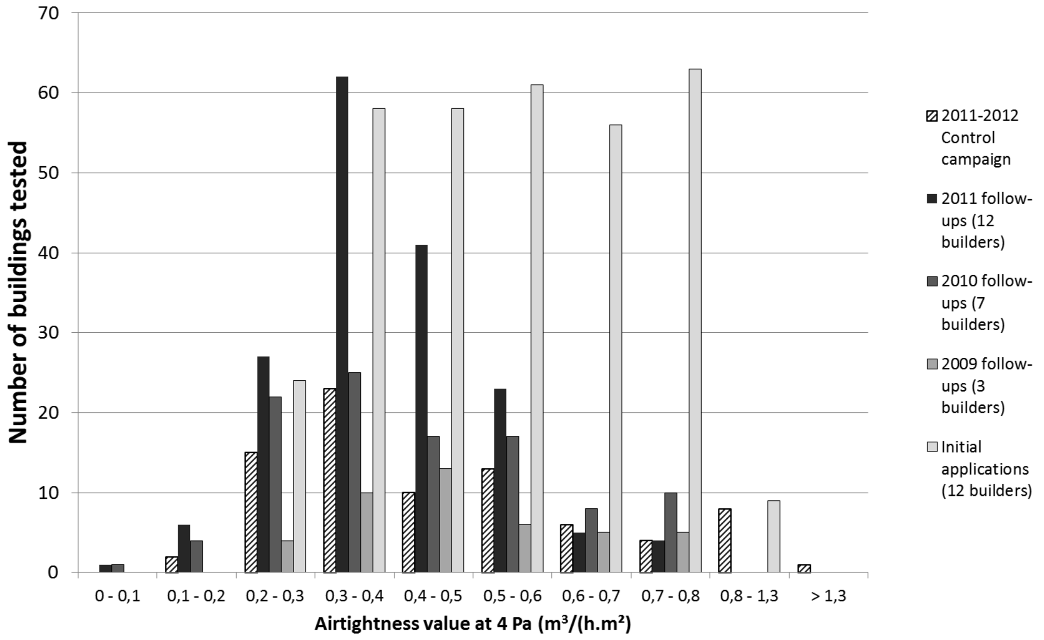


Figure 3: Measured values reported by builders in initial applications and yearly follow-ups (from 2008 until 2011), and from 2011-2012 control campaign (all builders together)

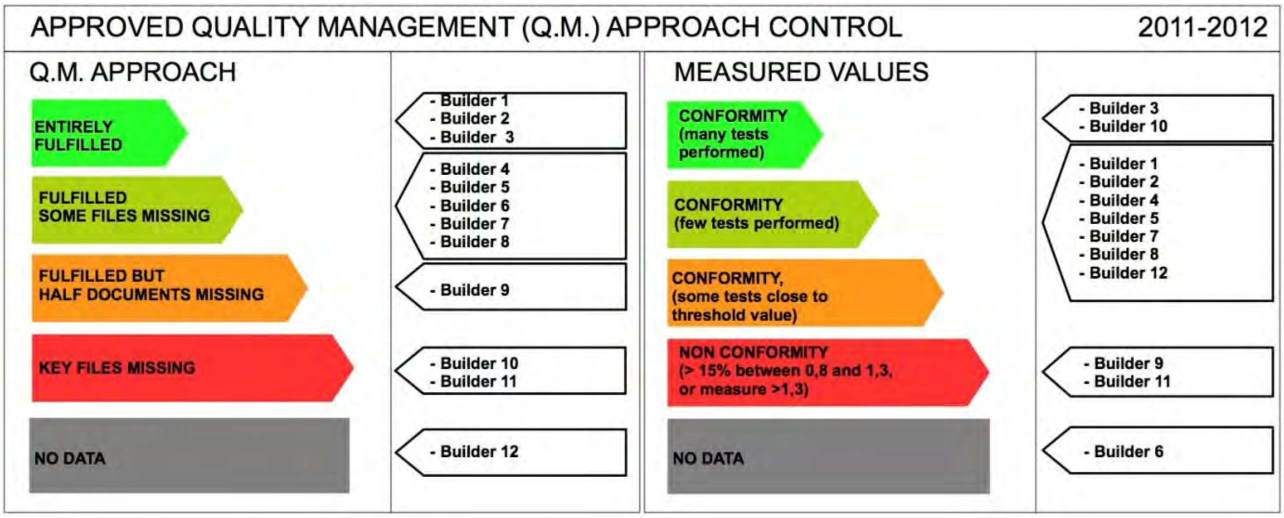


Figure 4: Summary of first control campaign.

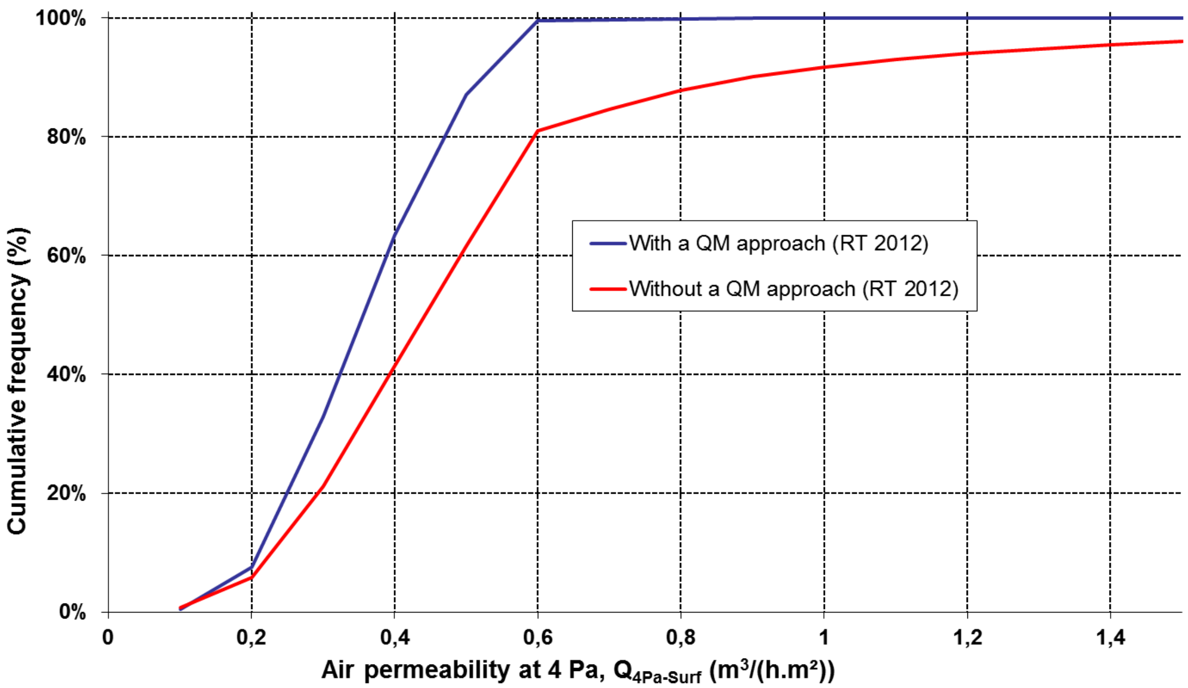


Figure 5: Distribution of measured airtightness of houses with and without implementation of a certified QM approach.

Penalties

In theory, the French penal code foresees sanctions that can go up to 45.000 €, and 75.000 € with 6 month imprisonment (in case of repeat offence) for non-compliance to the building code, including the energy performance regulation. Non-compliance is established by sworn-in civil servants who ask the building owner to take remedial actions; in parallel, they also formally report to the general attorney on the non-compliance and status of remedial actions. Although the building owner is responsible for the application of the regulation, in turn, the responsibility bears on the persons "skilled in the art" (architects, contractors, etc.).

The general attorney may decide to take sanctions foreseen by the penal code as soon as non-compliance is established. In practice, the preferred path is to compel the professionals involved to undertake remedial actions, which may in some cases be very expensive.

This general principle could apply to failure to achieve the airtightness claimed in the approach on one particular building; however, in practice, the preferred path is to de-certify the applicant (who is in fact responsible for the failure). The ministry has established a number of failures which may lead to de-certification[2]. These failures include insufficient achieved airtightness levels as well as incorrect implementation of the approach.

It is premature to evaluate how dissuasive these penalties are. One possible option would be to establish proportionate penalties ranging from simple fines up to de-certification, either in the French context or if the scheme is replicated elsewhere.

Financial aspects

As a rule of thumb, a production of 50 dwellings a year is a minimum to balance the cost of the development and implementation of the QM approach compared to systematic measurements. This does not include the positive side effects of the implementation of a QM approach, for instance to lower customer service costs.

Until 2014, the commission did not charge for the examination of applications. There was no information available on the true cost for the examination of the applications. The cost for the evaluation by certification bodies is not available at the time we are writing this paper.

[2] www.rt-batiment.fr/fileadmin/documents/RT2005/etancheite/AnnexeVII_texte_RT/Cerema_Manquements_Graves_Arrete_26102010.pdf

Overall evaluation

Despite legitimate concerns about its market penetration, its effectiveness, and its potential biases to competition, the current approach has proved to be successful among builders, to positively question applicants about their methods to reach good or at least required airtightness levels, and to be consistent with the achievement of better airtightness levels (Figure 5). The evaluation of the process conducted by the state authority has confirmed the relevance of the approach; it has also shown weaknesses that should be dealt with and strongly suggests reinforcing in situ controls to avoid deviations which may in turn question the relevance of the approach.. Overall, the pros and cons are summarised in Table 4.

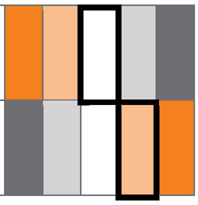
Pros	**Cons**
✓ Encouraging builders to question their current practice and engage in QM	✓ Cost for developing the approach and independent audits
✓ Great market impact	✓ Applicable mostly to single-family builders with a production of at least 50 houses / year
✓ Reduces testing cost if production is sufficient	✓ Examination/approval of the applications is time-consuming and requires well-developed procedures
✓ Possible monitoring of the progress as applicants have to file a yearly report	✓ Finding independent examiners and confidentiality of the approaches
✓ Improvement of workers skills	

Table 4: Overall pros and cons of the approach

The approach entails a number of issues to be carefully addressed, summarised in Table 5 as hints and pitfalls to avoid. Overall, the replication potential in other contexts seems rather high; however, it is a relatively complex approach to set up that requires time to be implemented properly (at least one year), even if it is done progressively as was the case in France. In addition, one key pre-requisite lies in having a substantial reward for good airtightness in the regulation to push stakeholders to consider this approach.

Level of complexity
(dark orange = simplest)

Potential for replication
(dark orange = best)



Prerequisite:
Substantial reward for good airtightness in EP calculation

Hints	**Pitfalls**
✓ Stress the benefits of QM approaches to secure airtightness level and comply with the regulation among stakeholders ✓ Discuss options with stakeholders ✓ Progressively increase QM requirements ✓ Ensure fair evaluation of the applications ✓ Conduct in situ controls ✓ Carefully estimate the minimum size of the sample to be measured	✓ Resources for examining applications ✓ Proof of application of standard drawings is not sufficient, some measurements must be done

Table 5: Overall hints and pitfalls to avoid when developing such an approach

References

Annexe VII. 2014. Arrêté du 19 décembre 2014 modifiant les modalités de validation d'une démarche qualité pour le contrôle de l'étanchéité à l'air par un constructeur de maisons individuelles ou de logements collectifs et relatif aux caractéristiques thermiques et aux exigences de performance énergétique applicables aux bâtiments collectifs nouveaux et aux parties nouvelles de bâtiment collectif. Official Journal of the French Republic of 26 December 2014.

Charrier, S., Ponthieux, J., Huet, A. 2014. The Airtightness Quality Management Approach in France - Assessment after more than Five Years of Operation. International Journal of Ventilation. ISSN 1473-3315. Vol. 13(2), pp. 125-140.

Guillot, K. and Litvak A. 2000. Étanchéité à l'air des constructions. Campagne de mesure de perméabilité à l'air et de ventilation de 70 logements. CETE de Lyon. Rapport DVT n°00.173. Septembre 2000. ADEME.

Litvak, A., et al. 2000. Étanchéité à l'air des constructions. État de l'art et recensement des pratiques. CETE de Lyon. Rapport DVT n°00.41. Avril 2000. ADEME.

Litvak, A., et al. 2005. Campagne de mesure de l'étanchéité à l'air de 123 logements. CETE Sud Ouest. Rapport n°DAI.GVCH.05.10. ADEME-DGUHC.

RT 2012. 2010. Arrêté du 26 octobre 2010 relatif aux caractéristiques thermiques et aux exigences de performance énergétique des bâtiments nouveaux et des parties nouvelles de bâtiments. Official Journal of the French Republic of 27 October 2010.

RT 2005. 2006. Arrêté du 24 mai 2006 relatif aux caractéristiques thermiques des bâtiments nouveaux et des parties nouvelles de bâtiments, Official Journal of the French Republic of 25 May 2006.

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Authors
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Technology	Aspect	Country
Ventilation and air tightness	Compliant and easily accessible EPC input data	France

FRENCH VOLUNTARY SCHEME FOR HARMONISED PUBLICATION OF VENTILATION PRODUCT DATA

A voluntary scheme defining the data to be announced in the product documentation has been launched in 2012 by Uniclima, the French association of ventilation product manufacturers. It ensures that product characteristics are provided under a harmonised form (same physical quantity, unit and assessment method), and facilitates access to relevant input data for the energy performance calculation of a building. The scheme contributes to enhancing the compliance of published data.

Residential buildings ☑	Non-residential buildings ☑	Specific buildings: ……
New buildings ☑	Existing buildings ☑	

Context

Even if testing methods are well defined in European standards, it may happen that product characteristics are not made available in a harmonised way by various manufacturers in their documentation.

Quantities announced and units used may differ, because of ambiguities, different interpretations, or misunderstandings of the standard. Differences may also exist because no regulation requires and defines how to publish product data (as for example do or will do the regulations that implement the "Ecodesign" Directive[1] or the "Energy labelling" Directive[2]). This could make difficult to find the data needed for the energy performance calculation of a building, as well as for its energy rating on the Energy Performance Certificate (EPC).

For this reason, a voluntary scheme that defines the data to be published in the manufacturer documentation has been launched in 2012 by Uniclima, the French association of ventilation product manufacturers.

The present document aims at:

- ✓ presenting this approach, that may be transposed to other countries than France,
- ✓ showing how it provides an *easy access* to data that are used as input data for the energy performance calculation of a building, and
- ✓ discuss to what extent such a scheme can also provide an *evidence of compliance* of these data, even without a systematic control by a third-party.

Objectives and problems addressed

The objective was to give better information to stakeholders (contractors, installers, building owners and consumers) about ventilation and air handling products, offering an easy access to their characteristics, especially those that are needed for checking the compliance with regulations, as for example the characteristics used as input data in the buildings energy performance calculation.

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[1] *Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products*

[2] *Directive 2010/30/EU of the European Parliament and of the Council of 19 May 2010 on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products*

The problems addressed can be illustrated by the following examples:

- different approaches may exist for publishing operation curves for fans, showing air flow rates vs. pressures, either by using total pressure or static pressure,
- different values may be published for the heat recovery efficiency of a balanced ventilation fan box, corresponding to different operating conditions described by the testing method,
- acoustic performance may be published by using different quantities (sound power, sound pressure at different distances).

In this context, decision was taken by French manufacturers, within their association Uniclima, to develop a voluntary scheme that would define the minimum set of product data to be included in the manufacturer documentation, and the format under which they have to be displayed.

It was also necessary to define the rules under which manufacturers undertake to comply with this scheme, while retaining their freedom to provide information beyond this minimum requirement.

The scheme was launched in 2012, after having been prepared in 2010-2011 by a working group of Uniclima, with the technical support of CETIAT, the French Technical Centre of HVAC manufacturers.

The scheme covers ventilation and air handling products that can be installed in all types of buildings (residential, commercial or even industrial), new or existing.

Approach to overcome identified problems

Products covered

The voluntary data publication scheme applies to a series of 19 ventilation and air handling products:

- ✓ humidity controlled air inlets,
- ✓ pressure difference self-adjust air inlets,
- ✓ humidity controlled air exhausts,
- ✓ pressure difference controlled exhaust air terminal devices,
- ✓ temperature controlled exhaust air terminal devices,
- ✓ indoor air terminals devices,
- ✓ flexible and semi-rigid air ducts,
- ✓ rigid air ducts and ductwork components,
- ✓ active fittings for circular ductwork (airflow regulators, dampers, valves),
- ✓ fire dampers,
- ✓ exhaust fan units for houses,
- ✓ exhaust fan units for commercial buildings or collective dwellings,
- ✓ balanced ventilation fan units for individual dwellings,
- ✓ balanced ventilation fan units for commercial buildings or collective dwellings,
- ✓ exhaust fan units for humidity controlled ventilation systems for individual dwellings,
- ✓ exhaust and/or fire smoke extraction roof fans,
- ✓ fire smoke extraction fan units,
- ✓ fan coil units,
- ✓ active chilled beams.

Figure 1: Logo used to identify products for which data are published according to the scheme

Data publication rules

The product data covered are those intended to be published in technical sheets, website, catalogue, price list and on the product packaging. Depending on the products, at least one of these media has to include all the characteristics announced.

For each product, the following rules have been defined in dedicated sheets:

- ✓ The list of minimum characteristics that have to be published by the manufacturer.

- ✓ The conditions for obtaining and displaying these minimum characteristics, as well as some optional characteristics, with reference to the appropriate standards (NF, EN, ISO) and certifications (for example NF, CSTBat, Eurovent).
- ✓ The list of communication media where the characteristics should be displayed.

These rules are regularly updated to take into account the evolutions of standards and regulations.

Data published according to the scheme are identified by a specific logo (see Figure 1).

Example of data for one product

As an example, Table 1 shows the minimum list of data required for a balanced ventilation fan unit with heat recovery intended for a one-family house.

At least one of the following communication media: technical documentations, price list, or website must include all the data listed in Table 1. In addition, the characteristics that must be found on the price list for professionals and the packaging of the products if they are sold in do-it-yourself stores are also mentioned.

Characteristics	Units	Standard or definition	Data required in technical documents and website	Data required in price list and on the packaging
Brand			X	X
Commercial reference			X	X
Designation			X	X
Product dimensions	To be chosen (mm, cm…)		X	X
Certification if any		French NF Mark (certification rules NF 205)	X	X
Area of use		According to the certification rules NF 205, or indication of the minimum and maximum sizes of the house that can be equipped	X	X
Heat recovery efficiency		EN 13141-7 with the following conditions: - balanced air flow rate at +/-10% in volume - temperature conditions according to EN308 - exhaust air flow rate: 120 m^3/h - pressure difference inlet/outlet: 50 Pa - fans in operation	X	X
Effective electrical power input (P)	W	According to EN 13141-7 and certification rules NF 205	X (min. and max. values)	X (all values)
Sound power level (Lw)	dB(A)	EN ISO 5135 and certification rules NF 205	Optional	X (+ information required by certification rules NF205)
Air flow/pressure curve	Pa vs. m^3/h		Optional	X
Filter classes in supply and exhaust		EN 779	X	X

Table 1: Data to be published for a balanced ventilation fan unit with heat recovery for a one-family house

Who can apply?

The scheme is managed by the French ventilation manufacturer association, Uniclima. It has been defined with the technical support of CETIAT.

Detailed rules and logo are available from Uniclima.

The scheme is opened to all manufacturers and products distributors, even if they are not members of Uniclima. Manufacturers choose themselves which of their products will be covered.

Links with the regulatory background

Data covered are useful to compare products but also to check compliance with various regulations:

- ✓ either directly when the regulation includes limit values (as for example regulations about air flow rates, or regulations that are / will be implementing the "Eco-design" and "Energy labelling" Directives),
- ✓ or by being used as input data for a calculation that will allow to check compliance (as for example the calculation of the energy performance of a building, or the calculation of the sound pressure level in the rooms of a building).

The manufacturer remains responsible for the product data that are published.

Does the scheme provide evidence of compliance of the data for the energy performance calculation of buildings?

The scheme helps to find product data that are presented in a harmonised way.

It contributes to provide an easy access to these data, making possible to compare products, to check without difficulty their compliance with mandatory levels (if required by a regulation). Those data can also be used in the calculations needed by regulations (as for example the energy performance calculation of a building).

In case of dispute about the compliance of the published data, the parties involved (i.e. the concerned manufacturer and the one who disputes the data, for example another manufacturer) try to find an amicable solution, under the auspices of Uniclima. If the disputed data are proven to be wrong, they must be corrected in very short delay. If the disputed data are proven to be right, for example by the test report of an independent laboratory, the published data remain unchanged.

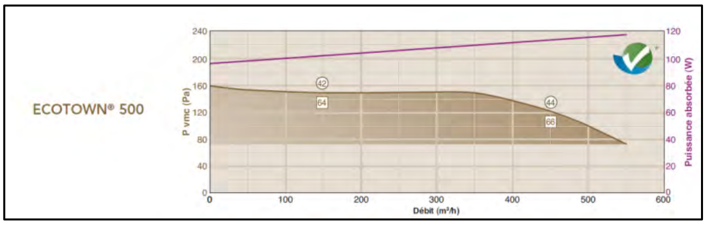
This contributes to improve the compliance of the published data. If a manufacturer ever would take the risk to publish wrong or incomplete data, he would expose himself to such a dispute.

Although such a scheme does not give an "a priori" evidence that the published data have been determined according to the required procedures, and thus does not fully guarantee their compliance, it helps surely for it as it makes a wrong declaration more difficult and more risky.

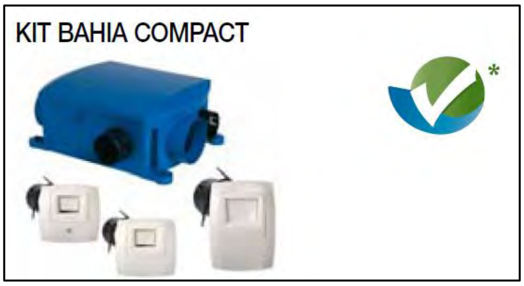
Market acceptance of the approach

In May 2014, Uniclima estimated that the scheme had been used by over 25 manufacturers in France, for a total number of almost one million of installed ventilation systems for year 2013 (based on the number of residential and non-residential products put on the market).

Examples of use of the logo

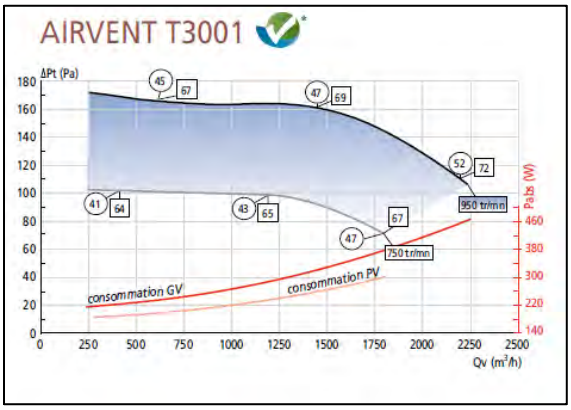


Source: http://caladair.com

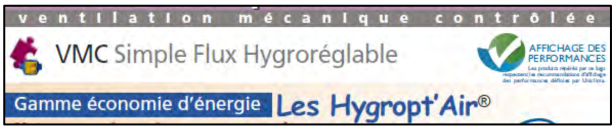


Source: http://pro.aldes.fr

Source: www.lindab.com/fr



Source: www.atlantic-ventilation.fr



Source: www.autogyre.fr

Source: www.vim.fr

Source: www.nather.fr

Figure 2: Examples of product documentation in which the logo can be seen

Pros and cons of possible options

The following table summarises the options that have been taken when defining and implementing this scheme. It shows some pros and cons.

Option	Pros	Cons
✓ Voluntary scheme	✓ Organised and managed by manufacturers, well informed of the product data that are required by their customers ✓ No public funding	✓ The approach is interesting if a great number of manufacturers follow the scheme for a big number of their products
✓ Free access	✓ Allows all interested manufacturers to adopt the scheme, without being obliged to become members of the manufacturer association	✓ No available dedicated budget to promote or improve the scheme ✓ Relies only on the effort that each manufacturer will operate to implement and manage the scheme
✓ Covering of a minimum set of data, leaving freedom to the manufacturer for others	✓ Concentrates on the data that are useful to compare products and to check compliance with regulations	
✓ Publication of harmonised data by each manufacturer	✓ If no centralised product database exists, good way to provide an easy access to product data, used either as input data for the EPC calculation or for checking compliance with regulations ✓ Allows everyone to compare products based on defined criteria	✓ All data are not available at the same place ✓ Comparison limited to products that follow the scheme
✓ Disputes first discussed with the concerned manufacturer	✓ Research for an amicable solution, under the auspices of the manufacturer association ✓ Contributes to the compliance of the data	✓ Does not fully guarantee the compliance of the data, as would do for example a systematic control by a third-party

Table 2: Description of the options taken in this scheme, together with their pros and cons

Compliance concerns related to EP certificates

The following table shows whether the described scheme avoids or limits some of the most typical cases of non-compliance.

No reporting ☐	Wrong reporting ☑	Not meeting the performance requirements ☑

Compliance concerns related to EP certificates

It has been explained ahead why the scheme can be seen as contributing to the publication of more surely compliant data.

Some of these data are used as input data to calculate the energy performance of a building and to determine its rating on the Energy Performance Certificate. The fact that these input data are more surely compliant reduces the risk of non-compliance of the energy performance with the requirements of the regulation.

Financial aspects

The scheme relies on the efforts of the manufacturers, with the help of their association (Uniclima) and their Technical Centre (CETIAT). It requires no public funding and remains of free access.

Overall evaluation

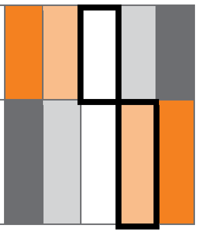
The pros and cons of the described approach are summarised in Table 3. Hints and pitfalls are shown in Table 4.

Pros	Cons
✓ Voluntary scheme, free access	✓ Interesting if a sufficient number of manufacturers and products are covered
✓ Provides an easy access to harmonised data	✓ The data are not put together at the same place
✓ Reduces the risk of wrong or incomplete data, and thus contributes to more surely compliant data	✓ The compliance is not fully guaranteed
✓ Allows to check compliance with other regulations than the one about the building energy performance	

Table 3: Overall pros and cons of the approach

Level of complexity
(dark orange = simplest)

Potential for replication
(dark orange = best)



Prerequisites

Will of a sufficient number of manufacturers to implement the scheme through their national association

Hints	Pitfalls
✓ Time needed to implement the scheme (to list the products to be covered, to define the contents of the sheets with a consensus between manufacturers involved, to implement the scheme in the manufacturer documentation) ✓ Need to communicate about the scheme so that the market asks for it	✓ The scheme has to be continuously updated (changes in the standards or in the regulations) ✓ Certain risk that only a few manufacturers join the scheme if the market is not aware of it

Table 4: Overall hints and pitfalls to avoid when developing such an approach

References

1. UNICLIMA. 2012. Ventilation et traitement d'air des bâtiments. Dossier de presse. http://www.uniclima.fr/fileadmin/BASE_DOCUMENTAIRE_UNICLIMA/Actualites/DP_Uniclima_ventilation_air.pdf
2. UNICLIMA. 2014. Recommandations d'affichage des performances produits. http://www.uniclima.fr/fileadmin/BASE_DOCUMENTAIRE_UNICLIMA/Documentation/2014_04_01_Affichage_des_performances_produits_-_Liste_fiches_validees.pdf

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

Author
Samuel Caillou (BBRI)

Technology Ventilation and airtightness; Transmission characteristics; Sustainable summer comfort	*Aspect* Compliant and easily accessible EPC input data	*Country* Belgium

VOLUNTARY SCHEME AND DATABASE FOR COMPLIANT AND EASILY ACCESSIBLE EPC PRODUCT INPUT DATA IN BELGIUM

The "EPB product database" in Belgium is an effective scheme to improve the compliance and easy access to product characteristics used as input data for the Energy Performance Certificate (EPC) calculation. The acceptance of this scheme by the market has been successful for many years. The present factsheet explains this Belgian scheme and tries to identify the reasons for its success and the prerequisites for the implementation of similar schemes in other countries.

Residential buildings ☑	Non-residential buildings ☑	Specific buildings: ……
New buildings ☑	(Existing buildings ☑)	

Context

For the calculation of the Energy Performance of Buildings (EPB), the input data are crucial to ensure compliant Energy Performance Certificates (EPC).

Different types of data are necessary as input for the EPC calculation, such as basic building data (climate, orientation, surfaces, etc.), data linked to the building execution (e.g. measured airtightness of the building envelope), and **construction product and system data** (e.g. efficiency of heat recovery devices). In the rest of the document, these will be called product data.

In the QUALICHeCK project (see [1]), two important properties of EPC input data have been identified:

- ✓ **Compliant** input data: established in line with the procedures in force in the context of the applicable legislation;
- ✓ **Easily accessible** input data: can be found, seen and used by taking "reasonable time, effort or money".

To improve both the **compliance** and the **accessibility** of EPC **product data**, a voluntary scheme has been developed for many years by the three Regions of Belgium responsible for the Energy Performance of Buildings regulations. This scheme is a database providing data about the energy performance of products with a recognition process (i.e. verification and publication of the data) based on third-party control. This database is called the "EPB product database" in Belgium and is available on http://www.epbd.be.

The present document describes the principles of this scheme developed in Belgium, with its advantages and its pitfalls for possibly further implementation of similar schemes in other countries.

Objectives and problems addressed

The general aim of the EPB product database developed in Belgium is to improve the compliance and the accessibility of product data used as input data in Energy Performance calculations and certificates.

Such product data are for example:

- ✓ Thermal conductivity of insulating materials,
- ✓ Properties of sunscreens,
- ✓ Efficiency of heat recovery units for ventilation,
- ✓ Capacity of background ventilators (supply openings for natural and exhaust ventilation systems),
- ✓ Etc.

These product properties should be tested in laboratory on a product sample according using the assessment method described in the EPC calculation method, referring as much as possible to international standards.

However, several problems can cause a lack of compliance of product data.

- Data mentioned in product documentation and/or in advertising documents sometimes do not comply with the assessment method.
- The manufacturer is not sufficiently informed about the required assessment method.
- It is often unclear if the mentioned data for a given product is also valid for other products or variants in a product line. Sometimes only one product in a line has actually been tested.
- The assessment method is not always clear enough.
- Because the assessment method is sometimes different from one country to another (for products not completely covered by international standardization), product data might not be compliant in a given country although it is in another.
- Some test reports mention references to standards but use national or specific deviations to these standards, possibly having an impact on the result.
- In worse cases, actual fraud will occur from intentionally publishing wrong data.

To overcome these problems, the aim of the Belgian scheme is to improve product data compliance by third-party controls.

Another problem of product input data concerns the accessibility to the information for the builders, designers and "EPB rapporteurs" (the "EPB rapporteur" is the specific person responsible, in the Belgian context, for the Energy Performance calculation and certificate).

- Product performance is announced in an inhomogeneous way in the manufacturer's documentation.
- Quantities announced and units used are not always the same.
- The effort to find the product data by the EPB rapporteur can be too high (variety of information sources: website, brochures, test reports, etc.).

In the Belgian scheme, the recognized product data are published on a unique web page, being then easily accessible.

This Belgian scheme has been first developed in the context of EPC for new buildings, residential and commercial.

Nevertheless, the scheme is also used in the context of EPC for existing buildings: published data in the database are considered as "acceptable evidences" in this context. However, this is only useful for relatively recent renovations of existing buildings because the available data only cover products which are currently available on the market.

Approach to overcome identified problems

Regulatory background

The EPC regulatory background is quite specific in Belgium with an effective system of compliance checking (see [2] for more details). The most important elements in the context of the scheme described in the present document are as follows.

- ✓ The EPC calculation and declaration occurs after completion of the work based on the "as built" situation;
- ✓ The EPC calculation and declaration is carried out by an EPB rapporteur (for whom requirements are specified in the regulation);
- ✓ Sanctions (fines) are defined by the regulation in case of wrong declaration (fine to the EPB rapporteur) and in case the Energy Performance requirements are not fulfilled (fine to the building owner).

Because of this EPC framework in Belgium, the responsibility of the EPB rapporteur for correct EPC declaration and compliant EPC input data is high. In case of wrong data or wrong reporting, they are subject to administrative fines

For this reason, the request of the EPB rapporteur for compliant EPC product input data is a key driving force for the success of this scheme in Belgium.

Third-party control

The key element of the EPB product database in Belgium is the control of the compliance of the data carried out by a third-party (Neutral Control Organism). Each product data recognized and published in the EPB product database in Belgium has been controlled in details by a third-party.

Depending on the type of product data, the control by the third-party can include for example:

- ✓ Control if the test procedure used to measure the product data comply with the assessment method required in the Energy Performance regulation (possibly referring to international standards);
- ✓ Control if the tested product is the same as the product for which the publication is requested. If needed, clarification of the different product variants for which the data is valid;
- ✓ Verification of the competence of the laboratory where the tests have been carried out;
- ✓ Etc.

The scheme describes for each product category the list of controls to be carried out by the third-party. Moreover, the extent of this control can vary according to the type of product and to the type of laboratory, for example:

- ✓ For product properties covered by the CE marking according to the Construction Product Regulation (for example thermal conductivity of insulation materials), there is no third-party control required;
- ✓ If the product properties have to be determined according to an EN standard and if the tests have been carried out in a laboratory accredited for this EN standard, the control by the third-party is very limited;
- ✓ If the tests are carried out in a non-accredited laboratory, the third-party has to control the competence of the laboratory (availability of test procedures, of qualified staff, of calibrated measurement instruments, etc.);
- ✓ If the tests are carried out in a manufacturer laboratory (only allowed for certain product categories), the third-party has to be present during the test.

To act as Neutral Control Organism (third-party), there are some requirements to fulfill (for example notification in the framework of the Construction Product Directive). The Neutral Control Organism market is a free market. In theory, a Neutral Control Organism can be chosen by the manufacturer outside Belgium, provided that this organisation fulfills the relevant requirements.

Voluntary scheme

The EPB product database in Belgium is a voluntary framework.

The manufacturers (as well as importers, distributors, etc.) may request to have their product data recognized and published in the database, but this is not mandatory.

The EPB rapporteurs may voluntary use the recognized and published data.

Assessment method for the product data

Basically, the requirements for the assessment methods for the product data are described in the Energy Performance regulation itself, referring as much as possible to international (EN) standards.

Moreover, there are specific procedures in the scheme for each product category, describing:

- ✓ The list of data/properties to be published;
- ✓ The requirements on the test laboratory responsible for each data;
- ✓ The requirements on the third-party controls for each data;
- ✓ The general requirements on the third-party itself;
- ✓ Some clarifications, if necessary, on the measurement methods of the product data.

Comparison of product data outside and inside the scheme

Because the EPB product database in Belgium is a voluntary scheme, it is also possible to use product data which are not recognized and published in the database.

The following table compares the steps and requirements for product data outside and inside the scheme.

	Product data outside the database	Product data recognized and published in the database
Assessment methods	Described in Energy Performance regulation	Described in Energy Performance regulation Additional clarifications
Requirements on the measurement of product data	Required to be tested	Additional requirements on the laboratory, report content, etc.
Third-party control	-	Third-party control depending on the type of data and type of laboratory
Source of product data for EPB rapporteurs	Data to be found case by case by the EPB rapporteur (manufacturer's documentation, etc.)	Recognized product data are published on a public website
Control of EPC by the authorities	Random controls on the compliance of EPC input data	No additional control by authorities needed

Table 1: Comparison of product data outside and inside the scheme

Overview of the scheme and the parties involved

The working principles of the EPB product database in Belgium can be summarized as follows:

- The use of this scheme by the manufacturers is voluntary.
- The product data result from laboratory tests according to the assessment method in the Energy Performance regulation.
- The evidence of compliance of the data relies on controls by a third-party.
- The scheme is managed by an independent operating agent on behalf of the Regional authorities. The working costs are paid by the manufacturers.
- The recognized data are available on a public website and can be used by EPB rapporteurs.

The main parties involved are presented in the figure below.

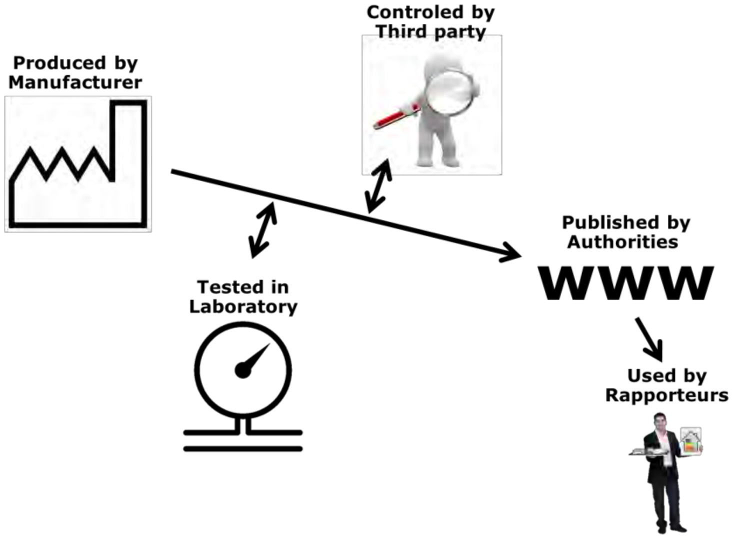


Figure 1: Roles of the main parties involved in the EPB product database in Belgium.

The manufacturers (or distributors, importers, etc.) and in some cases the manufacturer associations, play a key role in the process.

- Because the scheme is voluntary, they are responsible to apply, if they want to, for recognition and publication of their products in the database.

- The manufacturers are responsible for the test of the product by the laboratories and for the control by the third-party. They have to pay for both.
- The manufacturers remain responsible for the published data in case of error, product change, change of the assessment method, etc.

The test **laboratories** are chosen by the manufacturer in Belgium or in other countries. There are requirements for the test laboratories and they have to carry out the test according to the assessment method in force in the EPC context in Belgium.

The **Neutral Control Organism (third-party)** is also chosen by the manufacturer, in Belgium or in principle also in other countries. Some requirements apply to the Neutral Control Organism and the control can be easier (less expensive) with a Neutral Control Organism having experience with the Belgian scheme.

The **authorities** (the three Regions in Belgium: Flemish Region, Brussels-Capital Region, and Wallonia) have developed the scheme and are responsible for its operation. The management of the scheme itself (management of the dossiers, publication of the data, etc.) is delegated to a unique and independent **operating agent** in Belgium. This unique operating agent (in place of the three Regions) simplifies the process for the manufacturers. The Belgium Building Research Institute (BBRI) is the operating agent for the EPB product database in Belgium.

The building professionals and particularly the **EPB rapporteurs** also play a key role in this scheme. They are free to use the data from the database. But because the EPB rapporteurs are deeply responsible for the EPC calculation (and compliance of the EPC input data) and for the EPC in the Belgian context, they are requesting compliant product data. The EPB rapporteurs are really the **driving force** of this **voluntary** framework.

Market acceptance of the approach

Although the EPB product database in Belgium is voluntary, the approach is successful and the market acceptance is very high. Moreover, the manufacturers themselves are requesting this scheme as well as recognition of their products in the currently available categories. They are also interested in the development of new product categories. For example, a new category is under development for demand controlled ventilation systems.

The framework has been operational for nearly 10 years for the first group of products. The table below gives an overview of the number of recognized products for the different current product categories.

Category of product	Number of recognized products in June 2015
Insulation materials	More than 600
Opaque components (blocks, …)	200
Sunscreens	Thousands
Background ventilators (Natural ventilation supply openings)	28
Fans and ventilation units	225

Table 2: Number of recognized products in the EPB product database in Belgium

The success of the EPB product database in Belgium can be at least partially explained by the following elements.

- The EPC framework in Belgium.
- The responsibility of the EPB rapporteurs in the EPC framework in Belgium.
- Market actors have been involved in the development process of the scheme through regular informational and consultation meetings, both for the global framework and for the development of the specific procedures for each product category.
- Communication is very important at different levels: towards the EPB rapporteurs about their responsibility, towards the manufacturer about the advantages of the database, etc.
- The success of each product category depends also on competition in the market for the different products. For example, for fans and ventilation units, the high number of different manufacturers and product creates higher request for the EPC database than in the case of background ventilators covered by a more limited number of manufacturers.

Pros and cons of possible options

The third-party controls required in this scheme are really the key element which can significantly improve compliance of the product data. Such systematic and detailed controls would be difficult to organize by the authorities themselves, because of the financial and human resources needed. In this scheme, the additional costs for the third-party controls are supported by the manufacturers themselves in a free market (free choice of the third-party provided that it fulfils the requirements).

The fact that the scheme is voluntary is related to this first point. It is only because the scheme is voluntary that it is possible to require a higher level of compliance (with third-party controls) involving costs covered by the manufacturers. But it is also more difficult for a voluntary scheme to succeed because a certain degree of motivation of the market and of the manufacturers is needed. Good communication with the market can help to convince.

It can be tempting to add some requirements to the assessment method for the product data in the framework of the scheme itself in addition to the requirements of the Energy Performance regulation. This may be desired to increase the accuracy of the product data. However this can be a pitfall: if the additional requirement is too severe and because the scheme is voluntary, this will discourage the manufacturers from entering the system.

The Energy Performance regulation in Belgium is a regional competency but the EPC calculation methods are nevertheless very similar in the three Regions of Belgium. To simplify the administrative load for the manufacturer, the scheme is managed by a unique operating agent.

Option	Pros	Cons
✓ Third-party control	✓ Secures compliance of the data ✓ Fewer controls needed by the authorities	✓ Additional costs for the manufacturers
✓ Voluntary scheme	✓ Allows achievement of higher quality (higher requirements and accordingly possibly higher costs)	✓ Requires motivation of the market to succeed ✓ Needs good communication toward the market
✓ Additional requirements in the scheme for the assessment method of product data	✓ Can increase the accuracy of the product data recognized in the scheme and/or clarify the required assessment method	✓ Can weaken the interest of the market for the scheme (too severe in comparison to be outside the scheme)
✓ Management of the scheme by an unique operating agent	✓ Common scheme for several authorities (specific to the 3 Regions in Belgium) ✓ Unique contact point for the manufacturers, whatever the product	✓ Maybe not always needed, depending on the national situation
✓ Scheme at national level	✓ Answers a need to comply with national Energy Performance regulation	✓ Possibly several schemes and several costs in different countries for the same product

Table 3: Overview of possible options of the Belgian scheme with pros and cons

Compliance concerns related to EP certificates and to the QM approach

No reporting ☐	Wrong reporting ☑	Not meeting the performance requirements ☑

Compliance concerns related to EP certificates (see QUALICHeCK terms and definitions)

Improvement of compliance

Because each recognized and published data in this scheme has been controlled by a third-party, compliance can be achieved at a high level.

This scheme is very effective to improve the compliance of product data, as demonstrated in the following example.

- Several years ago, the efficiency of heat recovery units for ventilation was not yet covered by this scheme.
- At that moment, the main source of information for heat recovery efficiency to be used in EPC calculation by EPB rapporteurs was the technical documentation from the manufacturers.
- Such technical documentation could sometime mention very high (and in some cases very unrealistic) values of heat recovery efficiency. They did not always refer clearly to EN standards required for this product data in the Energy Performance regulation.
- There were no guarantees that these declared values were the result of an effective measurement of the product according to this standard, especially for different products in a product line; in some cases, the heat exchanger alone (in place of the complete unit) could have been tested; or the declared value could have been measured for different air flow rates than the one required.
- After this scheme had been launched for heat recovery units, the EPB rapporteurs understood very well that the declared values in the technical documentation were not always compliant and that they were taking a risk by using non-compliant data (they may be fined). In case of doubt about the product data declared by manufacturers they preferred to use the default value (which is quite unfavourable) in EPC calculations.
- Even if this scheme is voluntary, the manufacturers understood well that their interest was to have published data in the EPB product database, ensuring higher compliance and above all higher confidence and credibility on the market.

Penalties

For products that the manufacturers have requested to be recognized and published in the EPB product database:

- ✓ In case of non-compliance to the scheme, there are no penalties but possibly indirect costs: new or additional laboratory tests, additional third-party controls, etc.

For products which are not recognized in this scheme and in case of non-compliance with the Energy Performance regulation, there are different possible penalties:

- ✓ In case of wrong EPC reporting by the EPB rapporteurs (including non-compliant EPC input data), the EPB rapporteur is liable to administrative fines. He/she can initiate a procedure to demonstrate the responsibility of the manufacturer and to try to be compensated by the manufacturer.
- ✓ In case the Energy Performance requirements are not fulfilled (higher energy consumption than the maximum allowed), the owner is liable to administrative fines defined in the Energy Performance regulation in Belgium.

The possible fines for the EPB rapporteurs in case of wrong EPC declaration and their high responsibility are the main incentives for them to demand compliant product data from this voluntary scheme.

Financial aspects

The costs for the manufacturers for the EPB product database are as follows:

- ✓ For the operation and management of the scheme by the operating agent, there are initial (100 € per product, limited to maximum 600 €/per application and per manufacturer) and annual costs (600 €/year per manufacturer, up to 100 products). Special reduced fees exist for common requests (> 100 products) introduced by manufacturers associations.
- ✓ The third-party controls are supported by the manufacturer. These vary according to the product category (complexity) and to the number of product in the request (e.g. for ventilation units with heat recovery, a few thousand euros for around five units).
- ✓ The tests in laboratories are also paid by the manufacturer. These tests are required by the Energy Performance regulation, even outside this scheme (see Table 1). In some cases however, the prices of the tests carried out in this scheme can be higher depending on additional requirements (e.g. required to be measured in a laboratory independent from the manufacturer).

The development of the scheme, the global and the specific procedures has been funded by the authorities (three Regions of Belgium).

Overall evaluation

The EPB product database in Belgium is a very efficient scheme for improving the compliance of EPC product data, and the acceptance of this scheme by the market has been successful for many years (e.g. for six years for insulation materials and for three years for fans and ventilation units).

Pros	Cons
✓ Evidence of compliance of the published/recognized data (third party control)	✓ Limited to Belgium while there is an international market for construction products and systems
✓ Easy access to compliant data	✓ The approach is interesting if a great number of manufacturers follow the scheme
✓ Voluntary scheme allowing higher compliance	✓ Limited to EPC input data (does not cover other product performances such as acoustical data)
✓ For the manufacturers: • Higher confidence of the building owners • Higher visibility • Compliant and unquestionable product data	✓ Communication and information of the actors (manufacturers and EPB rapporteurs) is crucial to create the market will
✓ For the EPB rapporteurs: • Lower risk (responsibility) • Easier access to compliant data	✓ Costs for the manufacturers
✓ For the authorities: • Higher compliance • Less controls needed for EPC declarations	
✓ For the builders and owners: • Allows comparison of products	

Table 4: Overall pros and cons of the approach

Level of complexity

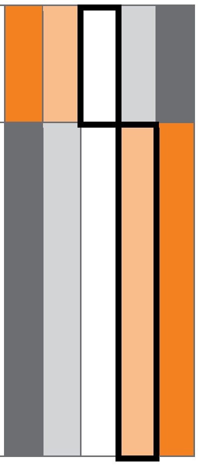
(dark orange = simplest)

3/5

Potential for replication

(dark orange = best)

4/5



Prerequisites

Effective EPC compliant framework (responsibility of the EPB rapporteurs)

Main elements of the assessment methods for product data already mandatory in the Energy Performance regulation

Political will

Communication and involvement of the market

Will of the manufacturers to be involved

Hints	Pitfalls
✓ Lobby action can help to convince the manufacturer to participate to the scheme. ✓ Need to communicate about the scheme so that the market asks for it.	✓ Time, resources and funding to develop the scheme at the beginning and new specific procedures for new product categories. ✓ It should be avoided to add requirement on the assessment method for product data in the scheme itself compared to the Energy Performance regulation. ✓ The scheme has to be continuously updated (changes in the standards or in the regulations).

Table 5: Overall hints and pitfalls to avoid when developing such an approach

References

[1] F. Durier et al. (2014). How to get compliant and accessible data for the energy rating calculation of a building?. QUALICHeCK report. http://qualicheck-platform.eu/results/reports/

[2] X. Loncour (2015). Energy Performance of buildings regulations in Belgium - The key puzzle pieces for an effective regulation. Presentation at the QUALICHeCK Workshop, 16-17 March 2015, Lund, Sweden. http://qualicheck-platform.eu/events/workshops/

[3] BBRI. (Unknown). Données produits PEB. Online www.epbd.be

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Technology Ventilation and airtightness	*Aspect* Compliance frameworks	*Country* France

REGULATORY COMPLIANCE CHECKS OF RESIDENTIAL VENTILATION SYSTEMS IN FRANCE

Regulatory compliance checks on samples of residential ventilation systems are operational in France. The analysis of their results shows a significant rate of non-compliance with the ventilation regulation (rate on the order of 50%).

Residential buildings ☑	Non-residential buildings ☑	Specific buildings: ……
New buildings ☑	Existing buildings ☐	

Context

It is generally accepted that building ventilation is a very important feature to provide good indoor air quality. While there are a range of industrial products that prove to be efficient if properly designed and implemented, there is also evidence of recurrent design, installation, and maintenance problems in the field detrimental to ventilation system performance. These problems are magnified with the trend towards Nearly Zero-Energy Buildings, as the energy use through ventilation is usually proportionally greater in these buildings compared to less energy efficient buildings. In addition, energy efficiency must not compromise indoor air quality. Article 4 of the Energy Performance of Buildings Directive recast (EPBD, 2010) states that "requirements shall take account of general indoor climate conditions, in order to avoid negative effects such as inadequate ventilation".

The EPBD recast also introduced Articles 18 and 27 which require member states to implement independent control systems for energy performance certificates and reports of the inspection of heating and air-conditioning systems as well as penalties in case of non-compliance. These requirements do not explicitly cover the ventilation compliance checks, although this could make sense to account for the energy impact of ventilation and the negative side effects of poor ventilation mentioned in Article 4 of the EPBD. In addition, member states may want to develop such compliance checks on the grounds of their ventilation regulation alone. Sweden and its "OVK" procedures are often cited in this respect (Andersson, 2013; Andersson, 2015).

In the French context, regulatory compliance checks on samples of the yearly production of new buildings have been introduced since the early 1970s to urge contractors and project owners to build according to the rules set by the building code and to monitor the application of the regulations. These checks cover the compliance to the ventilation regulation.

This document gives the status on the ground regarding the compliance of residential ventilation systems in France based on the results of this compliance framework and outlines its pros and cons. Note that it deals only with regulatory checks, which are today legally limited to checks that are ordered by the state, i.e., not checks that can be performed on a voluntary basis.

Objectives and scope of ventilation compliance checks in France

The principal objective of the ventilation checks performed in France is to evaluate and reduce the risks of non-compliance with the ventilation regulation whose aim is to provide outdoor air to the occupants and remove pollutants from the building.

Although the law allows the state to undertake checks in all new buildings, in practice, ventilation compliance checks are implemented in France mostly in new residential multi-family buildings.

Approach to regulatory compliance checks

Regulatory background

In the framework of regulatory compliance checks of ventilation systems developed in France, the ministry in charge of construction appoints trained sworn-in employees of CEREMA (which is a public institute) to undertake checks on a sample of the yearly production of buildings. The controls are ordered by the ministry as a judiciary police mission. By law, they can be performed on site within three years after the building is declared finished by the owner (Ministère du logement, 2009).

The French regulation on ventilation in new residential buildings is mostly based on the order of 24/03/1982. It is based on four major requirements (Carrié and Garin, 2004):

1. The air renewal must be global and permanent throughout the dwelling.

2. The air must flow from main rooms where the air inlets are located, to service rooms, where outlets are located.

3. New dwellings must be equipped with a ventilation system. The system may be natural, mechanical, or hybrid, but the ventilation cannot rely on window opening only. The ventilation system must be able to extract given airflow rates (in average winter conditions) that depend on the dwelling type. Base and boost airflow rates are defined.

4. Airflow rates can be reduced if the indoor air quality is maintained and condensation risks are not increased. Therefore, humidity-controlled systems can be used.

In summary, there are both functional measures and given airflow rates that must be attained in order to comply with the regulation.

Sample selection

The sample to be checked is defined by state authorities based on suggested representative samples provided by the ORTEC (Observatoire de la Réglementation Technique) database – a database managed by CSTB. Today, it typically represents around 5% of the yearly production of new residential buildings in France.

Control procedure

The control of the ventilation regulation includes a visual control of the functional requirements (e.g., the location and characteristics of air inlets and outlets) and measurements for the performance requirements (mechanical extract airflow rates).

Controllers follow a protocol and report on standard forms for statistical processing.

Penalties

Non-compliance with regulation is an offense and controllers' reports are sent to national authorities. By law, the building owner is liable for the compliance of his building with the regulation; however, in turn, the responsibility usually falls on the persons "skilled in the art" (architects, contractors, etc.). In case of non-compliance, the attorney general can give financial penalties—in theory, up to 45.000 €, and, in case of repeat offence, up to 75.000 € with 6 month imprisonment—or ban professionals from practicing. In reality, penalties are very rarely applied; however, the owner is compelled to apply remedial actions to comply with the regulation.

Status on the ground

The quantitative results of on-site controls ordered by the Ministry may be summarized as follows:

- ✓ 50% of the controlled buildings do not meet the requirements in terms of ventilation technical equipment;
- ✓ 43% of the controlled buildings do not comply with the regulatory airflows rates:
  - ➢ 84% of non-complying exhaust flows are insufficient;
  - ➢ 16% of non-complying exhaust flows are excessive;
- ✓ For single-family buildings, the non-compliance average rate of technical equipment exceeds 60%.

These results have been relatively stable over the years. A specific study on ventilation systems compliance in French residential buildings (Jobert, 2012; Jobert and al., 2013) identified six main types of non-conformities: non-conformities of the exhaust airflow rates, the air inlet system, the air outlet system, the system configuration, the ventilation unit, the ductwork, and the air transfer. The analysis of 373 reports of French regulatory checks, representing 1287 dwellings, has shown 604 non-compliant items or defects, which is close to non-compliance rate observed at national level. Jobert and collaborators (2012, 2013) report 1246 problems, further detailed in Figure 1. 46% of controlled buildings presented a non-compliance of the air inlet and outlet system. 27% were non-compliant with regard to the required airflow rates. Furthermore, the French Agency for Construction Quality has shown that defects in ventilation installations resulted primarily from installation and design problems (46% and 33%, respectively, see Figure 2).

Overall, these studies show that, nowadays in France, little attention is paid to the quality of ventilation system installations and their actual efficiency despite the implementation of compliance checks for many years. Therefore, it questions the relevance of the measures meant to be dissuasive in this scheme, in particular the penalties, which are rarely applied.

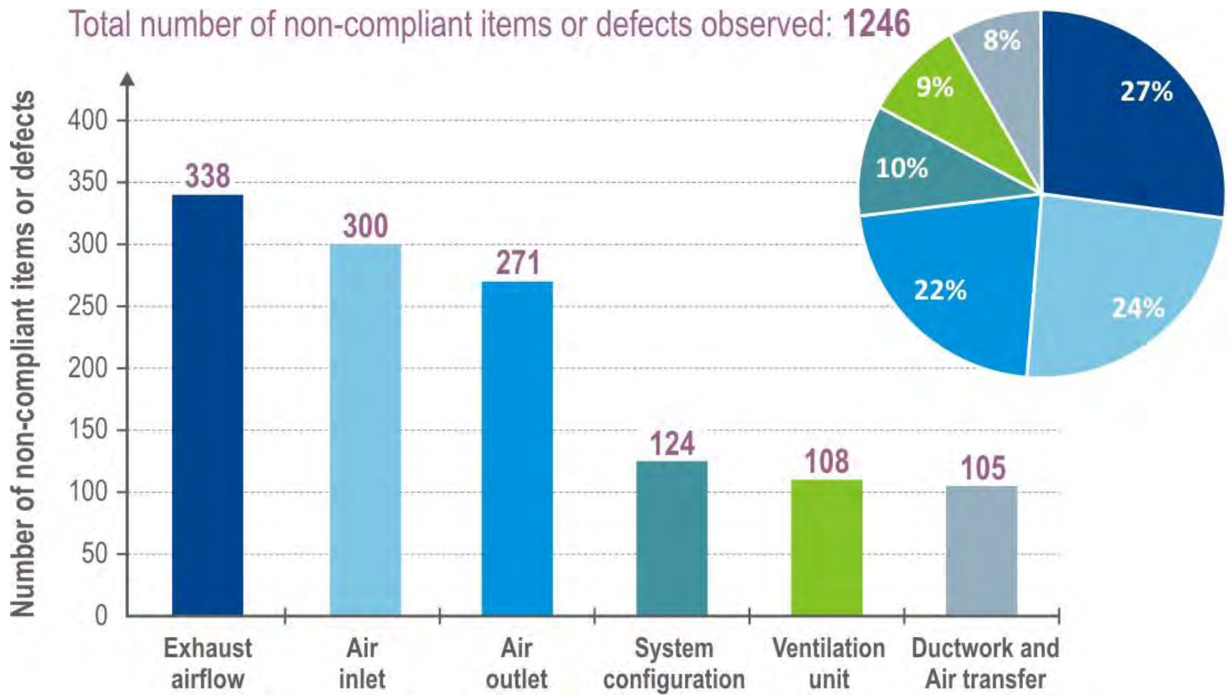


Figure 1: Number of non-compliance or defects per category in a sample of 1287 dwellings, see Jobert and collaborators (2012, 2013)

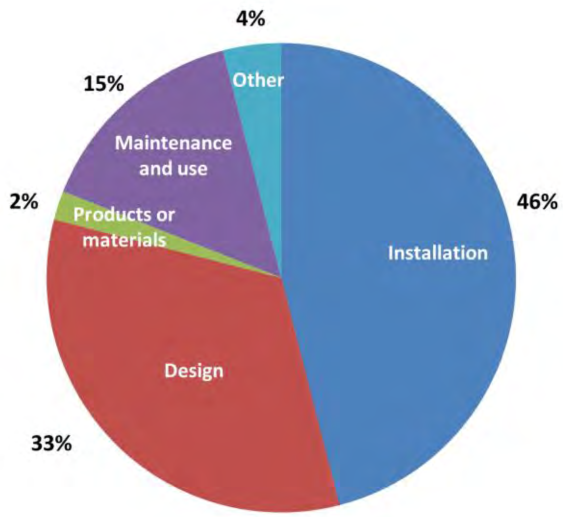


Figure 2: Origin of defects observed in residential ventilation systems in France (Sycodes, 2012)

Market acceptance of the approach

There is no data about the market acceptance of regulatory compliance checks of ventilation systems; however, our feeling is that few stakeholders (manufacturers, installers, architects, etc.) and nearly no end-users are aware that controls can occur. To our knowledge, the French authorities have started to release information to the public on this subject in 2009 with information on their website and a flyer to explain the overall procedure (http://www.developpement-durable.gouv.fr/IMG/DGALN_plaquette_controle%20respect%20regles%20construction_avril2009.pdf).

Based on unstructured feedback from consultation platforms and controllers, it seems that people are mostly pleased when they learn that state authorities have a control policy. On the other hand, people liable for problems in a building which is controlled probably have a different feeling if costly non-conformities are found (this may be the case, for instance, if the ventilation ductwork or the fan have to be replaced to meet the required airflow rates, a window has to be changed to be able to install an air inlet, etc.).

Pros and cons of possible options

This paper describes regulatory compliance checks as performed in France. This section presents several aspects that should be discussed when developing or reviewing similar frameworks.

State controls, third-party checks and self-control

The French control scheme is directly managed by the state. This involvement seems relevant to evaluate the application of the regulation but is obviously not sufficient to improve the situation. Complementary measures that could be envisioned include the following:

- ✓ Increase the sample checked. The major drawback lies with the availability of additional financial resources at state level;
- ✓ Specify evidence of compliance. The regulation does not impose any justification that the requirements (including the actual airflow rates) are met in practice. Even without requiring third-party checks, such a justification could help raise awareness amongst professionals through the checks they would be required to perform or order;
- ✓ Require third-party checks. This is experimented in the voluntary Effinergie+ label[1]. This option is attractive but four issues should be carefully considered depending on the context in which it is implemented. First, it implies extra costs for the owner. Second, the tester is under pressure to please his client. A certification scheme could alleviate this problem but would amplify the cost issue. Third, this “third-party” requirement can be by-passed by creating a testing company which is legally independent, although under the authority of the same person(s) in reality. Fourth, it requires enough independent testers available to match the demand;
- ✓ Require self-checks. Experience on envelope airtightness has shown that builders have made significant progress by implementing self-check procedures.

Certified installers

The certification of installers could be a complementary measure to regulatory compliance checks. Certified installers would therefore be subjected to controls of the quality of their installations either on samples or on all of their projects. A major obstacle to this approach lies in the costs implied for the owner, which may discourage installers from engaging in a certification process or professionals as well as owners to require certified installers, unless it is required by regulation or a specific programme.

Visual checks and/or measurements

Visual checks are attractive because they are cheap and easy to perform, compared to airflow rate and pressure measurements. In addition, with appropriate checklists and archiving procedures, in-house visual checks are likely to be very effective to urge professionals to pay attention to the ventilation installation.

Nevertheless, visual checks are limited with regard to compliance of minimum airflow rates. Measurements are necessary to check the compliance of the airflow rates; however, appropriate standards are lacking to perform in situ airflow rate measurements with reasonable effort and confidence in the results.

[1] *This label is firmly based on the energy performance regulation—i.e. it is based on the same input data and calculation procedures, but sets additional and more stringent requirements compared to those imposed by the regulation. For more information, see Effinergie+ references in reference list and www.effinergie.org.*

Option	Pros	Cons
✓ State controls	✓ Direct access to evaluation of the application of the regulation ✓ No direct cost for the owner and building professionals	✓ Availability of financial and human resources at state level ✓ Size of the sample checked
✓ Third-party checks versus self-control	✓ Confidence in completeness of checks	✓ Cost for the building professionals/owner ✓ Professionals learn with self-checks ✓ Need to have a matching number of independent testers available ✓ Testers may be independent on paper but not in practice ✓ Pressure to please client
✓ Certified installers	✓ Confidence in compliance of the installation	✓ Cost for the building professionals/owner
✓ Visual checks	✓ Cheap and easy to carry out	✓ Limited to check to the compliance of airflow rates
✓ Measurements	✓ Allow checking compliance of airflow rates	✓ Lack of non-destructive and reliable standards

Table 2: Description of pros and cons of different options

Compliance concerns related to EP regulation

No reporting ☐	Wrong reporting ☐	Not meeting the performance requirements ☐

Compliance concerns related to EP regulation

The ventilation compliance checks described in this fact sheet are based on the requirements of the regulation on ventilation; however, because the controllers involved are usually competent regarding EP regulatory controls as well, their results may be partially used to check compliance with the EP regulation, in particular, concerning the existence of an EP calculation and certificate and the consistency of the input data used for the types of system installed or the fan power. On the other hand, there are no specific requirements on ventilation performance in the EP regulation (although this performance affects the overall building energy use which must comply with a minimum requirement). Therefore, if excessive airflows are measured by the State inspector, no modification to the energy performance calculation is required.

Financial aspects

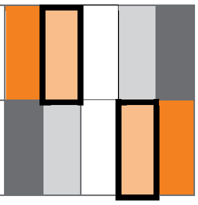
Altogether, regulatory compliance checks in France represent about 5% of the yearly production of new residential buildings, and involve about 70 full-time equivalent controllers in France, plus the persons managing the overall process and controlling campaigns. Note that these numbers concern all regulatory compliance checks in buildings, i.e., they are not restricted to ventilation aspects.

Overall evaluation

Although regulatory compliance checks performed on ventilation system in new residences in France seem very useful to have a good picture of the status on the ground, they seem to have little or no effect on the high non-compliance rate observed for many years. This may be partly due the penalties actually applied which are rarely dissuasive; the absence of a link with the EP calculation; or the size of the sample checked, although the latter is already significant. The replication potential in other contexts seems rather high; however, the pros and cons as well as the hints and pitfalls summarised in Table 4 and Table 5 should be carefully considered.

Pros	Cons
✓ Benefit to owner without direct cost	✓ Cost for the state
✓ Direct assessment of the application of the ventilation regulation	✓ No link to EP calculation in present scheme
	✓ Little effect to improve non-compliance rate in practice (probably due to ineffective penalties or inadequate sample)

Table 4: Overall pros and cons of the approach

Level of complexity (dark orange = simplest)	
Potential for replication (dark orange = best)	

Prerequisite:

Existence of verifiable ventilation requirements and penalties in case of non-compliance

Hints	Pitfalls
✓ Define realistic but dissuasive penalties ✓ Carefully estimate the sample size to be dissuasive ✓ Consider links with EP regulation to be even more dissuasive ✓ Consider complementary measures to improve compliance such as third-party checks, self-control, or certification ✓ Carefully evaluate the cost/benefit of measurements over visual checks	✓ Penalties not applied in practice ✓ Inappropriate human and financial resources to perform checks ✓ Inappropriate measurement methods to give unambiguous statements on compliance

Table 5: Overall hints and pitfalls to avoid when developing such an approach

References

Andersson, J. 2013. Quality of ventilation systems in residential buildings: status and perspectives in Sweden. In edited proceedings of the AIVC- TightVent international workshop, Brussels, 18-19 March 2013, ISBN 2-930471-43-3, INIVE, Belgium. pp. 159-166.

Andersson, J. 2015. AMA and Certification of Ventilation Installers: two swedish ways of improving the quality of HVAC-systems. REHVA Journal, August 2015, Vol 52(4), pp.23-25. ISSN 1307-3729.

Arrêté du 24 mars 1982 relatif à l'aération des logements. Official Journal of the French Republic of 27 March 1982, modified 15 novembre 1983.

Carrié, F. R. and Garin, D. 2004. Checking the compliance of residential ventilation systems in France. In 25th AIVC Conference. Prague, Czech republic. AIVC. pp. 261-266.

Carrié, F.R. and Charrier, S. 2015. Building regulations can foster quality management – the French example on building airtightness. QUALICHeCK fact sheet # 01, available at http://qualicheck-platform.eu/wp-content/uploads/2015/02/QUALICHeCK-Factsheet-01.pdf

Charrier, S., Bailly A. and Carrié, F.R. 2015. Building airtightness in France: regulatory context, control procedures, results. QUALICHeCK fact sheet under review.

Effinergie +, Règles Techniques applicables aux bâtiments neufs faisant l'objet d'une de demande de label Effinergie+, Validées par le CA du 3 juin 2014. (http://www.effinergie.org/images/BaseDoc/1066/20140603_r%C3%A8gles_techniques_Effinergie+_V5.pdf)

Effinergie +, Protocole de contrôle des systèmes de ventilation des bâtiments demandant le label effinergie +, Version 2 - Décembre 2013. Available at http://www.effinergie.org/images/BaseDoc/1204/20131212_protocole_contr%C3%B4le_ventilation_V4.pdf

Jobert, R., Guyot, G. 2013. Detailed analysis of regulatory compliance controls of 1287 dwellings ventilation systems. 34th AIVC Conference, Energy conservation technologies for mitigation and adaptation in the built environment: the role of ventilation strategies and smart materials, Athens, Greece, 25-26th September 2013.

Jobert R. 2012. "La ventilation mécanique des bâtiments résidentiels neufs : État de l'art général - Analyse qualitative et technique des dysfonctionnements". Mémoire professionnel, France, 125 p.

Ministère du logement. 2009. Contrôle des Règles de Construction. Un outil au service de la qualité des bâtiments. Avril 2009. 8 p. Available at http://www.developpement-durable.gouv.fr/IMG/DGALN_plaquette_controle%20respect%20regles%20construction_avril2009.pdf

SYCODES 2012. Les indicateurs d'évolution de la qualité des constructions, Tableau de bord 2012. Publications de l'agence qualité construction (AQC), 2012, 68 p.

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Technology	Aspect	Country
Ventilation and airtightness	Compliance frameworks	France

BUILDING AIRTIGHTNESS IN FRANCE: REGULATORY CONTEXT, CONTROL PROCEDURES, RESULTS

Since 2006, there has been a significant reward in the French energy regulations for good airtightness, which has been combined with a minimum requirement for residential buildings in the 2012 version of the regulation. Airtightness test results show that the average building airtightness performance has improved by nearly 50% in single- and multi-family buildings since 2006 and now stabilises below the minimum requirements around q_{50} *= 2.8 m*^{3}*/h per m*^{2} *of envelope area, excluding lowest floor (or about* n_{50} *= 1.8 h*$^{-1}$*).*

Residential buildings ☑	Non-residential buildings ☑	Specific buildings: ……
New buildings ☑	Existing buildings ☐	

Context

There is a large body of literature showing that air leaking unintentionally through building cracks can severely affect the energy performance of a building, and that the energy impact of poor airtightness is proportionally greater in energy-efficient buildings. This is why building airtightness, which had been introduced in some energy performance regulations since several decades, is now taken into account in the regulations of most member states of the European Union (AIVC, 2012).

The French energy performance regulation for buildings has been updated in depth 5 times since its first introduction in 1974. With regard to envelope airtightness, the 1982 and 1988 versions already accounted for leakages through specific components (some vents, windows, roller shutter casings). The 2000 version used the air permeability consistently with ISO 9972:1996 as an input parameter for the energy performance assessment. However, these changes proved to be inefficient to drive the market towards better practice regarding building airtightness, probably because the calculated energy savings for better airtightness were small compared to the risk of choosing a better value than the default value (which by definition, can be used without any justification of the actual airtightness level attained).

An important step was the 2005 regulation (RT 2005) as it introduced a significant reward on the overall building energy performance assessment when justifying a better-than-default value for the air permeability of the envelope. A second very important step was taken with the introduction of a minimum requirement in the 2012 regulation (RT 2012) for residential buildings (Table 1). This means that for every new residential building, the actual envelope airtightness has to be justified, either by a measurement, or by the application of an airtightness quality management approach.

Therefore, gradually, many professionals have called into question their previous methods for implementing and controlling building airtightness to comply with the regulation or to be able to use a better airtightness value than the default value or the minimum requirement.

This fact sheet focuses on French regulation requirements since 2012, the control procedures and the field results. It does not detail the option to justify for a given airtightness level with a quality management approach which is detailed in QUALICHeCK Fact Sheet #1.

Objectives of the new regulatory framework for building airtightness

The objective of the regulatory measures introduced in 2012 was to urge professionals to consider building airtightness which can be detrimental to the overall building performance. They aimed at giving a strong signal to building professionals as, although several earlier versions of the regulation accounted for building airtightness, they had proved to be inefficient to drive the market towards better practice in this area.

Note that building airtightness is considered in the French regulation both in residential and non-residential buildings, although the requirements are of different nature.

Approach to improve building airtightness through regulatory measures

Regulatory background

The French indicator for the building envelope airtightness is $Q_{4PaSurf}$, which is the airflow rate at 4 Pa divided by envelope surface area (excluding lowest floor). It is an input data for the calculation which affects the overall energy performance assessment.

In the 2012 version of the French EP regulation (called "RT 2012"), the airtightness level of residential building envelope must not exceed 0.6 $m^3.h^{-1}.m^{-2}$ at 4 Pa for single-family buildings and 1 $m^3.h^{-1}.m^{-2}$ at 4 Pa for multi-family buildings. These airtightness levels are minimum requirements which must be justified. Note that better values can be also used, provided that they are justified.

For non-residential buildings, there is no minimum requirement but the airtightness is taken into account either by the default value (1.7 $m^3.h^{-1}.m^{-2}$ or 3 $m^3.h^{-1}.m^{-2}$ depending on the building use), or by a better-than-default value. The better-than-default value has to be justified.

	Minimum requirement	Possible values in case of Quality Management (QM) approach (multiples of 0,1 $m^3/h/m^2$	Default value
Single-family buildings	0.6 (3.2)	0.3-0.6 (1.6-3.2)	
Multi-family buildings	1.0 (5.4)	0.3-1.0 (1.6-5.4)	
Non-residential buildings		0.3-1.7 (1.6-9.2) or 0.3-3.0 (1.6-16.2) depending on building type (QM no longer applicable as of July 2015)	1.7 (9.2) or 3.0 (16.2) depending on building type

Table 1: Airtightness levels in the 2012 French regulation in m^3/h per m^2 of envelope surface area at 4 Pa. Approximate corresponding values at 50 Pa are shown in parenthesis.

Justification of airtightness level

The French EP regulation gives two options to justify the building airtightness level used as an input in the EP calculation:

- ✓ Either with an airtightness test of each building (with sampling rules for apartments in multi-family buildings and housing developments described in GA P50-784 (2014)), performed by a qualified tester;
- ✓ Or by the application of a certified quality management approach on the building airtightness (Annex VII of the regulation), that allows to test only a sample of buildings (see fact sheet #1).

In both cases, airtightness tests must be performed by a third-party tester, qualified by the certification body, Qualibat. To be qualified, a tester has to:

- ✓ Undergo a qualifying State-approved training,
- ✓ Pass the training examination (the theoretical part, with a State-approved multiple choice questionnaire; and the practical part, with a test performed *in situ* with a qualified tester);
- ✓ Justify sufficient testing experience with a minimum 10 tests performed.

Once qualified, every tester is subjected to yearly follow-up checks, organised by the certification body. The follow-up checks include an analysis of some reports to verify its compliance with applicable standards and guidelines.

The certification body can control the testers based on the documentation sent every year, but also on site, in particular, in case of complaints or doubts about their work. Those checks can lead to de-certification. All decisions about delivering qualification, re-issuing qualification or handling of complaints are taken by a committee involving stakeholders.

As of February 2015, there are about 920 qualified testers.

Test protocol and reporting

Tests must comply with the European standard EN 13829 and the French application guide (GA P50-784). Whenever a test is performed, either for a certified QM approach or for a systematic test, it must be performed at the end of the construction, after any works that can impact the final airtightness value have concluded. The nature and extent of works that can affect the final airtightness value is left to the appreciation of the tester.

The guide specifies the reporting format. The report specifies if the building airtightness complies with the input value used in the EP calculation.

Moreover, qualified testers are required to fill in a database with all test results (including intermediate tests and tests on existing buildings) and provide this database to the certification body each year for the follow-up of their certification.

Penalties

The ministry in charge of construction appoints trained sworn-in employees of Cerema (which is a public institute) to undertake checks on a sample of the yearly production of buildings. The controls are ordered by the ministry as a judiciary police mission. By law, they can be performed on site within three years after the building is declared finished by the owner.

Non-compliance with regulation is an offense and controllers' reports are sent to national authorities. By law, the building owner is liable for the compliance of his building with the regulation; however, in turn, the responsibility usually bears on the persons "skilled in the art" (architects, contractors, etc.). In case of non-compliance, the attorney general can give financial penalties—in theory, up to 45,000 €, and, in case of repeat offence, 75,000 € with 6 month imprisonment—or ban professionals from practicing. In practice, these penalties are very rarely applied; however, the owner is usually compelled to apply remedial actions to comply with the regulation.

Note also that, in the particular case of building airtightness, the controls are limited to checking that the justification for the airtightness level (see above) is correct, i.e., that the value used as input in the regulatory energy performance assessment is consistent with either a test report from a qualified tester or an applicable QMA.

Market acceptance of the approach

It seems to be generally recognised that accounting for building airtightness in the EP regulation is appropriate. The minimum requirement for residential buildings was anticipated by the voluntary but regulatory-based label BBC-Effinergie[1] in 2006, legally based on an order of the ministry in charge of Construction. This minimum requirement seems to have been well-integrated by front-runners and to have allowed a reasonable transition to its generalisation to all new residential buildings. Bailly et al. (2013) have shown that the building air leakage rate has decreased since 2006 and is now quite stable around 0.5 $m^3.h^{-1}.m^{-2}$ at 4 Pa (Figure 1), or about q_{50} = 2.8 $m^3.h^{-1}.m^{-2}$ at 50 Pa (or n_{50} = 1.8 h^{-1}).

Since 2006, both the requirement to justify the building airtightness level (first only in the BBC-Effinergie label and then for all new residential buildings) and the possibility to justify that level either by a systematic measurement or by a qualified QM approach, have been accompanied by an overall control scheme that drove:

- ✓ designers and workers to learn, train and apply proper building airtightness solutions and methods;

[1] *This label was firmly based on the energy performance regulation—i.e., it was based on the same input data and calculation procedures, but set additional and more stringent requirements compared to those imposed by the regulation. Its aim was to experiment and tune requirements for the 2012 regulation. It was a pre-requisite for many public subsidies. For more information, see http://www.effinergie.org.*

- ✓ testers towards good practice of airtightness measurements and to a qualification procedure;
- ✓ good practice in both implementation of airtightness solutions and measurement.

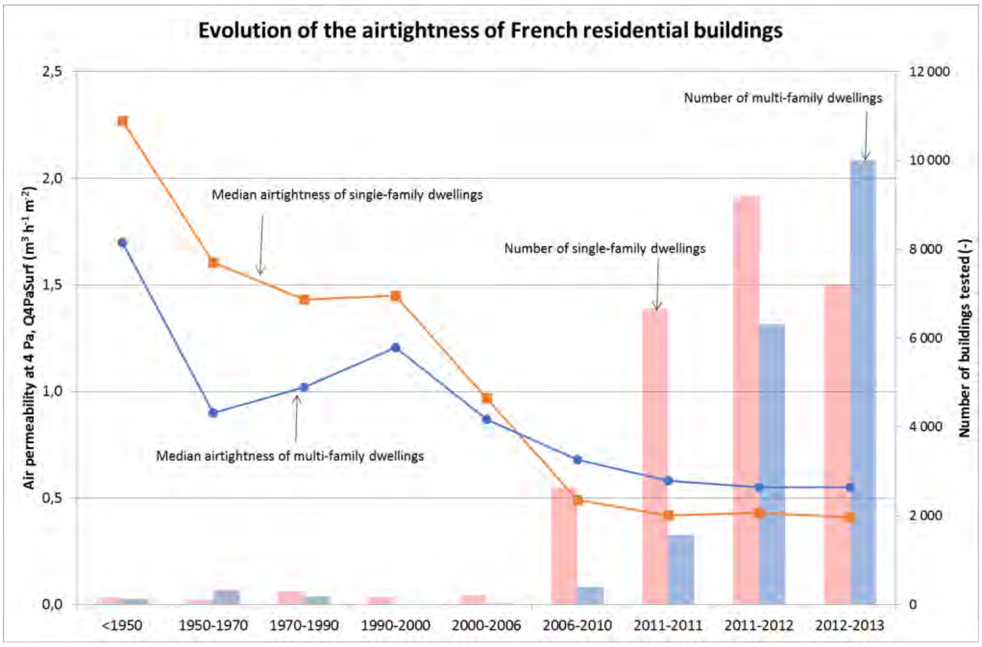


Figure 1: Specific building air leakage rate at 4 Pa performance depending on the construction year of measured buildings

Pros and cons of possible options

This part summarises options that could be considered when developing or reviewing similar frameworks to improve building airtightness.

Minimum airtightness requirement versus default value

The voluntary BBC-Effinergie label, which introduced in 2006 a minimum requirement and required justification of the airtightness level achieved in residential buildings coincides with better airtightness values (Figure 1) compared to pre-2006 values. Trends of pre-2006 field results requiring testing only when choosing a better-than-default value are difficult to analyse, given the relatively small samples; however, they seem consistent with the little impact of the regulations between 1974 and 2000 in practice, and a transition period between 2000-2006 (see Figure 1), (we think) mostly with front-runners.

In other contexts, it may be more acceptable for the market to set a realistic default value giving a fair reward for better airtightness, but the signal is not as strong. (In that case, if a building owner chooses not to justify the airtightness level achieved, he will have to use the default value, which may not be cost-effective compared to other options he will have to implement to meet the overall energy performance requirement.)

Compel airtightness justification with better-than-default values

Justifying only better-than-default values (which in the French context, translates to requiring justification for the building airtightness of residential buildings or better-than-default airtightness values for non-residential buildings) is likely sensible in all contexts to ease energy performance compliance checks. Otherwise, compliance checks would require testing from the control body.

Quality management approach versus justification with a systematic test

French authorities decided to propose two options to justify for better-than-default values: either a systematic test, or the application of a certified quality management approach (QMA).

This last option, which applies mostly to builders with a sufficient production, allows them to perform tests only on a sample of their production provided that they apply a certified QMA (see QUALICHeCK Fact Sheet #1 for more details). It was an important option for market acceptance in France, but requires time and resources to be developed without distorting market competition.

Mandatory qualification required for testers

Justifying building airtightness (whether on systematic testing or partly on sample testing) raises the issue of the reliability of the measurement. To address this question, the French government decided to set up a competent tester scheme and to require testers to be competent for the test to be acceptable for justification. This process was found useful given the success rate of applicants (Leprince and Carrié, 2014) and improvements observed in the testers' practice. Relying on existing standards alone without a specific scheme to train and follow-up testers seems risky.

Measurement by an independent third-party check versus self-control

The present French scheme requires legally independent third-party testing both for systematic tests and for tests performed with a QMA. Although it seems legitimate to have confidence in the result, several issues should be considered:

- ✓ it implies extra costs for the owner;
- ✓ the tester is under pressure to please his client. This could explain the abrupt break in the distribution of air tightness levels of houses running for the BBC-Effinergie label, shown in Figure 2;
- ✓ this "third-party" requirement can be by-passed by, creating a testing company which is legally independent, although under the authority of the same person(s) in reality.
- ✓ it requires enough independent testers available to match the demand.

In addition, experience has shown that professionals have made significant progress by implementing self-check procedures.

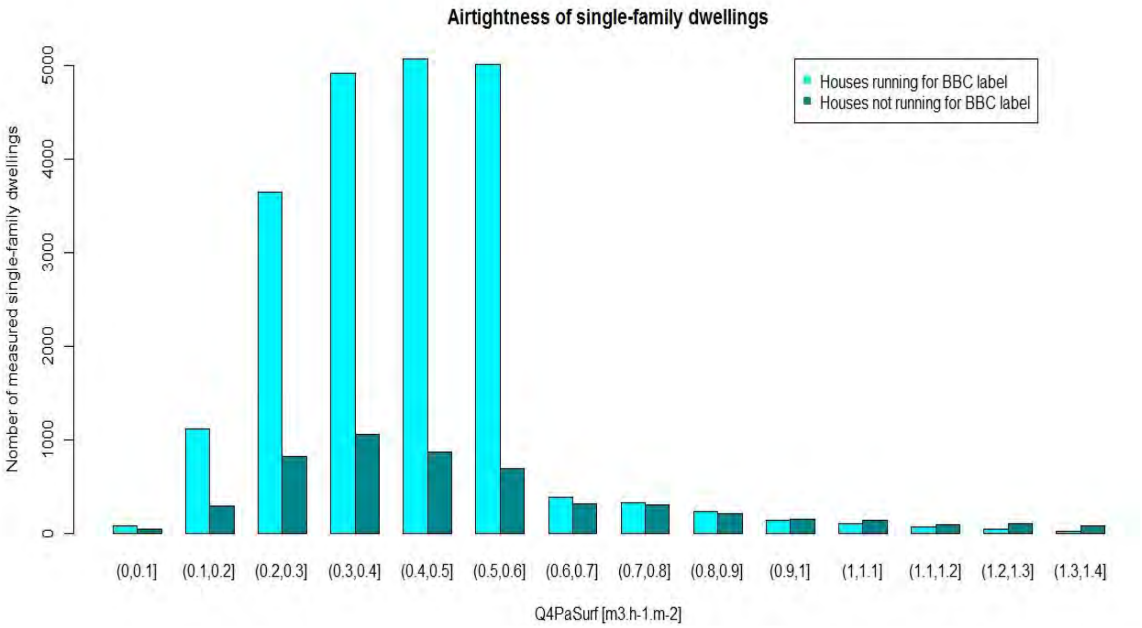


Figure 2: Airtightness performance on buildings running or not running for the BBC-Effinergie label. Year of construction ranges between 2006 and 2013 for 96% of the sample.

Regulatory requirement versus voluntary approach

The BBC-Effinergie label was a) firmly based on the EP regulation[1]; b) set as a pre-condition for subsidies; and c) a strong point for marketing lower energy bills and lower environmental impact. These three aspects were likely key in the success of the label, although it was voluntary. This experience has been a strong basis to set the RT 2012 requirements.

Private scheme holders versus public scheme holders

Should schemes to justify a given airtightness level be managed by private bodies or by public authorities? The answer will of course strongly depend on the context, including financial and human public resources available. In the French context, the schemes developed to qualify testers and certify quality management approaches were first managed by public authorities to allow the government to test the schemes and make them evolve to meet their needs before transferring them to private bodies, when the number of applications became incompatible with public resources. Although successful in the French context, this approach may not be relevant in other regions.

Option	Pros	Cons
✓ Minimum airtightness requirement (in contrast to default value)	✓ Strong signal to the market	✓ Lack of societal support if not gradually introduced
✓ Compel airtightness justification with better-than-default values	✓ Pre-condition to undertake compliance checks	✓ Cost of the justification
✓ Quality management approach (in contrast to justification with a systematic test)	✓ Possibility to put forward a quality management approach on airtightness. ✓ Testing cost abatements	✓ Multiplication of the processes to justify the airtightness (and all their management) ✓ Possible market distortion ✓ Cost of scheme development and operation, making it relevant mostly for builders with a production of 50-100 houses per year
✓ Mandatory qualification required for testers	✓ Reliability of airtightness test results	✓ Cost for testers ✓ Cost scheme development and operation
✓ Measurement by an independent third-party check (in contrast to self-control	✓ Testing by a third party increases the confidence in test results	✓ Cost for the building professionals/owner ✓ Building contractors learn with self-checks ✓ Need to have a matching number of independent testers available ✓ Testers may be independent on paper but not in practice
✓ Regulatory requirement (in contrast to voluntary approach)	✓ Urges professionals to adapt and comply with new requirements	✓ Does not account for learning process pushed by front-runners with voluntary approaches ✓ It is difficult to enable experimenting with new types of requirements and new procedures to enhance market acceptance
✓ Private scheme holders (in contrast to public scheme holders)	✓ Easier to deal with human and financial resources to match large demand	✓ Beginning by a public entity enables to test the process and to make it evolve progressively, with experience ✓ Applications through public entity can be free of charge

Table 2: Pros and cons of various options

Compliance concerns related to EP regulation

No reporting ☐	Wrong reporting ☑	Not meeting the performance requirements ☐

Compliance concerns related to EP regulation (see QUALICHeCK terms and definitions)

In the French energy calculation, building airtightness is an input data. It is converted into an airflow rate taken into account for the heating and cooling needs calculation.

The qualification scheme reduces the risk of wrong reporting in the EP calculation due to unintentional mistakes (lack of competence). The results displayed in Figure 1 are positive, but it is difficult to judge or quantify the contribution of the specific qualification schemes, compliance checks, or other measures implemented for this purpose.

Financial aspects

In the French context, the following costs apply to qualification of testers:

- ✓ the cost of State-approved training: between 1.500 € and 3.000 € (exc. staff cost);
- ✓ the cost for a tester to be qualified (about 900 € as of February 2015); yearly costs for insurances and calibration.

Therefore, considering the cost of the measurement equipment which is around 6.000 €, testers have to invest around 9.000 € to be operational and qualified. The cost qualified testers can charge for each test is around 300-400 €. Additional information regarding the certification of QMA is available in QUALICHeCK Fact Sheet #1.

Overall evaluation

Undoubtedly, the regulatory measures and control procedures have profoundly changed the building airtightness market in France. Within a few years, they have led to significant improvements in airtightness test results. Note however that this change is the result of a number of measures and procedures that have been implemented, including:

- ✓ Minimum requirements for residential buildings and substantial reward for better-than-default values for non-residential buildings;
- ✓ Compulsory justification for residences and better-than-default values with two routes: systematic testing or application of a certified QMA;
- ✓ Mandatory qualification of testers and certification of QMA to justify airtightness values;
- ✓ Follow-up of test results, including statistical analysis to monitor the impact of the regulation.

In addition, the BBC-Effinergie label in 2006 has been a fundamental step both to raise awareness and to experiment with measures to revise the regulation. Given the number of simultaneous changes, the impact of each one is difficult to isolate from the others.

The overall approach has produced very positive results with regard to its original objectives; however, several points merit further attention, in particular:

- ✓ Testers are under pressure to please their clients with the present third-party testing requirement. They are also under time pressure, which may affect the quality of their measurements. This calls for dissuasive controls by the scheme holder;
- ✓ Tests performed at commissioning do not reflect the airtightness during the buildings lifetime, especially when last-minute corrections are implemented to meet the target value. Durability issues should be considered, but there is a significant research gap to address this issue in compliance frameworks today.

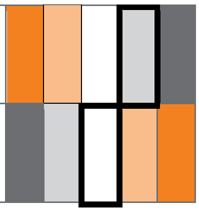
Finally, this evaluation brings to light several questions for the next version of the regulation, including:

- ✓ Should French next regulation further increase building airtightness requirements?
- ✓ Would designers and workers be able to achieve better objectives?
- ✓ Should French authorities focus now on ventilation requirements, without reinforcing envelope airtightness requirements?

The evaluation of the Effinergie+ label, meant to test requirements for the next regulation update including more stringent requirements for ventilation systems and building airtightness, should help answer these questions.

Pros	Cons
✓ Encourages professionals to improve envelope airtightness	✓ Cost and time to develop and implement the approach
✓ Great market impact	✓ Cost of the required justifications
✓ Increased confidence in results with justifications required	✓

Table 3: Overall pros and cons of the French regulatory approach to improve building airtightness

Level of complexity (dark orange = simplest)	
Potential for replication (dark orange = best)	

Prerequisites

Strong political will to improve building airtightness

Hints	Pitfalls
✓ Detail technical requirements (standards, experience) ✓ Detail yearly validation process (yearly control) ✓ Inform control processes can occur ✓ Gradual introduction of the requirements: first in a label, and then in regulation ✓ Let the choice for the justification (e.g., systematic test or quality management approach) ✓ Gradual introduction of control processes: first headed by public authorities, and then by better-dimensioned private bodies	✓ Resources for overall scheme ✓ Resources for control processes (reliability of the scheme)

Table 4: Overall hints and pitfalls to avoid when developing such an approach

References

AIVC. 2012. Achieving relevant and durable airtightness levels: status, options and progress needed. Proceedings of the international workshop held on 28-29 March 2012, Brussels.

Bailly, A., Jiang, Y., Guyot, G., Desfougères, F. 2013. Preliminary analysis of a French Buildings Airtightness Database. 34th AIVC Conference, Energy conservation technologies for mitigation and adaptation in the built environment: the role of ventilation strategies and smart materials, Athens, Greece, 25-26th September 2013.

Carrié, F.R. and Charrier, S. 2015. Building regulations can foster quality management – the French example on building airtightness. QUALICHeCK fact sheet # 01, available at http://qualicheck-platform.eu/wp-content/uploads/2015/02/QUALICHeCK-Factsheet-01.pdf

Charrier, S., Ponthieux, J., Huet, A. 2014. The Airtightness Quality Management Approach in France - Assessment after more than Five Years of Operation. International Journal of Ventilation. ISSN 1473-3315. Vol. 13(2), pp. 125-140.

Effinergie +, Règles Techniques applicables aux bâtiments neufs faisant l'objet d'une de demande de label Effinergie+, Validées par le CA du 3 juin 2014. (http://www.effinergie.org/images/BaseDoc/1066/20140603_r%C3%A8gles_techniques_Effinergie+_V5.pdf)

GA P50-784. 2014. Performance thermique des bâtiments - Guide d'application de la norme NF EN 13829 : 2001.

ISO 9972:1996. Thermal insulation - Determination of building airtightness - Fan pressurization method.

Leprince, V. and Carrié, F.R. 2014. Reasons behind and lessons learnt with the development of airtightness testers schemes in 11 European countries. Proceedings of the AIVC Workshop on Quality of Methods for Measuring Ventilation and Air Infiltration in Buildings, Brussels, Belgium. pp. 103-107.

RT 2012. 2010. Arrêté du 26 octobre 2010 relatif aux caractéristiques thermiques et aux exigences de performance énergétique des bâtiments nouveaux et des parties nouvelles de bâtiments. Official Journal of the French Republic of 27 October 2010.

RT 2005. 2006. Arrêté du 24 mai 2006 relatif aux caractéristiques thermiques des bâtiments nouveaux et des parties nouvelles de bâtiments, Official Journal of the French Republic of 25 May 2006.

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Technology Transmission characteristics Ventilation & airtightness	*Aspect* Quality of the works	*Country* Sweden

AMA - GENERAL MATERIAL AND WORKMANSHIP SPECIFICATIONS

AMA (General material and workmanship specifications) has been used in Sweden for more than sixty years. The different parts of AMA are used as reference documents in technical specifications. Between 90 and 95% of all building projects in Sweden refer to AMA in the contract documents.

Residential buildings ☑	Non-residential buildings ☑	Specific buildings: ……
New buildings ☑	Existing buildings ☑	

Context

In the building industry many different entrepreneurs and contractors are involved in each project. A common framework and language makes communication between disciplines and between the different phases in the project easier.

AMA (General material and workmanship specifications) is a reference framework available as series of volumes that describes requirements on materials, work and result related to all types of building projects. It is produced for the following different areas: site work, building construction, heating, sanitation and ventilation, cooling technology and electricity.

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

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

AMA is managed by Svensk Byggtjänst AB (the Swedish Building Centre), that aims to coordinate, inform and support the building sector with appropriate framework material.

Objectives and problems addressed

The objective of AMA is to provide the building sector with a framework of requirements based on what is regarded as good praxis, accepted quality, proven technology, and good workmanship, following the current regulations. It supports quality assurance from the first tender documents to the final inspection. AMA is updated every three years.

Approach to overcome identified problems

The texts of AMA are arranged according to a system of codes and headings, called BSAB 96 (Byggandets samordning AB, Construction coordination). The BSAB system defines various construction parts or production results in the building sector.

In AMA, demands on all types of buildings and infrastructures are included. Its current main books are:

- AMA AF 12- administrative
- AMA Anläggning 13 – site works
- AMA Hus 14, – building construction
- AMA VVS & Kyl 16 – heating, sanitation, ventilation and cooling technology
- AMA EL 16 - electricity

The administrative guidelines AMA AF are also available in English, under the title 'Guidance for the preparation of particular conditions for Building and Civil Engineering Works and Building Services Contracts'. There is also a special volume for measurements and remuneration rules in site works (for example to determine the amount of masses of excavations and how the costs should be calculated) called MER Anläggning (site works) and MER Hus (building).

The volumes of AMA are used as reference documents for technical specifications. From all the alternatives the specifier, or drafter, selects the ones suitable for the current project by writing the code and its headline in the specification. When using a code and headline in a specification, the requirements specified in AMA are to be applied by the contractor. To each volume of AMA there is a supplement, RA (Råd och Anvisningar/Advice and Directions), with advisory notes and directions as an aid for the specifier.

The AMA requirements are complementary to statutory rules, regulations and specified building standards laid down by the authorities. Statutory demands, that have to be followed by the building proprietor and the contractor, are based on EU requirements, laws, statutes and directions.

In addition to these compulsory demands both parties also have to follow the requirements in the contract once it is signed. The contract documents include a building specification referring, by codes and headings, to specified AMA demands.

AMA is updated every third year. In order to update the content in AMA to new building technologies, laws, standards, and regulations from the authorities in the period between updated AMA volumes, the AMA-nytt (AMA-news) is used. AMA-nytt is issued biannually and gives information regarding new regulations and recommendations, new techniques, and new and amended standards which affect the text in AMA. The experiences resulting from AMA-nytt is incorporated in the next edition of AMA.

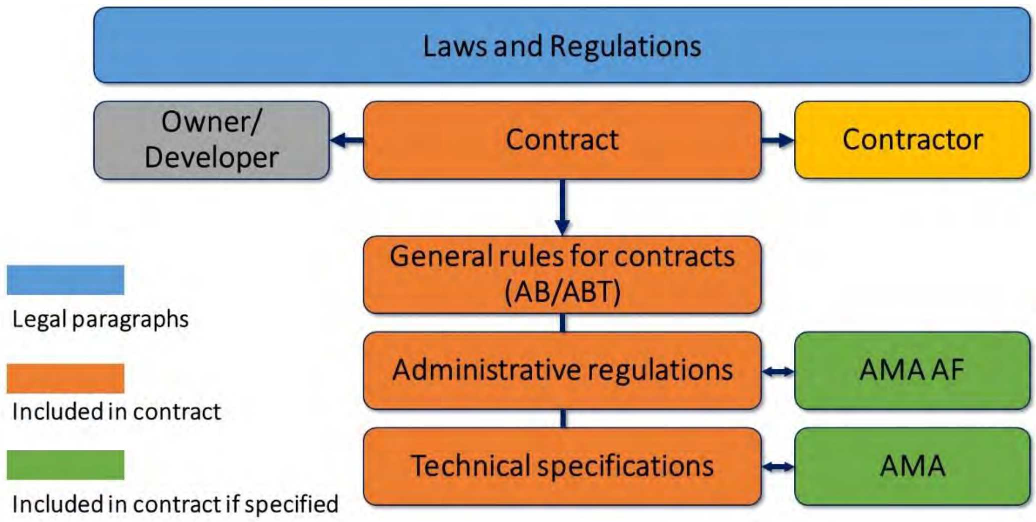

Figure 1: The use of AMA

Market acceptance of the approach

The scheme governs all major Swedish building projects since a long time. Approximately 90-95% of all contracted works use AMA.

There is practically no extra cost or extra time when using AMA as it is, in principle, the standard in all contracted works.

Pros and cons of possible options

All parts of AMA, including, RA (with advisory notes and directions), and Motiv för AMA, AF and MER (with additional explanation for administration, including background and motivation) are available on-line at AMA (ama.byggtjanst.se or byggtjanst.se/bokhandel/ama). Furthermore, the books are also available in the form of e-books and pdfs.

Each part of AMA, including associated notes and directions, RA, and the special volumes for measurements and remuneration rules, MER Anläggning (site works) and MER Hus (building), takes 18 months to update. The revision is performed by specialists within the different areas and the work is coordinated by Svensk Byggtjänst. All additions and changes that are suggested are sent out on referral and are then included in the new editions. Since each part of AMA is revised every third year, there is always ongoing revision work in some areas and start-up of revision work in other areas.

The editorial staff of Svensk Byggtjänst AMA, consist of 13 persons that coordinate the revision work, perform editing and produce final texts. The total cost for an update of one of the AMA volumes varies between the different areas and is totally financed by the earnings for the printed books and from AMA-online. Each volume of AMA-online costs approximately 450 Euro.

The AMA framework has been under development since the 1950s in Sweden and it is well established. However, it is difficult to say how it can be adjusted to other nation's routines and regulations. There is no similar work that provides the same services as AMA in Sweden. It is of course possible not to use AMA but this includes a higher risk of error, misunderstanding and non-compliance with regulations. A similar framework exists in Norway (Standard NS 3420). In Germany there is a system called "Standardleistungsbuch - STLB" which is a library of specification texts for standard construction works. The work is organised by "The German Committee for construction contract procedure" under the umbrella of the Federal Building Ministry and published by DIN (German Institute for Standardisation).

Option	Pros	Cons
✓ AMA	✓ Systemized knowledge about good building praxis ✓ Governs execution and quality ✓ Standardized documents ✓ Prerequisites for a rational work for all parties.	✓ Extensive work, in total 6400 pages in the books ✓ Initially time consuming to create and to implement ✓ Cost associated to purchase AMA

Table 1: Pros and cons for using AMA

Compliance concerns related to EP certificates and to the QM approach

No reporting ☐	Wrong reporting ☐	Not meeting the performance requirements ☑

Table 2: Compliance concerns related to EP certificates (see QUALICHeCK terms and definitions)

The approach of having a general frame work, such as AMA is facilitating for all parties involved. Instead of describing procedures and designs in detail, there is a volume and chapter in AMA to refer to. This decreases the amount of error possibilities and increases compliance with regulations. Furthermore, the acceptance by the market is great.

The demands in AMA are specified in measurable units and in such a way that the tenderers and contractors understand them and are able to calculate a price for their commitments. The demands are – whenever possible – combined with prescribed systems for measuring and reporting the results. Experience from the more than 60 year old use of AMA has shown that it has led to substantially raised quality levels (Andersson, 2015).

Financial aspects

Developing a reference framework like AMA is time and cost consuming. However, AMA has been under development in Sweden since the 1950s so, at present, the main costs concern the updating of the work. This is fully financed by the incomes from selling books and from AMA-online. Using AMA is voluntary. For the buyer of AMA, the cost of an online volume is approximately 450 Euro.

Overall evaluation

The framework of AMA promotes good praxis, high quality, proven technology and good workmanship. It facilitates compliance to regulations and communication between contractor and client. The AMA framework has been under development since the 1950s and is well established.

Hints	Pitfalls
✓ Can become a good practice and promote good quality ✓ Has the ability to facilitate compliance to regulations ✓ Can facilitate communication between contractor and client ✓ For other countries a good starting point might be to use the Swedish AMA, the Norwegian NS 3420 or possibly the German Standardleistungsbuch - STLB as a starting point	✓ Requires extensive work for the organization in charge of setting up the specifications ✓ Initially time consuming to create and to implement

Table 3: Overall hints and pitfalls to avoid when developing such an approach

References

Andersson J. (2015), AMA and certification of ventilation installers- two ways of improving the quality of HVAC-systems. REHVA journal, 04/2015

Information in Swedish available at http://byggtjanst.se/bokhandel/ama/

Information in English available at

http://byggtjanst.se/bokhandel/kategorier/projektering-upphandling/program-projektering-beskrivning/AMA-AF-07-Engelsk-utgava/

Standard NS 3420, https://www.standard.no, Norway 2015

DIN Deutsches Institut für Normung e.V.: STLB-Bau [library of specification texts for standard construction works]. Available at http://www.beuth.de/de/publikation/stlb-bau-komplettpaket-grundlizenz-dvd/53865395

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Technology Transmission characteristics, ventilation, heating, hot water	*Aspect* Status on the Ground	*Country* Sweden

THE SWEDISH **LÅGAN PROGRAM**ME FOR BUILDINGS WITH LOW ENERGY USE

The Lågan programme (financed by the Swedish Energy Agency) reports about low energy buildings in Sweden. By providing grants for demonstration projects and regional/local cooperation initiatives, the Lågan programme aims to increase the number of low energy buildings in Sweden.

Residential buildings ☑	Non-residential buildings ☑	Specific buildings: ......
New buildings ☑	Existing buildings ☑	

Context

There are 4.6 million apartments in Sweden and around 150 million m^2 floor area in service buildings. In 2014, the number of apartments in low energy buildings was 10,000 which gives a share of around 0.2% of the total number of apartments. The floor area of low energy service buildings was around 1 million m^2 which is around 0.7% of the total floor area [1]. The Lågan programme (2010-2015) reports about low energy buildings in Sweden since 2000 and comprises built and buildings planned to be built until 2014 [2].

So far, the conclusions of the Lågan programme are that there is a slow but increasing market development. The average building cost for low energy buildings is approximately 7% higher than for buildings meeting the general energy performance requirements (BBR 16, 18 and 20). By providing grants for demonstration projects and regional/local cooperation initiatives, the Lågan programme aims to increase the number of low energy buildings in Sweden. The programme also focuses on providing support to the development of ideas by evaluating and disseminating information from the demonstration project [1].

Objectives and problems addressed

The objectives of Lågan are to collect and disseminate knowledge about low energy buildings. The programme supports improved and unified input data for energy (performance) calculations, improved work practice, improved project evaluation and improved energy performance certificates (EPC).

The industry identified that there was a gap between the possible energy performance in new buildings and what is required by legislation. The aim of Lågan is to promote buildings with low energy use. This is done by visualising the national market for buildings with low energy use, and contributing to a broad national portfolio of suppliers of products and services.

The programme's focus is on new buildings and deep renovated buildings.

Approach to overcome identified problems

The Lågan programme for buildings with low energy use is a national programme for low energy buildings hosted by the Swedish Construction Federation (Sveriges Byggindustrier), with support from the Swedish Energy Agency, Västra Götaland Region, Formas (the Swedish research council) and others. The programme coordinates and administrates a programme comprising:

- ✓ 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's criteria;

- ✓ national cooperation - coordination of regional projects; support enabling regional projects to take part in national knowledge enhancement;
- ✓ implementation support - financial support to participating building actors that develop various tools (education, models, procedures, etc.) to support implementation of low energy buildings on a commercial basis.

The programme has defined 4 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.

One of the main outcomes is a web-based database with low energy building projects. It contains good practice examples to support market development and shows which actors are involved in which regions. As of October 2015, reports are available from 13 demonstration projects, 7 cooperation projects and 25 implementation projects.

The programme funds 25% of the additional project costs for building low energy buildings instead of conventional buildings. The application process has been a continuous evaluation of project applications. If the programme continues after 2015, this will most likely be changed to a call-based funding scheme.

Who can apply

Only companies can apply for funding of projects through Lågan. It is recommended that either the property owner or the developer applies, since these are the ones who will be involved in all stages of the project. However, anyone involved in the project can apply.

New building projects that are eligible for support have an energy use of 50% below the national requirements (BBR 18). Renovation projects are eligible for support if the energy use is reduced by 50% or 40% below the national requirements (BBR 18), or if the energy use is reduced by 75%.

The programme has funded implementation projects like new climate data files for energy calculations and development of industry standards in this area, e.g. ByggaE and Sveby.

Market acceptance of the approach

The construction of low energy residential buildings accelerated in 2009, and 2,500 new apartments in low energy buildings are ready since 2013. Kronoberg County (in the south of Sweden) has the highest share of new-built low energy buildings, with a 23% share of the total number of built apartments (2009-2013). The average in Sweden is only 5%. About 25% of the low energy buildings have been or will be built in Western Sweden, where Halland County has the highest concentration of low energy buildings, with 3.7 apartments per 1,000 inhabitants [1].

Regarding the development of low energy service buildings, Västernorrland County (in the north of Sweden) has the highest share with 21% (2009-2013), while the average in Sweden is only 4%. Fifty percent (50%) of the low energy service buildings are located in Stockholm County, while Örebro County (in the middle of Sweden) has the highest m^2 per inhabitant in low energy buildings, with 0.2 m^2 per inhabitant. Out of in total 450 low energy buildings, about 25% are certified according to an energy and/or environmental classification system. “Feby” and “Miljöbyggnad” (both Swedish), are the most common for residential buildings, while “Green building” and “Miljöbyggnad” are the most common for service buildings [1].

Pros and cons of possible options

The applicant is free to choose how the follow-up of the demonstration project should be performed. The specifications only foresee that follow-up should be performed, not how. This will probably become stricter if the programme is continued after 2015. In some cases it was difficult to obtain the follow-up of the energy performance. This is probably because only a small part of the funding is foreseen for the follow-up reporting of the project. It is difficult to get applicants if too much emphasis is put on the follow-up.

The industry supports the Lågan programme by co-funding the applicants for demonstration projects. The information is disseminated through newsletters, conference presentations, an online video, reports and the web-based database with low energy buildings. This should lead to spreading of knowledge in the industry and spin-off effects.

Compliance concerns related to EPC and to the quality management approach

The Lågan programme focuses on measurements in the follow-up of the energy performance. Therefore the programme contributes to gather knowledge on how to measure and what to measure to evaluate the energy performance correctly. Since EPC in Sweden are based on the measured energy performance, the output in this area from Lågan supports overall EPC compliance.

The database contains mostly new constructions. There are only a few retrofitting projects. With more retrofitting projects in Lågan in the future it would be possible to validate the performance of the retrofitting measures suggested in the EPCs.

No reporting ☐	Wrong reporting ☑	Not meeting the performance requirements ☑

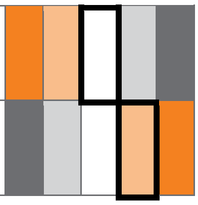
Compliance concerns related to EPC (see QUALICHeCK terms and definitions).

Overall evaluation

The Lågan programme aims to promote low energy buildings and to follow-up the energy performance of buildings correctly. However, it has been difficult to obtain the follow-up because only a small part of the funding is allocated for this. The database of low energy buildings is a good source of information.

Pros	Cons
✓ Industry involvement	✓ Hard to obtain follow-up
✓ Knowledge dissemination	
✓ Demonstration projects	
✓ Industry learns how to measure correctly	

Table 3: Overall pros and cons of the approach.

Level of complexity (dark orange = simplest)		Prerequisites
Potential for replication (dark orange = best)		Tougher energy performance requirements in the future. Need for demonstration projects.

Hints	Pitfalls
✓ Industry involvement ✓ Network essential	✓ Hard to motivate companies to apply ✓ Education needed to identify problems

Table 4: Overall hints and pitfalls to avoid when developing such an approach.

References

[1] P. Filipsson, C. Heincke, Å. Wahlström, Sammanställning av lågenergibyggnader i Sverige (Summary of low energy buildings in Sweden). [In Sweden], CIT Energy Management, Gothenburg, Sweden, 2013.

[2] Å. Wahlström, LÅGAN - Program för byggnader med mycket låg energianvändning (LÅGAN Programme for Buildings with Low Energy Use). [In Swedish], CIT Energy Management, Gothenburg, Sweden, http://www.laganbygg.se, Accessed on September 25, 2015.

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Technology	*Aspect*	*Country*
Transmission characteristics, ventilation, heating, hot water	Status on the Ground	Sweden

THE SWEDISH SVEBY SCHEME – STANDARDISE AND VERIFY THE ENERGY PERFORMANCE OF BUILDINGS

The calculation and verification of the energy performance of buildings is a cumbersome process. The Swedish scheme Sveby aims to clarify and ensure the quality of the entire building process from early stage design requirements to verified results. One objective of Sveby is to provide standardised input data for energy use calculations and recommendations for a common calculation and reporting procedure in Sweden.

Residential buildings ☑	Non-residential buildings ☑	Specific buildings: ……
New buildings ☑	Existing buildings ☑	

Context

In Sweden, in order to get a building permit for a new building, or for changing an existing building, an energy use calculation has to be handed in to the municipality. In general, the calculated energy use for heating, cooling, operation of HVAC systems and domestic hot water should be equal to, or lower than a defined maximum value for a reference year and in a reference climate zone, assuming a normal use of the building (hot water, indoor temperature, internal loads, airing, etc.). The recommended maximum average thermal transmittance for the complete building envelope is specified in the building code. The average thermal transmittance of the building envelope should be calculated according to SS-EN ISO 13789:2007 and SS 02 42 30. However, the calculation procedure for the energy use of buildings is not specified. Furthermore, designers are free to choose the energy simulation software and the input data based on their preference and experience.

The calculated energy use has to be verified by measurements of the energy use which are performed during at least 12 months, and within 24 months after commissioning. The measured data should be corrected to a reference year (usually performed automatically) and to normal behaviour (rarely performed). The deviation between the calculated and measured energy use has mainly two causes: errors in the input data (wrong heated area in the building, changes made to the original design not taken into account and differences related to the use of the building; hot water use, indoor temperature, internal loads, airing, etc.) and errors in the energy use measurements.

Objectives and problems addressed

The calculation and verification processes of the energy performance of buildings in Sweden are not standardised. Sveby ("Standardise and verify the energy performance of buildings") is a scheme which aims to clarify and ensure the quality of the entire building process from early stage design requirements to verified results.

The fact that the normal use referred to in the EPC scheme is not defined, is problematic for the calculations and measurements which cannot be adjusted accordingly. It is also a problem for the developer and the occupants that energy use calculations are not updated to reflect changes in the building after the design stage.

The Sveby scheme includes an agreement for turnkey projects, recommended input data (such as for hot water use, indoor temperature and airing) for residential building and offices, as well as guidelines on how to measure and verify the energy performance.

Approach to overcome identified problems

Sveby is a voluntary national scheme involving major actors in the Swedish building sector aiming for increased compliance with the Energy Performance of Buildings Directive (EPBD). One objective of Sveby is to provide standardised input data for energy calculations and recommendations regarding the verification of (compliance with) the required energy performance of buildings, consequently providing a necessary supplement to the more general recommendations of the Swedish building code BBR. In 2006, BBR was changed and all technical requirements were removed and replaced with energy performance requirements. The new performance based requirements introduced more freedom as regards the choice of technical solutions, but also introduced new issues. The Swedish organisation for property owners was concerned about how to deal with the situation when the requirements were not fulfilled. In the view of the Swedish organisation for property owners, non-compliance would result in fines for the property owners. The National Board of Housing, Building and Planning (Boverket) did not provide the industry with any recommendations on how to deal with these situations. Therefore, organisations of developers, property owners and a number of building contractors started the projects which resulted in the Sveby approach. It was started in 2008 with a pre-study which resulted in the three parts available today, with recommendations on how to write a contract and how to perform the calculations and verification (see Figure 1).

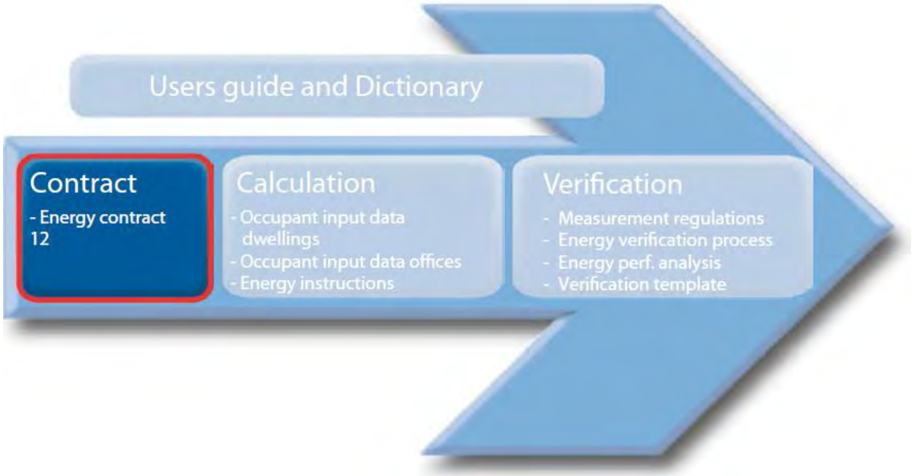


Figure 1: Description of the three steps in the Sveby scheme [1].

The most demanding task was to agree on how to formulate the agreement in the turnkey contract. It was published in 2012 and called "Energy contract 12". This agreement is used to define the verification of the building's energy performance [2]. This is intended to be used in turnkey contracts in which the parties agree to apply ABT 06 (Swedish industry contract standard) and the Sveby scheme for agreement on energy use. The agreement contains special regulations for when the measured energy performance deviates from the calculations, with a sanction package which replaces these parts specified in ABT 06. The Energy contract is attached to the tender documents, so that tenderers can submit their prices based on prevailing conditions. The Energy contract is annexed to the main contract.

The Energy contract assumes that the building owner is responsible for the operation and maintenance of the technical systems that control and affect the building's energy performance. It is important that the parties to each contract agree on how the contractors' views on the operation and maintenance should be considered. The contractor should be informed and given the opportunity to comment on the developer's plan for the operation and maintenance of the building, regarding the parts where the plan may affect the building's energy performance. If possible, this could happen already in the tendering stage.

In the next step, the energy performance calculation is performed following the procedures and data given by Sveby [3, 4]. There is an Excel sheet at the Sveby webpage to help designers in their selection of appropriate input data.

When the building has been commissioned, the energy performance should be measured and registered every month. Different energy carriers should be measured separately for space heating, domestic hot water, cooling and facility electricity. The measured energy use should then be adjusted to normal use of the building. This means correcting the energy use for use that deviates from Sveby's data, or from data agreed on in the project. The verification is performed by repeated energy use calculations where the deviating input data are used instead of the data defined by Sveby (or in the project) in the same calculation file as the original energy use calculation. The difference between the calculation results are used to correct the measured energy performance. For cooling there is no standardised method for correcting it to the reference year, which calls for new calculations based on the real climate during the year [2, 5]. There is an Excel sheet at the Sveby webpage to aid in the verification process. There are also guidelines available on how to categorise different energy uses between facility electricity and household electricity. Such examples are electric engine heaters, lighting in common areas of multi-family buildings, and heat cables in the ground for melting snow.

Some categories of what is normal use are listed by Sveby [3] as standardised occupancy profiles:

- ✓ indoor temperature;
- ✓ airing and ventilation;
- ✓ solar control strategies (curtains, awning);
- ✓ household electricity;
- ✓ domestic hot water use.

Indoor temperature

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 [3].

Airing and ventilation

The airing behaviour influences the energy use, both by increasing the air volume that has to be heated, and by decreasing the efficiency of the heat recovery in the air handling unit. Sveby has defined a general addition of 4 kWh/m^2 as acceptable to take airing into account [3]. This value is based on measurements in multi-family buildings, but due to lack of data for single-family houses the value should be used also in these energy use calculations.

Cooking behaviour influences the energy use for the kitchen fan with forced air flow. The recommended calculation value is 30 min forced ventilation per day [3].

Solar control strategies (curtains, awning)

The surrounding objects and use of solar shading devices has to be taken into account. There is little information on the behavioural aspects of solar shading in Sweden. For the behavioural part of solar shading, the reduction of insolation due to curtains, etc. is 0.71 in Sveby for both multi-family buildings and single-family houses. For fixed solar shading from objects the factor is also 0.71. These two factors give 0.5 insolation reduction, when combined [3]. Apart from this, there is also an insolation reduction caused by the glass properties which is often referred to as the g-value.

Household electricity

The general recommended value is 30 kWh/m^2 for both multi-family buildings and single-family houses. This value varies during the year, and the energy use can be 30% higher than the annual average in the winter and 30% lower in summer. Around 70% of this energy use can be accounted for as space heating [3].

Domestic hot water

Measurements of the energy use for domestic hot water in different households showed that it is on average 25 kWh/m^2 in multi-family buildings, and 20 kWh/m^2 in single-family houses. This value should not be reduced if there is an individual measurement and billing of the hot water consumption. This was previously recommended to be accounted for by an energy use reduction of 0-20%, but recent measurements have shown that the energy savings are too small. The losses in circulation hot water circuits have not been included in these values, since these are not related to behaviour [3].

Market acceptance of the approach

The industry shows a resistance to installing energy meters in the buildings, with the argument that they require maintenance and a larger initial investment. The recommendations for the validation part of Sveby is therefore aiming to minimise the number of meters. In some cases this resulted in insufficient number of sensors, which made the follow-up difficult. Therefore, the recommendations were rewritten in 2011 to be brought in line with the new regulations.

In the framework of Sveby, a competition was arranged during the autumn of 2010 to find out how well energy consultants can calculate the energy use in buildings. The aim was to acquire knowledge on how the data selection and choice of calculation software influenced the accuracy of the calculations. The result of the competition showed that more work is needed, both in quality assurance of calculations and in measurements [6]. A follow up with a second competition is being performed by Sveby in the autumn of 2015.

The framework has been used in parts and is not fully implemented by the industry. It is especially the agreement part that has not been used very much. At least 69 projects had used parts of the Sveby scheme until 2013. However, Sveby is the only national standardisation process where the industry is involved in all steps of the process, from agreement to calculation and verification. It is more and more common that municipalities require data on the energy use for building permits to be specified according to Sveby, which means that the use of the standard will increase in the future.

The Sveby scheme was evaluated in 2013, and during the period January 2012 to August 2013 the total number of downloads from the Sveby homepage was 17,000, of which 15,400 represented unique visitors. The most downloaded report was the report with input data for energy calculations of multi-family buildings, with 3,510 unique downloads. This shows that it is mainly the calculation part which is used by the industry. A coarse approximation is that the Sveby energy contract has been used in around 1,000 buildings in Sweden. So far, the public housing corporations and other public sector property owners are pushing the development.

Pros and cons of possible options

The Sveby scheme will not be reformulated into a real standard in the future. The industry is reluctant to pay the cost for using standards and for the relevant standardisation work. There is a problem of lack of skilled and qualified energy consultants, and therefore Sveby will arrange courses and certify consultants who are trained in using the scheme.

It is difficult to give generalised input data for all situations and occupant profiles. An investigation by Fremling [7] on the energy use in multi-family buildings showed that none of the standardised input data from Sveby for hot water use matches the measured data in the buildings. To be able to track where the energy is used and to propose energy savings measures, individual metering should be installed in new constructions. A parameter which is specifically difficult to forecast is the energy use caused by airing. The parameter which causes people to open their windows differs in the calculation models and should be further investigated. Since even small open gaps (when airing) can lead to large energy losses, gaps should be avoided as far as possible, so that there is no constant draft causing high energy losses.

Compliance concerns related to EP certificates and to the QM approach

The aim of Sveby is to make sure that the buildings follow the energy performance defined in the building code. The main aim is not to build a building with an energy use as designed, but to fulfil the legal requirement. So far, it has not been possible to evaluate whether Sveby has improved the agreement between the calculated and measured energy use. The energy calculation competition in 2015 will reveal knowledge on what is the current state of the industry.

No reporting ☐	Wrong reporting ☑	Not meeting the performance requirements ☑

Compliance concerns related to EPC (see QUALICHeCK terms and definitions).

Financial aspects

In the agreement part of Sveby, the basic idea is that, when the energy use is below the design value, the profit is shared between the property owner and the main contractor, while when the energy use is above the design value the contractor pays a fee for the excess in the energy bill.

The Sveby scheme is an industry initiated and industry driven scheme. It is financially supported by the Swedish Energy Agency. To be part of the governing board of Sveby, a company pays an annual fee of 20,000 SEK (2,100 €). For all other participants and users, the scheme is free to use.

Overall evaluation

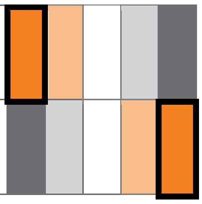
The strength of the scheme is that it was initiated by the industry and therefore fulfils a need identified by the industry. With harder demands on the energy performance of buildings in the near future, calculation and validation will increase in importance.

Pros	Cons
✓ Initiated by the industry	✓ Not a real standard
✓ Supported by governmental agencies	✓ Development funded separately for each part
✓ Usable throughout the entire building project	✓ No certification

Table 3: Overall pros and cons of the approach.

Level of complexity
(dark orange = simplest)

Potential for replication
(dark orange = best)



Prerequisites

Legislation demanding follow-up of measured energy performance

Hints	Pitfalls
✓ Collaboration ✓ Transparency	✓ Hidden agendas ✓ Financing

Table 4: Overall hints and pitfalls to avoid when developing such an approach.

References

[1] Swedish Energy Agency, Sveby Standard for the Energy use in Buildings (ET2014:03), Swedish Energy Agency, Eskilstuna, Sweden, 2014.

[2] Sveby, Energiavtal 12 för överenskommelse om energianvändning. Svebyprogrammet 2012-10-10. (Energy contract 12 for agreement on energy use) [In Swedish], Sveby Standardisera och verifiera energiprestanda för byggnader and Byggandets Kontraktskommitté, BKK, Stockholm, Sweden, 2012.

[3] Sveby, Brukarindata bostäder - Version 1.0, 2012-10-10 (Input data for occupant's behaviour in dwellings). [In Swedish], Sveby Standardisera och verifiera energiprestanda för byggnader, Stockholm, Sweden, 2012.

[4] Sveby, Brukarindata kontor- Version 1.1, 2013-06-05 (Input data for occupant's behaviour in offices). [In Swedish], Sveby Standardisera och verifiera energiprestanda för byggnader, Stockholm, Sweden 2013.

[5] Å. Wahlström, P. Levin, Energiprestandaanalys – avvikelse som kan härledas till brukare, verksamhet eller ökat kylbehov - Version 1.0 2012-10-10 (Energy performance analysis - deviation that can be traced to the occupant, services, or increased cooling demand). [In Swedish], Sveby Standardisera och verifiera energiprestanda för byggnader, Stockholm, Sweden, 2012.

[6] Sveby, Resultat från energiberäkningstävling för ett flerbostadshus. Projektrapport 2011-10-03. (Results from competition on calculating the energy use in a multi-family dwelling). [In Swedish], Sveby Standardisera och verifiera energiprestanda för byggnader, Stockholm, Sweden, 2011.

[7] A. Fremling, Users impact on energy consumption in a low energy building, Chalmers University of Technology, Department of Civil and Environmental Engineering, Gothenburg, Sweden, 2013.

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Technology Ventilation, thermal comfort	*Aspect* Status on the ground	*Country* Greece

QUALICHECK STUDY GREECE - COMPLIANCE WITH THE REFERENCE VALUES OF THE TECHNICAL DIRECTIVES: ON-SITE MEASUREMENTS OF VENTILATION, TEMPERATURE AND RELATIVE HUMIDITY AND COMPARISON WITH THE REFERENCE VALUES OF THE NATIONAL TECHNICAL GUIDES

Within the Greek framework for Energy Performance Certificates (EPCs) the methodology is based on a calculation tool with specifications according to the directives of the Technical Chamber of Greece and to the Energy Performance of Buildings Regulations (K.En.A.K.). The Ministry for the Environment, Energy and Climate Change (YPEKA), having completed the legal framework on the energy efficiency of buildings, has developed a set of financial incentives, with co-funding from the European Union, for the implementation of energy efficiency upgrading interventions in residential buildings, via the "Energy Efficiency at Household Buildings" Programme. In the present study the compliance with the reference values of the Technical Guides is investigated regarding ventilation, temperature and relative humidity.

Residential buildings ☑	Non-residential buildings ☑	Specific buildings: ……
New buildings ☐	Existing (renovated) buildings ☑	

Context

The implementation of the Energy Performance of Buildings Directive (EPBD) in Greece is the overall responsibility of the Ministry of Environment, Energy and Climate Change (YPEKA). The law for the transposition of the EPBD was approved by the parliament in May 2008 (Law 3661). For the implementation of the EPBD, a Ministerial decision for the new 'Regulation of Energy Performance of Buildings' (KENAK) has been issued in April 2010 (Ministerial decision D6/B/5825 National Gazette 407). The Presidential decree necessary for the definition of the qualifications and training of energy auditors was published in the National Gazette in October 2010 (Presidential Decree 100/NG177). Full implementation started in January 2011, for all types of buildings and building use, new or existing undergoing major renovation. The implementation and quality control is performed by the Secretariat for the Environment and Energy Inspectorate, a public entity within the Ministry, established for this purpose.

The Energy Performance of Buildings Regulations (K.En.A.K.) determines minimum technical specifications and energy efficiency requirements of new and substantially refurbished and the calculation method of the energy performance of buildings. It constitutes an obligation of the country not only to the requirements asked by the European Union (EU Directive), but even more to its citizens.

The Technical Chamber of Greece, in cooperation with the State, drew up the necessary Technical Guides, which shall specify the standards of energy studies and audits for the buildings sector, according to the Greek climate and building data. The Technical Chamber of Greece has issued the directive T.O.T.E.E. 20701/2010 which defines the national standards for the calculation and the certification of energy performance of buildings, the thermophysical properties of the materials and the insulation efficiency. It also provides guidelines for the energy audits.

The existing building stock is highly energy consuming and the main reasons for this is the age of the buildings and the lack of built-in state-of-the art technology, a result of deficiencies in the building regulations and weaknesses in the implementation over the last 30 years. Most of these buildings have problems related to:

- ✓ partial or total lack of heat insulation;
- ✓ outdated technology for windows/doors (frames/single glazing);
- ✓ lack of sun protection on southern and western sides;
- ✓ inadequate use of the country's high solar potential;
- ✓ inadequate maintenance of heating / air conditioning systems, resulting in poor performance.

Within this context, the Ministry for the Environment, Energy and Climate Change (YPEKA), having completed the legal framework on the energy efficiency of buildings, has developed a set of financial incentives, with co-funding from the European Union, for the implementation of energy efficiency upgrading interventions in residential buildings, via the "Energy Efficiency at Household Buildings" Programme. To join the programme, energy audits are required (before, as well as after the intervention), the cost of which is covered at 100% from the programme, in any case after the successful implementation of the project.

This means that initially, the energy auditor examines the building and issues the certificate for the existing condition of the building and then proposing appropriate interventions in order to improve the energy efficiency. Once the interventions are completed, the energy auditor must examine again the building, certify that the proposed interventions were implemented and issue the new EPC in which the building must necessarily have risen by one energy class, or its energy consumption is reduced by 30%.

Objectives and problems addressed

This study focuses on the ventilation and thermal comfort characteristics of the buildings renovated under the "Energy Efficiency at Household Buildings" Programme. Measurements of ventilation rates, temperature and relative humidity were carried out and the results were compared against the reference values of the directive T.O.T.E.E. 20701/2010.

Results of the study

Ventilation

Air flow rates were determined with tracer gas testing for nineteen case studies as previously described. Figure 1 presents the air flow rates of the case buildings. The results were compared against the reference value of $0.75 m^3/h/m^2$ for single and multi-family buildings (Technical Chamber of Greece Directive TOTEE 20701/2010). According to Figure 1 ten case studies have ventilation rates higher than the indicated value and in six case studies the measured ventilation rate is lower than the indicative value. In four case studies the ventilation rate is almost equal to the reference value. Although there are differences from the reference value, the variation could be considered rather small. Thus from the results it could be concluded that the installation of the door and window frames in the buildings allowed for good compliance with the reference values.

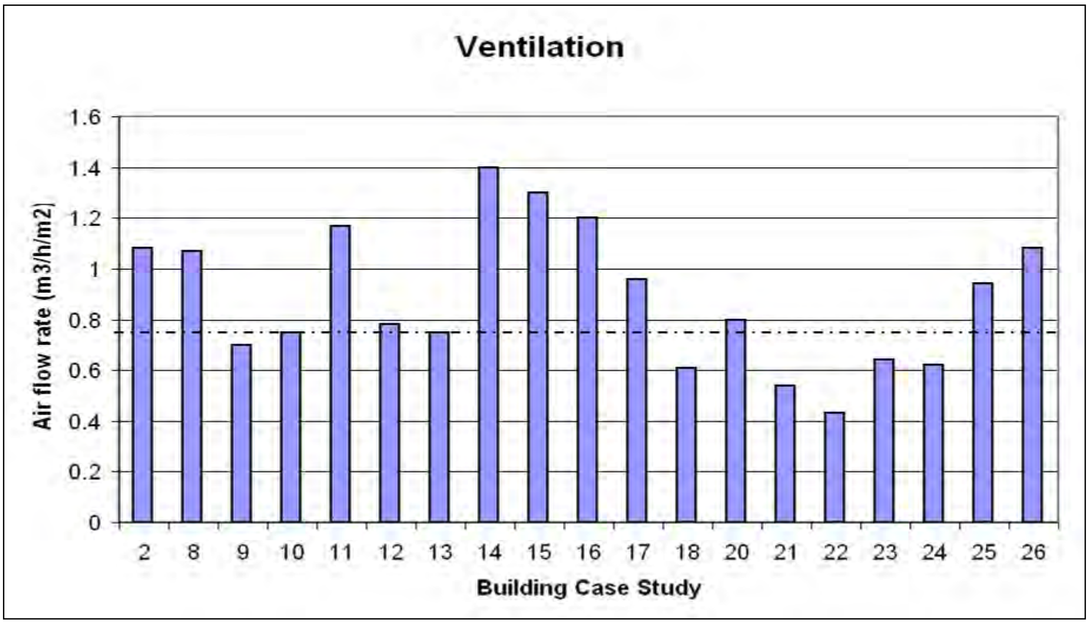

Figure 1: Air flow rates of the building case studies.

Temperature

Indoor temperature was assessed using TinyTag dataloggers placed in different spots in the building (e.g. living room, bedroom etc.). The results were averaged to produce the total area temperature value. Then they were compared against the reference value of 26ºC for the summer period (Figure 2) and 20ºC for the winter period (Figure 3) (Technical Chamber of Greece Directive TOTEE 20701/2010). As the diagrams illustrate, in most of the cases the mean values are higher than the reference values for the summer period. That occurs because of the following reasons:

The majority of the case studies are buildings that are renovated under the "Energy Efficiency at Household Buildings" Framework which imposes the improvement of their energy efficiency by one energy class after the interventions. One common way to achieve this target is the installation of a solar collector which however does not necessarily improve the thermal comfort of the buildings. Thus, during summer and winter conditions, the buildings have internal temperatures that exceed the reference values. It is worth noticing that the building with the higher mean temperatures (Case study 13) is an apartment where the interventions did not include the installation of external insulation. Moreover, the inhabitants use the cooling systems only in exceptional cases when heat waves occur.

During the winter period mean daily values do not vary significantly from the reference value.

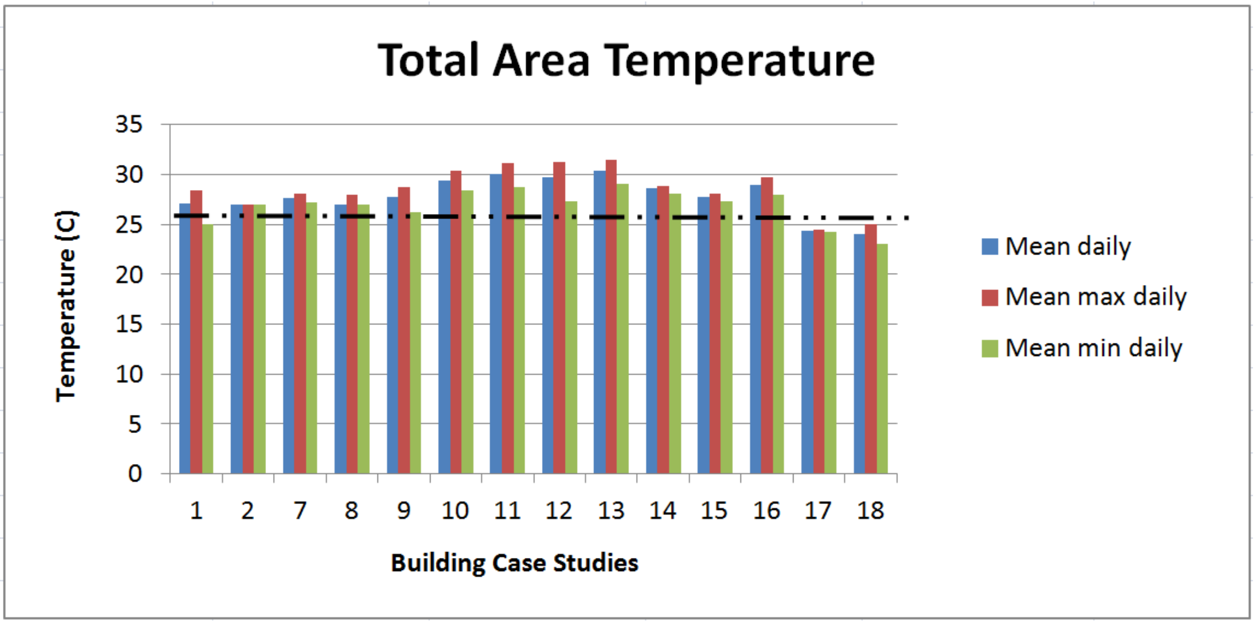

Figure 2: Total area temperature of the case studies (summer).

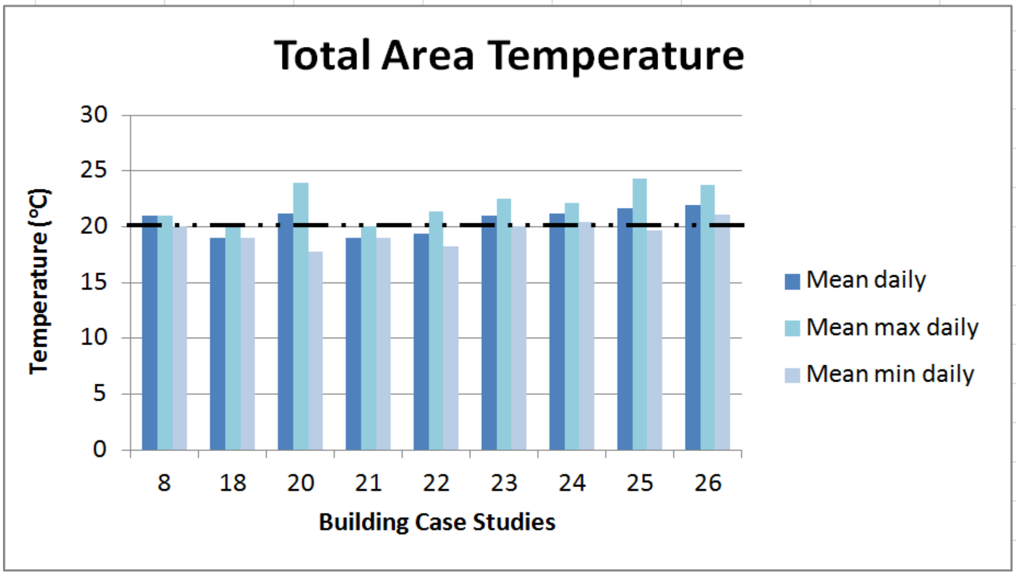

Figure 3: Total area temperature of the case studies (winter).

Relative humidity

Relative humidity was assessed using TinyTag dataloggers placed in different spots in the building (e.g. living room, bedroom etc.). The results were averaged to produce the total area RH value. Then, they were compared against the reference value of 45% for the summer period (Figure 4) and 40% for the winter period (Figure 5) (Technical Chamber of Greece Directive TOTEE 20701/2010). As depicted in the diagram, the relative humidity varies between the case studies. During the summer, most of the tenants used to keep the windows open, so indoor relative humidity is influenced by the external conditions. It must be noted that the measurements took place at different time intervals in each case. Another reason for the observed differences is that the use of appliances (cooking) increase the relative humidity and the tenants have different habits.

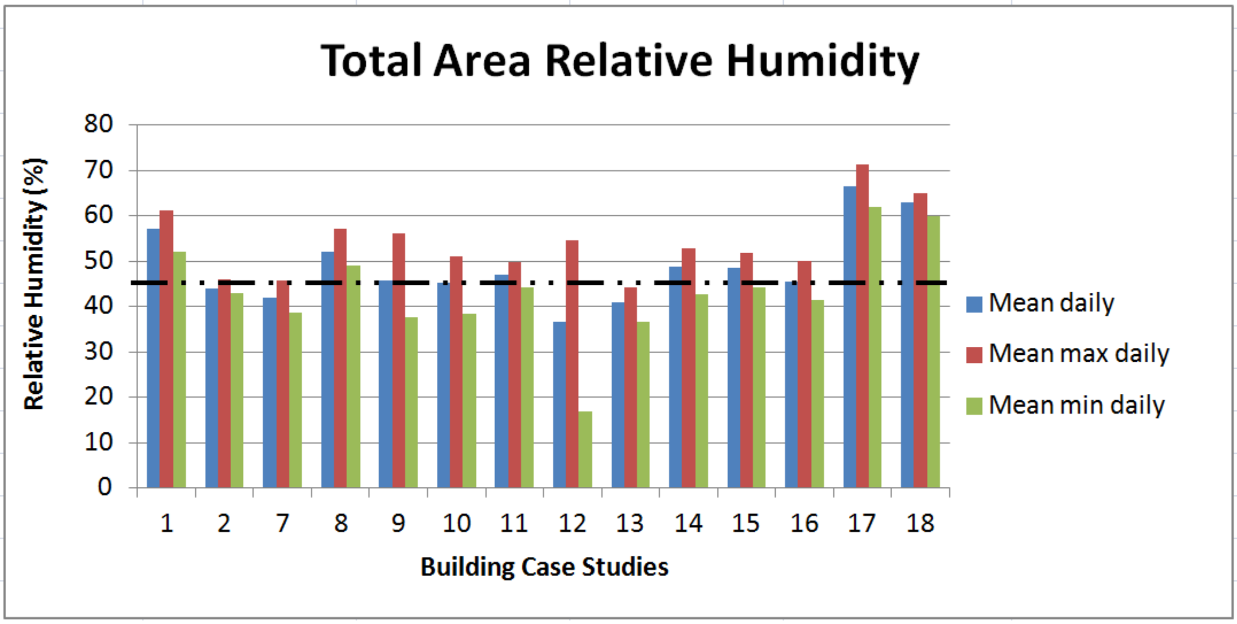

Figure 4: Total area humidity of the case studies (summer).

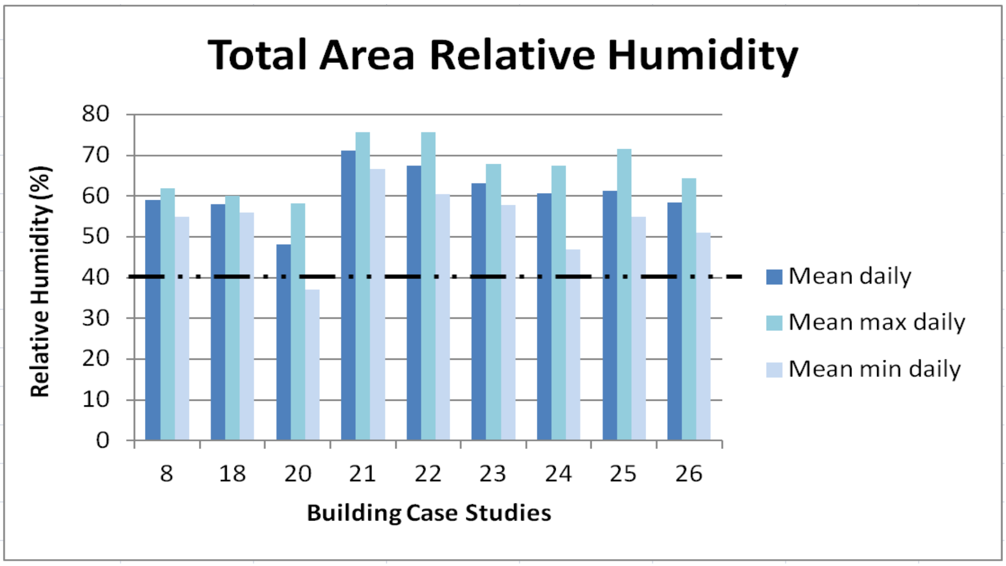

Figure 5: Total area humidity of the case studies (winter).

Conclusions and remarks

Regarding the compliance with the reference values (ventilation, temperature and relative humidity) according to the Technical Chamber of Greece Directive (TOTEE 20701/2010) it is concluded that:

- ✓ The ventilation rates of the buildings are close to the reference value of 0.75m3/h/m2 for single- and multi-family buildings, thus from the results it could be concluded that the installation of the door and window frames in the buildings allowed for good compliance with the reference values.
- ✓ The internal temperature of the buildings for the summer period in most of the cases is higher than the reference value of 26ºC. This happens because in the majority of the cases the energy efficiency of the buildings was improved by the installation of a solar collector and this intervention does not improve the thermal comfort. In addition, the inhabitants use the cooling systems only when heat waves occur.
- ✓ The relative humidity varies between the case studies examined. This is assigned mainly to the external conditions that affect the relative humidity inside the buildings since the users tend to keep the windows open during the summer. Moreover, the use of cooking appliances affects the relative humidity and this is an uncontrolled variable.

References

[1] "Energy Efficiency at Household Buildings" Programme http://exoikonomisi.ypeka.gr

[2] Technical Chamber of Greece Directive of National Standards for the calculation of Energy Performance of Buildings and Issue of Energy Performance Certificate http://portal.tee.gr/portal/page/portal/tptee/totee/TOTEE-20701-1-Final-%D4%C5%C5-2nd.pdf

[3] "Regulation of Energy Performance of Buildings" (KENAK) https://www.buildingcert.gr/nomiko_plaisio/kenak.pdf

Authors
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Technology Airtightness and ventilation	*Aspect* Status on the ground	*Country* Belgium

QUALITY FRAMEWORK FOR RELIABLE FAN PRESSURISATION TESTS

Airtightness performance of the building has a significant weight in the Belgian EPB-calculation and the number of pressurisation tests in new buildings is strongly increasing. To face the potential lack of tester's skills and to ensure a reliable value, a quality framework has been achieved according to which testers have to pass an exam and could be controlled. This factsheet describes the relevant quality framework and its context.

Residential buildings ☑	Non-residential buildings ☑	Specific buildings: ......
New buildings ☑	Existing buildings ☐	

Context

Airtightness of the building's envelop is taken into account in the regional energy performance regulations in Belgium. But making a pressurisation test is not mandatory and there is no requirement regarding the airtightness performance of new buildings. Actually, if a test is not realised, the energy consumption for heating and cooling is calculated with quite unfavourable v50 air permeability default values. These values are equal to 12 $m^3/(h\ m^2)$ for heating calculations and 0 $m^3/(h\ m^2)$ for the risk of overheating and cooling calculations. If a pressurisation test is done, the result can be used as input data for new buildings (residential buildings, offices and schools). This data has a huge impact on the energy performance-calculation, which can reach 15% according to the configuration.

Practically and considering the reinforcement of the energy requirements in the 3 regions, the number of pressurisation tests in new building is strongly increasing. This increasing market is quite attractive and a lot of testers start their activities. However, with no requirements set on testers, it appears that some of them do not present the needed competences.

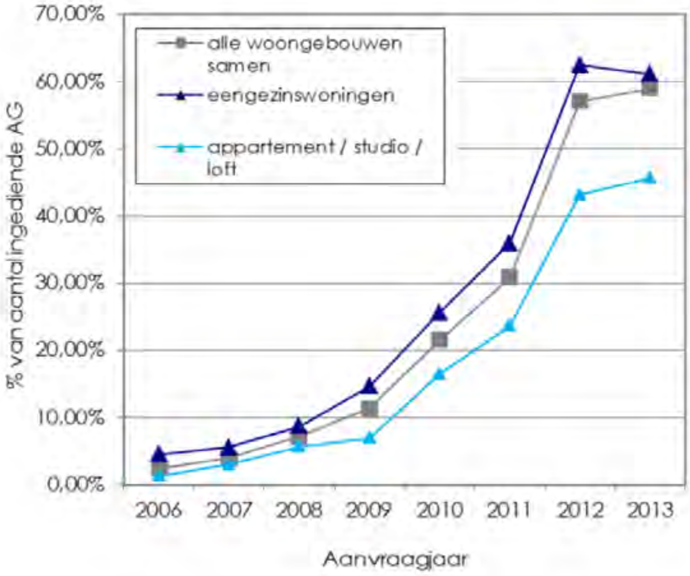


Figure 1: Evolution of pressurisation test numbers for new buildings in the Flemish Region of Belgium.

The non-reliable results would be a major barrier in this area. A quality framework is needed and also stakeholders ask for it.

Objectives and problems addressed

The main objective of this approach is to ensure the compliance of the airtightness performance reported. The group targeted by this measure is the testers. The quality framework aims to check the testers' skills and the quality of their work, including the test itself and the reporting.

Note that both residential and non-residential buildings (offices and schools) are concerned.

Approach to overcome identified problems

The Belgian Construction Certification Association (BCCA) has developed a certification system that allows to certify airtightness testers and companies in Belgium.

The qualification of testers is based on:

- ✓ optional theoretical lessons;
- ✓ a theoretical examination (multiple choice questions);
- ✓ a practical examination (practical measurement);
- ✓ a requirement for minimum experience in the field (supply of at least 5 test reports).

Principles of ISO 9712 [0] have been taken into consideration for the development of the qualification system.

In order to be recognised, companies must fulfil the following requirements:

- ✓ to have civil liability insurance;
- ✓ to have all necessary measuring instruments and software;
- ✓ to employ at least one qualified tester.

It is worth noting that accredited companies can be automatically recognised without further requirements.

Control and declaration of conformity

In order to manage quality effectively, a control system has also been put in place. It includes control of test reports and on site controls. A dedicated web application must be used.

Basic information regarding measurements must be given at least one day in advance through the web application; it concerns mainly the address of the building, the type of building, the name of the tester and a tentative date.

Before starting the measurement it is required to send a short message by phone (SMS) to BCCA with the file number and the expected finish time. At the end of the measurement another SMS must be send (from the same phone) with the air leakage rate.

There can be on-site controls during or after the measurement. If any, the tester receives a SMS at the latest 15 minutes after having sent the completion message.

When available, the test report must be uploaded through the web application. Controls are also organised at that stage.

Respecting all requirements and the whole procedure permits to deliver a declaration of conformity generated by the web application. This declaration is required for all measurements to be valued in the framework of the Energy Performance of Buildings (EPB) regulation in the Flemish region.

Market acceptance of the approach

At the time of writing this factsheet (March 2015), about 170 Belgian companies are already recognised.

Compliance concerns related to EPC

The increasing market for pressurisation tests is quite attractive. But it appears that a lot of testers who start their activities do not have the needed skills. The consequences are a wrong report and a discredit of the airtightness measurement. The quality framework prevents such situations.

Table 1 shows whether the described scheme avoids or limits some of the most typical cases of non-compliance.

No reporting ☐	Wrong reporting ☑	Not meeting the performance requirements ☐

Table 1: Compliance concerns related to EPC
(for more information about typical cases of non-compliance see http://qualicheck-platform.eu/results/terms/)

Financial aspects

- ✓ An extra cost has to be charged to the customer as follows:
  - o around 40 € per dwelling;
  - o in the case of apartments: 40 € for the first apartment and 10 € for the remaining apartments in the same building.
- ✓ Testers undertake:
  - o the training (optional);
  - o the theoretical exam: 150 € (half day);
  - o the practical exam: 475 € (one day);
  - o the encoding of the results in order to build up a database (half hour per measure).

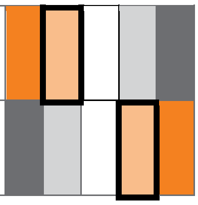
Overall evaluation

The overall benefits per target group are summarised as follows.

- ✓ For the clients and the final user:
  - o availability of a list of recognised competent professionals;
  - o assurance of results and quality.
- ✓ For the authorities:
  - o reliable input data;
  - o less control needed at the moment of energy performance declarations.
- ✓ For the airtightness testers:
  - o higher confidence of the owners;
  - o value for higher quality.

Pros	Cons
✓ Higher compliance to standards and reference document	✓ Extra-cost
✓ Cheating is becoming very hard	
✓ Only competent testers may perform conform measurements	

Table 2: Overall pros and cons of the approach

Level of complexity (dark orange = simplest) Potential for replication (dark orange = best)		Prerequisites

References

[1] EN 13829:2000 Thermal performance of buildings - Determination of air permeability of buildings - Fan pressurization method (ISO 9972:1996, modified). European Committee for Standardization, Brussels, 2000.

[2] European Parliament (2002). Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings. Official Journal of the European Communities, L1, 65-71. Brussels, 2002.

[3] ISO 9712:2012. Non-destructive testing - Qualification and certification of NDT personnel. International Organization for Standardization, Geneva, 2012.

[4] ISO 9972:2006 (Amd 1:2009). Thermal performance of buildings - Determination of air permeability of buildings - Fan pressurization method. International Organization for Standardization, Geneva, 2012.

[5] STS-P 71-3 Etanchéité à l'air des bâtiments - Essai de pressurisation. SPF Economie, P.M.E., Classes moyennes et Energie, Bruxelles, 2014.

[6] Delmotte, C., Mees C., Loncour, X., New framework for reliable pressurization tests of buildings in Belgium, Buildair Conference, Kassel, 2015.

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

Author
Cristina Florit (IBO), Susanne Geissler (OEGNB)

Technology All technologies	Aspect Status on the ground	Country Austria

THE AUSTRIAN BUILDING CERTIFICATION SYSTEM IBO OEKOPASS

The IBO OEKOPASS is an Austrian building certification system specially developed for new residential complexes (multi-unit residential buildings). It aims at voluntarily showing proof of building quality on the basis of building energy efficiency, ecology and indoor comfort principles as well as making use of it as a tool for marketing and quality assurance.

The structure and procedures for the assessment system were jointly developed by IBO, the Austrian Institute for Healthy and Ecological Buildings, and the property developer Mischek[1], one of the most important market players in Austria. IBO OEKOPASS is compatible with the voluntary building assessment scheme of the national Austrian Climate Protection Program called klimaaktiv[2].

Residential buildings ☑	Non-residential buildings ☐	Specific buildings: ……
New buildings ☑	Existing buildings ☐	

Context

During their whole lifecycle, buildings have an extensive impact on the environment due to their demand for energy, water and raw materials and their generation of waste and atmospheric emissions during construction, occupancy, and demolition phases.

This evidence, in combination with the purpose of IBO to counteract global climate change, have prompted in the development of a building rating system aiming at mitigating the impact of buildings through sustainable design and construction carried out according to the defined requirements. In addition, this certification program helps to guide, demonstrate, and document efforts to deliver sustainable and high-performance buildings in the Austrian marketplace.

IBO OEKOPASS has been specially developed for new multi-residential buildings and assesses performance in 8 criteria allocated to two categories, called “Quality of use” and “Ecological quality”.

Criteria allocated to “Quality of use”[3]:

- ✓ Comfort in summer and winter (Behaglichkeit im Sommer und Winter);
- ✓ Indoor air quality (Innenraumluftqualität);
- ✓ Noise protection (Schallschutz);
- ✓ Daylight and insolation (Tageslicht und Besonnung);
- ✓ Electromagnetic quality (Elektromagnetische Qualität).

Criteria allocated to “Ecological quality”:

- ✓ Ecological quality of the building materials and structures (Ökologische Qualität der Baustoffe und Konstruktionen);
- ✓ Overall energy concept (Gesamtenergiekonzept);
- ✓ Use of water (Wassernutzung).

[1] http://www.klimaaktiv.at/english.html
[2] http://www.mischek.at
[3] German terms in brackets to better understand Figure 1.

The rating of a building on the basis of the IBO OEKOPASS is carried out in two steps, a preliminary assessment at the beginning of the construction works, and a final assessment with awarding the IBO OEKOPASS after completion of the construction works and prior to handing over the housing complex.

Preliminary assessment

The preliminary assessment is carried out on the basis of the planning documents and measured values of buildings of a similar design that have already been completed. In addition, a considerable number of insights gained from scientific projects of the research and development program (R&D) "Building of Tomorrow[4]", one of the most extensive R&D initiatives in the field of sustainable building in Europe, are included.

Final assessment

After completion of the residential complex, the eight criteria listed above are verified on-site by IBO and other testing agencies commissioned by IBO. The assessments refer to unfurnished flats with standard equipment for flooring and wall coverings at the time of assessment and/or the spot-sampling measurements. In addition, building complexes benefit from these random checks as building deficiencies can be detected rapidly or even preventively avoided.

After finalisation of on-site control the measured data is valued and scored.

The IBO OEKOPASS is made available to the residents during hand-over of their flats. Future residents can look up the detailed measurement results in the online database of IBO where all extensive test reports are made available (more information under "Determination of samples and related procedures").

Rating

All eight criteria have the same weighting in the rating scheme to reflect their independent and equal importance. Unlike other building assessment systems there is no overall grade for the whole building, and each single category must achieve a defined minimal score for obtaining the IBO OEKOPASS certificate (more information under "Overview of criteria, requirements, and verification methods on-site").

A scale consisting of four quality levels[5] is applied for the rating of residential buildings:

Score: excellent (Ausgezeichnet)

This score is attributed to very ambitious building solutions which guarantee an excellent comfort and low operating costs for residents, and are especially resource-efficient and environmentally friendly.

Score: very good (Sehr gut)

This score is attributed to excellent solutions which considerably increase living comfort and are environmentally friendly.

Score: good (Gut)

This score describes solid solutions that are considerably better than conventional solutions.

Score: satisfactory (Befriedigend)

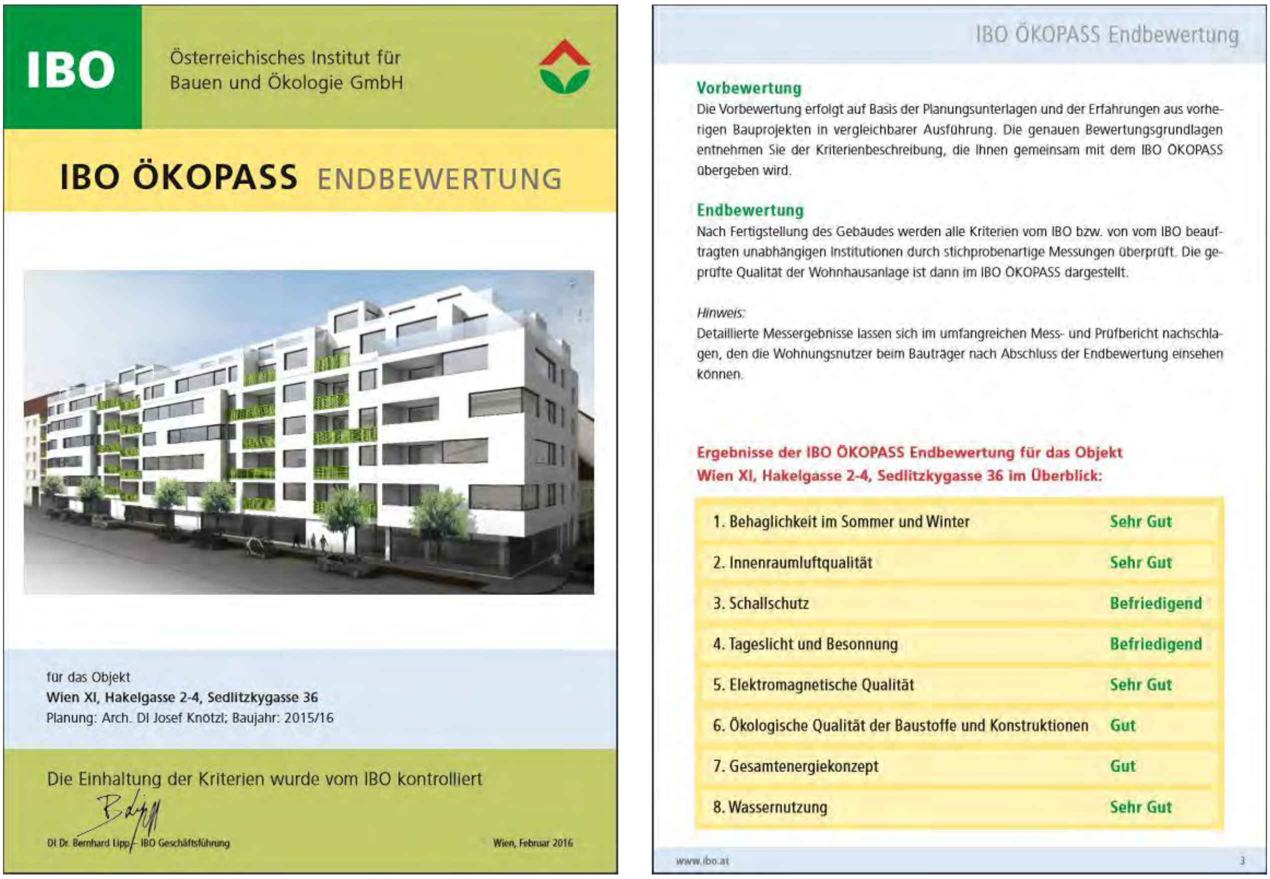
This score confirms compliance with the IBO OEKOPASS criteria that go beyond the statutory provisions and reference values in most cases.

Regulatory background

The voluntary IBO OEKOPASS assessment is carried out on the basis of a wide range of regulatory requirements in terms of minimum target values and assessment procedures. In case of missing regulatory requirements or regulations, the evaluation is done by referring to international state-of-the-art research, voluntary building standards, or precautionary principles (more information under "Overview of criteria, requirements, and verification methods on-site").

[4] https://nachhaltigwirtschaften.at/en/hdz/

[5] German terms in brackets to better understand Figure 1.


IBO

Österreichisches Institut für Bauen und Ökologie GmbH

IBO ÖKOPASS ENDBEWERTUNG

für das Objekt
Wien XI, Hakelgasse 2-4, Sedlitzkygasse 36
Planung: Arch. DI Josef Knötzl; Baujahr: 2015/16

Die Einhaltung der Kriterien wurde vom IBO kontrolliert

DI Dr. Bernhard Lipp / IBO Geschäftsführung

Wien, Februar 2016

IBO ÖKOPASS Endbewertung

Vorbewertung

Die Vorbewertung erfolgt auf Basis der Planungsunterlagen und der Erfahrungen aus vorherigen Bauprojekten in vergleichbarer Ausführung. Die genauen Bewertungsgrundlagen entnehmen Sie der Kriterienbeschreibung, die Ihnen gemeinsam mit dem IBO ÖKOPASS übergeben wird.

Endbewertung

Nach Fertigstellung des Gebäudes werden alle Kriterien vom IBO bzw. von vom IBO beauftragten unabhängigen Institutionen durch stichprobenartige Messungen überprüft. Die geprüfte Qualität der Wohnhausanlage ist dann im IBO ÖKOPASS dargestellt.

Hinweis:

Detaillierte Messergebnisse lassen sich im umfangreichen Mess- und Prüfbericht nachschlagen, den die Wohnungsnutzer beim Bauträger nach Abschluss der Endbewertung einsehen können.

Ergebnisse der IBO ÖKOPASS Endbewertung für das Objekt Wien XI, Hakelgasse 2-4, Sedlitzkygasse 36 im Überblick:

1. Behaglichkeit im Sommer und Winter	Sehr Gut
2. Innenraumluftqualität	Sehr Gut
3. Schallschutz	Befriedigend
4. Tageslicht und Besonnung	Befriedigend
5. Elektromagnetische Qualität	Sehr Gut
6. Ökologische Qualität der Baustoffe und Konstruktionen	Gut
7. Gesamtenergiekonzept	Gut
8. Wassernutzung	Sehr Gut

www.ibo.at 3

Figure 1: Front page and third page of the IBO OEKOPASS.

Objectives and problems addressed

The building sector causes about one third of energy consumption, not to mention material and water consumption and all related negative impact on the environment and the occupants' health. Thus, various actions address the relevant stakeholders aiming at improving the situation and facilitating the transition towards sustainable buildings. In Austria, residential buildings have the biggest share, namely about 85% of the building stock. Although the number of single- and double-family buildings dominates with about 75% of the building stock, in terms of apartments this is approximately 45%. In Austria, more than half of all apartments are located in multi-unit residential buildings. Since the 1980ies, guidelines on energy efficient and ecological building design have been developed and adopted by innovators, and have become mainstream in terms of awareness. However, when developers have to cut on costs, unfortunately ambitious ecologically based targets are often put aside first. Although some projects may achieve a high ecological performance standard in design stage, the lack of third party control during construction can lead to fall short by completion. IBO OEKOPASS´s quality assessment, based on spot-sampling measurements and random checks, provides trusted verification with real sustainability credentials. In addition, the validated compliance testing protects the building occupants against misleading information used in advertising or "green" marketing claims. As it is easier and more effective to work with companies responsible for a high number of apartments than to work with individual building owners, IBO decided to focus efforts and to address developers of multi-unit residential buildings. In 2001, IBO joined forces with the developer Mischek GmbH in order to develop the structure and procedures for the IBO OEKOPASS.

Mischek's motivation was to demonstrate their commitment to sustainability and establish a unique position in the target market. It was clearly an objective to contribute to improving as-built quality of multi-unit residential buildings and to promote their features, to create awareness and more demand for buildings with verified quality, resulting in an edge over conventional buildings. In order to support the Austrian Energy Strategy at implementing the EU requirements for 2020 and beyond, continuous further development of the IBO OEKOPASS criteria has been carried out. Special focus has been laid on nearly zero or energy plus buildings, as well as the use of non-renewable energies for targeting this goal.

Of course, further development takes place without leaving aside IBO´s concerns for ecology and wellbeing, as for example:

- ✓ As global average temperature is predicted to rise, overheating problems in buildings during summer time are likely to increase due to architectural preferences for huge, unshaded glazing and light construction systems. A far more accurate tool for predicting overheating has to be implemented in order to counteract occupants comfort problems and avoid, as well, peak cooling demands.
- ✓ Airtight buildings, short construction phases and the increase in the use of chemical products (cleaning products, personal hygiene products, air fresheners, etc.) should lead to a tighter prevention of the exposure of hazardous substances in the indoor air during building occupancy and not only, as so far, during the timeslot between post-construction and pre-occupancy. Therefore special attention is to be given to ventilation requirements and the control of, for example, air changes rates and flow rates during occupancy.
- ✓ Building materials should not only be addressed with respect to human health and indoor air quality but in regard, as well, of environmental protection. The environmental indicator of buildings could be widening to new environmental parameters, as photochemical ozone creation protection (POCP), substances of very high concern (SVHC), biocides, etc.

Approach to overcome identified problems: detailed description of IBO OEKOPASS structure and procedures

This chapter focuses on the final assessment, checking the as-built situation. It presents an overview of criteria, requirements and verification methods, as well as quality assurance procedures defined.

Overview of criteria, requirements, and verification methods on-site

The following paragraphs provide more information about requirements and assessment scales as well as information about methods applied for on-site measurements or checking performance achieved after completion of construction.

"Comfort in summer and winter" and "Overall energy concept"

The statutory requirements regarding residential buildings for the IBO OEKOPASS criteria "Comfort in summer and winter" and "Overall energy concept" are defined by the OIB Guideline 6 "Energy saving and heat insulation" of the Austrian Institute for Construction Engineering (OIB). The OIB Guideline 6 is a performance-based code that is available to the nine Austrian federal states (Länder) and provides a common basis for the regional building laws.

The IBO OEKOPASS requires an Energy Performance Certificate (EPC) displaying the expected energy consumption (which is the calculated energy demand), as well as effective thermal mass calculations and the assessment of the shading options of the building complexes.

Verification of these criteria is based on checking documents and calculations. Input data are cross-checked with the real situation on-site.

The IBO OEKOPASS scoring ranges from "satisfactory" when achieving compliance with mandatory minimum requirements, through "good" when meeting the more ambitious Austrian housing subsidy thresholds regarding energy efficiency and "very good" by the voluntary application of very low energy classes, to "excellent" when Passive House standards are to be implemented.

"Indoor air quality"

At present, there are no Austrian statutory requirements regarding the quality of the indoor air in residential buildings.

The IBO OEKOPASS assessment criteria rely on the recommended standard values of the issued guidelines of the Austrian Ministry of Environment[6] and the Austrian Academy of Sciences[7], as well as on the current international state of research and the precautionary principle in particular, as for example the WHO-Guidelines for indoor air quality[8].

During the IBO OEKOPASS final assessment sample testing of VOC, formaldehyde emissions and mould are undertaken. Mould tests must result in zero loadings as a precondition for receiving the IBO OEKOPASS.

[6] https://www.bmlfuw.gv.at/
[7] https://www.oeaw.ac.at/en/austrian-academy-of-sciences/
[8] http://www.who.int/en/

Building airtightness testing is a crucial step in ensuring optimal building performance. The required blower door tests are performed in accordance to the test methodology of the standard DIN EN13829 - Method A for "testing of a building in use". The airtightness thresholds are established in the OIB Guideline 6.

Rating	Requirements VOC (40% weighting)	Requirements Formaldehyde (30% weighting)	Requirements Airtightness (30% weighting)
Excellent	Sum of VOC < 300 µg/m³ (measurement 4 weeks after approval)	< 0.03 mg/m³ or 0.025 ppm	n_{50} < 0.6 [LW/h] with mechanical ventilation with heat recovery
Very good	Sum of VOC < 500 µg/m³ (measurement 4 weeks after approval)	< 0.06 mg/m³ or 0.05 ppm	n_{50} < 1.0 [LW/h] with mechanical ventilation or mechanical ventilation with heat recovery in the main rooms
Good	Sum of VOC < 1,000 µg/m³ (measurement 4 weeks after approval)	< 0.10 mg/m³ or 0.08 ppm	n_{50} < 1.25 [LW/h] with mechanical ventilation system or mechanical ventilation with heat recovery in main rooms
Satis-factory	Sum of VOC < 2,000 µg/m³ (measurement 4 weeks after approval)	< 0.12 mg/m³ or 0.1 ppm	n_{50} < 2.0 [LW/h] with natural ventilation (windows) or demand oriented mechanical ventilation or n_{50} < 1,5 [LW/h] with permanent mechanical ventilation or mechanical ventilation with heat recovery in main rooms

Table 1: Assessment scale and verification methods: Indoor air quality (LW/h = air exchange rate per hour).

"Noise protection"

The IBO OEKOPASS category "Noise protection" for residential buildings measures and valuates the sound insulation for airborne sound [DnT,w] and impact sound [L'nT,w], the A-weighted energy-equivalent continuous sound level [LA,eq] of the air conditioning, as well as the basic noise level of the urban environment during night time [LA,eq,nT].

The legal framework regarding requirements and carrying out measurements on-site is set up by the OIB Guideline 5 "Protection against noise" and the Austrian standard B8115-3 "Sound insulation and architectural acoustics in building construction" of the Austrian Standards Institute[9].

The IBO OEKOPASS scoring ranges from "satisfactory" when achieving compliance with minimal mandatory standards to "excellent" when demonstrating extraordinary performance in noise protection.

Rating	Requirements Protection against airborne noise (wall) (weighting 15%)	Requirements Protection against airborne noise (ceiling) (weighting 15%)	Requirements Protection against footfall sound (weighting 30%)	Requirements Protection against surrounding noise (night) (weighting 10%)	Equivalent continuous sound pressure level (weighting 30%)
Ex-cellent	DnT,w + C50-3150 > 63 dB(A)	DnT,w + C50-3150 > 63 dB(A)	L'nT,w < 35 dB(A) and L'nT,w + CI < 40 dB(A) and L'nT,w + CI,50-2500 < 45 dB(A)	LA,eq (Night) < 45 dB(A)	LA,eq,nT - Night <16 dB(A) or with mech. ventilation: LA,eq,nT ≤ 18 dB(A) and LC,eq,nT < 30 dB(C)
Very good	DnT,w + C50-3150 > 60 dB(A)	DnT,w + C50-3150 > 60 dB(A)	L'nT,w < 38 dB(A) and L'nT,w + CI <	LA,eq (Night) < 50 dB(A)	LA,eq,nT - Night <18 dB(A) or with

[9] https://www.austrian-standards.at/en/home/

			43 dB(A) and L‘nT,w + CI,50-2500 < 48 dB(A)		mech. ventilation: LA,eq,nT ≤ 20 dB(A) and LC,eq,nT < 35 dB(C)
Good	DnT,w + C50-3150 > 55 dB(A)	DnT,w + C50-3150 > 55 dB(A)	L‘nT,w < 43 dB(A) And L‘nT,w +CI < 43 dB(A)	LA,eq (Night) < 55 dB(A)	LA,eq,nT - Night <20 dB(A) or with mech. ventilation: LA,eq,nT ≤ 23 dB(A) and LC,eq,nT < 40 dB(C)
Satis-factory	DnT,w > 55 dB(A)	DnT,w > 55 dB(A)	L‘nT,w < 48 dB(A)	LA,eq (Night) < 60 dB(A)	LA,eq,nT - Night <22 dB(A) or with mech. ventilation: LA,eq,nT ≤ 25 dB(A) and LC,eq,nT < 45 dB(C)

Table 2: Assessment scale and verification methods: Noise protection.

"Daylight and insolation"

There are no Austrian statutory requirements regarding the quality of the natural indoor light in residential buildings, the IBO OEKOPASS, however, attaches great importance to this criterion. Minimal requirements are met, when 25% of all flats in a housing complex achieve a daylight factor of at least 2% at a designated location in the living room. The higher the percentage of fulfilment, the better the IBO OEKOPASS rating. Daylight factor measurements are executed according to the German Standard DIN 5034.

In the same way, the second requirement is met when at least 25% of all flats prove more than 1.5 hours direct insolation time in winter, according to sun path diagrams measurements (horizontal projection of the sky dome for 48 degrees north latitude).

	Daylight factor	Insolation
Verification after construction works	Photometer measurements taken at a height of 0.85 m and at a specific point in the living room (2 meters from outside wall and 1 meter from partition wall)	Winter solstice sun path diagrams for local latitude (48 degrees north latitude))

Table 3: Verification methods: Daylight and insolation.

Rating	Daylight factor: Requirements	Insolation: Requirements
Excellent	85% of all flats in a housing complex achieve a daylight factor of at least 2%	85% of all flats in a housing complex prove more than 1.5 hours direct insolation in winter
Very good	55% of all flats in a housing complex achieve a daylight factor of at least 2%	55% of all flats in a housing complex prove more than 1.5 hours direct insolation in winter
Good	40% of all flats in a housing complex achieve a daylight factor of at least 2%	40% of all flats in a housing complex prove more than 1.5 hours direct insolation in winter
Satisfactory	25% of all flats in a housing complex achieve a daylight factor of at least 2%	25% of all flats in a housing complex prove more than 1.5 hours direct insolation in winter

Table 4: Assessment scale: Daylight and insolation.

Electromagnetic quality

The Austrian legal limit values for the admissible intensity of electric and magnetic fields in residential housing are defined in the pre-standard OEVE/OENORM E 8850:2006-02-01 "Electric, magnetic and electromagnetic fields in the frequency range from 0 Hz to 300 GHz - Restrictions on human exposure". However, the IBO OEKOPASS assessment criteria are based on the precautionary principle, limiting the statutory requirements by a factor of 1,000. On-site measurement of the following parameters is carried out: Magnetic fields in strength in low frequency range, Electric field strength for alternating fields, Electric field strength for constant fields, Low frequency pulsed high-frequency fields.

Rating	Magnetic fields in strength in low frequency range: Requirements	Electric field strength for alternating fields: Requirements	Electric field strength for constant fields: Requirements	Low frequency pulsed high-frequency fields: Requirements
Excellent	B < 100 nT	E < 10 V/m	E < 200 V/m	S < 0.01 mWm^2
Very good	B < 200 nT	E < 20 V/m	E < 400 V/m	S < 0.1 mWm^2
Good	B < 400 nT	E < 30 V/m	E < 1,000 V/m	S < 1.0 mWm^2
Satisfactory	B < 1,000 nT	E < 50 V/m	E < 5,000 V/m	S < 3.0 mWm^2

Table 5: Assessment scale and verification methods: Electromagnetic quality.

Ecological quality of building materials and structures

The IBO OEKOPASS category "Ecological quality of building materials and structures" values and compares the environmental impact of buildings by considering different paths of verification approach, all based on life cycle analysis and documents of proof such as labels and declarations:

- ✓ Calculation of the environmental indicator of the building, the so called OI3- Indicator[10]: This approach developed by IBO assesses building materials by means of a cumulative-step life cycle assessment (LCA) up to the "ex-factory" point in time. The calculation methods are based on the environmental indicators contained in the IBO building materials database, including global warming potential (GWP-100), acidification potential (AP) and the primary energy content in terms of non-renewable energy resources (PENRT) which were gathered from representative or average factory assessments of building materials. The LCA method is regulated in the standard series OENORM EN ISO 14040 and in the instructions for the implementation of a life cycle assessment "Lifecycle assessment: an operational guide to the ISO Standards" (CML 2004).
- ✓ Measurement of the disposal properties of the building materials of a building by calculating the disposal indicator, the so called EI-Indicator[11], developed by IBO.
- ✓ Avoidance of critical materials such as CFCs and PVCs.
- ✓ Use of ecolabels on building products.

Use of water

There are no Austrian statutory requirements regarding water saving measurements in residential housing, but nevertheless the IBO OEKOPASS puts a high value on conserving water resources and decreasing wastewater. Therefore, the installation of water-saving fittings and metering equipment, the existence of enough drainage areas in the outdoor facilities or the use of rain water contribute to a better rating and encourage the overall water use reduction. The assessment scale has been defined based on research results, various policy documents and experts' judgements. Verification is based on on-site flow rate measurements and plumbing product data sheets.

Determination of samples and related procedures

A larger sample can yield more accurate results and provide more quality assurance, but excessive sample measurements are pricey and can lead to cost overruns. A checklist has been developed to consistently collect information and establish criteria to strike a balance.

Following parameters play a key role in determining the required number of sample measurements: size of the building complexes, number of residential units as well as the different types of standard equipment.

Generally speaking, this means an average of 3 testing dwellings per building complex.

[10] http://www.ibo.at/documents/OI3-LeitfadenV22_06_2011_english.pdf
[11] http://www.ibo.at/documents/EI_Guidelines_V1_english.pdf, EI=EntsorgungsIndikator

Once the number of measurements is established, potential study areas within each building are defined and checked for feasibility in coordination with the site supervisor. The study areas are then randomly selected by IBO and other testing agencies commissioned by IBO for more extensive evaluation.

Once the certification process is completed, all detailed measurements are handed over to the building promoter. In order to fulfil public interest, the results are published also on the online IBO database, available under http://www.ibo.at/de/oekopass/objekte.htm.

Qualified staff for checking performance

IBO OEKOPASS was launched in an effort to develop a market driven rating system in order to accelerate the implementation of sustainable practices in the building sector. As research, technology and legal aspects rapidly evolve and market matures IBO OEKOPASS criteria, the methodology and benchmarks are constantly updated and further developed in order to ensure state-of-the-art assessment. This task is done by the members of the IBO board, an independent, scientific, non-profit society. Additional control mechanisms such as Third Party Control have not been implemented.

The checking performance is carried out by qualified IBO staff and commisioned testing agencies. The combination of sustainability expertise, construction site experience and practice in overcoming operational problems are essential requisites for fulfilling this task.

Market acceptance of the approach

IBO OEKOPASS has dominated building assessment for the last 15 years in the market sector of subsidised housing in Vienna and eastern Austria. Being a voluntary certification scheme, the extent to which sustainable performance can be enhanced is determined by market acceptance of the assessment criteria, the certification cost, and the perceived benefits to the building developer.

The fact that other building assessment systems operate and coexist in Austria has not confounded the market. This is most probably due to clear differentiation of the different assessment systems by addressing different target groups, and the ease of use of the IBO OEKOPASS system.

In addition, this assessment system benefits from the overall tenants' perception that IBO OEKOPASS certified buildings are comparatively healthier, more comfortable, more energy efficient and with lower adverse environmental impacts than conventional buildings.

BUILDING ASSESSMENT SYSTEM	COUNTRY	CERTIFIED PROJECTS IN AUSTRIA	CERTIFIED PROJECTS WORLDWIDE
klimaaktiv		440	440
IBO ÖKOPASS		320	320
TQB / ÖGNB		113 *	113 *
EU Green Building		75	1.058
DGNB / ÖGNI		92 *	850 *
LEED		29 *	ca. 86.000 *
BREEAM		12	ca. 538.000 * (seit 1990)

Table 6: Comparison of different building assessment systems in Austria.
**) Includes all projects under certification, detailed figures not available.*
Note: Figures refer to all building types, not only housing complexes.
Source: IBO survey of individual building label websites, Status: February 2016.
In accordance with Table 1 of the report "Der klimaaktiv Gebäudestandard im Vergleich mit ausgewählten Gebäudebewertungssystemen".

Pros and cons of possible options: comparing voluntary with mandatory schemes

IBO OEKOPASS is a private initiative resulting from cooperation between the research and consulting NGO IBO and the innovative developer Mischek GmbH. It has combined the general need for resource efficiency with the occupants' interest in healthy buildings. Every apartment rented or sold by the developer is accompanied by the IBO OEKOPASS. The quality assurance and assessment scheme was developed together with Mischek GmbH, but the service provided by IBO is available also to other developers, and demand is growing. Compared with mandatory schemes, it is the advantage of a voluntary scheme that organisations developing the system are free to choose what they consider the best option, while the development of a mandatory scheme will have to undergo a political adjustment process which might lead to unintended modifications. However, even though the procedures and scope might be ideal to achieve the objectives, voluntary schemes are prone to remaining small-scale initiatives for lack of obligation.

The case of IBO OEKOPASS represents a third approach: teaming up with one of the most important developers in Austria helped the voluntary scheme to gain traction.

The table below describes and compares the three options mentioned above, addressing the transition of the construction sector towards sustainable building.

Option	Pros	Cons
✓ Option 1: Voluntary assessment	✓ Development of the ideal system in terms of objectives and procedures is possible.	✓ Market introduction is expensive and market penetration is difficult, especially in the residential building market dominated by demand.
✓ Option 2: Mandatory assessment	✓ A mandatory scheme must be implemented and will be widely applied. Thus, it will be effective in achieving the objectives, provided that the scheme includes an appropriate component of checking compliance.	✓ The scheme will be subject to adjustments due to political reasons, in order to ensure social acceptance. This could weaken the scheme and compromise achievement of original objectives.
✓ Option 3: Voluntary assessment together with a major market actor (developer)	✓ Scientific expertise and market knowledge are combined and used to develop a scheme which is adopted by an important market player on the basis of self-commitment. This facilitates market introduction and makes the scheme widely visible, in order to attract other market players.	✓ If there is no independent control, the scheme will be in a tenuous position. It could be difficult to defend the scheme against accusations of being biased by the priorities of the major market actor (developer).

Table 7: Description of pros and cons.

Compliance concerns related to EP certificates and to the QM approach

No reporting ☐	Wrong reporting ☑	Not meeting the performance requirements ☐

Table 8: Compliance concerns related to EP certificates (see QUALICHeCK terms and definitions).

Especially in the east of Austria where the IBO OEKOPASS is well-known, checking buildings after completion is not yet business as usual procedure. Thus, the voluntary scheme is an important contribution to preventing wrong reporting and helping to ensure compliance.

Financial aspects

The IBO OEKOPASS certification fees are based on the size of the housing project and the number of spot-sampling measurements required for ensuring strict quality assurance (more information under "Determination of samples and related procedures"). Payment is carried out after completion of each of the two assessment stages.

For these reasons overall fees can vary from 8,000 € for a single-building project, to 20,000 € for multi-residential complexes. This represents a favourable pricing comparing to other Austrian building assessment systems.

Overall evaluation

In the last years, the growing popularity of the building assessment systems has speeded up the market transformation towards sustainable and eco-friendly buildings by driving the awareness and the understanding of green attributes to market acceptance.

Nevertheless, developers' reluctance is still to overcome, for they are not always willing to invest, for instance in ecology, climate protection or healthy construction materials that only benefit tenants or the environment but not directly the project promoters. In fact, the difficulty of appreciating and valuing many of these soft benefits, as well as the absence of regulations or incentives programs have an adverse impact on the implementation and the acceptance of environmental guidelines that by far exceed local or state government requirements.

For this reason, the IBO OEKOPASS assessment system offers practical instruments highlighting these soft benefits in a quantifiable and, ultimately, far more understandable way.

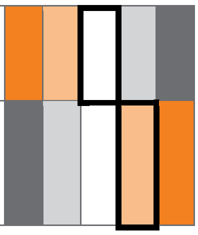
The above said explains why IBO OEKOPASS criteria related to energy efficiency imposed by statuary mandatory regulations are, in most cases, readily met, and a higher scoring awarded when developers benefit from the more ambitious requirements of the Austrian housing subsidy scheme. The achievement of the thresholds in categories such as "Indoor air quality", "Ecological quality of building materials " or "Use of water" have turned out to be far more challenging.

Pros	Cons
✓ Trusted verifications with real sustainability credentials avoid misleading information or "green" market claims.	✓ IBO OEKOPASS is a private initiative and there is no control by independent institutions. The success of the instrument relies on the reputation of the involved entities.
✓ Certified IBO OEKOPASS building complexes benefit from lower operating costs due to reduced energy demand and water consumption, longer lifespans and shorter material replacement effects.	
✓ IBO OEKOPASS is used as consumer information and for a landmark marketing instrument.	
✓ System criteria can be used as a guideline for planning, construction and quality assurance for optimising the building quality.	
✓ As a national evaluation system, IBO OEKOPASS has the advantage of representing the Austrian local building culture.	

Table 9: Overall pros and cons of the approach.

Level of complexity
(dark orange = simplest)

Potential for replication
(dark orange = best)



Prerequisites

Good collaboration between research and consulting oriented institutions and developers with substantial market share.

Hints	Pitfalls
✓ It is recommended to seek collaboration between research and consulting and innovators from the real estate sector (developers) to facilitate market introduction and help the scheme to gain momentum. ✓ Market acceptance will require cost efficient and pragmatic solutions: focus on the relevant parameters for checking building performance and decide to neglect the minor ones.	✓ The challenge to correctly identify the relevant parameters and to find a good balance between effort for checking and benefits of detecting mistakes.

Table10: Overall hints and pitfalls to avoid when developing such an approach.

References

[1] OIB-Richtlinie 5 - Schallschutz, Austrian Institute for Construction and Engineering, March 2015.

[2] OIB-Richtlinie 6 - Energieeinsparung und Wärmeschutz, Austrian Institute for Construction and Engineering, March 2015.

[3] Önorm B 8110 - Wärmeschutz im Hochbau - Teil 6: Grundlagen und Nachweisverfahren - Heizwärmebedarf und Kühlbedarf, Austrian Standards Institut.

[4] Önorm EN ISO 14040 - Umweltmanagement - Ökobilanz Grundsätze und Rahmenbedingungen, Austrian Standards Institut.

[5] OEVE/OENORM E 8850:2006-02- ÖVE/ÖNORM E 8850 -Elektrische, magnetische und elektromagnetische Felder im Frequenzbereich von 0 Hz bis 300 GHz - Beschränkung der Exposition von Personen, Austrian Standards Institut.

[6] DIN EN13829 - Bestimmung der Luftdurchlässigkeit von Gebäuden, Normenausschuss Bauwesen (NABau) im DIN Deutsches Institut für Normung e.V.

[7] BMLFUW (2011): Richtlinie zur Bewertung der Innenraumluft, erarbeitet vom Arbeitskreis Innenraumluft am Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft und der Österreichischen Akademie der Wissenschaften, Blau- Weiße Reihe (Loseblattsammlung).

[8] Akademie der Wissenschaften (1997): Flüchtige Kohlenwasserstoffe in der Atmosphäre, Luftqualitätskriterien VOC, Band 2, Hrsg. Bundesministerium für Umwelt, Jugend und Familie.

[9] WHO (2010): WHO-Guidelines for indoor air quality: selected pollutants. World Health Organisation (WHO), Regional Office for Europe, Copenhagen.

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Technology All technologies	*Aspect* Quality of the Works	*Country* Austria

VOLUNTARY GREEN BUILDING ASSESSMENT PAVES THE WAY FOR BETTER AS-BUILT QUALITY

The work on the Austrian voluntary green building assessment scheme called TQB (Total Quality Building) started at the end of the 1990ies, responding to a serious problem: Quite often, building designs optimised in terms of sustainability including energy efficiency and renewable energy use were not realised as planned but with lower quality, because of various reasons, such as lack of quality of the works, the intention to save investment cost, or faulty interfaces between staff involved in planning and staff involved in execution. In the end, the quality defined by means of certain indicators on paper did actually not correspond with the as-built situation. However, regarding reductions of energy consumption and emissions only the actually achieved status is relevant. For this reason, a two-step assessment approach was chosen from the beginning: first, assessment of the building design, and second, assessment of the completed building. Among others, the assessment requires the EPC as a supporting document. This factsheet presents the Austrian voluntary green building assessment scheme, how it is applied to facilitate smart city developments, and also explains how QUALICHeCK project results are being used to improve the system and the procedures.

Residential buildings ☑	Non-residential buildings ☑	Specific buildings: ......
New buildings ☑	Existing buildings ☑	

Context

In 1997, Austria joined the Green Building Challenge (GBC), an international platform for the development of green assessment schemes for buildings (successor organisation IISBE - International Initiative for a Sustainable Built Environment). The GBC team expected that building related requirements regarding energy, materials, water, land, indoor air quality, emissions, and many others, would substantially facilitate the transition towards a sustainable building sector. At that time, the BRE Environmental Assessment Method (BREEAM, developed in the UK) was already in place and experiences delivered valuable input for establishing an international platform facilitating the development of voluntary national green building assessment schemes by providing a common standard for orientation.

In Austria, the Austrian TQB (Total Quality Building) assessment scheme[1] was developed, tailored to the particular needs of the Austrian construction sector, and put into operation in 2003 following a testing phase [1,2].

The adjustment of assessment procedures to the Austrian planning and construction practice was necessary to keep effort for data collection and preparation of supporting and verification documents low, in order to avoid high transaction costs and to provide a tool for widespread application in the residential and non-residential sector.

Introduction on green building assessment schemes and TQ

There are several green building assessment schemes available on the market, and they differ substantially in terms of complexity, cost, scope, and level of detail. Which assessment scheme is the best depends on the purpose of the building assessment.

[1]*At that time called "TQ - Total Quality assessment scheme", which was changed after a major revision of the system to "TQB - Total Quality Building" in 2009.*

TQB has been developed with the support of the Austrian Federal Government to provide a guideline for building design, a tool for quality control, and a tool which displays trade-offs between design targets, thus delivering input in technology and product development.

It is evident, that building assessment schemes have the potential to deliver much more than the final result of a building assessment scheme, the so-called “certificate” or label, which is used in market communication (see Figure 1).

Building assessment schemes such as TQB consist of a criteria framework, scales, and a weighting system, which define sustainable building quality (general examples in brackets):

- ✓ Criteria: which kind of information is needed for assessment (e.g. heating energy consumption).
- ✓ Indicators: how to describe the performance of the defined criteria (e.g. kilowatt hours per square meter heated gross floor area and year).
- ✓ Assessment scale: defines which performance is good and which one is bad by allocation of scores (e.g. heating energy consumption less than 15 kilowatt hours per square meter heated gross floor area and year receives the highest score).
- ✓ Weighting: which criteria are more important than others, and by how much (e.g. more points are allocated to energy related criteria than to material related criteria).

In addition, the assessment procedure is clearly specified in terms of data collection, check of data, awarding of points based on the data provided, awarding the certificate based on the assessment result.

TQB is a third party certification scheme, and the procedure is carried out in five steps:

- ✓ Building documentation using online declaration tools is carried out by OEGNB consultants who are appointed by the OEGNB
- ✓ Handover of submitted project to the OEGNB and application for third party check
- ✓ Verification of proof by OEGNB auditors, which are listed by the OEGNB, if necessary revision of proof by OEGNB consultants
- ✓ Approval of assessment results by OEGNB after consulting with submitters
- ✓ Publication of assessment results in OEGNB press, above all on OEGNB website

The assessment result contains two parts:

- ✓ Compilation of quantitative data and qualitative information about the building.
- ✓ Assessment result for market communication, in order to tell consumers how good the performance of the building is.

Data collection and data assessment should be well separated, to make use of the data apart from the sustainability assessment scheme.

While the data compilation as such remains the same and contains useful objective information about the building, the interpretation may change, depending on the assessment scheme applied (see Figure 1 for the general explanation and Figure 3 showing two assessment results, namely TQB and klimaaktiv).

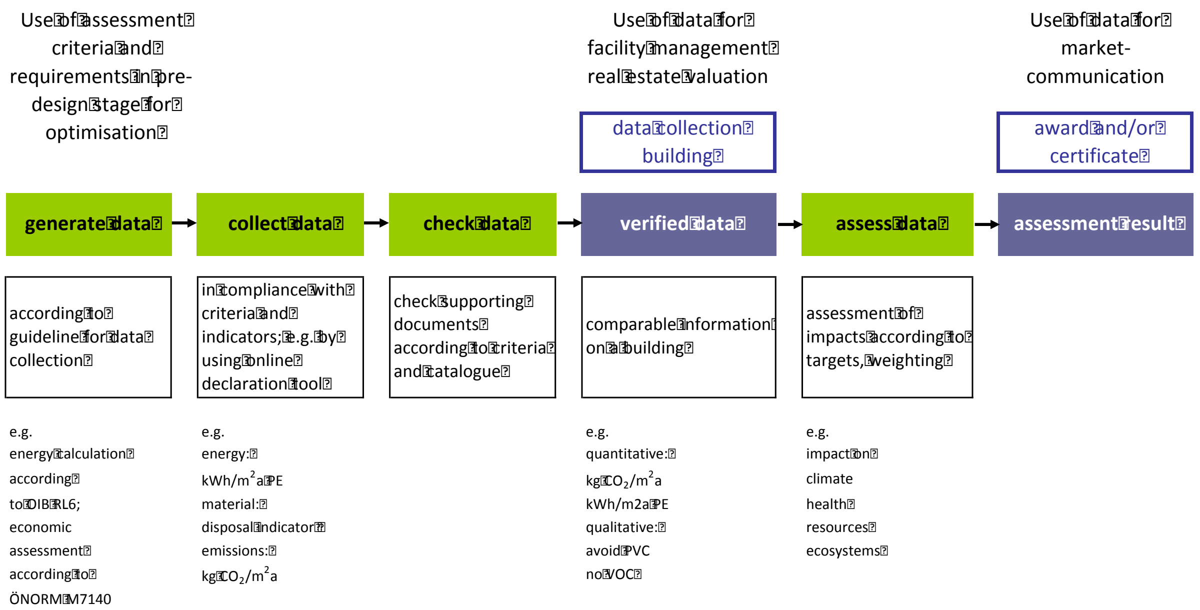


Figure 1: Overview of TQB building assessment scheme

Objectives and problems addressed

The problem: buildings are not always constructed according to design

At the time of the Green Building Challenge, Austrian pioneers in sustainable building quite often encountered the problem that building designs optimised in terms of sustainability including energy efficiency and renewable energy use were not realised as planned but with lower quality, because of various reasons, such as lack of quality of the works, the intention to save investment cost, or faulty interfaces between staff involved in planning and staff involved in execution. In the end, the quality defined by means of certain indicators on paper did actually not correspond with the as-built situation. However, regarding reductions of energy consumption and emissions only the actually achieved status is relevant.

How to address the problem: developing a two-step building assessment scheme

In the beginning, a survey was conducted among developers and clearly pointed out that performance criteria limited to energy efficiency measures, renewable energy technologies, and ecological materials would lack acceptance. However, developers were willing to apply a comprehensive building assessment scheme which includes aspects such as noise protection, indoor air quality, flexibility, and others besides environment-related criteria. Furthermore, the assessment scheme should be useful as a quality control tool as well as a marketing instrument.

Therefore, the TQB assessment scheme was composed of a comprehensive set of criteria to be applied at the very beginning of a project to adjust design targets accordingly, in order to have the chance to achieve a good assessment result. In order for buildings to pass the TQB assessment, checks are made twice, first at the end of the planning stage and then after completion of construction. After the planning phase, drawings and calculations are checked, and after completion the compliance with the design is examined, and measurements are carried out. The building is awarded a certificate two times, once after completion of design and once after completion of construction. There are two objectives: First, there is the objective to ensure that the building was constructed in compliance with the design which will be especially important if the building is designed in an integrated way. In this case, architectural aspects and energy technology aspects are intertwined and small changes during construction to reduce costs will result in substantial problems concerning comfort and energy performance during building operation.

Second, there is the objective to avoid mistakes during execution and to ensure the quality of the works. Mistakes during construction will affect the actual energy consumption during building operation, and the higher the energy efficiency standard is, the more serious the negative impact will be.

Smart city developments with a focus on the optimised operation of the low voltage grid have drawn even more the attention to both aspects, stressing their crucial role in the transition phase towards a sustainable energy system.

The importance of ventilation systems for indoor air quality and energy consumption

In this respect, the importance of ventilation systems comes to the fore: in highly energy efficient buildings ventilation with heat recovery is certainly essential. Interviews with occupants of residential buildings have shown that noise of ventilation systems is often a serious problem, as people switch their systems off as a consequence of feeling disturbed especially at night [3]. This has an impact on indoor air quality as well as on the actual energy consumption. Inappropriate noise levels can be due to faulty designs, mistakes during construction, or both.

The strategy how to make an impact

TQB criteria catalogues are available for residential and non-residential buildings at no cost. Since 2009, OEGNB has provided and maintained this free of charge building assessment tool via the website www.oegnb.net, in order to ensure wide dissemination. OEGNB only collects a fee for carrying out checks of the design or the completed building and for issuing the TQB certificate (see also Table 14).

Figure 2 shows a screen shot of the tool. When entering the tool through the Internet, it will appear as shown on the left hand side. Clicking on a specific category, the criteria will show (see category C *Energy and Supply* in Figure 2 on the left hand side). Clicking on a specific criterion will show the detailed allocation of points and the verification documents requested. In Figure 2, the criterion *Final Energy Demand* is shown as example on the right hand side.

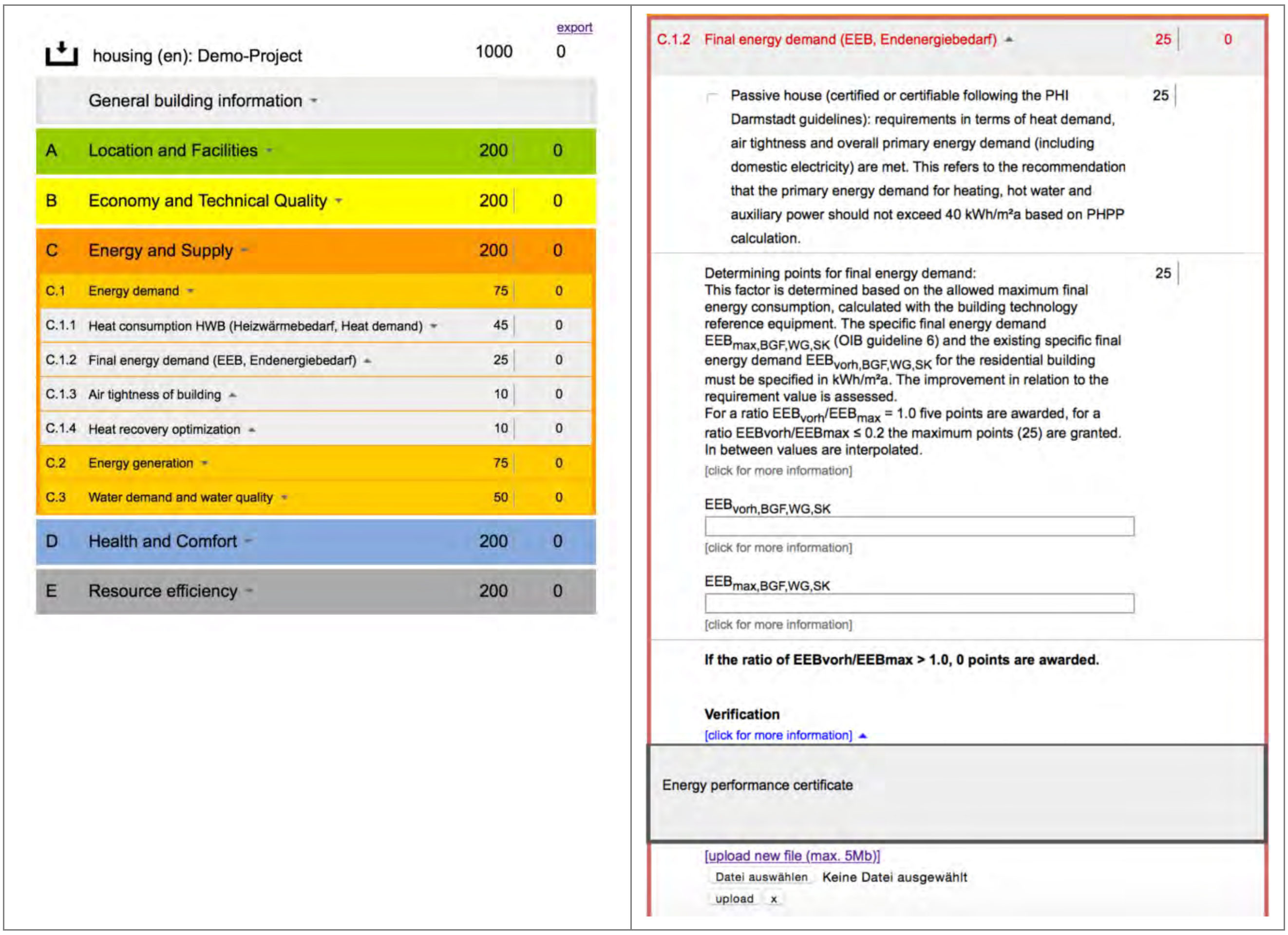


Figure 2: Screen shots of TQB Tool

Short description of the Austrian voluntary green building assessment scheme

The following chapters briefly present the structure of the scheme and the assessment procedure. In the subsequent parts, a few criteria (see orange marks in Tables 1-5) especially relevant in the context of QUALICHeCK and quality of the works are dealt with in more detail on an exemplary basis. Full information is available at https://www.oegnb.net/en/tqbtest.htm, including the internet-based TQB-Tool which is used to manage the assessment procedure.

Examples displayed below refer to multi-unit residential buildings.

Overview of assessment system – criteria framework

The criteria framework consists of five categories which are explained in the tables below. The weighting is based on the allocation of scores which are summed up, representing the assessment result.

The highest possible mark is 1000 points. The tables below show the maximum available number of points. Points will be allocated depending on the rating result, determining which level of the assessment scale is achieved. Criteria especially relevant for the topic of this fact sheet and in connection with energy efficiency are marked orange.

The **criteria group A "Location and facilities"** evaluates the location quality (infrastructure, location safety and building land quality) and the quality of the facilities as realised in the object and on the premises as well as the accessibility. This criteria group makes up 20% of the total evaluation.

A.	Location and facilities	max. 200
A.1	Infrastructure	max. 50
A.1.1	Connection to public transport	max. 20
A.1.2	Quality of local supply	max. 10
A.1.3	Quality of social infrastructure	max. 10
A.1.4	Proximity to recreation areas and recreational facilities	max. 10

A.2	Location safety and building land quality	max. 50
A.2.1	Basic risk of natural hazards	max. 10
A.2.2	Quality of building land and sealing	max. 20
A.2.3	Alternating magnetic fields in low frequency range	max. 10
A.2.4	Low frequency-pulsed high frequency fields	max. 10
A.3	Facilities quality	max. 50
A.3.1	Interior development	max. 10
A.3.2	Facilities of apartment building	max. 20
A.3.3	Apartment-related open spaces	max. 10
A.3.4	Burglary protection	max. 10
A.4	Accessibility	max. 50
A.4.1	Accessibility	max. 50

Table 1: Overview of the quality criteria of criteria group A "Location and facilities" and their weighting

Criteria group B "Economy and technical quality" focuses on factors which can have a significant impact on the building's economic efficiency as well as factors such as construction site management and fire protection. Group B accounts for 20% of the overall evaluation.

B.	Economy and technical quality	max. 200
B.1	Profitability within the life cycle	max. 100
B.1.1	Profitability analyses - LCCA (Life Cycle Cost Analysis)	max. 50
B.1.2	Integral Planning and variation analysis	max. 25
B.1.3	Basis for building operation	max. 25
B.2	Construction site management	max. 30
B.2.1	Construction site management and logistics	max. 30
B.3	Flexibility and Durability	max. 40
B.3.1	Dimensioning and static concept	max. 20
B.3.2	Expandability/ Core removal	max. 20
B.4	Fire Protection	max. 30
B.4.1	Requirements for separate fire sub-section components	max. 10
B.4.2	Fire alarm facilities	max. 10
B.4.3	Special fire extinguisher systems	max. 10

Table 2: Overview of the quality criteria of criteria group B "Economy and technical quality" and their weighting

Criteria group **C "Energy and Supply"** focuses on the assessment of energy demand and energy generation and assesses water-saving measures. The group accounts for 20% of the overall assessment.

C.	Energy and supply	max. 200
C.1	Energy demand	max. 75
C.1.1	Heat demand	max. 45
C.1.2	Final energy demand	max. 25
C.1.3	Air tightness of building	max. 10
C.1.4	Heat recovery optimization	max. 10
C.2	Energy generation	max. 75
C.2.1	Primary energy demand	max. 50
C.2.2	Photovoltaic system	max. 20
C.2.3	Energy efficient ventilation system	max. 10
C.2.4	CO_2-emissions from building operation	max. 50
C.3	Water demand and water quality	max. 50
C.3.1	Individual consumption-based billing	max. 5
C.3.2	Use of rain water	max. 15
C.3.3	Water-saving sanitary technology	max. 20
C.3.4	Hygienic quality of cold and hot water	max. 25

Table 3: Overview of the quality criteria of criteria group C "Energy and supply" and their weighting

The focus in assessing the criteria group **D "Health and Comfort"** is on several aspects relating closely to the social quality of buildings. This criteria group accounts for a total of 20% of the overall assessment.

D	Health and comfort	max. 200
D.1	Thermal comfort	max. 50
D.1.1	Thermal comfort in winter	max. 20
D.1.2	Thermal comfort in summer	max. 30
D.1.3	Building automation and occupant interference	max. 20
D.2	Indoor air quality	max. 50
D.2.1	Ventilation	max. 25
D.2.2	Low-emission and low pollutant construction materials in interior fittings	max. 40
D.2.3	Mould and moisture prevention / pollutant inspection	max. 10
D.3	Sound insulation	max. 50
D.3.1	Ambient noise	max. 12
D.3.2	Acoustically effective layout	max. 12
D.3.3	Noise protection of partition walls	max. 12
D.3.4	Noise protection of partition ceilings	max. 12
D.3.5	Impact sound protection of partition ceilings	max. 12
D.3.6	Measurement of external facade, basic indoor noise level (night) or noise level of ventilation system	max. 12
D.4	Daylight and sunlight	max. 50
D.4.1	Daylight factor	max. 25
D.4.2	Direct sunlight penetration during winter	max. 25

Table 4: Overview of the quality criteria of criteria group D "Health and comfort" and their weighting

In the **criteria group E "Resource efficiency"** the use of resources is evaluated. This criteria group makes up 20% of the total evaluation.

E	Resource efficiency	max. 200
E1	Avoidance of critical material	max. 50
E1.1	Avoidance of CFC	max. 15
E1.2	Avoidance of PVC	max. 40
E1.3	Avoidance of VOC (except for use in interior construction - D.2.2)	
E2	Regional products, recycling share, certified products	max. 50
E2.1	Regionality	max. 20
E2.2	Use of recycling material	max. 20
E2.3	Use of products with environmental certificates	max. 25
E3	Eco-efficiency of entire building	max. 50
E3.1	OI3 Calculation as leading indicator for the eco efficiency of the building	max. 50
E4	Disposal	max. 50
E4.1	Disposal indicator	max. 50

Table 5: Overview of the quality criteria of criteria group E "Resource efficiency" and their weighting

Overview of assessment system – Assessment scale

For each criterion, a scale is defined, representing building requirements. Depending on the rating, a specific number of points will be allocated, up to the maximum defined in the criteria framework. The rating is based on supporting documents or another method of proof and can be different in the design stage and construction stage. If needed there is also a differentiation between new construction and renovation. Always, the method of verification is clearly specified.

The tables below show a few examples relevant for both, indoor air quality and energy. Ventilation is especially important, because if it is not operated as planned, it will not only affect indoor air quality but also actual energy consumption. The more efficient a building is, the higher the negative impact will be.

Criterion D2.1 Ventilation specifies two assessment scales depending on the chosen building concept: "Fresh-air systems without Heat Recovery" and "Comfort ventilation with Heat Recovery". Requirements are sufficiently specific, thus allowing for checking the design as well as the as-built situation after completion without causing too much additional effort.

D.2.1. Ventilation

Quality criteria	Points
Fresh-air systems without Heat Recovery	
Demand-driven air supply: Control for each unit (e.g. controlling CO_2 or humidity), manual controls require at least three control levels	4
Design in accordance with H 6038, DIN 1946 or standard occupancy 30m³/(h,pers)	4
Air openings (air outlets in exterior walls) are soundproof, have insect screens and are easily accessible	4
Air openings are positioned above the heating unit so as to warm up external air and avoid draught	4
Sufficiently large ventilation areas to ensure additional air flow between rooms. Free area >= 150 cm², such as overflow diffuser or door pane shortened approx. 12 to 15 mm	4
Comfort ventilation with Heat Recovery	
Design in accordance with ÖN H 6038 , DIN 1946 or through supply air volume for standard occupancy 30 m³/(h,pers) airflow (minimum air exchange rate: 0.3 1/h)	4
Easily accessible and replacable filters, automatic indicator for filter change	2
Outside air filter F 7 in accordance with DIN EN 779, exhaust air filters minimum G4 in accordance with DIN EN 779	3
The unit can be adjusted according to demand on at least three control levels	4
Unit has bypass to avoid Heat Recovery in summer	3
Fresh air intake at a height of at least 1.5 metres and placed sufficiently far from parking areas and waste storage sites	2
Disbalance between fresh air and exhaust air flow permanent <= 10%	3
Max. internal vents from leakages 3% at 100 Pa	2
User manual/user information is in place (extractor operating in recirculating-air mode only, condenser dryer is the only option, heating unit and fireplaces can only be operated in the air-tight shell without using the surrounding air)	2
The building does not have any ventilation system supplying the main living rooms with fresh air, or the built-in ventilation system does not comply with any of the points in the above-mentioned criteria.	0

Table 6: Overview of assessment scale of criterion D.2.1. Ventilation

Criterion D.2.3. Mould and moisture prevention / Pollutant inspection is an example for differentiating between requirements to be met in the design stage and in the planning stage of new constructions, and requirements to be met in building renovation projects.

D.2.3. Mould and moisture prevention / Pollutant inspection

Quality criteria	Points
NEW BUILDINGS	
In the planning stage	
Site concept as means of avoiding water damages and moisture entry is in place	5
Drying periods are adhered to.	5
There are no measures planned	0
After completion	
No noticable sources of mold in the interior	5
No water damages during the construction stage.	5
EXISTING BUILDINGS AND RENOVATIONS	
There has been no inspection of pollutants (for existing buildings and renovations).	0
Inspection of pollutants (Schadstoffbegehung) in compliance with ÖN S 5730 in existing buildings or measurements were conducted in cases of suspicion (this regards pollutants mold-spores, asbestos, PCB and PAK lead substance Benzo-(a)-Pyren, Biozide).	10

Table 7: Overview of assessment scale of criterion D.2.3. Mould and moisture prevention / Pollutant inspection

Criterion D.3.6. Measurement of external facade, basic indoor noise level (night) or noise level of ventilation system shows the assessment scale making it evident that different verification methods are applied depending on the building phase: in the planning phase, a calculation according to a specified procedure has to be presented, while measurements are required in the implementation phase (more exemplary information on verification methods see next chapter).

D.3.6. Measurement of external facade, basic indoor noise level (night) or noise level of ventilation system

Quality criteria	Points
In PLANNING CASES: Calculation value $R'_{res,w}$	
For new constructions/renovations: Detailed proof (calculated weighted noise insulation-rate $R'_{res,w}$ for critical rooms) is presented, standard requirements in accordance to ÖN B 8115-2 are met.	12
For IMPLEMENTATION / EXISTING BUILDINGS:	
Residential buildings with window ventilation A-weighted basic level $L_{A,95}$ at night (=basic noise level) in bedroom	
$L_{A,95}$ (night) > 20 dB(A) or no measurements are presented	0
19 dB(A) < $L_{A,95}$ (night) ≤ 20 dB(A)	2
18 dB(A) < $L_{A,95}$ (night) ≤ 19 dB(A)	4
17 dB(A) < $L_{A,95}$ (night) ≤ 18 dB(A)	6
16 dB(A) < $L_{A,95}$ (night) ≤ 17 dB(A)	8
15 dB(A) < $L_{A,95}$ (night) ≤ 16 dB(A)	10
$L_{A,95}$ (night) ≤ 15 dB(A)	12
Or	
Residential buildings with mechanical ventilation in main living areas Measurement constant ventilation sound, measured in bedroom	
$L_{A,eq,nT}$ (night) > 25 dB(A) or no measurements are presented	0
22 dB(A) < $L_{A,eq,nT}$ (night) ≤ 25 dB(A) and $L_{C,eq,nT}$ (night) ≤ 42 dB(C)	2
20 dB(A) < $L_{A,eq,nT}$ (night) ≤ 22 dB(A) and $L_{C,eq,nT}$ (night) ≤ 42 dB(C), max. 20 dB above $L_{A,eq,nT}$ (night)	4
20 dB(A) < $L_{A,eq,nT}$ (night) ≤ 22 dB(A) und $L_{C,eq,nT}$ (night) ≤ 40 dB(C), max. 18 dB above $L_{A,eq,nT}$ (night)	6
18 dB(A) < $L_{A,eq,nT}$ (night) ≤ 20 dB(A) und $L_{C,eq,nT}$ (night) ≤ 38 dB(C), max. 18 dB above $L_{A,eq,nT}$ (night)	8
18 dB(A) < $L_{A,eq,nT}$ (night) ≤ 20 dB(A) and $L_{C,eq,nT}$ (night) ≤ 36 dB(C), max. 16 dB above $L_{A,eq,nT}$ (night)	10
$L_{A,eq,nT}$ (night) ≤ 18 dB(A) and $L_{C,eq,nT}$ (night) ≤ 38 dB(C), max. 20 dB above $L_{A,eq,nT}$ (night)	12

Table 8: Overview of assessment scale of criterion D.3.6. Measurement of external facade, basic indoor noise level (night) or noise level of ventilation system

Overview of assessment system – method of verification

The following tables present the methods of verification for selected criteria from groups C “Energy and supply” and D “Health and comfort”.

In group C “Energy and Supply”, the EPC according to OIB Guideline 6 and respective Standards is an acknowledged verification document to prove energy performance indicators for all buildings except the ones meeting passive house standard. For highly energy efficient buildings, the calculation carried out with the software PHPP - PassivHausProjektierungsPaket[2] is required. PHPP is well known for delivering realistic calculation results in temperate climates because the programme has been validated with measured values since many years.

Currently, there is no differentiation between planning and completion stage regarding energy performance indicators. However, there is a differentiation regarding airtightness of buildings: while target values and possibly tender documents are requested in the planning phase, measurement results must be presented for the assessment after completion.

[2] *http://www.passiv.de/de/04_phpp/04_phpp.htm*

At present, all other verification methods related with energy performance either on the demand side or on the supply side are based on calculations and test certificates, but not on measurements (see Table 9).

C	Energy and Supply	Verification
1.	Energy demand	
1.1	Heat consumption (Heizwärmebedarf = HWB)	Passive house (PH) (certified or certifiable PH according to the PHI Darmstadt guidelines): Requirement Heat demand (HWB) (according to PHPP - Passive house project planning package (a calculation program) <= 15 kWh/m^2_{EBF}a or Heating load < 10 W/ m^2_{EBF}
1.2	Final energy demand (Endenergiebedarf = EEB)	Passive house (certified or certifiable following the PHI Darmstadt guidelines): requirements in terms of heat demand, air tightness and overall primary energy demand (including domestic electricity) are met. This refers to the recommendation that the primary energy demand for heating, hot water and auxiliary power should not exceed 40 kWh/m²a based on PHPP calculation.
1.3	Air tightness of building	Planning: target value, possibly tender documents Construction: air tightness measurement following ÖN EN 13829 (one series of measures each with negative pressure and excess pressure)
1.4	Heat recovery optimization	• Drawing of relevant construction details (M 1:20 or larger) The following details/thermal bridges must be drawn/reported: connections of windows, window doors and house doors (especially lower connections of windows are problematic), external wall/basement ceiling or interior wall/basement ceiling, balcony, external wall/floor ceiling, connection verge/eaves, penetration or weakening of insulation layers, further thermal bridges depending on project circumstances • Plans (layouts, sections) • Quantitative proof of thermal bridge impact: ¤ Determining length-related thermal bridge loss coefficient Psii and punctual thermal bridge loss coefficient Chii by means of calculations following ÖN EN ISO 10211 or by use of comparable values from thermal bridge catalogues ¤ Determining length of relevant (length-related) thermal bridges li and number of punctual thermal bridges ni ¤ Determining the conductive value increments caused by thermal bridges Psii * li * fi * fFHi + Chii * ni * fi * fFHi, fi refers to temperature correction factor, fFHi correction factor floor space radiators ¤ Increasing mean U-value of building shell through (length-related) thermal bridges (= sum of conductive value increments caused by thermal bridges divided by surface of thermal building shell)
2.	Energy supply	
2.1	Primary energy demand (Primärenergiebedarf = PEB)	• Determining primary energy demand on the basis of calculated results of energy performance certificate according to OIB-guideline 6 • Optionally, determining primary energy demand (non-renewable) in accordance with PHPP calculation. When using PHPP calculation, it will be necessary to extend the parameters by PV; this must be taken into account when verifying
2.2	Photovoltaic system	• System planning (primarily internal use; indication of positioning and surface of solar modules, interconnection) and yield calculation using appropriate software program with local climate information, considering local shading • Data sheets of components chosen (modules, inverters)
2.3	Energy efficient ventilation system	• Assessment according to demand: Proof e.g. with PHPP statutory notices, ventilation (for download at www.passiv.de), Adjustment: Proof e.g. with PHPP statutory notices, ventilation (for download at www.passiv.de) • Line scheme of ventilation system with specification of air volume and channel dimensions for each line section • Air volume-specific electric power consumption: Verification by means of certificates. Power consumption including control and without anti-freeze heating to be determined. • Heat supply rate: Proof of requirements through test certificate or certificate, e.g. PHI • Window ventilation: Description of ventilation concept (possibly with planning documents)
2.4	CO_2-emissions from building operation	• Determining CO_2-emissions on the basis of parameters of energy performance certificate according to OIB-guideline 6, taking the primary energy demand into consideration (see C.2.1.)

Table 9: Selected quality criteria of group C “Energy and Supply” and methods of verification

In group D “Health and comfort”, in the indoor air quality section focus is on reducing the source of non-anthropogenic emissions and ensuring the hygienically required air exchange.

Measurements related with ventilation refer to indoor air pollutants and the actual noise level caused by ventilation systems, reflecting the occupants’ and thus also developers’ priorities.

Performance of ventilation systems as such, including the verification of energy efficiency and thus electricity consumption declarations, are assessed based on documents requested from planners and/or manufacturers. Currently, there is no measurement how the ventilation systems performs under operational conditions.

D	Health and Comfort	Verification
2.	Indoor air quality	
2.1	Ventilation	Proof by HKLS-planner or ventilation manufacturer verifying that the requirements are met Product data sheet of ventilation system, design calculation, installation protocol Proof of design and of installation of the ventilation system for passive houses can be done using a notice, which can be downloaded at www.passiv.de or is part of the PHPP-CD-Rom delivery package.
2.2	Low emission and low pollutant construction materials in interior fittings	Product management: It is the careful selection and operational control of construction materials (construction products and chemicals) to avoid indoor air pollutants. It is conducted by independent third parties and comprises the establishment of ecological criteria for the tendering procedure and for awarding contracts, approval of construction products before they are used on construction site, as well as continuous quality assurance at the construction site. Successful implementation is documented in a brief report by a professional consultant and is subject to indoor air measurement control. Simplified verification of low-emission construction materials by presenting proof is allowed if acknowledged certificates demonstrate that specific substances are below a defined threshold. The number of indoor pollutant measurements is defined for residential buildings depending on the number of rooms.
2.3	Mold and moisture prevention / Pollutant inspection	Verification - planning: module lists; construction period plan, protective measures against water entry Verification - completion: ¤ Inspection of specific living areas and visual inspection (measurements, in cases of suspicions). ¤ Confirmation from construction firms verifying that there was no water or moisture damage during construction (in the case of damage, a damage report listing the damages, affected apartments and renovation measures taken, must be submitted). Verification - existing buildings and renovations: Inspection protocol in accordance with ÖN S 5730 „Surveying procedure for pollutants and other harmful substances in building structures“, measurements and appropriate renovation measures must be ordered, if there are any suspicions. Mould and mould spore testing in accordance with the „Position paper on indoor mold“.
3.	Sound insulation	
3.6	Measurement of external facade, basic indoor noise level (night) or noise level of ventilation system	In the planning stage the measurement of exposed exterior facades and compliance with standard requirements for the weighted noise insulation rate R’res,w of highly critical rooms (e.g. high percentage of glazing, highly exposed facades) are rated in reference to the relevant outdoor noise level in accordance with ÖN B 8115-2. After completion of the building, an (indirect) inspection of the outdoor elements’ insulation quality is conducted, either by measuring the basic noise level LGg during the night in critical bedrooms, or by directly determining the relevant outdoor noise level, as wel as determining the R’res,w for the most widely exposed facade (rooms worth protecting, large percentage of glazing, etc). For dominant sources of indoor noise (e.g. ventilation system operating all night long) the ventilation’s noise level LA,eq,nT in the bedrooms is used for the assessment.

Table 10: Selected quality criteria of group D “Health and comfort” and methods of verification

To lower the barrier for wide dissemination with a step-wise system: klimaaktiv

Although the assessment scheme was developed according to developers’ needs, market up-take was quite slow (see Table 11), and especially the use of the assessment results in marketing communication was lacking. It turned out that estate agents did not know how to use the assessment result in the selling or renting process, largely because they were not trained in aspects such as indoor air quality, primary energy consumption of materials or CO_2-emissions. It seemed as if the barrier for the construction sector was too high, with exception of a few innovators. Therefore, green building assessment was integrated in the climate protection programme “klimaaktiv”, launched by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management in 2004. The programme targets a substantial reduction of CO_2-emissions and a substantial increase in energy efficiency in the building and transport sector, in industry, and households, by funding comprehensive activities such as the production of information material, consulting services, network development, and the elaboration of quality control procedures [4].

The sub-programme “construction and refurbishment” offers the klimaaktiv building standard for residential and non-residential buildings, and for new build constructions as well as for refurbishments[3]. This standard consists of selected criteria of the TQB standard with focus on outdoor and indoor environment, to communicate individual benefits along with the reduction of CO_2-emissions. Corresponding with the objectives of the programme, energy is given the strongest weighting:

The system comprises the following categories, and in total maximum 1000 points can be achieved:

A. Design and Construction (maximum 130 points to achieve)
B. Energy and Supply (maximum 600 points to achieve)
C. Materials and Structure (maximum 150 points to achieve)
D. Comfort and Indoor Air Quality (maximum 120 points to achieve)

Since the full implementation of the EU Directive 2002/91/EC (EPBD) in 2009, a step-wise system has been in place. The combined model was chosen to lower barriers for companies to become familiar with environmentally conscious design and construction. It was the objective to make use of the dynamism stemming from the EPBD, and to facilitate market penetration of eco-buildings by linking the voluntary building assessment schemes with the mandatory energy certificate [4].

Since 2009, the OEGNB - Austrian Sustainable Building Council has been involved in both building assessment schemes.

Figure 3: Building Certificate issued for a building rated according to klimaaktiv and TQB

The klimaaktiv category “B Energy and Supply” fully corresponds with the Energy Performance Certificate, because the first step is a good energy performance documented by the mandatory EPC. If the developer or building owner seeks good performance beyond the energy sphere, the remaining klimaaktiv criteria can be fulfilled, and after a plausibility check the klimaaktiv label will be awarded.

If there is the willingness to document also other noticeable building qualities (e.g. noise protection), then there is the option to build upon the klimaaktiv data and to extend the data collection to receive the TQB certificate. The building must pass a detailed check of data carried out by authorised staff.

The Building Certificate on the left was issued for a building achieving klimaaktiv Gold Standard with 943 points and 867 points according to TQB. The difference is due to the different weighting systems: while TQB weighs 5 categories equally, klimaaktiv weighs energy performance much stronger than the remaining categories. Therefore, buildings with good energy performance are likely to achieve a good rating result. One relevant indicator is heating energy demand per m^2 conditioned area which is 15.1 $kWh/m^2.yr$ in this certificate.

[3]The most current klimaaktiv catalogues are available for download at *http://www.klimaaktiv.at/bauen-sanieren/gebaeudedeklaration.html*

Market acceptance of the approach

In November 2016, 118 building were certified according to TQB, and 402 buildings received a klimaaktiv label. These projects hold completion certificates. The overall certification number is definitely low, taking into account that the assessment scheme has been operating since 2003 (TQB) and 2004 (klimaaktiv), respectively.

Details for TQB completion certificates are shown in Table 11.

Type of building	New constructions	Existing buildings / renovations	Total
Residential	72	7	79
Office	16	4	20
Shopping mall	2	0	2
Hotel / hospitality	2	1	3
Industry	4	0	4
Education	5	5	10
Total	101	17	118

Table 11: Overview of buildings holding a TQB certificate (November 2016)

The fact that only few buildings hold TQB completion certificates might give the impression that there is a severe lack of market acceptance. The main reason for the low number of certificates is that the TQB assessment system has not only targeted office buildings but mainly the residential sector, as residential buildings represent the largest share of the building stock and thus are of major importance for achieving energy efficiency targets. However, in the residential sector, incentives are extremely important but no incentives have been introduced for those undergoing the quality assessment procedure, and clients rarely have asked for certified quality. Thus, the motivation for developers to carry out actions needed for certification has been certainly low. However, discussion with stakeholders showed that many professionals and developers use the criteria catalogue and the published material to improve their internal quality assurance procedures. In this respect, the objective to widely disseminate the TQB material has been clearly achieved. Bearing in mind that several companies have adopted the freely accessible TQB assessment scheme as part of their internal quality assurance scheme without going for third party certification, and in view of other third party certification schemes with even lower certification numbers[4] than TQB, market acceptance of TQB is considered to be good.

With regard to dissemination, elements of TQB have been integrated in klimaaktiv at the federal level and in the social housing subsidy schemes of the Austrian provinces. It is also the basis for the quality assurance scheme applied in Vienna's Urban Lakeside, the first Viennese Smart City project. All buildings **constructed in Vienna's Urban Lakeside (Seestadt Aspern)** are subject to a mandatory quality control scheme based on the TQB procedure. Land for construction is awarded based on a competition, and at the beginning of the development it was a condition that the planning certificate had to show at least 750 points. Later, the target value was raised to at least 800 points[5]. It is mandatory for all buildings to also present a completion certificate.

In this regard, the voluntary TQB scheme serves as a pool of ideas and as a test case. In fact, this is only possible because of public support granted by the Federal Ministry of Transport, Innovation and Technology, and the Federal Ministry of Agriculture, Forestry, Environment and Water Management.

[4] DGNB completed certificates in Austria: 34 (Source: DGNB Project Database)
BREEAM completed certificates in Austria: 6 (Source: BREEAM Project Database)
LEED completed certificates in Austria: 22 (Source: LEED Project Database)
[5] https://monitor.aspern-seestadt.at/whois.htm

Pros and cons of possible options: voluntary versus mandatory systems

It is a fact that planning and construction will be carried out more carefully if there is a chance that control takes place. Measurements representing the as-built situation are the most effective form of control. In Austria, there is a lot of discussion among scientists, consultants, and representatives of industry and administration about the degree of compulsion: is it better to have a mandatory or a voluntary scheme? A summary of pros and cons are pointed out in the table below.

Option	Pros	Cons
✓ Measurements as part of a voluntary assessment scheme - third party certification	✓ Gives companies the chance to prepare for up-to-date requirements ✓ Developers can use it in market communication to show what they do ✓ No additional cost for the public administration	✓ Will be only effective if clients ask for the confirmed quality in the form of a certificate; but in the residential sector awareness is still low, and lack of affordable flats downgrade people's expectations ✓ In the non-residential sector certificates issued by well-known schemes such as LEED are requested by investors; not much demand for national schemes
✓ Measurements as part of a mandatory assessment scheme	✓ Creates equal conditions for all market players and ensures that crucial parameters are controlled	✓ Introduction could be problematic because of the tendency to implement the least demanding option
✓ Measurements as part of an assessment scheme linked with financial incentives	✓ Rewards companies complying with requirements more ambitious than the building law	✓ Additional financial burden on the public administration for providing the incentives and for administrating control procedures
✓ Measurements as part of the internal quality assurance procedure	✓ Contributes to improving the quality in general ✓ Cost effective if done based on a targeted sampling strategy	✓ No publicly available information about the way of implementation and success

Table 12: Description of pros and cons of options: degree of compulsion of measurements as quality control tool

Compliance concerns related to EP certificates and to the QM approach

No reporting ☐	Wrong reporting ☑	Not meeting the performance requirements ☐

Table 13: Compliance concerns related to EP certificates (see QUALICHeCK terms and definitions)

Checking the actual as-built situation by means of measurements will ensure compliance. With regard to energy, in the Austrian TQB scheme measurements are only carried out to verify the airtightness of buildings. All other aspects are covered by the EPC and the PHPP calculation. At the moment there is no legal obligation to present measurement data, neither as input for calculating the EPC representing the completion stage, nor for control based on measurements carried out in sample buildings. In fact, EPC quality is difficult to check because of the legal framework in place. This was also demonstrated by the national study carried out as part of the QUALICHeCK project. In addition it showed that EPC results are not always realistic compared with the actually constructed building [5].

In Austria, it is difficult to initiate a process for further developing the legal framework as issuing of EPCs is regulated at the regional level. Therefore, the voluntary klimaaktiv scheme is used to integrate a new module responding to the challenges identified with the use of the EPC as a verification document.

Currently, the so called klimaaktiv "Betriebsdeklaration" is under development: buildings will be rated depending on the comparison of projected energy consumption and actual energy consumption during building operation. A guideline is under development listing the important aspects influencing the informative value of an EPC and how to deal with them.

It is the intention to motivate stakeholders to actually update the EPC at completion stage and verify the quality of the works with measurements as this will be the precondition to achieve a good rating result.

Financial aspects

The nominal charge presented below (see Table 14) includes the fees for the OEGNB auditors (third party certification). They do not, however, include the preparation of the verification and quality assurance documents, in compliance with the OEGNB assessment scheme, performed by the OEGNB consultants. These fees for preparation of calculations, collection of test certificates and other documents required, as well as carrying out measurements, must be stipulated with the respective consulting company.

Gross floor area [m²]	Cost [€]		
	Planning Certificate	Construction Certificate	Total
150	60	60	120
500	200	200	400
1.000	400	400	800
Nominal charge calculation formula for buildings up to 1,000 m² gross floor area (applies to planning and construction): gross floor area x 0.4 Euro.			
2,000	700	700	1,400
3,000	1,000	1,000	2,000
4,000	1,300	1,300	2,600
6,000	1,900	1,900	3,800
8,000	2,500	2,500	5,000
10,000	3,100	3,100	6,200
Nominal charge calculation formula for buildings from 1,000 m² to 10,000 m² gross floor area (applies to planning and construction): 400 Euro + (gross floor area - 1000) x 0.3 Euro.			
12,500	3,600	3,600	7,200
15,000	4,100	4,100	8,200
17,500	4,600	4,600	9,200
20,000	5,100	5,100	10,200
22,500	5,600	5,600	11,200
>=25,000	6,100	6,100	12,200
Nominal charge calculation formula for buildings from 10,000 m² to 25,000 m² gross floor area (applies to planning and construction): 3,100 Euro + (gross floor area - 1000) x 0.2 Euro.			

Table 14: Cost of third party certification

For objects > 25,000 m² the nominal charge for planning and construction is 6,100 Euro. All prices plus the legal value added tax (VAT).

Overall evaluation

Measurements are an essential element in quality assurance procedures. However, they also cause additional cost considered unnecessary at the moment because they are not legally required and not demanded by clients. In order to create acceptance it is essential to keep cost low, also in view of possibly making measurements mandatory. Thus, measurements must be carefully chosen and have to address crucial parameters. Regarding control of building qualities other than the group C "Energy and supply" it seems that chosen measurements are both, effective and efficient.

Measuring the noise level of ventilation systems is important because experience shows that occupants switch them off if they feel disturbed by noise. This will not only have a negative impact on indoor air quality but also increase energy consumption due to ventilation heat losses.

Regarding control of actual energy performance which would detect also mistakes during construction, measurements are limited to airtightness. For all other indicators, the EPC is required as a proof.

However, the national QUALICHeCK study resulted in the conclusion that presently the legally required EPC cannot be regarded as verification document representing the as-built situation. In this regard, room for improvement has been identified [5]. Future efforts to further develop TQB based on the principle of continuous improvement will take into account input resulting from the QUALICHeCK project.

Pros and cons of a voluntary green building assessment approach like TQB are summarized in Table 15.

Pros	Cons
✓ A voluntary approach can be easily adapted and further developed to respond to actual challenges and if weaknesses are identified	✓ Wide application will only be possible if made mandatory in defined contexts or if substantial promotion activities take place

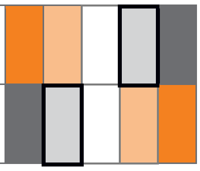
Table 15: Overall pros and cons of the voluntary building assessment scheme

Hints and pitfalls of a voluntary green building assessment approach like TQB are summarized in Table 16.

Hints	Pitfalls
✓ The success of voluntary schemes is either driven by a strong market demand or substantial promotion activities. Energy cost is low and climate change is difficult to comprehend for the general public. Market demand for energy efficiency is limited. ✓ Governmental support is essential and justified because of legal obligations on the European and international level.	✓ Stakeholder involvement during the development of a voluntary scheme is necessary but does not guarantee that they will actually make use of it. ✓ Implementation of a quality assurance scheme causes additional cost which will result in cost savings elsewhere in the company. This argument is not always convincing, it seems that "bad quality of the works" is still cheaper.

Table 16: Overall hints and pitfalls to avoid when developing such an approach

Level of complexity (dark orange = simplest)	
Potential for replication (dark orange = best)	



Prerequisites

Budget for financing the development and the operation of a voluntary scheme has to be secured.

Options depending on the situation on the market: (1) Provide public support for developing and running the scheme; (2) Providing incentives from public budget for developers to undergo third party certification; (3) create demand on the market by running marketing activities to promote third party certification

References

[1] Bruck, M., Geissler, S.(2001): ECO-Building - Optimierung von Gebäuden. Entwicklung eines Systems für die integrierte Gebäudebewertung in Österreich. Berichte aus Energie- und Umweltforschung, Schriftenreihe 29/01, Wien: Bundesministerium für Verkehr, Innovation und Technologie

[2] Geissler, S., Bruck, M., Lechner, R. (2004): Total Quality (TQ) Planung und Bewertung von Gebäuden. Berichte aus Energie- und Umweltforschung, Schriftenreihe 08/04, Wien: Bundesministerium für Verkehr, Innovation und Technologie

[3] Haselsteiner, E., Geissler, S., Klug, S., Bargehr, G., Steinbacher, S. (2014): GINGER - Gender-Aspekte In der Nutzung von Gebäuden, Energie und Ressourcen. Studie gefördert im Programm FEMtech des bm:vit

[4] Geissler, S.; Spitzbart, C. (2010): Sustainable buildings in Austria - performance indicators and implications on the construction industry. In: ECO Architecture III, Harmonisation Between Architecture and Nature, 539-550. Southampton: Wessex Institute of Technology, WITPRESS

[5] Maul, L., Wohlschak, M. (2016): Austria - Assessment of EPC input data based on recalculation and on-site validation. QUALICHeCK Study

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Technology	*Aspect*	*Country*
Ventilation, heating, hot water, cooling, transmission characteristics	Quality of the works	Germany

CRITICAL SITUATIONS ON THE CONSTRUCTION SITE AND IDEAS FOR QUALITY ASSURANCE PROCEDURES: THE GERMAN PERSPECTIVE

The outcomes of the EU IEE project QUALICHeCK with a focus on improved quality on the construction site were mirrored in a dedicated workshop with 15 research experts in the field of energy efficient new buildings, renovations and energy efficient city quarters. The experts have assessed critical situations emerging on construction sites that were collected within the IEE project and have discussed quality assurance procedures available and needed in Germany.

Residential buildings ☑	Non-residential buildings ☑	Specific buildings: Whole city quarters
New buildings ☑	Existing buildings ☑	

Context

“EnergieEffizienzBauen” is the new umbrella brand for the two research initiatives “Energy Optimised Buildings (EnOB)” [1] and “Energy Efficient Cities (EnEff:Stadt)” [2], both financed by the German Federal Ministry for Economic Affairs and Energy. Both research initiatives contain a series of high level pilot projects of either energy efficient buildings (up to net zero energy buildings and plus energy buildings) or energy efficient city quarters (up to plus energy quarters). Additionally, they support technology and tool developments in the two sectors. Fraunhofer Institute for Building Physics IBP is a member of the accompanying research team [3] that evaluates the projects, determines trends and benchmarks and contributes to the communication and dissemination of the initiatives. One of the tasks of the accompanying research team is to hold semi-annual meetings for the project managers in charge of the individual projects that are part of these research initiatives. The meetings include interactive workshops for the exchange of experiences among the project managers and the accompanying research team. A workshop topic featured in a project manager meeting addressed the experiences made on the construction site regarding quality and the necessary quality assurance procedures. Fraunhofer IBP used the work and outcomes of IEE QUALICHeCK to introduce the topic with trigger presentations, and prepared posters and tasks that allowed mirroring the international work with the perspective of German demonstration project managers on high performance buildings and city quarters. In total, 15 project managers participated in the workshop.

Objectives and problems addressed

Feedback was sought especially regarding the most critical situations on the construction site with impact on the energy efficiency of the building and regarding advisable quality assurance schemes that help to overcome faulty realisations.

Critical situations on the construction site

IEE QUALICHeCK has collected 70 potential critical situations on the construction site, ranging from general issues like poor specifications, time pressure or language barriers to issues in connection with the building envelope (e.g. inadequate insulation material, incomplete insulation layers, wet material, incomplete air or moisture barriers) to issues connected with the building services systems like wrong system components, wrong settings of controls, no hydraulic calibration, etc. They are presented in the report “Documented examples of existing situations regarding the quality of works” [4] and have been accompanied by relevant studies or documented experiences and best practice solutions to avoid low quality realisations. The report also contains an Annex giving clarifications with respect to critical situations.

Critical situations compiled by IEE QUALICHeCK

The following critical situations have been gathered by the IEE QUALICHeCK team:

Critical situations on the construction site			
Very general			No or poor specifications of product performances
			No or poor specifications of execution performances
			No framework for control of performances
			Time pressure
			Language barriers at construction sites
			Insufficient knowledge of new technologies/construction workers not adequately trained
			Necessary specialists not part of the construction team
			Poor communication between planners and contractors
			Lack of technical details (improvisation on construction site)
			Constructed building components/ technologies not documented as a basis for subsequent maintenance
Building envelope	Opaque	General	Wrong (insulation) material: λ-value, thickness, etc.
			Incomplete or incorrectly installed insulation layer: gaps, uneven surfaces
			Incompatible (insulation) material to specific situations: e.g. vacuum insulation
			Damages of insulation material during construction
			Wet (insulation) material: storage on site, protection during construction
			Incorrect waterproof layers in wet areas (bathrooms, etc.)
			Not enough drying time for built-in moisture (concrete, wood)
			Wrong airtightness material
			Incomplete air or moisture barrier
			Damages of air or moisture barrier during the implementation
			Joints not realised with insulation according to requirements/design
			Joints not watertight/airtight
			Incorrectly realised joints due to installations (pipes, ducts)
		Components to ground	Wrong (insulation) material: water resistance
		Base slab/foundations	Wrong (insulation) material: pressure resistance
		Ventilated roof	Not enough air space for ventilated roof
			Not enough openings for ventilated roof
		Cool roof	Wrong coating for cool roof
	Transparent	General	Wrong windows or façade elements: U-value
			Wrong windows or façade elements: g-value, τ-value
			Joints between windows and walls not insulated
			Joints between windows and walls not watertight/airtight
		Shading systems	Top mounted roller shutters uninsulated at contact surface to wall
			Blinds without sufficient rear-ventilation
Building service systems	General		Wrong system components installed: collector peak load, inverter efficiency, fan efficiency, pump efficiency, etc.
			Incorrect setting of hydraulic flows
			No hydraulic calibration
	Fixation		Incompatible mounting material: anchors, etc.
	Pipes/ducts		Wrong diameters of pipes/ducts
			No/poor insulation of pipes/ducts
			No accessibility for cleaning
			Duct connections not airtight
			Joints with other system components not airtight: fan, AHU
	Control		Wrong settings: night setback, CO_2/humidity/temperature controls

Table 1: Critical situations on the construction site as compiled by the IEE project QUALICHeCK

Critical situations on the construction site (cont.)			
Building service systems (cont.)	Technologies	PV system	Damaged PV cells
			Not enough rear ventilation
			Cables: no mechanical protection
			Cables: Mistakes regarding parallel vs. series connection
			No connection to inverter
			Insulation behind the arrays not resistant to high temperatures
			Incorrect installation on the roof, causing water leakage
			Incorrect installation on the roof, causing damages on the roof/PV cells after storms
		Solar thermal	Not enough distance/insulation behind collectors at walls/roofs
			Insulation behind the panels not resistant to high temperatures (e.g. integrated in facades)
			Storage feed-in at middle/top
			Wrong type of antifreeze liquid
			Safety valve not fitted to container/ container not empty
		Heat pump	Setting: no priority for DHW
			Storage feed-in at top (DHW) and middle (heating)
			Too low refrigerant quantity
			Incorrect positioning of the outdoor unit (too close to walls, in an attic) -> poor performance
			Time for defrosting of the outdoor heat exchanger set at a too low value -> poor performance
		Wood boiler	Incorrect flue gas exhaust at boiler
			Incorrect ventilation openings in boiler room
		Ventilation system	Setting of airflow rate on default instead of specific necessary setting/wrong air flow rates
			Required filters not included
			No electrical connection of the auxiliary heating
			Installation without accessibility for maintenance
			Noise: ventilation unit in wrong position
			Noise: silencers not properly installed

Table 1: Critical situations on the construction site as compiled by the IEE project QUALICHeCK (cont.)

Critical situations as experienced by the German project managers of demonstration projects on high performance buildings and city quarters

During the workshop the project managers were asked to reflect which of the critical situations on the list made by QUALICHeCK have occurred on the construction sites of their projects. The term ‘projects’ related not only to the current research and demonstration projects, but to their general expertise with regard to building projects. The situations were presented on posters, and the project managers indicated (similar to a tally sheet) which situations matched their personal experiences. Nearly all critical situations seem to occur (also) on German construction sites. The situations with the most matches including the number of matches were:

- ✓ Incorrect setting of hydraulic flows (14 out of possible 15 matches)
- ✓ No hydraulic calibration (12)
- ✓ Wrong settings: night setback, CO_2/humidity/temperature controls (10)
- ✓ No framework for control of performances (10)
- ✓ Time pressure (9)
- ✓ No or poor specifications of product performances (7)
- ✓ Insufficient knowledge of new technologies/construction workers not adequately trained (7)
- ✓ Lack of technical details (improvisation on construction site) (7)
- ✓ Wrong system components installed: collector peak load, inverter efficiency, fan efficiency, pump efficiency, etc. (7)
- ✓ Setting of airflow rate on default instead of specific necessary setting/wrong air flow rates (7)
- ✓ Installation without accessibility for maintenance (7)

Additional critical situations reported by the German project managers of demonstrations projects on high performance buildings and city quarters

Additional critical situations have been collected on stickers and allocated to the four main areas as defined in the QUALICHeCK report [4]:

1. Poor specifications at level of projects, standards and/or regulations

Experiences included planning material not updated according to the current design or modified boundary conditions, missing functional descriptions, missing installation manuals, missing return valves that caused back flow and ill-conceived technologies.

2. Lack of competence at designer level, at execution level or language barriers

Here many different experiences have been made. It seems that the responsible persons often lack general understanding for energy efficiency. In many cases problems occur at the interface of two competences. In addition the following concrete situations were identified:

- ✓ faulty or lacking hydraulic calibration of heating surfaces
- ✓ estimated heating load (wrong or missing calculation of the heating load)
- ✓ wrong adjustment of pumps („auto adapt“)
- ✓ wrong installation of monitoring devices
- ✓ no optimisation of the heating system
- ✓ incomplete design documents at the sub-sub-sub-subcontractor level
- ✓ operation/installation manual not read
- ✓ mistakes in the EP calculations
- ✓ no or not enough planning details
- ✓ wrong airtightness concepts
- ✓ wrong materials (vapour barrier not UV-resistant)
- ✓ wrong wiring of the ventilation systems

3. Critical economic conditions (financial or timing)

The participants pointed out that it is a problem with bids from public building owners that always the cheapest bid has to be taken, without considering the quality and the references of the bidder. Additionally, negative experiences have been made due to insolvency of constructors or operators during the construction time. Furthermore, the need of approval despite faults, because of time pressure to get the building into use, was reported.

4. Lack of control

The participants reported about untidy construction sites and faulty approvals by the building owner or his representatives. The check of the realisation according to the EPC was not always done. In some cases the installed building service system (heating/ventilation) was not exactly according to the concept specified in the EPC. The installed automation system needs to be controlled for each data point. Sensors have been incorrectly installed, wrongly connected, not tested or wrong converter figures have been used. The change of the control strategy between summer and winter has not been made. Controls have been set wrongly or not at all. Components have been defect.

Quality assurance procedures

After the exchange of experiences with critical situations, quality assurance procedures used in Germany were collected and discussed. Subsequently, additionally needed procedures have been proposed by the participants such as:

1. Procedure for commissioning and training of a commissioning manager

The commissioning or hand-over of a complete building or a building service system seems to be a situation in which many mistakes are made. In most cases, the reason for these mistakes is lacking competence on the part of the building owners or their representatives. Buildings in general contain various building services system components and in the case of the demonstration projects of the German research initiative also innovative (new or advanced) system components as well as complicated control strategies and control systems were used. Building owners or their representatives are in many cases not up to the task of checking the correct functioning and setting of the systems. A procedure such as a detailed guideline including checklists for each system component and the controls would facilitate the commissioning process and lead to a more thorough check of the completed building and a well-functioning and, mostly, also more energy efficient building.

A second idea was that the task of checking the building and its components might require a specific education or at least training. The job of a commissioning manager could be trained and even certified.

Within the LEED procedure [5] such a detailed commissioning process is suggested and will add to the rating.

2. Coupling of training and certification to insurances

If the installation of insulation or a particular building service system reaches a certain level of complexity, specific training of the installers helps to improve the quality of the building. Such training and certification schemes are available in many countries. A further step in the developing the training and education schemes is coupling these quality assurance procedures to insurances for the correct realisation, as used for example by CIGA [6]. CIGA is a quality framework for the insulation of cavity walls. The Cavity Insulation Guarantee Agency is an independent body that provides 25 year guarantees for cavity wall insulation fitted by registered installers in the UK and Channel islands. The standard guarantee covers traditionally constructed residential property, although a CIGA commercial guarantee is also available to owners of qualifying non-residential property. By the addition of an insurance, the building owner has the guarantee that the installed system or insulation will be correctly installed, because in case mistakes are found later on, the insurance will pay for the costs of the necessary repairs. The German project managers deemed this a very interesting scheme.

3. Procedure and training for detailed analysis of existing buildings

The inspection of a building as one of the first steps to develop a concept for the energy efficient renovation or issuing a calculated energy performance certificate requires profound knowledge of building components and building service systems in order to determine the input parameters for the calculations. There are a few simplification rules [7], [8], checklists [9], [10] and basic tools [11], [12] available that support the building inspector. However there is no fixed procedure defined or training scheme offered with this focus. A common understanding on the level of detail of the building analysis and agreed default values in case of unascertainable data, such as the thermal conductivity of wall materials in the case of missing plans, would lead to more reliable calculation results. The procedure could be fixed in an official national guideline, and on this basis training schemes could be developed.

4. Coupling of the bidding system to experienced and certified constructors

The tendering procedure for public buildings (new buildings or buildings to be retrofitted owned by public authorities) requests that the contract has to be given to the most economically efficient (cheapest) bid. The workshop participants suggested that not only the price of the bid should be the basis of the decision, but also the experience and maybe even existing quality certificates of the construction companies should be considered. This could certainly improve the quality of work on the construction site. Clear decision criteria regarding the price of the offer and the other criteria (e.g. in percentages) are necessary. Alternatively the presentation of earlier work and references can be included as a pre-condition for the bidding. This is possible in the public tendering procedure already now and can be transferred to private or commercial tender processes as well.

5. Product developments to reduce the error-rate

The development of building and building service products that are less error-prone can be a very good way to increase the quality of work on the construction site. This can be done either by the product itself or by better installation guides that are easier to follow. The installation guides should include less text (which is often not read by the installers because of time pressure) but instead more graphics, where suitable. An example for a product development that can prevent mistakes on the construction site is a bathroom radiator that can be connected from both sides to either supply or return flow with the help of an extra 2-way valve [13] based on an earlier patent for a connecting device [14].

Compliance concerns related to EP certificates and to the QM approach

No reporting ☐	Wrong reporting ☑	Not meeting the performance requirements ☑

Compliance concerns related to EP certificates (see QUALICHeCK terms and definitions)

All included quality assurance procedures have the aim to improve the quality of works on the construction site. They can primarily lead to a construction that meets the performance requirements and accordingly also prevent wrong reporting.

Overall evaluation

The discussion of the IEE QUALICHeCK outcomes with the project managers of energy-efficient buildings and city quarters within the two German research initiatives EnOB and EnEff:Stadt has shown that nearly all of the gathered critical situations have also been experienced on German construction sites. Apart from some general issues like time pressure, poor specifications or lack of knowledge/training of the construction workers the most critical situations are on the side of building service systems like incorrect settings of controls, air-flow rates and missing hydraulic calibration. A brainstorming for helpful quality assurance procedures came up with five interesting ideas that can be useful also in other countries.

References

[1] German Federal Ministry for Economic Affairs and Energy: EnOB - Research for energy-optimised building. Website of the research initiative with pilot projects, new technologies, software and tools, etc. Available at www.enob.info/en. (Last accessed: 14/12/16)

[2] German Federal Ministry for Economic Affairs and Energy: EnEff:Stadt and EnEff:Wärme - Research for energy efficiency. Website of the research initiative with pilot projects, heating and cooling network projects, new technologies, design tools, etc. Available at www.eneff-stadt.info/en. (Last accessed: 14/12/16)

[3] Accompanying research team of the research initiatives EnOB and EnEff:Stadt: Tasks, contact and outcomes. Available in German at www.eneff-stadt.info/en/begleitforschung. (Last accessed: 14/12/16)

[4] Erhorn-Kluttig, H.; Erhorn, H.; Doster, S.: Towards improved quality of the works - Documented examples of existing situations regarding quality of works. Report of the IEE project QUALICHeCK. 2016. Available at http://qualicheck-platform.eu/2016/03/report-quality-of-the-works-final. (Last accessed: 14/12/16)

[5] US Green Building Council: LEED (Leadership in Energy and Environmental Design). Website of the LEED third party verification for green buildings. Available at http://www.usgbc.org/leed. (Last accessed: 14/12/16).

[6] CIGA - Cavity insulation guarantee agency: Welcome to CIGA. Website of CIGA available at https://ciga.co.uk. (Last accessed: 14/12/16)

[7] German Federal Ministry for Economic Affairs and Energy and German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety: Bekanntmachung der Regeln zur Datenaufnahme und Datenverwendung im Nichtwohngebäudebestand. April 2015. Available in German at http://www.bbsr-energieeinsparung.de/EnEVPortal/DE/EnEV/Bekanntmachungen/Download/NWGDatenaufnahme2013.pdf?__blob=publicationFile&v=4. (Last accessed: 15/12/16)

[8] German Federal Ministry for Economic Affairs and Energy and German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety: Bekanntmachung der Regeln zur Datenaufnahme und Datenverwendung im Wohngebäudebestand. April 2015. Available in German at http://www.bbsr-energieeinsparung.de/EnEVPortal/DE/EnEV/Bekanntmachungen/Download/WGDatenaufnahme2013.pdf?__blob=publicationFile&v=5. (Last accessed: 15/12/16)

[9] Erhorn-Kluttig, H.; Staudt, A.; Stößel, F.; Weber, H.; Erhorn, H.; Wössner, S.: Elektronische Gebäude- und Anlagen-Checkliste als Basis für die Berechnung nach DIN V 18599. Final report incl. a paper version of the checklist developed within the research initiative ZukunftBau of the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety. 2009. Available in German at https://www.baufachinformation.de/literatur/09099022220. Short version of the report in English: https://www.irbnet.de/daten/kbf/kbf_e_F_2745.pdf. (Last accessed: 15/12/16)

[10] Jentsch, W.; David, R.; Janta, O.; Regel, R.: Schlussbericht für das Forschungsvorhaben HoEff im Rahmen des Förderkonzeptes EnBop - Energetische Betriebsoptimierung. Weiterentwicklung der Gebäude- und Anlagen-Checkliste des Fraunhofer IBP. Report of Ebert Ingenieure and Hochschule München. 2013. Available in German at

http://www.enob.info/fileadmin/media/Projektberichte/Betriebsoptimierung/0327470A_B_HoEffx.pdf. (Last accessed: 15/12/16)

[11] Fraunhofer Institute for Building Physics: Elektronische Checkliste zur Aufnahme von Bestands-gebäuden für die Berechnung nach DIN V 18599. Software in German available for download at http://www.checkliste18599.de. (Last accessed: 15/12/16)

[12] Fraunhofer Institute for Building Physics: IT-Toolkit für energieeffiziente Sanierungsmanahmen. [IT-Toolkit for Energy Efficient Retrofit Measures]. Software developed within the IEA EBC Annex 46 and the research initiative EnOB - Research for energy-optimised building of the German Federal Ministry for Economic Affairs and Energy. Available for download as German and English version at http://www.annex46.de/tool.html and http://www.annex46.de/tool_e.html. (Last accessed: 15/12/16)

[13] Kermi: Basic-50 - Design und Badheizkörper. Website of Kermi GmbH in German. https://www.kermi.de/raumklima/produkte/heizkoerper/design-und-badheizkoerper/basic-50/. (Last accessed: 21/12/16)

[14] European Patent Office: Connecting device for radiator - EP 1136765. Information available at http://www.google.de/patents/EP1136765A3?cl=en&hl=de. (Last accessed: 20/12/16)

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Technology Building air leakage	*Aspect* Status on the ground	*Country* All focus countries

BUILDING AIR LEAKAGE RATE IN ENERGY CALCULATION AND COMPLIANCE PROCEDURES

Building air leakage rate is taken into account in energy calculations, but mainly with default tabulated values. With tabulated values, there is an option to use measured values instead of more conservative tabulated values. Regarding compliance, usually there is no requirement to measure and verify the building air leakage rate (except in France).

✓ Residential buildings ☑	Non-residential buildings ☑	Specific buildings: ……
✓ New buildings ☑	Existing buildings ☑	

Austria

Context

OIB-RL6 2015 (OIB Guideline 6 on Heat Protection and Energy Saving) and the associated Calculation Guideline have been issued by OIB (Österreichisches Institut für Bautechnik - Austrian Institute of Construction Engineering - www.oib.or.at). This organisation is an association (Non-Profit Organisation) where all Austrian provinces are members, and it is the objective to harmonize the legislation which is the responsibility of the Austrian provinces, such as the building code. Therefore, all provinces have participated in developing the agreed OIB RL-6 which is the harmonized basis for the building codes at the provinces' level. The building code which is a law at the province level references the agreed OIB-RL 6. The OIB-RL6 references Austrian Standards, thus becoming part of the legislation. OIB-RL 6 has been revised: first version 2007, revised version 2011, and another revised version 2015 [1].

Building air leakage rate in energy calculations

OIB-RL6 states that in new construction the building envelope must be airtight, meaning that the air change rate of n50 at a pressure difference of 50 Pa must not exceed 3/h. If there is mechanical ventilation with or without heat recovery, n50 must not exceed 1.5/h.

Compliance procedures

OIB-RL6 does not require measurements.

Belgium

Context

In Belgium the implementation of the EPBD is the responsibility of the three regions (Brussels, Flanders and Wallonia). In this section only the EPBD regulations in the Flanders region are discussed, which came into force in 2006 in the EBP legislation (Energy Performance and Indoor Climate). The requirements concern both energy efficiency of the building and indoor climate (summer comfort and ventilation), and are specified in a number of sub-requirements to which all new and renovated buildings have to comply:

thermal insulation: maximum U-value of building envelope components and maximum K-level (measure for the volumetric transmission heat loss through the building envelope);

- ✓ maximum net energy demand for heating;
- ✓ maximum E-level (measure for total primary energy use of the project);
- ✓ minimum ventilation requirements;
- ✓ maximum value of overheating indicator (summer comfort), only for residential buildings.

The influence of building air leakage is taken into account in the calculation of the heat loss coefficient of the building, and has an influence on the energy demand for heating, the E-level, and the overheating indicator. There is no separate sub-requirement for building air tightness.

Building air leakage rate in energy calculations

Within the Flemish EPB method, the infiltration heat losses are calculated based on the air permeability of the envelope. This is expressed as a v50 value giving the volume flow rate of air infiltration at 50 Pa pressure difference normalized by the heat loss area. The heat loss area includes all building envelope components surrounding the protected volume of the building through which transmission heat losses occur, either directly from the inside to the exterior, or to unheated adjacent spaces, or via the ground. Party walls or floors separating adjacent protected volumes (e.g. apartments or terraced houses) are not included in the heat loss area.

While not compulsory, a measured value can be input to the software based on a pressurization test performed after completion of the building. In the absence of a measured value, a conservative default value of 12 $m^3/(h.m^2)$ is used within the calculation of the energy use for space heating, and a default value of 0 $m^3/(h.m^2)$ is used in the calculation of the energy use for cooling and of the overheating indicator.

The measured value should be obtained in a test conforming with method A of the standard EN 13829 [2] with additional regional guidelines dealing with building preparation and measuring procedure.

Compliance procedures

In Belgium, the energy performance of new and renovated buildings is assessed at the moment of completion of the works by an EPB-assessor, who collects the as-built information, creates the necessary input in the EPB-software, and evaluates whether the building meets the requirements. The EPB-declarations with the results are uploaded to a database, managed by the regional authorities. In case requirements are not met, the builder is charged with a fine proportional to the size and severity of the error.

When the result of a pressurization test is available the assessor can use this as an input. Although building airtightness testing is not compulsory, more and more buildings are being tested since the introduction of the EPB-legislation (Figure 1, based on 125,000 EPB-declarations). Since the difference between the conservative default values and the effective building air leakage may be large, taking a test is an easy way to achieve compliance with E-level requirements. While E-level requirements have been tightened every 2 years since 2010, also the share of tested buildings has increased.

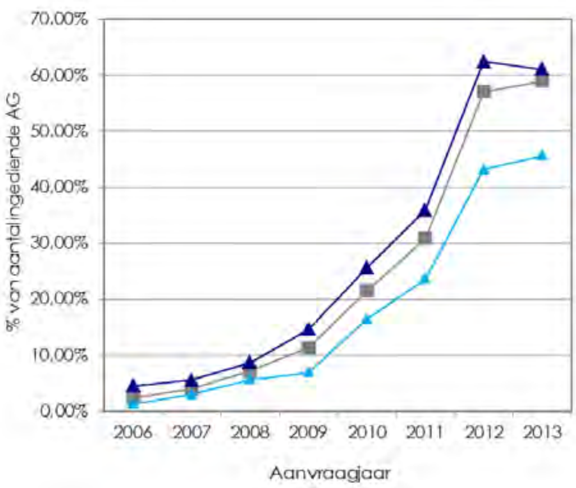

Figure 1: share of residential buildings with EPB-assessment based on measured building air leakage, as a function of the year of the building permit: dark blue-single family houses, light blue-apartments, grey-total (Source: VEA (Flemish Energy Agency), 2015, EPB-cijfers en statistieken 2006-2014 -in Dutch).

Before 2015 there were no requirements regarding competence of testers. Anyone who could demonstrate conformity to the test specifications and guidelines was allowed to perform the tests. However, since January 2015 measured values of building air leakage may only be taken into account in the EPB declaration on the condition that testers comply with a competent tester scheme [3]. This firstly means that the measurement should be performed by licensed testers. To receive a license, testers must show they possess the necessary knowledge and experience by taking a theoretical and practical examination. In March 2016, over 160 testers received a license. The conformity of test results with the scheme is verified by third party control.

Cyprus

Context

The verification of energy efficiency for the new buildings and buildings undergoing major renovation is based on the calculated primary energy use per square meter per year. The primary energy use is calculated for the building on according to its standardized use, and applied to the building as a whole: including energy needs for space heating, domestic hot water, cooling, lighting, ventilation, and electrical appliances. Requirements for buildings energy performance and calculation methodology are given in Cyprus legislation.

The "Methodology for Calculating the Energy Efficiency of a Building" and the "Building Insulation Guide (2^{nd} 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 program is used for calculating the energy performance of a building and issuing the EPC.

Building air leakage rate in energy calculations

All the necessary data about the properties of the building which is used in energy calculations (U-values, floor areas, ventilation and heating systems) is given when the drawings are prepared for the application for building permit. Building airtightness values are included in the SBEMcy software program as tabulated values, and can be used for calculating the energy performance of a building and issuing the EPC. Therefore, building airtightness is taken into account in energy calculations as tabulated value given by the software.

Compliance procedures

Measurements of the building airtightness are not required. However, airtightness influences energy performance and thermal comfort.

Estonia

Context

The verification of energy efficiency for the new buildings or buildings undergoing major renovation is based on the calculated primary energy use. The primary energy use is calculated for the building on according to its standardized use, and applied to the building as a whole: including energy needs for space heating, domestic hot water, cooling, lighting, ventilation, and electrical appliances. Requirements for buildings energy performance and calculation methodology are given in Estonian legislation [2],[3].

Building air leakage rate in energy calculations

Building air leakage rate is taken onto account in energy calculations. Average air leakage rate of the building must not exceed the air leakage value used in energy performance calculations. When the air-tightness of the building have not been measured or otherwise proven, the energy calculation is made with baseline given in legislation [3]. For example, air leakage rate baseline for the new detached house is 6 $m^3/(h·m^2)$ and for the other new buildings 3 $m^3/(h·m^2)$. If airtightness of the building is measured according to the standard EN 13829, or proven by the contractor of the building, air leakage value in energy calculations can be used according to the measured or proven value.

Compliance procedures

Measurements of the building airtightness in not required. Although the air leakage rate of the building must not exceed the air leakage value used in energy performance calculations, in practise there are no compliance and enforcement procedures.

France

Context

The 2012 thermal regulation (RT 2012) came into force on 1 January 2013 as a revision of the former RT2005 code. It is the regulation that authorizes or not the construction of a new building (from a thermal point of view); it applies for the residential and tertiary sector. Thermal regulatory calculations must be performed using standardized formulas which are incorporated in a CSTB (Scientific and Technical Centre for Building) approved software. RT 2012 thermal regulation considers three major aspects of the building which must be respected simultaneously: structure and envelope of the building, maximum permitted annual consumption of primary energy and summer thermal comfort.

Building air leakage rate in energy calculations

One of the novelties of the RT 2012, compared to RT 2005, is the mandatory requirement of the calculation of the envelope airtightness of individual, adjacent housing or collective housing.

According to RT 2012, the airtightness level of residential building envelope must not exceed 0.6 $m^3/h.m^2$ at 4 Pa for single-family buildings and 1 $m^3/h.m^2$ at 4 Pa for multi-family buildings. These values are minimum requirements; better values can also be used upon justification.

Air permeability measurements are performed according to the NF EN 13829 norm and its implementing guide GA P50-784. Since the publication of the ISO 9972 norm on the Determination of air permeability of buildings and its adoption on European level, the French national organization for standardization (AFNOR) has published the NF EN ISO 9972 norm, replacing the NF EN 13829. The two texts being very close, the measurement of air permeability of buildings has not changed in practice. The air permeability of the building can be calculated either by a measurement method or by adopting a quality approach of, approved by the Ministry in charge of construction. In the eyes of the RT2012 the measurement is valid only of it is performed by an operator licensed by the same Ministry. More information is available in Factsheet #01 "Building regulations can foster quality management: the French example on building airtightness" (QUALICHeCK-Factsheet-01.pdf) and Factsheet #07 "Building airtightness in France: regulatory context, control procedures, results" (QUALICHeCK-Factsheet-07.pdf).

As the energy performance calculation is performed prior to the construction of the building, the target value is used for the air tightness level. For the residential sector this points to the maximum permitted values: 0.6 $m^3/h.m^2$ at 4 Pa for single-family buildings and 1 $m^3/h.m^2$ at 4 Pa for multi-family buildings. A lower value can also be used for both cases. The airtightness measurement is later used to verify whether the initial value was correct and, in case of discrepancy, to update it. For the tertiary sector, default values can also be used, according to usage: 3 m3/h.m2 for commercial, transport, industrial and sport activity buildings and 1.7 1 $m^3/h.m^2$ for all others. Once again, the measured air leakage value can replace the initial one.

Compliance procedures

At the end of construction a Declaration Attesting Completion and Compliance of Works must be delivered to the planning department if the local Town Hall. This declaration certifies that the undertaken work is compliant with the Thermal Regulation RT2012, airtightness requirements included. It can be established by a technical controller, an architect, an accredited certification body or a diagnostician of energy performance.

The completion of the certificate requires:

- ✓ having performed a complete thermal study of the building using a RT2012 software;
- ✓ a site visit during which the person delivering the certificate verifies the compliance of the accomplished work and the synthesis of the thermal study; and
- ✓ the document justifying the air permeability of the building; the operator who carried out the air tightness test must provide a measurement report to the person delivering the certificate.

The air permeability report specifies if the input value used in the energy performance calculation complies with the measured airtightness level of the building. Even though it is usually not the case, the measured value can replace the initial airtightness value, especially if the former is higher than the later, provided that it respects the RT 2012 requirements.

After the deliverance of this certificate no further control or inspection is required by the current French legislation. However, controls of construction regulations (CRC) are performed annually on a sample of new buildings. They aim to raise stakeholder's awareness concerning the respect of construction regulations, improve the quality of buildings and the understanding of legislation.

Controls are performed at a departmental level, depending in particular on regional policy on quality construction. Controllers are commissioned state officials or local authorities.

Controllers may exercise the right of a site visit and of communication of technical documents during construction and up to 3 years after its completion. Each year a sample of new buildings is therefore controlled, based partly on a random draw and partly on local control policy.

In case of non-conformities, an official report is addressed to a public prosecutor who will decide the legal consequences. This may include closure of the case, closure of the case upon regularization of the situation, or prosecution specifying the required sanction (fines, demolition ...).

Greece

Context

Within the Greek context, the procedure of the energy efficiency assessment for the new buildings and buildings undergoing major renovation is based on the calculated primary energy use per square meter per year. The primary energy use is calculated for the building according to its standardized use, and applied to the building as a whole: including energy needs for space heating, domestic hot water, cooling, lighting, ventilation, and electrical appliances.

Building air leakage rate in energy calculations

All the necessary data about the properties of the building which is used in energy calculations (U-values, floor areas, ventilation and heating systems) is given when the drawings are prepared for the application for building permit. Building airtightness values are included in the software program and is used for calculating the energy performance of a building and issuing the EPC. According to the type of frame, the program selects values from a database. Therefore, building airtightness is taken into account in energy calculations.

Compliance procedures

Measurements of the building airtightness is not required in Greece. Although the air leakage rate of the building must not exceed the air leakage value used in energy performance calculations, in practice there are no compliance and enforcement procedures.

Romania

Context

The energy performance calculation methodology is set by [6], while the design of the ventilation and cooling systems are regulated within [7]. The Methodology (MC 001-2006) does not include minimum requirements for the building envelope, while the code I-5 include and support the natural ventilation system which is based on building permeability and sometimes on special openings in the building envelope (e.g. required by safety regulations for gas installations) to run. The permeability of the building envelope/facade is used to compensate the air flows extracted from service rooms (e.g. bathrooms, kitchen etc.). Without expressing it explicitly, the ventilation code seems based on the principle that "a completely tight building is unhealthy, even dangerous".

The minimum requirements regarding air tightness are set only for ventilation systems (air ducts, equipment, filters etc.). There is no separate sub-requirement for building air tightness.

Building air leakage rate in energy calculations

The influence of building air leakage is taken into account in the calculation of the heat loss coefficient of the building, and has an influence on the energy demand for heating (e.g. for residential buildings the ventilation rate for natural ventilation systems is taken as an average (default) value depending on the building envelope permeability class, which is defined based on air leakage rate). For designing the ventilation or cooling system there is no explicit use of air leakage rate.

There are no default values for building envelope airtightness and no minimum requirements are set in this respect.

Usually, the developer/commissioner decides on a requirement regarding the air tightness of the building envelope. In this case a fan pressurization test could be requested and it is performed based on

SR EN 13829 [2]. This could be the case of buildings which are developed to achieve passive house standard, however the number of these cases in practice is extremely low.

Compliance procedures

There are no compliance checks, enforcement procedures or quality framework related to the building envelope air tightness in Romania. Thus no building leakage measurements or testing are required in practice.

Spain

Context

The verification of energy efficiency for the new buildings is based on the calculated non-renewable primary energy use. The energy use is calculated for the building according to its standardized use, and applied to the building as a whole: including energy needs for space heating, domestic hot water, cooling, and, in case of tertiary building, lighting.

For residential buildings, there are given limits according the Climatic Zone and the size of the building. For Tertiary buildings, the non-renewable primary energy use must be at maximum 65% of the non-renewable primary energy use of the reference building. Roughly, reference building is built with the same shape as the original building but the envelope elements are substituted by given elements defined in the legislation. There are fixed values for the seasonal efficiencies of the Heating, Cooling and Domestic Hot Water systems.

For renovated existing buildings (more than 25% of the envelope area), the requirement is limited to a limit of the "joint net energy demand for heating and cooling", which must be below the value obtained for the reference building.

Requirements for buildings energy performance and calculation methodology are given in Spanish legislation [8], [9]. The methodology requires the hourly dynamic calculation of net energy demand, and the hourly simulation of the technical systems for calculation the non-renewable primary energy consumption.

Building air leakage rate in energy calculations

The calculation procedure uses the methodology of the EN 15242:2007. It is based on a loop method and retains the calculation of air infiltration through opaque elements, windows and air vents. It is possible to include the effect of indoor zoning that allows calculating (using mass conservation laws) the air flow between zones according to a model of single zone in pressures and single zone in air flows. Recently, in the frame of the additional capabilities for the official methodology, it has been prepared a programme that allows the calculation of the air interchanges according a multizone model for both pressures and air flows.

The default values for infiltration through opaque elements (cracks) follow the indications given in EN 15242:2007. In this standard, Table B.1 of the Annex B (normative) gives three values for the air permeability of the envelope depending on the air leakage level. From this data default values for infiltration through opaque elements (cracks) have been fixed at 1.8 m^3/h per square meter of exposed wall surface for single-family dwellings and 1.95 m^3/h per square meter of exposed wall surface for multi-story buildings. The rest of the details and some example calculations can be seen in [10].

There are minimum requirements derived from healthiness in the buildings, according to Basic document CTE-HS3 [11]. Technicians must calculate the air renovation in the building and the obtained value is given to the EPC tool.

Compliance verification process

There are no special compliance checking for the air tightness in Spain. It is included in the common procedures for checking the compliance, which are defined in the legislation. Inspections could be made when getting the initial EPC (from the project data), of the final EPC, after the construction process.

Sweden

Context

The verification of energy efficiency for the new buildings and buildings undergoing major renovation is based on the operational energy use, i.e. the measured energy use. The energy use has to be measured within two years after the building has been taken in operation. Calculated energy use is only required for the building permit, and is not a part of the energy certificate according to Swedish regulations.

Calculation of the energy use for the building permit requires use of the standard EN 13789 [4] (Thermal performance of buildings).

Building air leakage rate in energy calculations

When calculating the energy use in a building, the airtightness is taken into account. There is no requirement concerning airtightness for energy use, except in special cases such as buildings smaller than 50 m^2. These can have a maximum leakage of 0.6 l/s per m^2 envelope area at 50 Pa.

Usually, the developer/commissioner decides on a requirement. There is a supporting document for choosing airtightness requirement in the Swedish guideline ByggaL (Build Airtight) [12]. If there is a requirement for airtightness, a fan pressurization test is usually performed. This is made according to EN standard 13829 [2].

Conclusions and remarks

Building air leakage rate is taken into account in energy calculations, but mainly with default tabulated values. With tabulated values, there is an option to use measured values instead of more conservative tabulated values. How much this option is used in practice, differs between countries. Studied focus counties had three different approaches:

- ✓ tabulated values given in legislation or in energy calculation software; measured values are also allowed to use (Austria, Belgium, Estonia, Cyprus, Greece, Spain);
- ✓ developer/commissioner decides on a requirement (Sweden, Romania);
- ✓ target value is used in calculations and air leakage rate must be measured (France).

Regarding compliance, usually there is no requirement to measure and verify the building air leakage rate (except France). In Belgium, air leakage measurements are not mandatory but as tabulated default values are very conservative, the measurement eases the achievement of energy efficiency requirements. As a result, air leakage measurements have significantly increased in recent years.

References

[1] OIB-RL6 2015 (OIB Guideline 6 on Heat Protection and Energy Saving) and the associated Calculation Guideline, issued by OIB - Austrian Institute of Construction Engineering http://www.oib.or.at/en/about-us.

[2] EN 13829:2000, 2000, Thermal performance of buildings - Determination of air permeability of buildings - Fan pressurization method (ISO 9972:1996, modified)

[3] FOD economie (Federal Government), 2014, STS P 71-3, Luchtdichtheid van gebouwen - luchtdichtheidstest (in Dutch).

[4] Minimum requirements for energy performance of buildings. Estonian Government's Ordinance No.68. RT I, 05.09.2012, 4, 2012.

[5] Methodology for calculating the energy performance of buildings. Ministry of Economic Affairs and Communications's Ordinance No. 63. RT I, 18.10.2012, 1, 2012.

[6] Ministry Order 157/2007 (MDRAP) for the approval of the calculation methodology for the energy performance of buildings: MC 001/1-2006 - Building Envelope, MC 001/2-2006 - Energy Performance of Building Systems, MC 001/3-2006 - Building Energy Audit and Energy Performance Certificate (with further amendments and additional parts)

[7] Ministry Order 1659/2011 (MDRT) for the approval of the technical regulation I-5 for the design, execution and operation of ventilation and air conditioning system in buildings.

[8] Real Decreto 314/2006, de 17 de marzo, por el que se aprueba el Código Técnico de la Edificación. BOE núm. 74, 28 marzo 2006. Documento básico CTE-HE Ahorro de Energía. BOE 12/09/2013 and BOE 08/11/2013

[9] Real Decreto 235/2013, de 5 de abril, por el que se aprueba el procedimiento básico para la certificación de la eficiencia energética de los edificios

[10] Salmerón, JM, Sánchez de la Flor, FJ, Álvarez, S, Molina, JL: Analysis and repercussions of the updating of the Spanish regulation regarding infiltration and ventilation. International Journal of

Ventilation. 2013. Vol. 11. Núm. 4. Pag. 407-416. http://ijovent.org/doi/abs/10.5555/2044-4044-11.4.407

[11] Real Decreto 314/2006, de 17 de marzo, por el que se aprueba el Código Técnico de la Edificación. BOE núm. 74, 28 marzo 2006. Documento Básico HS-3 Ventilation and Indoor Air Quality

[12] Sikander E, A method to enrsure airtightness of the building envelope, AIVC International workshop, 28-29 March 2012, www.lufttat.se- Bygga L (In Swedish)

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Technology Renewables in multi-energy systems Ventilation and airtightness	*Aspect* Compliant and easily accessible EPC input data	*Country* France

SELECTING EPC INPUT DATA FOR HVAC SYSTEMS: A SERIES OF FRENCH GUIDANCE SHEETS

Because of the relative complexity of the French method for calculating the energy performance of new buildings, the selection of input data for heating, ventilation and air-conditioning (HVAC) systems can be a challenge without any guidance. In this context, Uniclima - the French association of HVAC system manufacturers - and CETIAT - the technical centre of HVAC system manufacturers - have developed and published a series of more than 20 guidance sheets, intended to help for determining the EPC input data for heat pumps, boilers, radiators, water heaters, hot water storage, solar thermal systems, ventilation fan boxes and air handling units.

Residential buildings ☑	Non-residential buildings ☑	Specific buildings: ……
New buildings ☑	Existing buildings ☐	

Context

The French regulation about the energy performance of new buildings (called "Réglementation Thermique 2012", or "RT2012") includes a calculation method of the energy performance of new buildings [1].

This calculation method, used to rate the energy performance and issue the Energy Performance Certificate (EPC), is based on a detailed approach, and thus requires a huge quantity of input data, with rather complex definitions, especially for HVAC systems.

The complexity of the method can be illustrated by the example of a gas condensing boiler, for which 33 different input data must be used, describing the characteristics and the performances of the appliance.

The document that describes the calculation method has almost 1400 pages, which means that software is required for the calculation. The method has been implemented by CSTB (Centre Scientifique et Technique du Bâtiment) into core software, which is embedded into eleven approved commercial software from eight providers (status January 2017) [2].

In this context, the French association of HVAC system manufacturers, Uniclima, identified a risk that errors or difficulties occur when experts in charge of operating a calculation have to select all the input data that are needed.

Together with CETIAT, the French technical centre of HVAC system manufacturers, Uniclima decided to develop guidance sheets to limit these risks and help taking into account HVAC systems in a compliant way.

Objectives and problems addressed

If experts selecting input data for the calculation meet difficulties in understanding what is needed, they can make errors that lead to an incorrect integration of some systems, or to under- or overestimation of their performance in the EPC.

In addition, difficulties in understanding how to select input data could disadvantage certain systems, by leading experts not to choose them at all.

In this context, the objective of these guidance sheets developed by Uniclima and CETIAT is to decrease the risk of errors and difficulties in determining and collecting input data by:

- ✓ summarizing the requirements of the calculation method concerning the input data of the HVAC system;
- ✓ providing useful additional explanation to the one given by the description of the calculation method;
- ✓ mentioning the risks of possible typical errors in the selection of input data;
- ✓ giving precisions about the way to cover variants of the considered system.

Approach to overcome identified problems

The guidance sheets

A total of 23 guidance sheets were developed, dedicated to different types of HVAC appliances.

The appliances covered by these guidance sheets are (status January 2017):

- ✓ Heating and cooling appliances (common input data for all systems)
- ✓ Heat pumps, air conditioning units and liquid-chilling packages (common input data)
- ✓ Air-to-air heat pumps
- ✓ Roof-top units
- ✓ Air-to-water heat pumps
- ✓ Brine-to-water heat pumps
- ✓ Water-to-water heat pumps
- ✓ Direct exchange geothermal heat pumps
- ✓ Combination heat pumps
- ✓ Domestic hot water heat pumps
- ✓ Condensing boilers using gaseous or liquid fuels
- ✓ Condensing boilers using solid fuels
- ✓ Hybrid systems (boiler/heat pump combination)
- ✓ Solar combisystems (heating and domestic hot water)
- ✓ Individual solar water heaters
- ✓ Collective solar water heaters with centralised storage
- ✓ Collective solar water heaters with decentralised storage
- ✓ Hot water storage tanks
- ✓ Storage water heaters using gaseous fuels
- ✓ Hot water radiators
- ✓ Micro-CHP appliances with internal combustion engines
- ✓ Micro-CHP appliances with Stirling engine
- ✓ Electrical power of ventilation fans

Figure 1: Cover page of some of the guidance sheets

Guidance sheets were written by experts from CETIAT, with a good knowledge of the calculation method, the concerned HVAC appliances and the way to describe their performance.

These sheets provide guidance based on the official calculation method itself, so that they are useful independently from the software that is going to be used for the building energy performance calculation. This means that the guidance sheets do not show screenshots nor detailed explanations on data entry for a given software.

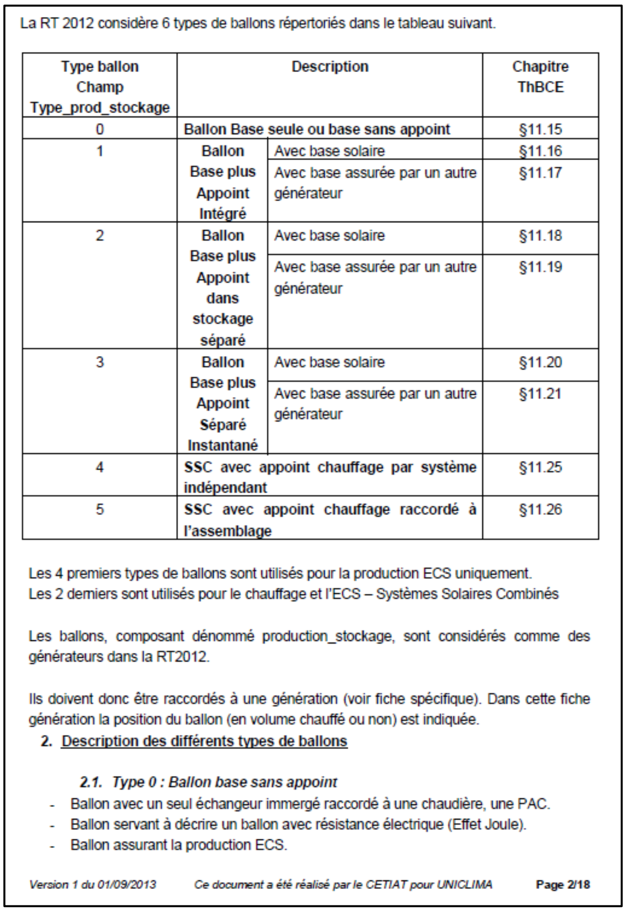
The guidance sheets were reviewed and validated by manufacturers through working groups within UNICLIMA.

Before publication, they were forwarded to the Ministry of Housing and CSTB for information and comments.

Contents of the guidance sheets

The content of each guidance sheet (typically 5 to 15 pages) includes:

- ✓ A general description of the system and the way by which it is treated by the calculation method (see for example Figure 2),
- ✓ A detailed description of the input data, with tables providing information about each of them (see for example Figure 3).



La RT 2012 considère 6 types de ballons répertoriés dans le tableau suivant.

Type ballon Champ Type_prod_stockage	Description		Chapitre ThBCE
0	**Ballon Base seule ou base sans appoint**		§11.15
1	**Ballon Base plus Appoint Intégré**	Avec base solaire	§11.16
		Avec base assurée par un autre générateur	§11.17
2	**Ballon Base plus Appoint dans stockage séparé**	Avec base solaire	§11.18
		Avec base assurée par un autre générateur	§11.19
3	**Ballon Base plus Appoint Séparé Instantané**	Avec base solaire	§11.20
		Avec base assurée par un autre générateur	§11.21
4	**SSC avec appoint chauffage par système indépendant**		§11.25
5	**SSC avec appoint chauffage raccordé à l'assemblage**		§11.26

Les 4 premiers types de ballons sont utilisés pour la production ECS uniquement.
Les 2 derniers sont utilisés pour le chauffage et l'ECS – Systèmes Solaires Combinés

Les ballons, composant dénommé production_stockage, sont considérés comme des générateurs dans la RT2012.

Ils doivent donc être raccordés à une génération (voir fiche spécifique). Dans cette fiche génération la position du ballon (en volume chauffé ou non) est indiquée.

2. Description des différents types de ballons

2.1. Type 0 : Ballon base sans appoint

- Ballon avec un seul échangeur immergé raccordé à une chaudière, une PAC.
- Ballon servant à décrire un ballon avec résistance électrique (Effet Joule).
- Ballon assurant la production ECS.

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Figure 2: Extract from the guidance sheet on hot water storage tanks.
This page describes the 6 types of tanks taken into account by the calculation method

Input data include:

- ✓ Codes taken from a pre-established list of figures (0, 1, 2, 3…) used to describe the system, its functions, its components, the control strategy…,
- ✓ measured values that characterise the system performance, that can be either declared by the manufacturer, determined by an independent laboratory or certified,
- ✓ default values.

<table>
<tr><td colspan="2" rowspan="2">Type_prod_stockage</td><td rowspan="2">0 : Ballon Base seule (ou sans appoint)</td><td rowspan="2">1 : Ballon Base + appoint intégré</td><td colspan="2">2 : Ballon Base + appoint dans stockage séparé</td><td colspan="3" rowspan="2">3 : Ballon Base + appoint séparé instantané</td><td rowspan="2">Ballon SSC Type 4 et 5</td></tr>
<tr><td>Ballon base</td><td>Ballon appoint</td></tr>
<tr><td colspan="2">Θ_max</td><td colspan="8">Température maximale du ballon entre 0 et 100°C - Valeur type : 90°C</td></tr>
<tr><td>Type_gest_base</td><td>Type de gestion du thermostat de base du ballon</td><td colspan="8">Soit 0 : permanent, Soit 1 : de nuit
De nuit indique de 23h à 5 h.
Cas des ballons raccordés à une chaudière : permanent
Inutile dans le cas d'une base solaire car toute la chaleur disponible est injectée automatiquement dans le ballon</td></tr>
<tr><td>Statut_ Δθ_base</td><td>Statut hystérésis régulation base</td><td colspan="8">Choix du type de valeur pour l'hystérésis de régulation de la base :
1 : valeur déclarée, 2 : valeur par défaut : 2K</td></tr>
<tr><td>Δθ_base</td><td>Valeur Hystérésis régulation base</td><td colspan="8">Valeur de l'hystérésis de régulation de la base, à indiquer si choix valeur déclarée pour Statut_Δθ_base.
Inutile dans le cas d'une base solaire car toute la chaleur disponible est injectée automatiquement dans le ballon</td></tr>
<tr><td>Hrel ech base</td><td>Hauteur relative de l'échangeur de base (entre 0 et 1)</td><td colspan="3">Hauteur échangeur de base depuis le fond du ballon (H1)/Htot
Voir Annexe 1</td><td colspan="2">NA</td><td colspan="3">Hauteur échangeur de base depuis le fond du ballon (H1)/Htot
Voir Annexe 1</td></tr>
<tr><td>Zreg_base</td><td>Numéro de la zone du ballon qui contient la sonde de régulation de la base</td><td>1 à 4 Selon projet</td><td colspan="2">Selon projet (1 si base solaire)</td><td colspan="2">NA</td><td>1 à 4 Selon projet</td><td colspan="2">NA</td></tr>
<tr><td>Statut f_aux</td><td>Indique le statut de la valeur de f_aux</td><td>NA</td><td>0 : Valeur à saisir
1 : Valeur par défaut (= 0.5)</td><td colspan="4">NA</td><td colspan="2">0 : Valeur à saisir
1 : Valeur par défaut (= 0.5)</td></tr>
</table>

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Figure 3: Extract from the guidance sheet on hot water storage tanks.
The table provides guidance for choosing some of the 24 input data that are needed.

Status of the guidance sheets

All the guidance sheets are available for free at Uniclima website and communication announced their availability.

These guidance sheets have no legal status: they rely on the initiative of manufacturers. They have been implemented by the French HVAC manufacturer association (Uniclima) and technical centre (CETIAT), and thus financed by manufacturers through their membership to these two organisations.

Even if they are dedicated to those who will operate this calculation, it is clear that these guidance sheets are also useful for manufacturers themselves, in order to guide them about the input data to be published in their own documents. The guidance sheets have the advantage to include, for one given appliance, all the input data that are needed, that are often described in several parts of the almost 1400 pages of the regulation.

In principle, there is no need to update the guidance sheets until a change of the calculation method. The development of new guidance sheets relies on a decision by the manufacturers within their association Uniclima.

Similar initiatives

It must be noted that similar initiatives have been taken by other French stakeholders:

- ✓ The official information website on the French regulation [4] includes 21 sheets that correspond to the main errors on input data made by the persons in charge of the calculation, as identified during the control of the Energy Performance Certificates. Some of these errors apply to input data for HVAC appliances (air handling units, ventilation air inlet) and systems (length and thermal insulation of water pipes, water temperature and flow rate of heating/cooling systems, type of controls for heating/cooling systems, ductwork airtightness). There is no overlap with the guidance sheets described in this factsheet.
- ✓ The gas distribution company GRDF has published 23 guidance sheets about input data for gas boilers, gas heat pumps, specific hybrid systems (gas boiler/heat pump combination), solar systems with gas boiler, micro-CHP appliances [5]. The guidance is linked to the use of two commercial software products. There is some overlap with the guidance sheets described in this factsheet, but these latter are more general as they are independent from a specific software.

- ✓ The French association Energies et Avenir published a guide [6] about the input data for heating and domestic hot water pipework in residential building. It is a good complement to the guidance sheets described in this factsheet.

All these documents are available for free.

Why such guidance is needed

These initiatives are clearly the consequence of a complex calculation method.

All the stakeholders that have decided to publish such guidance, including the public authorities, have identified a need to provide additional information to the calculation method itself and to the commercial software.

Without such additional information, there is a risk that errors occur on the choice of the input data; such errors have even been repeatedly identified in the controls of the EPCs.

The objective of these guidance documents is therefore to limit those errors, due to misunderstandings or wrong interpretations of the calculation method.

The written description of the calculation method is comprehensive and includes in general a clear description of each input data, but the document is very long and several parts have often to be looked at for a given HVAC appliance. In addition, software products give of course a full list of input data fields that have to be filled in, but in most cases do not provide a comprehensive help to the user to determine input data for each specific HVAC appliance.

Market acceptance of the approach

It is thought that guidance sheets are useful for experts in charge of operating a calculation even if no precise figure is available concerning the number of documents distributed.

It is sure that guidance sheets are useful for manufacturers as providing a comprehensive lists of product data that have to be published as EPC input data.

Promotional actions to inform about the publication of these guidance sheets included press release and presentation to software providers.

Pros and cons of possible options

The implementation of these 23 guidance sheets has been made by following the options mentioned in Table 1. This table summarize the pros and cons of these options.

In addition to Table 1, it can be noted that the access to the guidance sheets is very easy (free documents available on the internet). This makes possible a control by all stakeholders, including the public authorities, that the guidance does not include misunderstandings or wrong interpretations. If this were the case, action could be taken to ask for correction of the concerned guidance sheet.

Option	Pros	Cons
✓ Provide additional explanations on how to determine input data in energy performance calculation for a given HVAC appliance	✓ With a complex calculation method, additional guidance can be useful to help for compliance of the EPC input data	✓ The ideal would be that the calculation method in itself creates no risk that the input data are chosen with errors (due to misunderstandings or wrong interpretations).
✓ Let manufacturer organisation develop this guidance	✓ Manufacturers know the way to describe the characteristics of their products and can provide consistent advice	✓ The risk exists that guidance developed by private stakeholders includes misunderstandings or wrong interpretations of the calculation method
✓ Let guidance documents have a status of non-official documents	✓ Allows to publish guidance without public effort and by using the knowledge of product providers about the way to describe the characteristics of their products	✓ Creates a mix of official and non-official documents
✓ Provide guidance documents for free	✓ Ensures that no limitation will exist to the access to the documents	✓ None, except if stakeholders that develop guidance need a direct revenue to pay their work
✓ Provide guidance independently from the commercial software that will be used for the calculation	✓ Makes guidance more general and useful with different calculation tools	✓ Creates the risk that the guidance is too general and not adapted to a specific software
✓ Provide to manufacturers, through such a guidance, a unified information about the input data to be published in their own documentation	✓ Contributes to a better homogeneity between the publication of product characteristics by manufacturers	✓ If the guidance would include misunderstandings or wrong interpretations of the calculation method, all manufacturers would publish non-compliant data

Table 1: Description of the options followed and of their pros and cons

Compliance concerns related to EP certificates and to the QM approach

No reporting ☐	Wrong reporting ☑	Not meeting the performance requirements ☐

Compliance concerns related to EP certificates (see QUALICHeCK terms and definitions)

It is clear that guidance sheets contribute to a compliant choice of the EPC input data.

If there were several guidance documents from different stakeholders providing contradicting information, this would create problems. However this is not the case in the French context. In general, this must be avoided.

Anyway, compliance would be better secured with a calculation method that makes additional guidance unnecessary. Otherwise, if the calculation method is complex (as the French one), it appears better to propose guidance on the way to choose the input data.

Financial aspects

The guidance sheets have been developed with indirect financial contribution of HVAC system manufacturers, through their membership to their association on one hand and to their technical centre on the other hand. It can be estimated that each of the 23 guidance sheets has been produced by using approximately 30 h of work shared between several persons (main expert authors, reviewers, publisher and webmaster). This short time is possible because development of the guidance sheets builds upon the pre-existing expertise of the main expert authors and reviewers.

No public money has been required.

Overall evaluation

The overall evaluation of the approach is given in Table 2.

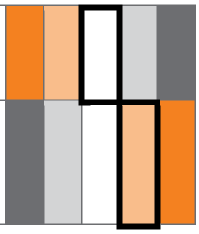
Hints and pitfalls are summarized in Table 3.

Pros	Cons
✓ Guidance sheets help for a better compliance of the EPC input data for HVAC systems, providing a synthesis of all the data needed for a given type of appliance.	✓ The complex calculation method has led several stakeholders to develop their own guidance documentation. Even if there is today no overlap, the co-existence of several non-official documents and the official calculation method description can create confusion.
✓ The guidance sheets have been developed by manufacturers, who know well their products and the way to present their characteristics	✓ The need to have private-based additional information to fulfil a regulation, due to its complexity, is not an ideal situation. Clear self-supporting regulations should be preferred
✓ Guidance sheets are available for free on the Internet. This easy access makes them fully public, with a possibility for authorities and other stakeholders to check that no interpretation or misunderstanding has occurred.	✓

Table 2: Overall pros and cons of the approach

Level of complexity
(dark orange = simplest)

Potential for replication
(dark orange = best)



Prerequisites

A prerequisite for such a scheme is that one or several stakeholders decide to contribute to a good implementation of a complex regulation.

Hints	Pitfalls
✓ A complex calculation method makes the collection of input data complicated and increases the risk of errors. ✓ If such a complex calculation method is chosen, the ideal would be that it includes very clear information for the user on the way to choose input data. ✓ If a complex calculation method does not include clear information about input data collection, then additional guidance developed by stakeholders is needed.	✓ Additional guidance documents should not change the official calculation method through wrong interpretations.

Table 3: Overall hints and pitfalls to avoid when developing such an approach

References

[1] Arrêté du 30 avril 2013 portant approbation de la méthode de calcul Th-BCE 2012 prévue aux articles 4, 5 et 6 de l'arrêté du 26 octobre 2010 relatif aux caractéristiques thermiques et aux exigences de performance énergétique des bâtiments nouveaux et des parties nouvelles de bâtiments. *Bulletin officiel du ministère de l'écologie, du développement durable et de l'énergie, 25 May 2013, pages 163-1541.* http://www.bulletin-officiel.developpement-durable.gouv.fr/fiches/BO20139/met_20130009_0100_0006.pdf

[2] Logiciels d'application. *Page of the website* www.rt-batiment.fr *"Les économies d'énergie dans le bâtiment", available in January 2017.* http://www.rt-batiment.fr/batiments-neufs/reglementation-thermique-2012/logiciels-dapplication.html

[3] Fiches d'aide à la saisie des équipements dans la RT 2012. *Page of the webiste* www.uniclima.fr, *available in January 2017.* http://www.uniclima.fr/documentation/guides-techniques.html

[4] Guide d'application de la RT2012 à l'intention des bureaux d'études. *Page of the website* www.rt-batiment.fr *"Les économies d'énergie dans le bâtiment", available in January 2017.* http://www.rt-batiment.fr/batiments-neufs/reglementation-thermique-2012/documents-dapplication.html

[5] Fiches de saisie RT 2012 : solutions gaz naturel et énergies renouvelables. *Page of the website* www.cegibat.grdf.fr, *available in January 2017.* https://cegibat.grdf.fr/reglementation-energetique/fiche-saisie-rt-2012

[6] Saisie et optimisation des réseaux de distribution de chauffage et d'eau chaude sanitaire en résidentiel - Guide pratique RT2012. Energies et Avenir, 2012, 40 pages. *Available for download at:* http://www.energies-avenir.fr/page/guide-pratique-rt-2012-77

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Technology All technologies	*Aspect* Compliant and easily accessible EPC input data	*Country* Austria

baubook – EASILY ACCESSIBLE PRODUCT INFORMATION FOR EPC CALCULATION PROVIDED BY THE AUSTRIAN DATABASE

Providing the necessary product data for calculating Energy Performance Certificates (EPCs) is one of the main purposes of the Austrian baubook database. In addition, Life Cycle Assessment (LCA) data and other information about building products are included into the database to facilitate the holistic evaluation of buildings and building components as part of voluntary Sustainable Building Assessment Schemes. This fact sheet presents the baubook database and its functionalities; it provides detailed information about the process to ensure quality of data that can be used as input data for various calculation procedures.

Residential buildings ☑	Non-residential buildings ☑	Specific buildings: ……
New buildings ☑	Existing buildings ☑	

Context

Since 2008, the online product database baubook has offered easily accessible input data needed for the calculation of EPCs (Energy Performance Certificates) according to the Energy Performance of Buildings Directive 2010/31/EU (EPBD) and for the voluntary assessment of the environmental impact of buildings in Austria[1]. The product data are declared by the manufacturer. Prior to publication, all information is checked by qualified persons. In order to ensure highest accessibility, the data are transferred to EPC software programs which are approved for calculating and issuing EPCs in Austria, but also to other software programs and platforms applied for voluntary building assessments.

The data necessary for the calculation of building energy performance are expanded by additional product information about the ecological performance (Life Cycle Assessment (LCA) data, indoor quality data, …) and technical adjectives. Thus, baubook provides a central product database, containing ecological and energy-related data, and the basic data required to calculate EPC and LCA for buildings. This makes it useful for architects, consultants, developers and construction industry managers looking for tools assisting them in planning and building energy-efficient and ecological buildings.

Regulatory background

In Austria, the regulatory background for EPCs is defined by the nine federal provinces because the EPBD is transposed and implemented on the regional level. Thanks to coordination between the federal provinces, the method for calculating EPCs is harmonised to a high degree, though not identical [3, 4]. Declaration of EPC input data for products is based on European Standards, but there are still Austrian standards [5, 6, 7] which have to be considered. Therefore, product information and test certificates developed for other countries cannot be used in all cases in Austria, but have to be issued once again taking into account specific Austrian requirements. This poses an economic challenge especially for small markets such as the Austrian one.

[1] http://www.baubook.info and http://www.baubook.info/?SW=6&lng=2 (new: English version) (retrieved on 16.8.2016)

Whereas the method for calculating EPCs is harmonised at Austrian federal level, providing the software tool to calculate EPCs is left to the market. There are several companies offering approved software programmes to calculate EPCs. Therefore, there are several software suppliers with demand for a compliant database with information about building products.

Objectives and problems addressed: accessibility and quality assurance of data

Compliant data for construction products and heating, ventilation and air conditioning (HVAC) systems (e.g. thermal conductivity, heating capacity, …) are crucial for compliant Energy Performance Certificates (EPCs). Gathering compliant input data can be time consuming and thus an obstacle for establishing and controlling EPCs. Regulations on the level of federal provinces and standards which have to be considered in Austria, make the work of EPC experts more difficult.

A database such as baubook reduces the efforts linked with data collection on product properties and enhances the quality and the comparability of EPCs. Its objective is to provide easily accessible and compliant EPC input data.

The baubook approach

Contents and management of the database

The database provides characteristics of construction products (walls, floors, roofs, doors, windows, …) and of some building systems (wood heating appliances, heat pumps, ventilation fans, ducts and pipes, …). All data are accessible via the baubook internet platform, but also via other dedicated websites addressing the federal provinces and different target groups. In addition, the data are provided to software programmes which calculate and issue EPCs, but also software programmes which serve to tackle detailed questions such as determining thermal bridges and processing LCA data.

It is managed by the company baubook GmbH. This company is owned by the Energy Institute of Vorarlberg (a non-profit organisation belonging to the government of the federal province Vorarlberg) and IBO (Austrian Institute for Healthy and Ecological Building, an independent, scientific non-profit society).

The operation of the database is financed by fees of product and system manufacturers.

Accessibility of data

Access to the data is free of charge for its registered users, as well as for the software suppliers that choose to embed data in their software.

In the planning phase, where information about the products which will be actually used is not yet always available, baubook database offers generic values (thermal conductivity, density, heating capacity, …). These values allow to calculate the building energy performance in the early planning phase. They are on the safe side, resulting in an EPC which is likely to be worse than the final building energy performance. When planning is getting more detailed, these generic values can be replaced by specific product values declared by manufacturers.

Quality of data

Manufacturers can have their construction products declared in the baubook database. After entering the general company related information in the database via internet interface, the manufacturer enters the product information which covers physical, technical, and ecological characteristics. These details are further supplemented by a product description, images, technical and safety data sheets, ecolabels and test certificates. After entering all data in the database, a summary of the declaration is created, which has to be signed by the responsible company member. By agreeing to general terms and conditions, the manufacturers confirms the correctness and completeness of the data.

Before presenting the products in the public part of the database and exporting them to software programmes such as approved EPC calculation programmes, each declaration is checked by qualified staff, according to a checking procedure that defines the validation documents needed. These documents include European Technical Approval and CE Declaration of Performance (DoP) documents, as well as test reports (e.g. corresponding to EN 10077-2 [1], EN 1745 [2], and many others). Within the quality assurance process the compliance of each product characteristic with these documents is verified and the plausibility of the information is checked.

Test reports to verify data quality are stored centrally, but data accessibility is decentralised: once the quality assurance process has been passed, the manufacturer data are publicly available on all baubook websites.

Presentation of product data and provision of tools to make use of them

The baubook database presents product data uniformly and consistently.

In addition, baubook offers additional tools using these data:

- ✓ calculation of U-values and LCA indicators for building elements[2]
- ✓ calculation of LCA indicators for buildings[3]
- ✓ calculation of the ecological amortisation and the economic performance of insulation measures[4]

All functions facilitate decision-making on improving building performance, including energy efficiency.

Market acceptance of the baubook approach

Currently there are 3,500 products of 400 manufacturers declared in baubook database and 500 new products are declared every year. The associated websites have more than 36,000 visitors per week. On average, construction products receive 10-12 targeted clicks per week. Around 10,000 people are registered users of baubook. The EPC input data and the data to perform sustainable building assessments can also be retrieved from the dedicated software available on the Austrian market.

Using baubook data is free of charge for the software suppliers as well as for the users of the software. A contract between baubook and the software suppliers ensures that the software users will be able to update the data. Every month, such data are downloaded around 1,300 times.

Pros and cons of possible options: financing the product database

A question often discussed in the preparation phase of implementing the database was how to finance the system and how to maintain it in the long run.

The two following principles have been chosen:

1) Financing the scheme with the private sector approach

2) Striving for just one database in Austria

1) The scheme is financed by fees collected from manufacturers. This creates a strong interest to provide as many services as possible for the manufacturers, leading to new offers with the potential to contribute to the transformation of the building sector towards more energy efficiency and sustainability. The baubook database is not only limited to publication of data for calculating the energy performance of buildings. It includes all kinds of data such as LCA data, ecological product information, and technical data.

The incentives for innovations and new services are much higher for a market-based financing system, and thus the innovation process is much stronger.

This is also true for enlarging the database to other regions and other European countries in order to foster a domestic European market. A market-based system has a high interest to offer its services on a bigger market whereas publicly financed systems are limited to those countries or provinces providing the finance for the system.

Offering more services leads to more users of the database. More users strengthen the reason for manufacturers to declare their products. More products make the database even more useful for users, increasing the motivation of manufacturers to declare their products. Providing lots of different services for the producers allows baubook to have enough products in the database to run the system in a cost efficient way which is cheap for the manufacturers.

2) There is only one database at the Austrian level. There are several arguments for just having one database: first of all, it reduces cost for providing the necessary technical infrastructure.

The most important aspect is probably that it reduces the efforts for manufacturers to declare their products in the database and to keep the data at current status.

[2] www.baubook.info/btr_en (retrieved on 16.8.2016)
[3] www.baubook.info/eco2soft_en (retrieved on 16.8.2016)
[4] www.baubook.info/awr (retrieved on 16.8.2016)

And last but not least, it also reduces the users' efforts for gathering the information, as they just have one central database to check. In Austria, the discussions resulted in merging the two Austrian product databases existing prior to the foundation of baubook in 2008.

Option	Pros	Cons
✓ Financed by declaration fees of manufacturers instead of public finance	✓ Stronger incentive to develop additional services for manufacturers ✓ More innovation and more service orientation ✓ Not dependent on public financing ✓ Market based scheme easier to extend to other regions	✓ No cons identified
✓ One database instead of several databases	✓ Cost efficient and time saving solution for all stakeholders	✓ It can be difficult to include specific features required by a certain stakeholder group. This could lead to the creation of another database in case there is no publicly financed database but a market-based approach.

Table 1: Comparison of options

Compliance concerns related to EP certificates and to the QM approach

No reporting ☐	Wrong reporting ☑	Not meeting the performance requirements ☐

Table 2: Compliance concerns related to EP certificates (see QUALICHeCK terms and definitions)

The product database provides default values for calculating energy performance in the early design stage, and product specific values which can be used later in the design and execution process to substitute default values. Therefore, the product database creates the enabling environment for checking whether EPCs issue d at building permit stage have been updated with specific information after completion, taking design changes and changes occurring during execution into account. In this regard, the database provides the information needed to check whether the EPC represents the actual as-built situation or not.

However, this is well in theory but at present far from being applied throughout Austria. This is because there is no explicit building regulation requirement at the moment that EPCs must represent the as built-situation and have to be checked in this respect. It is current practice and compliant with the actual legal requirements that EPCs are only checked during the building permit application process.

Nevertheless, in case of tightening the legislation around the EPC, the infrastructure and data needed are available and ready for various applications.

Looking at the procedure to ensure the quality of the data published on baubook, it is admitted that the company baubook GmbH is in full private control. It could be argued that mistakes and even fraud could occur. This criticism can be invalidated by the following arguments:

- ✓ baubook GmbH is owned by the Energy Institute of Vorarlberg, which is a non-profit organisation belonging to the government of the federal province Vorarlberg and the renowned private organisation IBO. This type of shared ownership increases trust in the principles of operation.
- ✓ Product data are easily accessible and free of charge. The database has more than 10,000 registered users. There is some trust in social control, meaning that users will detect mistakes and competitors will scrutinise published data.

As a result of a cost-benefit-analysis, additional control mechanisms such as Third Party Control have not been implemented yet.

Financial aspects

The table below gives an overview of cost for declaration, listing, and amendments.

	Number of products			
	1 - 5	6 - 20	21 - 40	per additional
Declaration (one-time)				
General products	€ 69.00	€ 58.00	€ 47.00	€ 47.00
Window (composite)	€ 23.00			
Heat pumps, biomass boilers	€ 35.00	€ 29.00	€ 24.00	€ 24.00
Components	€ 80.00			
Listing on all platforms (per year)				
General products	€ 89.00	€ 68.00	€ 58.00	Free
Window (composite)				
Heat pumps, biomass boilers				
Components	€ 100.00			
Amendment with quality assurance				
General products	€ 42.00			
Window (composite)	€ 21.00			
Heat pumps, biomass boilers	€ 21.00			
Assigning dealers to products every year	€ 33.00	€ 22.00	€ 21.00	Free

Table 3: Cost per product 2016

Overall evaluation

The Austrian database baubook is considered a success. At the beginning, baubook GmbH has established collaboration with the national Austrian Climate Protection Program called klimaaktiv[5] and the governments of the federal provinces providing subsidies for building energy performance better than required by regulation. This was an important step because it created the audience necessary to motivate manufacturers to get interested in baubook. Offering additional services for various stakeholders has resulted in a growing database and a wide audience. A summary of pros and cons of the fee-based product database baubook is shown in the table below.

Pros	Cons
✓ Motivation to win manufacturers, e.g. by providing additional services for various stakeholder groups to get them involved and create an audience for manufacturers who want to advertise their products ✓ Innovation and service orientation to keep manufacturers interested ✓ Not dependent on scarce public financing ✓ Approach can easily be transferred to other regions as soon as a regional partner for the database is identified ✓ Quality assurance procedure and dissemination strategy is cost-efficient and time-saving for all stakeholders	✓ It can be difficult to include specific features required by a certain stakeholder group. This could lead to the creation of another database in case there is no publicly financed database but a market-based approach.

Table 3: Overall pros and cons of the fee-based product database baubook

[5] http://www.klimaaktiv.at/english.html (retrieved on 16.8.2016)

Level of complexity (dark orange = simplest)					
Potential for replication (dark orange = best)					

Prerequisites

There must be at least one organisation or institution taking ownership of the product database and ensuring operation.

Hints	Pitfalls
✓ Manufacturers will need a motivation to declare their products. The database concept, the quality assurance procedure, and the dissemination strategy must respond to this need.	✓ It takes some time to achieve the critical mass of manufacturers to make the database attractive for various types of users, and also the other way round. This must not be underestimated but needs realistic assessment when elaborating the business plan for database development and operation.

Table 4: Overall hints and pitfalls to avoid when developing such an approach

References

[1] EN ISO 10077-2 - Thermal performance of windows, doors and shutters - Calculation of thermal transmittance - Part 2: Numerical method for frames

[2] EN 1745 - Masonry and masonry products - Methods for determining thermal properties

[3] OIB-Richtlinie 6 - Energieeinsparung und Wärmeschutz, Austrian Institute for Construction and Engineering, March 2015

[4] ÖNORM B 8110-6 - Wärmeschutz im Hochbau - Teil 6: Grundlagen und Nachweisverfahren - Heizwärmebedarf und Kühlbedarf, Austrian Standards Institut

[5] ÖNORM B 8110-7 - Wärmeschutz im Hochbau - Teil 7: Tabellierte wärmeschutztechnische Bemessungswerte

[6] ÖNORM B 6015-2 - Bestimmung der Wärmeleitfähigkeit mit dem Plattengerät - Teil 2: Ermittlung des Nennwertes und des Bemessungswertes der Wärmeleitfähigkeit für homogene Baustoffe

[7] ÖNORM B 3200 - Mauerziegel - Anforderungen, Prüfungen, Klassifizierung und Kennzeichnung - Ergänzende Bestimmungen zur ÖNORM EN 771-1

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Technology	*Aspect*	*Country*
Transmission characteristics, ventilation, heating, hot water, cooling	Quality of the works	Germany

THE QUALITY ASSURANCE SYSTEM OF THE GERMAN RECONSTRUCTION LOAN CORPORATION (KREDITANSTALT FÜR WIEDERAUFBAU, KFW) IN THE FIELD OF ENERGY-EFFICIENT CONSTRUCTION AND RETROFITTING (RESIDENTIAL BUILDINGS)

In the scope of the KfW funding programmes "Energy-Efficient Construction and Refurbishment", loans and subsidies from federal funds are granted. Under this scheme, eligibility for funding implies stricter energy requirements on new constructions and on buildings subject to refurbishment than specified in legal regulations. To check on the effectiveness of its funding programmes "Energy-Efficient Construction and Refurbishment", KfW has developed a comprehensive quality assurance concept, which becomes effective already in the planning phase. This quality assurance concept is continuously improved.

Residential buildings ☑	Non-residential buildings ☐	Specific buildings: ……
New buildings ☑	Existing buildings ☑	

Context

The German KfW Bank is one of the world's leading promotional banks. On behalf of the federal government and the federal states it aims at improving the economic, social and environmental living conditions for people all over the world. Among other issues, its work focuses on funding programmes in the field of energy-efficient construction and refurbishment of residential buildings, to create incentives for energy-efficient new constructions and retrofitted existing buildings. In this context, KfW strives to promote a higher energy standard of the implemented structural measures than stipulated by the legal requirements specified in the German Energy Saving Ordinance (EnEV) [1].This complex matter requires special expertise, meticulous planning and correct implementation. For these reasons, KfW has developed a comprehensive quality assurance concept that comprises several closely integrated elements, which ensure the correct implementation of the funding standards. The key elements of the quality assurance concept include the quality control of the required documents, applications and verifications on the one hand and on-site quality assurance on the other. The required documents, applications and verifications must undergo plausibility checks and randomly selected inspections. For on-site quality assurance, however, it is mandatory to consult an independent, certified expert as early as in the planning stage. The expert will accompany the builder right through to completion of the project.

Objectives and problems addressed

The quality assurance concept was developed for the funding programmes that are to be applied for the energy-efficient construction and refurbishment of residential buildings. Builders must be safe to rely on the commitment that their building will definitely achieve the planned energy standard after completion. In particular, the quality assurance system aims to fulfil the following targets:

- ✓ Early identification of planning errors, ensuring and enhancing quality when implementing planning details
- ✓ Ensuring the correct implementation of the funding standards
- ✓ High quality of refurbishment and implementation in terms of consumer protection

- ✓ Responsible use of public funds: projects funded by public resources shall be inspected to verify that they are being implemented in accordance with the above programmes
- ✓ Securing the automated processes (plausibility checks and random inspections)
- ✓ Increasing the stakeholders' quality awareness (of builders and experts, in the first place) by carrying out clear-cut controls (on-site inspections)

At present, the quality assurance concept only applies to the housing construction sector. A quality assurance concept for non-residential buildings is currently under development.

Approach to overcome identified problems

Related funding programmes

The ambitious standards of the KfW Efficiency Houses and the individual measures pose high requirements to the quality of the energy-related concept and the planning as well as to the professional implementation. The quality assurance system is effected in the scope of three funding programmes:

- ✓ KfW loan (153): Energy-Efficient Construction (for the construction or the first purchase of a new KfW Efficiency House)
- ✓ KfW loan (151): Energy-Efficient Refurbishment - loan (for retrofitting an existing building to achieve the KfW Efficiency House standard or for individual energy measures)
- ✓ KfW subsidy (430): Energy-Efficient Refurbishment - investment grant (for retrofitting an existing building to achieve the KfW Efficiency House standard or for individual energy measures).

In all of the three funding programmes private individuals are eligible for funding, provided they are considered to be builders (owners) or first purchasers. In the case of existing buildings (funding programme 430), it is also possible for home owners' associations comprised of private individuals to apply for an investment grant. In the scope of the funding programmes 153 "Energy-Efficient Construction" and 151 "Energy-Efficient Refurbishment"), it is also possible for contractors to obtain funding in the form of a loan.

Quality assurance in four project phases

The quality assurance system consists of closely integrated elements, which become effective during four phases and are designed to ensure the implementation of the KfW funding standards. In detail, these four phases are: project planning, filing the application and commitment, implementation phase and completion of the project.

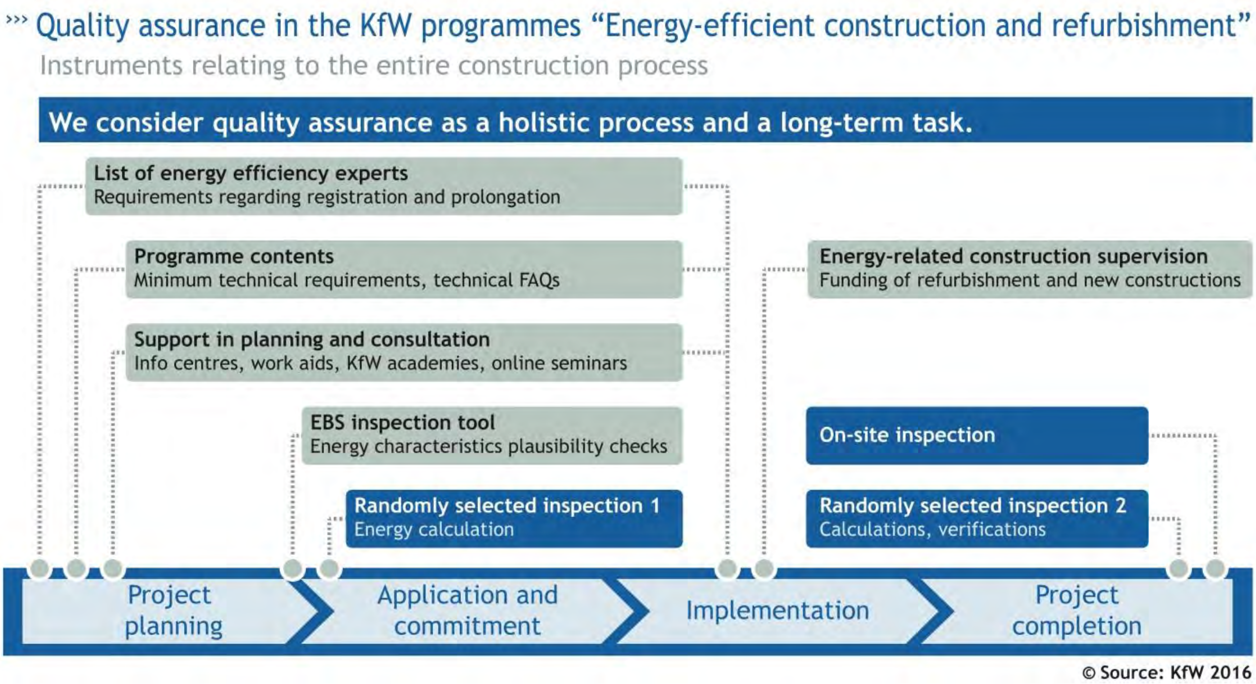


Figure 1: Quality assurance scheme relating to the KfW programmes "Energy-efficient Construction and Refurbishment", describing individual instruments applied during the entire construction process

The individual elements that are comprised in the quality assurance system are as follows:

- ✓ Technical minimum requirements (programme boundary conditions)
- ✓ Obligation to consult an independent expert who is registered in the quality-assured list of energy-efficiency experts
- ✓ Automatic plausibility check (online) using the so-called "Energy-Efficient Construction and Refurbishment Inspection Tool" (EBS inspection tool)
- ✓ Randomly selected inspection 1 (random checks of the calculation documents)
- ✓ Funding of energy-related construction supervision conducted by an independent expert
- ✓ Randomly selected inspection 2 (random checks of the technical verifications and calculations)
- ✓ On-site inspection after completion of the construction work

Project planning

In the first stage of project planning, technical minimum requirements of the appropriate funding programme must be considered, on the one hand. The technical minimum requirements describe any conditions that must be fulfilled to receive funding. Among other items, these conditions include calculation criteria for the KfW Efficiency House standards as well as energy-related characteristics, which need to be observed when implementing the respective individual measures. On the other hand, it became mandatory in 2014 to consult an expert who is registered in the quality-assured list of energy-efficiency experts. The expert provides competent consulting services to the builder, from planning through to the final acceptance of the measures performed. The technical minimum requirements also specify the (minimum) scope of services, which is expected to be rendered by an expert. The expert, too, constitutes part of the quality assurance concept, as the energy-experts list specifies exclusively experts whose qualifications have been examined. As a prerequisite for being enrolled in the official experts list, the specialists need to fulfil particular requirements regarding their professional skills. Besides, they need to document a completed further training course in the field of energy-efficient construction and refurbishment or comprehensive practical experience. In addition, the experts are required to prove every three years that they have attended further training courses; they also have to submit practical experience reports. Experts are listed under www.energie-effizienz-experten.de.

Application and commitment

In the second stage of the quality assurance process (“Application and commitment”), an automated plausibility check will take place, namely a check of the energy-efficiency calculations carried out by the expert in the scope of submitting the application. The automated plausibility check is done online, using the so-called 'Energy-efficient construction and-refurbishment inspection tool‘ (EBS inspection tool). This online tool allows the expert commissioned by the builder to check the key technical data and the energy performance characteristics of the building project. The EBS inspection tool provides a testing system, which allows comparing statistical empirical values, depending on the geometrical characteristics of the building. In this context, it is also checked whether the energy-related calculations are plausible and whether the technical minimum requirements are being fulfilled. In the case of mistakes and application-related issues occurring, the expert will be given well-targeted information. The construction project will only be admitted to apply for funding, if the project’s key technical data are complete and plausible. If this condition is fulfilled, the expert will receive an "Online confirmation of application“. The test results obtained from the EBS inspection tool have to be included in the application for funding. It is in this phase that the first randomly selected inspection takes place: immediately after commitment was granted ("Online confirmation of application“), KfW will request the energy-related calculation documentation which will be checked for correctness, based on random sampling.

Implementation phase

Subsequent to energy-related sectoral planning, the implementation phase commences. To ensure correct implementation of energy-related sectoral planning, the builder is obliged in this phase to contract additional, energy-related construction supervision services provided by the independent expert. During the energy-related construction supervision, the expert will control and document the implementation of the envisaged construction. The documentation will be supplied to the builder.

Project completion

The energy-related construction supervision also provides the basis for the confirmation document KfW requests on completion of the project to ascertain that all measures have been carried out according to schedule ("Confirmation of Implementation") - if the project has been funded in the form of a loan. If the project has been funded in the form of an investment subsidy, KfW will request a "Report on Expenditure of Funds". The "Confirmation of Implementation" must be submitted to the builder's finance partner within nine months after the total amount of the loan has been paid. It includes the documentation of the independent expert, invoices of the realised measures and protocols of airtightness measurements (if required) and of the hydraulic calibration.

The "Report on Expenditure of Funds" has to be submitted to KfW. This service rendered by the expert is also eligible for funding by KfW in the scope of the federal "CO_2 building rehabilitation programme". Funding for construction supervision is available to any builder who contracts energy-related sectoral planning and construction supervision services for residential buildings provided by an independent expert. The subsidy is only granted in connection with KfW products related to "Energy-efficient construction and refurbishment" (product numbers 151/152, 153, 430) or in connection with a programme launched by a federal state promotional institution. Further services rendered in connection with professional construction supervision that are eligible for funding include services regarding detailed planning, support during tendering and evaluation of the offers, controlling the execution of the construction work as well as acceptance and assessment of the measures.

Inspections by KfW

There will be two examinations which are prescribed by quality control: the second randomly selected inspection of calculations and verifications and the on-site inspection. Both inspections take place after the construction work has been completed. Any beneficiary who has been granted a loan or a subsidy can be selected by KfW in the scope of random sampling to be the subject of a randomly selected inspection and/or on-site inspection. The randomly selected inspection 2 is an instrument with which KfW checks bills and energy-related verification documents. In this way it is possible to ascertain whether the eligible costs were correctly reported and whether the energy-related characteristics were complied with. Further, KfW makes random checks to verify whether the expert has examined and documented the implemented measures in accordance with the "List of eligible measures".

Another important element of the KfW quality assurance system is the on-site inspection. The on-site inspection is carried out by a specialised inspector who has been commissioned by KfW. In this way, KfW can make sure that the construction project was implemented in accordance with the specifications and that the property has achieved the desired KfW Efficiency House standard. On site, the specialised inspector checks compliance with the minimum technical requirements. The result of the respective on-site inspection is presented to the builder. If any deficiencies were found that prevent achieving a KfW Efficiency House standard, the KfW standard including funding is adjusted to a lower level whenever possible. If this cannot be done, the funding amount must be paid back. Both procedures are intended to ensure the responsible use of public funds.

KfW is continually striving to improve its quality assurance concept. One example of this improvement is the KfW procedure for assessing thermal bridges, which provides experts with a simplified method when calculating the KfW Efficiency House standards. Currently, KfW is developing a quality assurance concept for non-residential buildings.

Market acceptance of the approach

The funding programmes launched by KfW and the associated quality assurance processes are well received by both builders and experts. This becomes evident when looking at several monitoring studies analysing the KfW programmes "Energy-Efficient Refurbishment" and "Energy-Efficient Construction" [9], [10], [11], which are issued on an annual basis. Regarding the total of projects funded, about one third of funding accounts for residential units under the "Energy-Efficient Construction" scheme, while two thirds of the residential units are funded under the "Energy-Efficient Refurbishment" programme. The monitoring reports further disclose that almost every second residential unit of all approved new buildings in Germany is funded from resources of the "Energy-Efficient Construction" programme.

On its website, KfW provides aids for planning, implementation, documentation as well as special information to standardize and simplify the process for all parties involved. In addition, KfW staff support all stakeholders on the phone and answer questions.

However, the on-site inspections that were carried out so far have shown that in many cases required documents for the verification of compliance still had to be completed. That applies to about 30% of the projects funded under the "Energy-Efficient Refurbishment" programme and even to 50% of the projects funded under the "Energy-Efficient Construction" programme (see Figure 2).

Share of funding commitments, share of funded flats in German new residential buildings from 2013 to 2015

In the scope of the KfW funding programmes "Energy-Efficient Construction and Refurbishment", loans and subsidies from federal funds are granted in order to create incentives for raising energy-efficient new constructions and for retrofitting existing buildings. To collect and describe the results achieved by the targets of these funding programmes (e.g. saving energy and reducing the output of greenhouse gases, in the first place) the Federal German Ministry for Economic Affairs and Energy (BMWi) and the KfW banking group provide means to conduct annual monitoring studies [9], [10], [11].

Within the framework of programmes 151 and 430 "Energy-Efficient Refurbishment", both individual measures and combinations of several measures will be performed as well as entire packages of measures in order to accomplish a KfW Efficiency House standard. In 2013, almost 111,000 funding commitments for measures to be performed at appr. 276,000 flats were granted under the "Energy-Efficient Refurbishment" programme [9]. In 2014, a little more than 97,000 funding commitments were granted for measures at about 230,000 flats [10]. In 2015, almost 105,000 funding commitments were granted for measures at about 237,000 flats [11].

In the field of new constructions, KfW promotes future-oriented standards for the entire building (programme 153 "Energy-Efficient Construction"). At present, the programme covers various KfW Efficiency House standards and passive houses. In all projects funded, the buildings have to achieve far higher energy efficiency standards than stipulated by the German Energy Saving Ordinance [1]. In 2013, 82,000 new construction projects comprising a total of about 129,000 dwellings were funded under KfW's programme 153 "Energy-Efficient Construction". Compared to the number of building permissions issued in 2013 (according to the statistics on building activity approximately 237,000 dwellings), funding thus reaches a share of about 54% in the sector of new residential construction in Germany [9]. In 2014, 73,000 new construction projects with about 108,000 dwellings were funded. Compared to the number of building permissions issued in 2014 (according to the statistics on building activity: approximately 246,000 dwellings), funding thus amounts to a share of about 44% [10]. In 2015, about 83,000 new construction projects with 142,000 dwellings were funded. This corresponds to a share of dwellings funded in the German sector of new residential construction of approximately 53% (according to the statistics on building activity, construction permits were issued for about 268,000 dwellings in 2015) [11].

Results of the on-site inspections from 2013 to 2015

After completion of the construction work, KfW carries out on-site inspections in the scope of a random spot check, during which compliance with the Efficiency House standard and/or the technical minimum requirements is examined. These on-site inspections are coordinated by the German Energy Agency, "Deutsche Energie-Agentur GmbH (dena)". Coordination is based on cooperation with about 30 specialized inspectors who record all relevant data on site. An assessment procedure was developed especially for the analysis of these inspections to ensure standardisation of the process. By performing these on-site inspections, KfW also aims at increasing the quality awareness of all parties involved. Between 2013 and 2015, more than 1,300 residential buildings were subjected to an on-site inspection [13]. This corresponds roughly to about 430 inspections per year and a sampling rate of about 0.3%.

Based on the on-site inspections performed between 2013 and 2015, KfW gained the following insights [13]:

- ✓ In the case of both KfW Efficiency Houses and KfW individual measures, the quality of planning and implementation is high
- ✓ In the case of KfW Efficiency Houses under refurbishment, there is a positive trend in first results (the number of cases in which a KfW Efficiency House standard was not achieved and cancellation followed, has declined (see Figure 2))
- ✓ Risks for non-compliance with programme requirements result from:
  - Calculation errors
  - Modifications in the construction progress that have not been compensated for
  - Absence of compliance verification documents

- ✓ The results confirm that quality assurance plays an important role in the entire planning and construction process.

The following graph shows the results of the on-site inspections made at KfW Efficiency Houses between 2013 and 2015 [13]. All in all, the analysis of the on-site inspections prompts very good results and proves the effectiveness of KfW's funding programmes. In 95 to 99% of all cases, an Efficiency House standard is achieved. Failure to achieve an Efficiency House standard remains on a low level, amounting to 1 to 5% of all projects. The graph also shows that 99% of the new construction projects achieved a KfW Efficiency House standard in 2013, 96% in 2014 and 95% in 2015 - including cases of late submission of required verification documents (relating to e.g. hydraulic balance, air tightness, thermal bridges).

The analysis of refurbishment projects yields similar results. Here, too, KfW Efficiency House standards were achieved after completed submission of required verification documents: 96% in 2013, 95% in 2014 and 97% in 2015. Taking a closer look at the inspected refurbishment projects, it can be noticed that in 15% (2013) and 8% (2015) of the cases funding was adapted to the actual situation, as the KfW Efficiency House standard that had initially been applied for was not entirely accomplished; i.e. the project was downgraded to an inferior KfW Efficiency House standard.

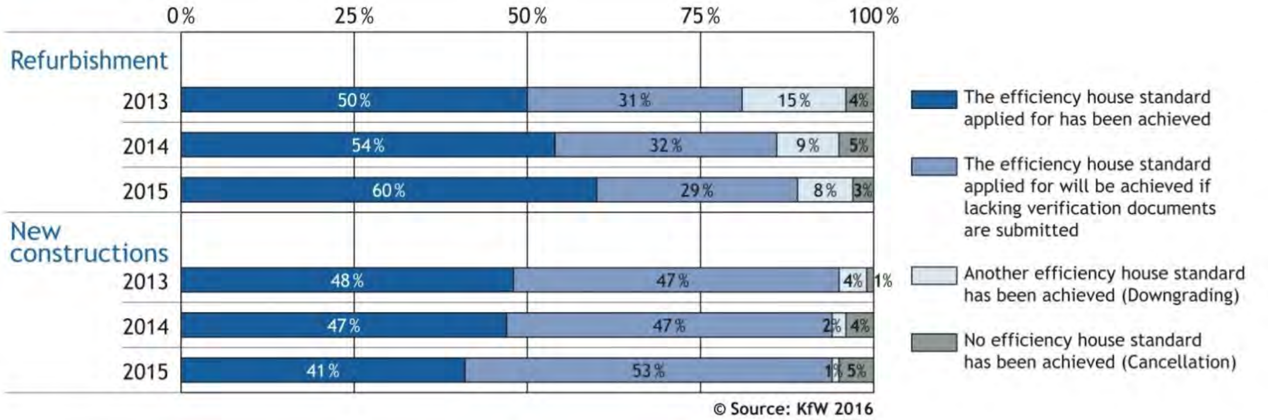


Figure 2: Results of the on-site inspections carried out on KfW Efficiency Houses between 2013 and 2015 (residential buildings) [13]

Analysed sources of defect

In most cases, several defects will add up between planning and completing the construction project. These errors may be made as early as in the energy balance calculations or they are caused by changes in the construction progress. Two categories of defects can be distinguished: defects of the building envelope and defects of the building services systems[13].

- ✓ In relation to the building envelope, typical mistakes include:
- ✓ Absent documentation of the U-value calculations
- ✓ Absent or faulty assessment of thermal bridges - when using the reduced allowance for thermal bridging
- ✓ Incorrect assumptions of the balancing zones (e.g. the heated basement area is not considered, the thermally relevant basement access is not taken into account as a heated space in an unheated area)
- ✓ At single or several building components, modifications of the insulation quality or the insulation thickness are made - while these modifications are not compensated for by increasing the insulation quality or the insulation thickness of other components
- ✓ There is no thermal insulation towards unheated building zones

Typical mistakes occurring in the field of building services systems include:

- ✓ Incorrect assumptions made for heat generators in the energy assessment (e.g. solar thermal fraction, electric immersion heater at heat pumps, wood-burning fireplace without hydraulic connection)
- ✓ Use of product-specific characteristics - without indication of the actual products used
- ✓ Modifications of the building services concept are made, which are not compensated for at another place
- ✓ Absence of verification documents, for instance for the hydraulic balance and for airtightness measurements

Compliance concerns related to EP certificates and to the QM approach

No reporting ☐	Wrong reporting ☑	Not meeting the performance requirements ☑

Compliance concerns related to EP certificates (see QUALICHeCK terms and definitions)

Financial aspects

The KfW's quality assurance concept not only implies higher efforts on behalf of KfW itself, but also causes greater financial efforts on the part of the builders. The exact amount of the costs incurred on KfW due to this quality assurance scheme is not known. The additional costs incurred on the builder (due to contracting an expert specified in the list of energy-efficiency experts) is partially accounted for by KfW subsidies.

Funding of "On-site Advice" (BAFA)

Prior to refurbishment, the German Federal Office of Economics and Export Control (Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA) funds a comprehensive energy consulting procedure, the so-called "On-site Advice". In the scope of this consultation, the energy adviser proposes an energy retrofitting concept and summarizes the results in an energy consulting report. In this case, the application for funding is submitted by the energy adviser.

For the consulting costs that are eligible for funding, a subsidy of 60% is granted. In the case of detached and semi-detached houses, maximum funding amounts to € 800; for apartment buildings comprising at least three residential units, the maximum sum totals € 1,100. For giving an additional presentation of the energy consulting report at the property owners' meeting or the advisory board meeting, the energy adviser will receive a subsidy amounting to 100% of the eligible costs for consultancy services. Here, funding is however limited to a maximum of € 500.

Funding of energy-related construction supervision

KfW will grant a separate subsidy covering up to 50% of the costs incurred for sectoral planning relating to energy performance and construction supervision by an independent expert. However, the maximum subsidies for each project amount to € 4,000. Any subsidy that amounts to less than € 300 will not be paid out. The expert's construction supervision services will be funded via the programme "Energy-Efficient Construction and Refurbishment" - subsidy for construction supervision (431). It is only available in combination with the KfW products 151/152, 430 and 153. Further services, which are included in the services of construction supervision, are:

- ✓ Services relating to detailed planning
- ✓ Support during tendering and evaluation of the offers
- ✓ Controlling the execution of the construction work and
- ✓ Acceptance and evaluation of the measures.

It is possible to combine both types of funding (i.e. funding of on-site advice (BAFA) and funding of energy-related construction supervision); separate applications for funding are however recommended.

The KfW quality assurance measures will raise additional costs also on the part of the independent expert who wants to be enrolled in the energy efficiency experts list. For instance, the listed experts have to pay a one-off fee of € 50 plus VAT when their names are entered on the list. Further, they have to pay an annual fee of € 100 plus VAT as soon as their names are published on the list. For members of network partners such as e.g. chambers, associations, and qualified networks, the annual fee is € 50 plus VAT, as registration via the respective organisation will be cheaper and less complicated for these experts. The one-off costs of € 50 plus VAT cover the financial effort for organisation, technical advancements of the list and the checking of the data submitted.

To sum it up:

- ✓ A one-off payment of € 50 plus VAT
- ✓ Recurring payments of € 100 plus VAT per year (for members of network partners: € 50 plus VAT)

No further costs will be incurred due to fines for non-compliance or technical minimum requirements or required characteristics. If any mistakes in specialist planning are detected, these may either be corrected or the application will be rejected, which means there will be no "Online confirmation of the application". If any deficiencies are identified on completion of the building project, which result in failing to achieve a specified KfW Efficiency House standard, the respective KfW standard including funding will be adapted to a lower level (if possible) - otherwise, the funding sum must be paid back. The application of this measure ensures responsible use of public funds.

Overall evaluation

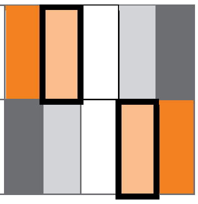
The comprehensive quality assurance concept developed by KfW for ensuring and checking the effectiveness of its funding programmes "Energy-Efficient Construction and Refurbishment" is very elaborate and well-structured. The individual elements that are comprised in this quality assurance system are interrelated and become effective as early as in the planning stage. The examination covers the entire construction process right through to completion of the project. However, KfW's quality assurance concept implies additional effort and additional expenditure for all parties involved. For instance, communication and the exchange of information and data among all stakeholders are vital for the successful completion of a construction project and must not be neglected. The quality assurance concept is not only useful for KfW - it is also beneficial for the builders to whom it provides additional security for their construction projects. Additional advantages and disadvantages associated with the quality assurance system have been compiled in table 1.

Pros	Cons
✓ Improved control ✓ Increased quality ✓ Surveillance by an independent expert ✓ The expert's qualification has been verified ✓ Documentation from the design phase through to completion ✓ Identification of planning errors before filing the application (EBS inspection tool) ✓ The results of the controls performed by KfW are submitted to the builder	✓ Requires additional effort for all parties involved ✓ Causes additional costs for all parties involved ✓ The expert must be included in the list of energy-efficiency experts for federal funding programmes (www.energie-effizienz-experten.de). It is not allowed to commission an expert "of one's own", who maybe enjoys more trust on the part of the builder but who is not included in the official list of energy-efficiency experts. ✓ The random inspections are not exhaustive tests; only part of the funded construction projects will be inspected

Table 1: Overall pros and cons of the approach

Level of complexity
(dark orange = simplest)

Potential for replication
(dark orange = best)



Prerequisites

If the concept of quality assurance is to work properly, it is essential to have clear and unequivocal definitions of the minimum requirements and the programme boundary conditions that must be observed. Moreover, it is necessary to keep and update a quality-assured list of registered energy-efficiency experts specifying certified specialists. The specialist/expert is required to have technical knowledge and practical experience. With regard to simplification, to error avoidance and to ensuring extensive controls/supervision, it is recommended to reasonably automate the inspection processes as far as possible. To enable detailed controls of verification documents, bills, and documentations during random checks, technically skilled and experienced staff is required. Cooperation with additional, independent specialized inspectors is needed to be able to control the quality of the projects on site. In this respect, too, it is important to develop standardised procedures, allowing every project to be subjected to equal controls.

Hints	Pitfalls
✓ Regarding quality assurance of funding measures, it is necessary to find a good balance between cost and benefit for all parties involved. ✓ The additional benefit for the builder (besides receiving funding) should be pointed out (e.g. better quality of the building measure, support in planning and implementation). ✓ The share of random inspections must be high enough to have an effect on the beneficiaries while remaining feasible. ✓ The use of an experts list that was created and monitored by another organisation facilitates the task.	✓ Establishing a well-functioning automated random inspection routine requires detailed knowledge of energy performance certificates and the calculation procedures used. ✓ The complexity of the application and the required monitoring procedure may have a deterrent effect on applicants. In this way, less refurbishment projects would be implemented. ✓ For a task like this, a promotional bank needs not only commercial staff, but also a technical division.

Table 2: Overall hints and pitfalls to avoid when developing such an approach

References

[1] Bundestag und Bundesrat/ German Parliament and Federal Council: Verordnung ueber energiesparenden Waermeschutz und energiesparende Anlagentechnik bei Gebaeuden (Energieeinsparverordnung - EnEV). [Energy saving Ordinance - EnEV]. Unofficial reading version, status as of 28 October 2015. Available under www.bbsr-energieeinsparung.de/EnEVPortal/DE/EnEV/EnEV2013/Download/Lesefassung_EnEV2013.pdf?__blob=publicationFile&v=11. [accessed: Jan. 9, 2017]

[2] KfW-News: Mehrstufiges Qualitaetssicherungskonzept der KfW. Meldung vom 02.07.2014. [The KfW multi-stage quality assurance concept. Announcement published July 2, 2014.] Website: https://www.kfw.de/KfW-Konzern/Newsroom/Aktuelles/News/News-Details_211329.html [accessed: Jan. 11, 2017]

[3] KfW-Partnerportal: Ueberblick Architekten, Ingenieure und Energieberater. Online-Bestaetigung. [Overview architects, engineers and energy consultants. Online confirmation.] Website: https://www.kfw.de/partner/KfW-Partnerportal/Architekten-Bauingenieure-Energieberater/Online-Bestätigung/index.jsp [accessed: Jan. 11, 2017]

[4] KfW-Fuer Privatpersonen/ Private customers: Energieeffizient Sanieren. Qualitaetssicherung. [Energy-efficient refurbishment. Quality assurance.] Website: https://www.kfw.de/inlandsfoerderung/Privatpersonen/Bestandsimmobilie/Energieeffizient-Sanieren/Qualitätssicherung/#1 [accessed: Jan. 11, 2017]

[5] KfW-Konzern: Download-Center. Energieeffizient Bauen und Sanieren - Zuschuss Baubegleitung (431) - Merkblatt. Stand 11/2016 [Energy-efficient construction and refurbishment - Subsidy construction supervision (431) - Fact sheet. Status as of Nov. 2016] Available at: https://www.kfw.de/KfW-Konzern/Service/Download-Center/Förderprogramme-(Inlandsf.)-(D-EN)/Barrierefreie-Dokumente/Energieeffizient-Bauen-und-Sanieren-Zuschuss-Baubegleitung-(431)-Merkblatt-ab-04-2016/ [accessed: Jan. 11, 2017]

[6] KfW-Fuer Privatpersonen/ Private customers: Energieeffizient Sanieren. Qualitaetssicherung. Nachweispruefung. [Energy-efficient refurbishment. Quality assurance. Verification of compliance documents.] Website:https://www.kfw.de/inlandsfoerderung/Privatpersonen/Bestandsimmobilie/Energieeffizient-Sanieren/Qualitaetssicherung/#3 [accessed: Jan. 11, 2017]

[7] KfW-News: Pressematerial. Themen kompakt: Bauen und Sanieren. Qualitaetssicherung. [Press material. Special topics service: Construction and Refurbishment. Quality assurance.] Website: https://www.kfw.de/KfW-Konzern/Newsroom/Pressematerial/Themen-kompakt/EBS/Qualitaetssicherung/ [accessed: Jan. 11, 2017]

[8] KfW-News: Pressematerial. Themen kompakt: Bauen und Sanieren. Weitere Fakten. [Press material. Special topics service: Construction and Refurbishment. Additional facts.] Website: https://www.kfw.de/KfW-Konzern/Newsroom/Pressematerial/Themen-kompakt/EBS/Weitere-Fakten/ [accessed: Jan. 11, 2017]

[9] Diefenbach, N., Stein, B., Loga, T., Rodenfels, M., Gabriel, J., Fette, M.,: Monitoring der KfW-Programme „Energieeffizient Sanieren“ und „Energieeffizient Bauen“ 2013. [Monitoring of the KfW programmes "Energy-efficient refurbishment“ and "Energy-efficient construction“ 2013.] Expert report. Status as of Dec. 5, 2014. Available at www.kfw.de/KfW-Konzern/Service/Download-Center/Konzernthemen-(D)/Research/Evaluationen/Evaluationen-Energieeffizient-Bauen-und-Sanieren/ [accessed: Jan. 17, 2017]

[10] Diefenbach, N., Stein, B., Loga, T., Rodenfels, M., Gabriel, J., Fette, M.: Monitoring der KfW-Programme „Energieeffizient Sanieren“ und „Energieeffizient Bauen“ 2014. [Monitoring of the KfW programmes "Energy-efficient refurbishment“ and "Energy-efficient construction“ 2014] Expert report. Status as of Nov. 24, 2015. Available at www.kfw.de/KfW-Konzern/Service/Download-Center/Konzernthemen-(D)/Research/Evaluationen/Evaluationen-Energieeffizient-Bauen-und-Sanieren/ [accessed: Jan. 17, 2017]

[11] Diefenbach, N., Stein, B., Loga, T., Rodenfels, M., Gabriel, J., Jahn, K.: Monitoring der KfW-Programme „Energieeffizient Sanieren“ und „Energieeffizient Bauen“ 2015. [Monitoring of the KfW programmes "Energy-efficient refurbishment“ and "Energy-efficient construction“ 2015] Expert report. Status as of Nov. 11, 2016. Available at www.kfw.de/KfW-Konzern/Service/Download-Center/Konzernthemen-(D)/Research/Evaluationen/Evaluationen-Energieeffizient-Bauen-und-Sanieren/ [accessed: Jan. 17, 2017]

[12] Statistisches Bundesamt/ Federal Statistical Office: Bautaetigkeit und Wohnungen. Fachserie 5, Reihe 1. [Construction activity and flats. Subject-matter series 5, series 1.] Published Aug. 12, 2016, corrected Sept. 28, 2016. Available at www.destatis.de/DE/Publikationen/Thematisch/Bauen/BautaetigkeitWohnungsbau/Bautaetigkeit.html [accessed: Jan. 17, 2017]

[13] Schenker, A., Voelksch, O.: KfW-Qualitaetssicherung: Die Dos and Don‘ts der Effizienzhausplanung. Praesentation. [KfW Quality assurance: The Dos and Don‘ts in efficiency house planning. Presentation.] Status as of Nov. 23, 2016. Available at http://www.dena-kongress.de/medien/vortraege-und-videomitschnitte/ [accessed: Jan. 17, 2017]

[14] KfW-Partnerportal: Architekten, Bauingenieure und Energieberater.[Architects, Civil Engineers and Energy Consultants.] Website: https://www.kfw.de/partner/KfW-Partnerportal/Architekten-Bauingenieure-Energieberater/index.jsp [accessed: Jan. 17, 2017]

[15] KfW-Zuschussportal: Online-Beantragung von Zuschuessen. [Filing an online application for subsidies.] Website: https://public.kfw.de/zuschussportal-web/ [accessed: Jan. 17, 2017]

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Technology	*Aspect*	*Country*
Ventilation and airtightness	Compliance frameworks	France

THE EFFINERGIE APPROACH TO EASE TRANSITIONS TO NEW REGULATORY REQUIREMENTS

Since 2006, the Effinergie certification has been a major market driver in France for energy efficiency initiatives in all building types, new and renovated. It has been a laboratory for the 2012 energy regulation in France, for instance, for the overall primary energy minimum requirements or for the mandatory justification of an envelope airtightness level. In the same vein, the Effinergie+ and Bepos labels operational since 2012 and 2013 experiment new requirements and methods, which will serve for the 2020 revision of the energy regulation. Effinergie also developed regulatory-based low-energy buildings certifications for renovated buildings which are operational since 2009.

Residential buildings ☑	Non-residential buildings ☑	Specific buildings: ……
New buildings ☑	Existing buildings ☑	

Context

Experience shows that the market uptake of new regulatory requirements can be difficult without a transition phase with intense information and pedagogy towards building professionals and project owners. Insufficiently prepared transitions can erode societal support in particular if the rules are poorly understood and applied, and therefore can jeopardize achieving the goals sought.

This fact sheet describes the genesis, results, and perspectives of the Effinergie certification which has been developed to cope with these problems, with a focus on airtightness and ventilation compliance checks.

Objectives

The Effinergie association was created in May 2006 to promote low energy buildings in France. For the first time, it introduced a minimum requirement on building airtightness to be justified either by a measurement or the application of an approved quality management approach (see fact sheets #01 and #07, [1] [3]). Beyond the rationale of this requirement based on the energy impact of envelope leakage, the underlying idea was also to initiate a move from paper checks towards as-built performance checks.

The overall objective of the Effinergie approach to building airtightness was to experiment a new type of requirement, which if successful, could be integrated in the revision of the energy regulation. This entailed as specific objective to set up a compliance framework for airtightness testers.

Genesis of the approach

The Effinergie initiative originally stemmed from regional authorities, associations, financial institutes, etc. seeking to bring forces together to achieve a radical change in building construction by urging and helping project owners to achieve low energy buildings. Looking at the levels of energy use achieved compared to standard buildings (≤ 50 kWh of primary energy including heating, cooling, ventilation, auxiliary equipment, domestic hot water, lighting), the Effinergie label could be compared to the Minergie or Passivhaus labels (http://passiv.de/en/, http://www.minergie.ch).

In 2006, the Effinergie association undertook several key actions to develop an approach to prefigure the revision of the building energy performance regulation, including:

- ✓ developing the label requirements with a set of rules that were discussed with stakeholders and updated when necessary based on field feedback;
- ✓ setting up regional or national subsidies to promote the label amongst project owners;
- ✓ coordinating with several certification bodies to deliver the label;
- ✓ developing a compliance framework, including for airtightness testing which was seen as a particular challenge given the status on the ground.

Note that the Effinergie label was firmly based on the energy performance regulation: it was based on the same input data and calculation procedures, but set additional or more stringent requirements compared to those imposed by the regulation. It was introduced by ministerial order as a state label "BBC" in 2007[1].

Compliance framework for building airtightness requirements

The compliance framework for building airtightness requirements was based on a set of rules laying down:

- ✓ the minimum requirements depending on building type (≤ 0.6 m^3/h per m^2 at 4 Pa of cold area excluding lowest floor for single-family buildings, 1,0 for multi-family buildings);
- ✓ the requirement that the airtightness test be performed by an approved qualified third party;
- ✓ procedures explaining how to show compliance including how to perform the airtightness test and removing discrepancies as a result of ambiguities and open options in EN 13829;
- ✓ the approval of the levels achieved by the certification body;
- ✓ the collection of airtightness tests results in a national registry (approved qualified testers were required to record all their test results in a registry to send yearly to a national committee to renew their approval);
- ✓ a national committee in charge of implementing rules to qualify and approve the testers;
- ✓ a national committee in charge of developing and approving rules and evaluating the market feedback and complaints (so-called Club Perméa).

Market progress monitoring and analysis of market feedback

At the end of September 2011, 42 000 individual houses, 230 000 multi-family dwellings and 4 millions of m^2 of non-residential buildings had been or were in the process of being Effinergie-labelled. There is no doubt that the financial incentives linked to the label have been a strong driver. Nevertheless, the handling process of the feedback of professionals and project owners has been a critical success factor, together with the field data collection. For instance, the requirements for the qualification of the testers or the reporting of the test results have regularly evolved between 2007 and 2010.

Note also that 2 years after the inauguration of the BBC-Effinergie label, the Ministry of the Environment and Effinergie teamed to co-develop the Observatoire BBC (www.observatoirebbc.org) to share experience and monitor the implementation of low energy buildings. Beyond being an effective communication and dissemination channel for the label, this has been a data mine gold to analyse the specificities of building complying with the label as well as to confirm market trends (see for instance the analysis of airtightness data in TightVent Newsletter # 3).

Statistical data summarising the number of operations is available with the Observatoire BBC (www.observatoirebbc.org), where graphs such as Figure 1-Figure 2- can be easily produced by the website visitor.

[1] *Arrêté du 8 mai 2007 relatif au contenu et aux conditions d'attribution du label « haute performance énergétique » Official Journal of the French republic of 15 May 2007, page 8909.*

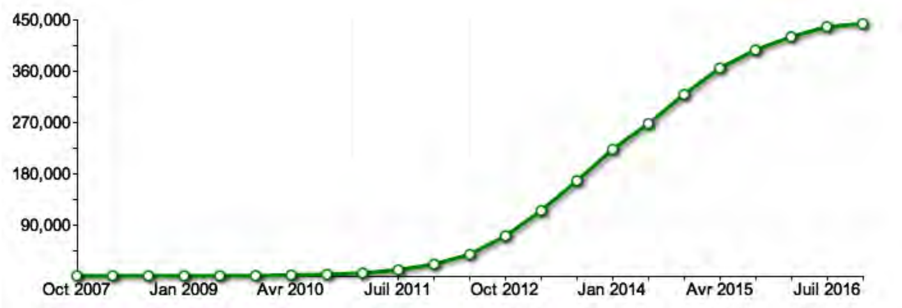

Figure 1: Cumulative number of BBC-Effinergie certified multi-family dwellings.

Figure 2: Cumulative number of BBC-Effinergie+ certified multi-family dwellings.

Integration in the 2012 regulation

The Effinergie label has been an extremely valuable experiment to set and tune the requirements of the 2012 regulation (RT 2012, [6]). In fact, the 2012 regulatory requirements are close to those of the Effinergie label. With regard to building airtightness, they are identical.

There was a radical step between the requirements of the 2005 and the 2012 regulations. Thanks to its active promotion amongst stakeholders using many communication channels including regional seminars reporting on pilot projects, the Effinergie label was a ramp to climb up to the new requirements and prepare the market. Of course, some stakeholders were still unprepared which could have jeopardized the effective adoption of the regulation, but the momentum of the front-runners and early followers was more than enough to balance that effect.

Additional ventilation and airtightness checking requirements with the Effinergie+ label in view of the *2020 revision of the energy regulation*

Given the uptake of the 2012 regulation, Effinergie decided to experiment additional requirements regarding ventilation provisions and ductwork airtightness [4]. These are known to be 2 weak spots, with field campaigns showing a non-compliance rate over 50% for ventilation provisions (see QUALICHeCK fact sheet # 06, [2]) or pointing out excessive ductwork leakage [7].

Note that there exists a ventilation regulation in France. It requires that both functional measures and given airflow rates must be attained in order to comply with the regulation. However, the regulation does not impose any justification that these requirements (including the actual airflow rates) are met in practice (see QUALICHeCK fact sheet #06).

To overcome this problem, the Effinergie+ label operational since 2012 introduced the following requirements [5]:

- ✓ the ductwork airtightness must comply with airtightness class A (the levels are defined in EN 12237 or EN 1507);
- ✓ the ventilation system must be commissioned with a protocol specified by Effinergie.

The protocol has been developed by one of the national committees aforementioned (Club Perméa). It spells out the rules to perform the airtightness test beyond the standards to remove ambiguities. This includes, for instance, the sampling rules to allow the test to be performed on parts of the ductwork system for practical reasons, or how to prepare the ductwork section for the test (which parts shall or shall not be included). The protocol also explains how to perform a visual check of the completeness of the system and gives guidelines to perform and analyse airflow rate measurements.

Note that while the protocol requires a visual check of the ventilation system, it does not require the measurement of the airflow rates as of today: airflow rate measurements are optional. This is due to the lack of knowledge on the uncertainties obtained when measuring airflow rates at air terminal devices when the label was developed. For this reason, Effinergie is a partner of the Promevent project (http://promevent.fr), supported by the French Energy Agency and the French government, which aims at increasing this knowledge to introduce airflow rate measurement requirements in voluntary approaches (e.g., Effinergie+) or regulatory requirements to be eligible for benefits (e.g., bonus for the land occupation density).

Because of the time span between a building project idea and commissioning, there is as of today little feedback from the field and it is too early to evaluate the relevance and acceptance of these new Effinergie+ requirements; however, this is clearly an objective for the association as soon as the data is sufficient.

Financial aspects

The Effinergie association has a staff of 5 persons but this represents a very small part of the overall cost of the Effinergie approach which involves many other parties e.g., staff from regional authorities, state authorities, and local or national energy agencies to handle the calls and subsidies. The overall cost is difficult to assess because of the time needed to develop and implement the framework, the tools developed to help the applicants, and the financial incentives at state and regional levels. The only publicly visible cost is the cost charged by the certification bodies to certify a given building: for Bepos or Effinergie+ certifications, the certification bodies charge between 200 and 250 € for an individual dwelling; Effinergie does not charge anything.

Overall evaluation

This fact sheet presents the Effinergie stepwise approach to strengthen or introduce new regulatory requirements since 2006. The basic idea is to prepare the market by introducing and encouraging the adoption of a label with requirements anticipating future regulations. This implies that the general objectives of the future regulations are clear enough when the label is developed.

The undeniable success of the Effinergie label highlights the key role of regional authorities in the initiative with calls for pilot projects complying with the label, but also the synergetic effect of everyone to promote the label as an experiment for the next regulation and to financially and technically support the project.

Obviously, the radical change to low-energy buildings with the 2012 regulation would not have been possible without the transition period with Effinergie and the lessons learnt from the original Effinergie requirements, with an efficient handling process of the feedback from stakeholders. The stakeholders' consultation for the development of the 2012 regulation built on these results with stakeholders globally supporting this radical change.

The compliance framework for building airtightness is now fully operational in the 2012 regulation. It has served as inspiration for additional requirements on ventilation system performance checks, including ductwork airtightness. These latter schemes remain to be evaluated to find out if they should be considered for the next revision of the building energy regulation.

Level of complexity (dark orange = simplest)	
Potential for replication (dark orange = best)	

Prerequisite:

Political support to develop the approach as it requires significant human and financial resources and a long-term vision of the evolution of the regulation

References

[1] Carrié, F.R. and Charrier, S. 2015. Building regulations can foster quality management – the French example on building airtightness. QUALICHeCK fact sheet # 01, available at http://qualicheck-platform.eu/wp-content/uploads/2015/02/QUALICHeCK-Factsheet-01.pdf

[2] Carrié, F.R., Charrier, S., and Bailly, A. 2015. Regulatory compliance checks of residential ventilation systems in France. QUALICHeCK fact sheet # 06, available at http://qualicheck-platform.eu/wp-content/uploads/2016/03/QUALICHeCK-Factsheet-06.pdf

[3] Charrier, S., Bailly, A., and Carrié, F.R. 2015. Building airtightness in France: regulatory context, control procedures, results. QUALICHeCK fact sheet # 07, available at http://qualicheck-platform.eu/wp-content/uploads/2016/03/QUALICHeCK-Factsheet-07.pdf

[4] Effinergie +. 2014. Règles Techniques applicables aux bâtiments neufs faisant l'objet d'une de demande de label Effinergie+, Validées par le CA du 3 juin 2014. http://www.effinergie.org/images/BaseDoc/1066/20140603_r%C3%A8gles_techniques_Effinergie+_V5.pdf

[5] Effinergie +. 2015. Protocole de contrôle des systèmes de ventilation des bâtiments demandant le label effinergie +, Version 3 - Mai 2015. http://www.effinergie.org/web/images/permea/20150512_protocole_contrôle_ventilation_V3.pdf

[6] RT 2012. 2010. Arrêté du 26 octobre 2010 relatif aux caractéristiques thermiques et aux exigences de performance énergétique des bâtiments nouveaux et des parties nouvelles de bâtiments. Official Journal of the French Republic of 27 October 2010.

[7] VIA-Qualité. 2016. Guide pratique à destination des constructeurs de maisons individuelles. Mettre en œuvre une démarche pour améliorer la qualité de l'air intérieur en maisons individuelles. Rapport Cerema, 2016.

Acknowledgement

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Technology ALL	*Aspect* Compliance frameworks	*Country* Belgium

BELGIUM/FLEMISH REGION CONTROL AND PENALTY SCHEME OF THE ENERGY PERFORMANCE LEGISLATION: CHECKING PROCEDURE AND FINES

Former studies showed that that the legislation is not respected if it is not combined with an operational control scheme. That is why in Belgium, a checking procedure, including on-site control, was implemented with the introduction of the Energy Performance legislation for new buildings. This fact sheet describes the checking procedure, including the penalty scheme and the role of the actors involved. It also gives some examples of the amount of the fines applicable in specific cases.

Residential buildings ☑	Non-residential buildings ☐	Specific buildings: ……
New buildings ☑	Existing buildings ☐	

Context

The Belgian SENVIV-study (1998) demonstrated that the new insulation regulation implemented in 1992 had nearly no impact on the building practice. The requirement was an insulation level ensuring not to exceed K65 maximum for individual dwellings and apartments[1], and later the more ambitious insulation level of K55 maximum was introduced. Figure 1 shows that there was no improvement of the average insulation level with the arrival (or the reinforcement) of this energy regulation: the black horizontal bars represent the requirements of K65 and K55, while the coloured vertical bars show the actual insulation level investigated by the SENVIV-study determined on 200 dwellings and apartments. We have to conclude that there was no respect of the legislation by lack of a control scheme.

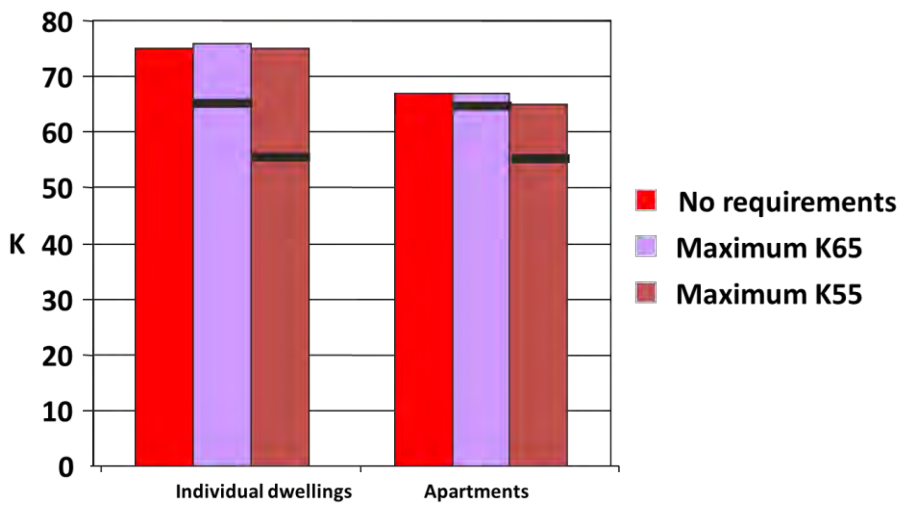


Figure 1: Evolution of the real K-performance according to the requirement level

The results of the SENVIV-study pointed out clearly that an effective compliance checking procedure, including fines, was needed.

[1] *A K65 performance corresponds for small buildings to an average U-value at the building level of 0.65 W/m²K.*

Therefore, a control procedure addressing the weak points identified was developed and introduced in 2006 [1]. The procedure embraces the period from submitting the building permit until 6 months after commissioning of the building (see Figure 2). The compliance check is no more done at the building permit stage but at the as-build stage when the construction works are finished and all compliant input data for the calculation are available.

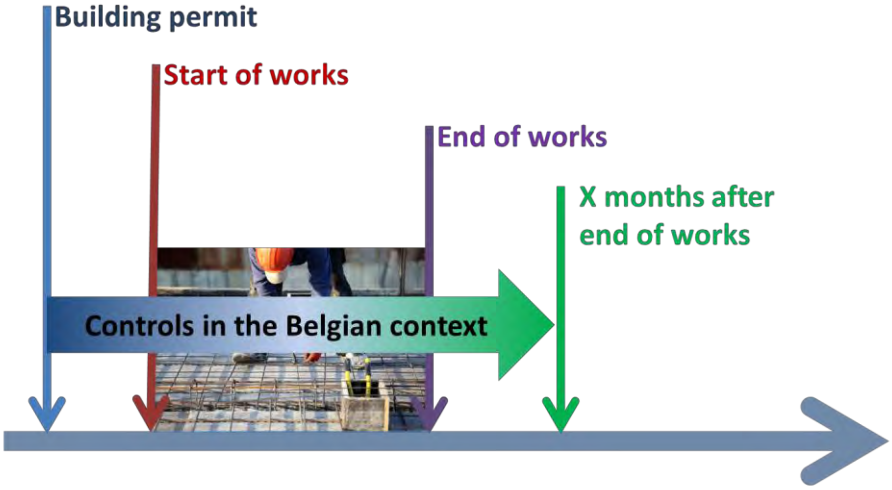


Figure 2: Period of possible controls in the Belgian context: from the building permit to six months after the end of works

The main points of this procedure are explained in this fact sheet.

Subject of control and applied methods

The official flemish calculation software produces the EPB (Energy Performance of Building) declaration serving as a proof of compliance, and there is only one single software product acknowledged by the competent authority. The competent authority for checking compliance is the Flemish Energy Agency VEA (Vlaams Energieagentschap) [2]. Table 1 provides an overview of minimum requirements for new residential buildings, which parameters are controlled at what stage of the process, and what method is applied for checking compliance.

	(1) Building permit submission	(2) After completion
Do the documents exist?	All the design parameters have to be reported in the INITIAL declaration (by the EPB rapporteur) If not, then no permit	All the design parameters have to be reported in the FINAL declaration by the EPC rapporteur If not, then penalty to the owner
Have the EPB-requirements been respected?	All the requirements are automatically controlled in INITIAL declaration thanks to the official EPB software and have to be fulfilled. If not, then no permit	All the requirements are automatically controlled in FINAL declaration thanks to the official EPC software and have to be fulfilled. If not, then penalty to the owner
Is the declared information compliant?	No control at this stage	The civil servant can carry out additional controls. For example control of the EPC product data or controls on site. The information in the FINAL declaration conform to the "as-built" situation. If not, penalty to the EPC rapporteur

Table 1: Overview of minimum requirements for new buildings and parameters to be checked

Control procedure

The control procedure is based on principles which are presented in the form of lead questions:

- ✓ Do the required documents exist?
- ✓ Have the EPB-requirements been respected?
- ✓ Is the declared information correct and compliant with the specific applicable rules?

More information is presented in the paragraphs below.

Do the documents exist?

For each building subjected to the energy performance regulation, a rapporteur has to be defined. He or she has to report all the information related to the calculation of the E-level[2] and other parameters that have to be respected regarding minimum requirements (insulation level, ventilation systems,…) through two documents:

- ✓ a first declaration ("startverklaring") made at the building permit stage and submitted to the authority;
- ✓ the final EPB declaration submitted to the authority within six months after commissioning of the property which is done prior to handing it over.

Documents are submitted electronically. The electronic submission procedure is an important element of the control system because checking of defined parameters is simple and effective, and includes all submitted declarations. Furthermore, it allows to define a targeted sample for on-site checking based on the results of the electronic check. The consequences of not submitting the declarations at the right time, or not all, are explained in the chapter "Penalty scheme".

Have the EPB-requirements been respected?

The control of the compliance with the requirements is done by an inspector who is a civil servant and refers to the actual building. The authority represented by the inspector is entitled to perform controls on the construction site, at different moments in the construction process (see Table 1):

- ✓ During the works: focus is on items that are difficult to check after completion of the building such as floor insulation, wall insulation, ...
- ✓ After completion of the works: focus is on the functioning of the heating installation or ventilation system, ….

It is the owner, and not the rapporteur, who is responsible for the compliance with the EP-requirements. Taking into account specific conditions related to the information of the owner during the construction process, a rapporteur reporting a non-compliance with the EP requirements based on correct input data does his duty properly and doesn't risk any sanction for that (see chapter on penalty scheme). It has to be mentioned that examples are existing in Europe where the IT systems makes that the declaration of a non-conformity is impossible. Such situations are forcing false declaration and have as a consequence a 100% compliance rate, which is not representing the reality.

The inspector checks whether the as-built condition complies with what is stated in the final EPB declaration. The database checks and detects automatically the compliance or non-compliance of the as-built situation of the project in the final declaration. In case of non-compliance, the procedure is being started to impose the fine.

Regarding the sample of checked buildings, there is no fixed number or ratio. Every year, it is decided to check a specific point with a specific depth, for example, to check the ventilation or heating installation in the building. The sample of the checked building varies. In 2016, 45 buildings have been controlled. In any case, if there is an incoming complaint, a checking procedure starts.

The consequences of not meeting the minimum requirements are explained in the chapter "Penalty scheme".

Is the declared information correct and compliant with the specific applicable rules?

The authority carries out the on-site control, allowing the inspector to check the trueness of declared data. The rapporteur is responsible for the correct reporting of all the means related to energy performance and indoor climate of the building. If the declaration is wrong and does not comply with the

[2] *Dimensionless E-level: the annual primary energy consumption divided by a reference consumption is the maximum allowed energy performance level [2]*

actual situation at the building site, he or she is responsible and has to pay a fine.
After fixing errors and correcting the declaration, the authorities require the submitting of a correct EPB declaration by the rapporteur. If the submitting is delayed beyond the deadline, the owner should pay an additional fine.

The consequences of presenting wrong information in the EPB declaration are explained in the chapter "Penalty scheme".

Penalty scheme

Who is responsible?

The inspectors do not have to investigate which parties are (partly) responsible. As briefly explained above, two main cases are considered:

- ✓ the rapporteur is responsible towards the authority for the correct declaration of the realized works;
- ✓ the owner is responsible towards the authority for the compliance with the EP requirements.

In the first case, the declaration is wrong in terms of input data used to produce the declaration, and so the rapporteur is responsible and has to pay the fine. Of course, the rapporteur should be able to transfer the fine to the person who made the error, by means of a civil lawsuit (independent of the energy performance legislation). Therefore, the rapporteur should have a strong case to recover cost from those who made the fault. For that, he or she has to collect relevant documents (invoices, technical prescriptions, visit reports, …).

Case two applies when the declaration is produced with correct input data and states that the building does not meet the requirements, or when the declaration was submitted too late or was not submitted at all. In this case, the owners are considered to be responsible and have to pay the fine. It could be pertinent to question the choice of making private owners responsible because they are considered as non-competent in building matters. However, the legislation specifies that "… the architect must inform the owner if certain decisions might lead to non-conformity with the legal requirements". Thus, it is the owner who is responsible for non-compliance resulting from specific decisions.

Note that the first case is met the most often.[3]

The different offences and roles of involved actors are summarized in Table 2.

Offence	Identified by:	Identified based on:	Results in penalty for:	Amount of penalty depends on:
The deadline for submitting the EPB declaration is not respected	Authority	Electronic submission procedure	The owner	For the first declaration, payable fine is 250 €. For the final declaration, the fine is 1,000 € +1 €/m² (with a maximum of 10,000 €). Another amount is added to the fine according to the delay: 10 € per day.
The EPB declaration does not correctly present the actually used materials and/or the techniques	Authority	On-site inspection, comparing actual situation with EPB declaration Connection between different databases (for instance green certificates for PV-panels)	The rapporteur	Depends on the non-conformity. The penalty is calculated on base of the difference between the reported value and the recalculated value by the inspector (Cf. examples in the Table 3)

[3] http://www2.vlaanderen.be/economie/energiesparen/epb/doc/veelgemaaktefout_asbuiltsituatie.pdf *(in Dutch)*

Offence	Identified by:	Identified based on:	Results in penalty for:	Amount of penalty depends on:
One or more EPB requirements are not met	The rapporteur	Input data provided by other parties and used for calculating the EPB declaration	The owner	No penalty; owner has the chance to correct decisions in order to achieve compliance
The control system points out one or more non-compliances of EPB requirements	Authority		The owner	Payable fine is transparent and shown in the calculation software

Table 2: Summary of who identifies the offences and who pays the fine

Effective and clear system of penalties

The Flemish control scheme is effective and clear:

- ✓ Firstly, sanctions (fines) are directly imposed by the administration (and not by a court). It is an administrative penalty and not a criminal penalty. The competent authority has the power to control and penalise in case of non-compliance. The typical duration between identification of a non-compliance and issuing the official notification regarding the payable penalty is a few months. However, for some files, the duration of the procedure could be more than one year.
- ✓ Secondly, the payable amounts are transparent because they are defined by the law according to the different factors.

For instance, for the transmission losses, the amount of the fine is fixed to 60 € per W/K deviation. For instance, if a window of 5 m² has a declared U-value of 2.5 W/(m².K) but the reality reveals an U-value of 3.0 W/(m².K), this leads to a fine of 150 € (to be paid by the rapporteur).

Another example: for ventilation airflow rates, the amount of the fine is fixed to 4 € per missing m³/h. Therefore, no ventilation in a bedroom with an imposed air flow rate of 36 m³/h, leads to a fine of 144 € (to be paid by the owner). These examples are resumed in Table 3.

Example 1 - Thermal transmission	Example 2 - Ventilation airflows
Window of 5 m² $U_{declared}$ = 2.5 W/m²K $U_{reality}$ = 3.0 W/m²K Fine = 5 * (3.0 -2.5) * 60 = 150 € To be paid by the rapporteur	4 € per missing m³/h No ventilation in a bedroom (requirement = 36m³/h) Fine = 36*4 = 144 € To be paid by owner

Table 3: Two examples of calculating fines

NB: Currently, nothing forbids the owner to rent or sell the building after having paid the fine.

The EPB software gives the amounts of the fine to be paid by the owner when the introduced data result in an EPB declaration not respecting the legislation's requirements. However, before imposing the fine, the authority declares a warning and gives the opportunity to correct the mistake.

For legal reasons it has not been possible in Flanders to add to this fine system the requirement to correct the situation and to impose the conformity. In any case, the EPC is modified to be in accordance with the built situation.

Market acceptance of the approach

Actually, 98% of new Flemish buildings respect the requirements. Most of the time, not respected exigencies are the ones related to the ventilation systems. Examples of non-compliance of the ventilation systems are: missing transfer devices, missing supply or exhaust devices in some spaces, or too low design flow rates.

The reason for the higher non-conformity for ventilation could be explained because, in contrast to insulation for example, many clients and many professionals are not yet convinced of the need to ventilate. This is a broader problem going beyond the EPC context and several actions are currently carried out to tackle this challenge:

- ✓ A new Technical Note has been published recently in Belgium [6] as a guide of good practice for the correct design and installation of ventilation systems in dwellings.
- ✓ A quality framework is under development in the Flemish Region in order to increase the quality of the ventilation systems [5] and a reference document describing quality criteria for ventilation has been recently published [7].

The social acceptance of the control scheme seems positive. The signals reached to the authorities are good because the procedure is clear and fair. This becomes evident in view of evaluation results, showing the improving building energy performance over time [2].

Pros and cons of possible options

Regarding the implementation of a control system, there are mainly two options how to go about it, namely (1) to empower a competent authority to check compliance and declare fines in case of non-compliance, and to fully entitle the authority with carrying out the entire scheme, and (2) to reduce effort for the authority by making use of external personnel to operate the control scheme and for carrying out on-site checks and identifying non-compliance. Table 4 compares pros and cons of the two approaches.

Option	Pros	Cons
The competent authority checks compliance and declares fines in case of non-compliance.	✓ The full scheme is under the authority which strengthens the authority's role in the perception of the general public. ✓ The experience made and the lessons learnt during on-site inspections will provide direct input in continuous improvement, and the quality of the entire scheme will benefit.	✓ The additional work load for the competent authority can be a budgetary challenge, because in most Member States the public administration is forced to reduce public debt. ✓ Personnel might not be well qualified and need further training to carry out meaningful checks.
The control system (including on-site checking) is outsourced to a third party, e.g. qualified experts who meet defined requirements.	✓ This could be more flexible. For example: According to the specific point to check, the authorities could ask for a qualified expert with specific expertise in the field chosen for in-depth checks.	✓ A mechanism will be needed to ensure quality of third party inspections and to ensure knowledge transfer from third party inspectors to the authority which is essential for continuous improvement.

Table 4: Description of pros and cons of different options

Compliance concerns related to EP regulation

The described scheme avoids or limits some of the most typical cases of non-compliance.

No reporting ☑	Wrong reporting ☑	Not meeting the performance requirements ☑

Compliance concerns related to EP regulation

Hints

Encourage the correct performance declaration

Correct performance declaration can be encouraged by facilitating the access to quality assured input data needed for the EPB declaration software tool. In this regard, Belgium benefits from a product database checked by an independent control system. The concerned products are insulation materials, fans and ventilation groups, trickle ventilators, solar protection devices, and others.

The working principle of this EPB product database is detailed in QUALICHeCK Factsheet #5 [3]. It can be summarized as follows:

- ✓ The use of this scheme by the manufacturers is voluntary.
- ✓ The product data has to be tested (in a laboratory) according to the assessment method which is in accordance with the EP regulation.
- ✓ The compliance of the data is ensured thanks to controls by a third-party.
- ✓ The scheme is managed by an independent operational agent on behalf of the authorities. The working costs are in charge of the appealing manufacturers.
- ✓ The accepted data are available on a public website and are widely used by EPB rapporteurs.

The approach is successful and market acceptance is very high.

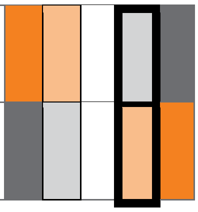
For other performances related to the building such as building airtightness or effective ventilation airflows, specific quality frameworks have been developed. They are also detailed in other QUALICHeCK Factsheets, such as Factsheet #21 [4].

Overall evaluation

The pros and cons of the described approach are summarized in Table 5. Overall, the approach is considered clear and effective. This assessment is underpinned by the market acceptance and societal support.

Pros	Cons
✓ The responsibility in case of different types of non-compliance is clearly defined. There is no need for the authority to determine responsibilities.	✓ On-site controls are necessary, but expensive and difficult to manage.
✓ The amounts of penalties are sufficiently high to deter cheating.	✓ No regularization of the non-conformities is required, meaning that in case of detected non-compliance the owner pays the fine and is allowed to sell or rent the non-compliant building.

Table 5: Overall pros and cons of the approach

Level of complexity (dark orange = simplest)	
Potential for replication (dark orange = best)	

Prerequisite: Regions interested in replicating the approach must have an electronic database to collect and administrate energy performance certificates. Minimum requirements must be defined in a way that allows checking compliance during site-visits.

A summary of hints and pitfalls for developing and implementing a control system including penalties is shown in Table 6.

Hints	Pitfalls
✓ The approach prevents fraud because the procedure is such that the rapporteur cannot take any advantage from a wrong declaration. ✓ In the same way, the amounts of penalties are sufficiently high to deter cheating.	✓ It is difficult to find a good balance between accuracy and reproducibility, in order to save cost and achieve the intended impact at the same time. ✓ Control on-site is needed but also expensive, and therefore concepts how to define samples and carry out the checks must be well-though-out.
✓ The fines have to be administrative, clearly determined and the stakeholders have to be informed about the consequences of mistakes. ✓ It is very effective to include the information about penalties in the software used to produce the EPB declaration.	✓ These procedures need to be regularly evaluated and if necessary modified, in order to take into account the experience from the field and ensure continuous improvement. ✓ It would be very short sighted and thus expensive in the long run to skip evaluation and necessary modification activities because of cost reasons.

Table 6: Overall hints and pitfalls to avoid when developing such an approach

References

[1] Website containing information related to the EPBD in the Flemish Region: www.energiesparen.be (in Dutch)

[2] Ann Collys, Maarten De Groote, Marijke De Meulenaer, Ineke De Schoenmaeker, Jens Franken, Wina Roelens (Flemish Energy Agency); Robrecht Van Rompuy, Sam De Coster, (Environment, Nature and Energy Department): Implementation of the EPBD in Belgium Flemish region, Status in December 2014. CA EPBD Country Report, available at http://www.epbd-ca.eu/countries/country-information

[3] Samuel Caillou: Voluntary scheme and database for compliant and easily accessible EPC product input data in Belgium. QUALICHeCK Fact Sheet No 05, 2015

[4] Clarisse Mees, Xavier Loncour: Quality framework for reliable fan pressurisation tests. QUALICHeCK fact sheet No 21, 2016

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Technology	Aspect	Country
Renewables in multi-energy systems Ventilation and airtightness	Compliant and easily accessible EPC input data	Europe

EUROPEAN CERTIFICATION OF HVAC PRODUCTS CAN PROVIDE EPC INPUT DATA

Systems providing space heating, ventilation, space cooling and/or domestic hot water (HVAC) to residential or commercial buildings are playing a major role in the building energy performance.

Eurovent Certita Certification manages a voluntary certification of the performance of heating, ventilation and air conditioning products, under the European mark "Eurovent Certified Performance".

Such a certification increases confidence in the published performance data of products and provides an easier access to input data for calculation of a building's energy performance.

Residential buildings ☑	Non-residential buildings ☑	Specific buildings: ……
New buildings ☑	Existing buildings ☑	

Context

Energy Performance Certificates (EPCs) must be established on the basis of compliant and easily accessible input data, especially data for describing the energy performance of heating, ventilation, cooling and domestic hot water systems installed in new or existing buildings.

Product certification schemes, through testing of products sampling and factory audits by an independent third party, provide reliable product data, usually published in electronic catalogues and databases. These data can be referred to by national or European regulations. If so, certification can provide compliant and easily accessible EPC input data.

This factsheet describes the example of a voluntary certification of the performance of heating, ventilation and cooling products managed by Eurovent Certita Certification, under the European mark "Eurovent Certified Performance". It shows how such certification at the European level can be useful for products that are dedicated to different national markets, with a possibility to link certified data with the input data required for the local energy performance calculation of buildings.

Objectives and problems addressed

Certification provides reliable and easily accessible data for building systems for space heating, ventilation, space cooling and domestic hot water production that will be installed in new buildings or as replacement in existing buildings.

The objectives of certification are to build up customer confidence in the product data published by manufacturers and to increase the reliability and accuracy of these data.

Electronic catalogues of products and databases that are publically available facilitate access to data. In addition, certified product data, if determined with the same rules as those required by the regulations, can provide compliant data, used for example as input data for the energy performance calculation of buildings.

This implies:

- ✓ To implement a robust certification scheme,
- ✓ To make a link between certified product data useful as input data for energy performance calculation and EPC calculation tools.

Approach to overcome identified problems

Certification of product performance

Since 1994 Eurovent Certification, integrated into Eurovent Certita Certification (ECC) in 2013, is a private certification body that implements and manages a voluntary certification of the performance of air-conditioning products at the European level (www.eurovent-certification.com). Among the 21 operated certification programmes[1] for residential and commercial buildings and industrial applications, the following heating, ventilation and cooling products are covered:

- ✓ Heat Pumps (Euro-HP)
- ✓ Comfort Air Conditioners (AC)
- ✓ Variable Refrigerant Flow systems (VRF)
- ✓ Rooftop units (RT)
- ✓ Liquid Chilling Packages and Heat Pumps (LCP-HP)
- ✓ Residential Air Handling Units (RAHU)
- ✓ Air Handling Units (AHU)
- ✓ Ventilation Ducts (DUCT)
- ✓ Fan Coil Units (FCU)
- ✓ Chilled Beams (CB)
- ✓ Cooling Towers (CT)

The "Eurovent Certified Performance" mark is delivered according to a yearly follow-up process, based mainly on factory audits and testing of sampled products. ECC is a certification body according to ISO 17065[2]. "Eurovent Certified Performance" relies on 15 European testing laboratories that are accredited according to ISO 17025[3] for performing independent third party testing of products.

The reference documents for the certification programmes are developed within Compliance Committees, i.e. manufacturers groups, dedicated to families of products. The technical content is established on the basis of European standards for testing of products. They are regularly updated to the latest versions of the standards and revised to follow the implementation of European regulations in order to provide input data where relevant.

Any manufacturer can apply for the "Eurovent Certified Performance", for the European market or abroad as far as the certification is valuable.

In most of the above certification programmes, the manufacturer shall declare all products covered by the programme or none (so-called "certify-all" procedure). Otherwise, certification is delivered by product range.

Product data are certified by annual testing of randomly selected products and annual factory audits.

In case of deviation between declared values and measured ones (within defined tolerances) is confirmed, the manufacturer shall choose between rerating or complete withdrawal of the product family from the catalogues.

Administration fees and publication fees for the electronic database, as well as factory audits and testing costs, are paid by the applicant/participant. No public funding is supporting this private process.

Today, the "Eurovent Certified Performance" is awarded to more than 115 000 product references, representing some 1600 tests and 160 factory audits conducted each year.

Availability of data

Certified products are available via the free access electronic directory from which performance data for different products can be compared, selected and extracted to an Excel sheet, with the assurance that the data have been checked.

[1] http://www.eurovent-certification.com/en/Certification_Programmes/Programme_Descriptions.php?rub=03&srub=01&ssrub=&lg=en
[2] ISO/IEC 17065:2012 - Conformity assessment - Requirements for bodies certifying products, processes and services
[3] ISO/IEC 17025:2005 - General requirements for the competence of testing and calibration laboratories

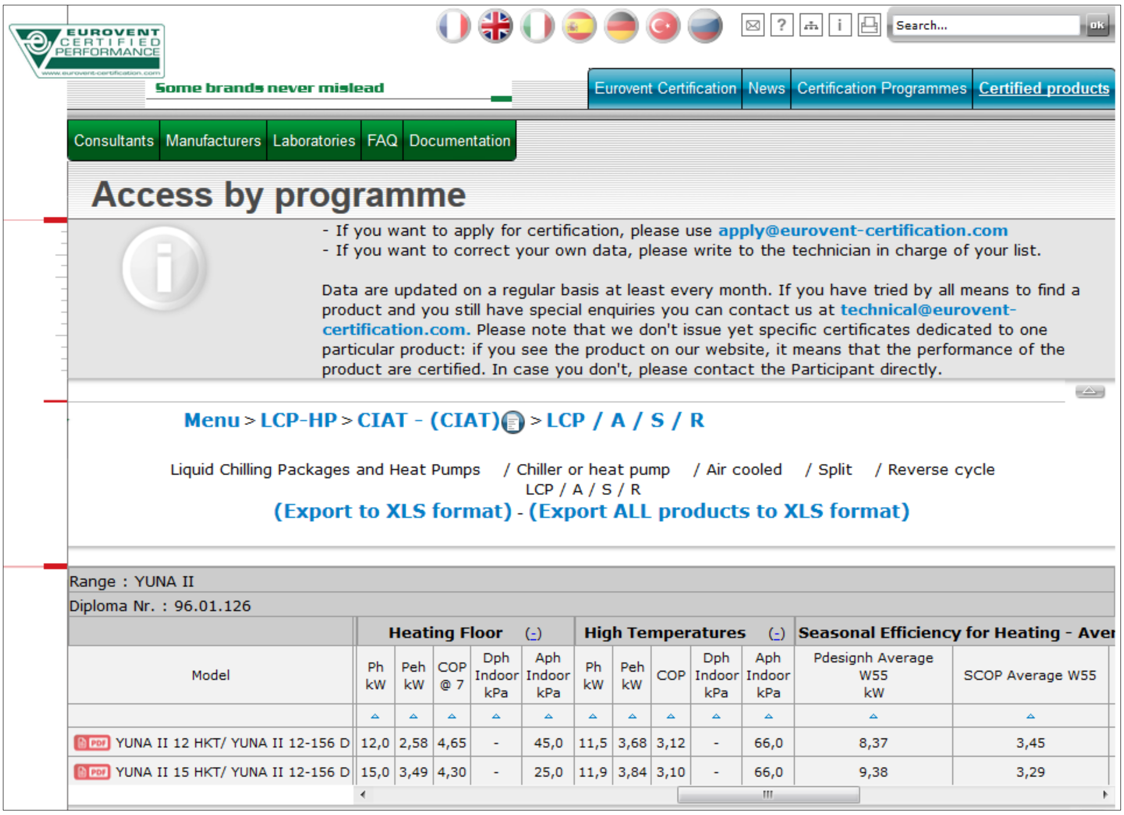


Figure 1: Extract of certified data available at http://www.eurovent-certification.com

Use of data

The database of certified data can be used for many purposes such as product selection or design of a building heating/cooling/ventilation system.

Certified data can also be used as input data for energy performance calculation of buildings in the framework of national implementation of EPBD, provided that the national procedures for determining input data are consistent with the methods (European or International standards) used for determining certified data.

Certified performance provides confidence in the quality of product data and in each manufactured product having the certified performance level. As a consequence, national regulations sometimes require certified EPC input data, with an option to use non-certified data with a penalty.

An example of such use of product certification can be found in the French building energy performance calculation method (RT2012 [4]) which for example applies penalising values for non-certified data of heat pumps, chillers and air conditioners.

Approved software for the energy performance calculation according to this French regulation are linked to product databases which are used to provide certified input data.

For example, Edibatec, a French organisation of software providers, collects input data for national EPBD implementing regulations on building equipment, for automatic download of certified performance data. Edibatec database can be activated from EPC calculation software, allowing the user to select the input data required for the calculation without intermediate "copy/paste" operation.

A direct link between Edibatec and the "Eurovent Certified Performance" database allows automatic access to certified data of heating and cooling systems for RT2012 calculations.

Market acceptance of the approach

Eurovent Certified Performance is a voluntary certification scheme developed by ECC together with manufacturers. Since the first certification programme for small air conditioners in 1994, the interest of such a scheme which can fit the needs of manufacturers on regulation and market aspects increased so that today 21 certification programmes are dedicated to HVAC&R products.

[4] http://www.bulletin-officiel.developpement-durable.gouv.fr/fiches/BO20139/met_20130009_0100_0006.pdf

This European scheme is followed by some 280 manufacturers representing 350 certified trade names and more than 115 000 certified products. Almost 300 members are participating in the so-called Compliance Committees for supporting and improving these programmes.

In 2016, 1 600 product tests and 200 factory audits were performed.

The free access to the directory of certified products allows other manufacturers, dealers, installers and end-users to find out certified data.

Pros and cons of possible options

The pros and cons of the options chosen for the described certification scheme are summarised in the table below.

Option	Pros	Cons
✓ Voluntary scheme	✓ Only interested people are participating	✓ Development of certification programmes for new products requires the interest of at least three industrial manufacturers from three countries
✓ Scheme developed and managed/steered in close cooperation with manufacturers	✓ Organised and managed by involved members ✓ Opportunity for manufacturers to get awareness on upcoming standardisation and regulations	✓ Consensus sometimes difficult to achieve
✓ European perimeter	✓ Uniform approach	✓ May not take into account national specificities in EPC input data, making the certified data not compliant with the specific requirements of the national regulation
✓ Certification scheme open to all manufacturers	✓ Allows all interested manufacturers or distributors to apply for the certification scheme, even if not being a member of a manufacturer association	✓
✓ Public electronic directory	✓ Centralized access to trustworthy performance data for all stakeholders ✓ Possible comparison of product data	✓ Comparison limited to certified products under the "Eurovent Certified Performance" scheme
✓ Direct link with EPC calculation tools	✓ Direct use of certified data with no possible "copy/paste" errors ✓ Advantage of certified products over non-certified products in some regulations (as for example in France)	✓ The certification may not cover all input data for EPC calculations
✓ Third party testing based on European standards and by accredited laboratories	✓ Uniform approach ✓ High chance that the certified data comply with the requirements of the regulation if both refer to European standards	

✓ Funding by manufacturers	✓ No public money needed	✓ Cost for manufacturers
✓ Yearly testing and factory audits	✓ Opportunity for manufacturers to review production processes and benchmark test rig ✓ Constant update of performance data and products	✓ Additional costs for manufacturers for testing and factory audits
✓ Certify-all approach	✓ Same level of treatment of all products ✓ The end-user cannot be misled by similar references of certified and not-certified products	✓

Table 2: description of pros and cons of the chosen options

Compliance concerns related to EP certificates and to the QM approach

No reporting ☐	Wrong reporting ☑	Not meeting the performance requirements ☑

Compliance concerns related to EP certificates (see QUALICHeCK terms and definitions)

The Eurovent certification scheme can be seen as contributing to the publication of more surely trustworthy data, with an easy access.
If these data can be considered as compliant according to the procedures of the applicable legislation (i.e. they have been determined by following these procedures), then the certified data can be used as EPC input data. In this case:

- ✓ Easy and free access to EPC input data via the electronic directory of certified products or through a link inside calculation software makes easier producing an EPC, rather than if no data is available or shall be found out in the technical documentation from the manufacturer.
- ✓ Wrong reporting can be limited or avoided by:
  - o Extracting data from the Eurovent Directory via an Excel sheet
  - o Direct link to database used by calculation software for EPC

Financial aspects

Besides the administrative and promotion costs, a large part of the certification costs is dedicated to certification qualification and follow-up procedures. These are namely the test measurements (installation, energy, immobilisation of the test rig, staff…) and the factory audits (audit preparation, on-site audit, and review of the corrective actions…). The budget can in some cases become important for manufacturers having a large number of products to certify, or represent a significant fixed cost for very small productions.

Test sampling is therefore defined as the best possible compromise between the acceptable number of random tests to be performed (from test duration and cost points of view) and the lifetime of models within a products family.

Nevertheless, this financial aspect is moderated by the following important facts:

- ✓ certification can be used as a marketing tool for reducing the communication budget, especially for a small or mid-size company,
- ✓ certification is often part of a continuous improvement approach by the manufacturer, which takes benefit of the tests and audit reports in its production, as well as the information received during the meetings and the communications,
- ✓ manufacturer can use the independent tests for benchmarking of products and/or own test facilities.

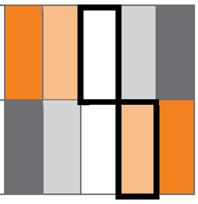
Overall evaluation

The overall evaluation of the approach is summarised in the following tables.

Pros	Cons
✓ Voluntary scheme developed by and for manufacturers and adapted to the market needs and regulation targets	✓ Cost of a third-party certification (tests, audits…)
✓ Free access to certified input data or direct link to EP calculation software reducing the risk of incomplete data and contributing to more surely compliant EPCs	✓

Table 3: Overall pros and cons of the approach

Level of complexity (dark orange = simplest) / Potential for replication (dark orange = best)	Prerequisites
Level of complexity (dark orange = simplest)	Interest from manufacturers and from the market
Potential for replication (dark orange = best)	



Hints	Pitfalls
✓ Involve manufacturers and other stakeholders in the development of the certification rules ✓ If the certification has to produce compliant data to be used as EPC input data, make sure that certification rules are based on the procedures of the regulation for the determination of input data ✓ Implement, where possible, a link between database of certified product/data and software for the building energy performance calculation	✓ Certification costs must remain acceptable for manufacturers ✓ National regulations can require different sets of EPC input data, making it difficult for the certification to provide compliant EPC input data for all countries

Table 4: Overall hints and pitfalls to avoid when developing such an approach

References

[1] Sandrine Marinhas - Certification of product data: Eurovent Certification for heating and air-conditioning products. *QUALICHeCK Workshop, Lyon, 17 January 2017,* http://qualicheck-platform.eu/wp-content/uploads/2017/01/QUALICHeCK-Lyon-3.1-Marinhas.pdf

[2] Sylvain Courtey - Certified Performance Database: tool for quality and compliance. *REHVA Journal, August 2015, pp. 28-29*

[3] Sylvain Courtey - The role certification can play to improve the reliability of input data: Eurovent certification example. *QUALICHeCK Workshop, Lund, 16-17 March 2015,* http://qualicheck-platform.eu/wp-content/uploads/2015/06/QUALICHeCK-Lund-03.1-Courtey.pdf

[4] François Durier, Susanne Geissler, Peter Wouters - Source book for improved compliance of Energy Performance Certificates (EPCs) of buildings. *QUALICHeCK report*, http://qualicheck-platform.eu/results/reports

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Technology Ventilation and airtightness	*Aspect* Compliance frameworks	*Country* France

DUCTWORK AIRTIGHTNESS IN FRANCE: REGULATORY CONTEXT, CONTROL PROCEDURES, RESULTS

*Ductwork airtightness is an input parameter in the French energy performance calculation method for new buildings (RT 2012) which influences the energy performance rating. If the ductwork airtightness class used in the calculation is better than the default value (2.5*class A), the ductwork airtightness has to be justified in accordance with a third-party testing scheme operational since 2014. Furthermore, there is a minimum ductwork airtightness requirement set to leakage class A if the building applies for the Effinergie+ or BEPOS labels. Field data collected through the testing scheme suggest that awareness is slowly growing as the leakage class distribution has shifted towards tighter systems compared to previous data.*

Residential buildings ☑	Non-residential buildings ☑	Specific buildings: ......
New buildings ☑	Existing buildings ☐	

Context

The French energy performance regulation for new buildings has been updated in depth 5 times since its first introduction in 1974. With regard to building airtightness, an important step was the 2005 Energy Performance regulation (EP regulation), which introduced a significant reward on the overall building energy performance assessment when justifying a better-than-default value for the air permeability of the envelope. Since 2012, professionals have to comply with mandatory limit values for building airtightness for residential buildings, and to justify compliance according to schemes developed since 2006 to secure the reliability of airtightness measurement and reporting. This has led to positive results on the market (see QUALICHeCK fact sheet #01 and #07, [4][7]).

Concerning ductwork airtightness, this subject has drawn comparatively less attention although it is also considered as an input parameter in the French EP calculation since 2000. Besides, unstructured feedback from the field suggests that much progress is possible to reduce considerably the permeability of ductwork systems both in a concern of energy conservation and indoor air quality. This is the reason why measures have been progressively introduced since 2013 to push better ductwork airtightness.

Objective and problems addressed

Duct leakage is known to be detrimental to energy performance and indoor climate [1][3]. In order to limit the negative effects of leaky duct systems, French authorities developed an approach to improve ductwork airtightness which builds on the success and lessons learnt from the envelope airtightness approach, including mandatory justification of the airtightness level achieved with third-party testing, unless the default value is used. The ultimate objective of these ductwork airtightness requirements is to boost the market similarly to what happened with the envelope airtightness market as described in fact sheet #07 [7].

Approach to overcome identified problems

Regulatory background and Effinergie labels

In the EP regulation, a default value for ductwork leakage class can be used based on leakage classes defined in EN standards 12237 and 1507, corresponding to 2.5*class A. Since the 2012 EP regulation, if a better-than-default class is used, it must be justified. Furthermore, the Effinergie+ and BEPOS-Effinergie labels [6], firmly based on the current regulation, require justifying achieving ductwork leakage class A as minimum. Figure 1 gives an overview of the evolution of the requirements since 2000. Note that both residential and non-residential buildings are concerned.

The Effinergie+ and BEPOS labels are meant to experiment requirements for the next updates of the regulation, similarly to the past BBC-Effinergie label (based on the 2005 EP regulation) which has been very popular and useful to tune the requirements of the 2012 EP regulation.

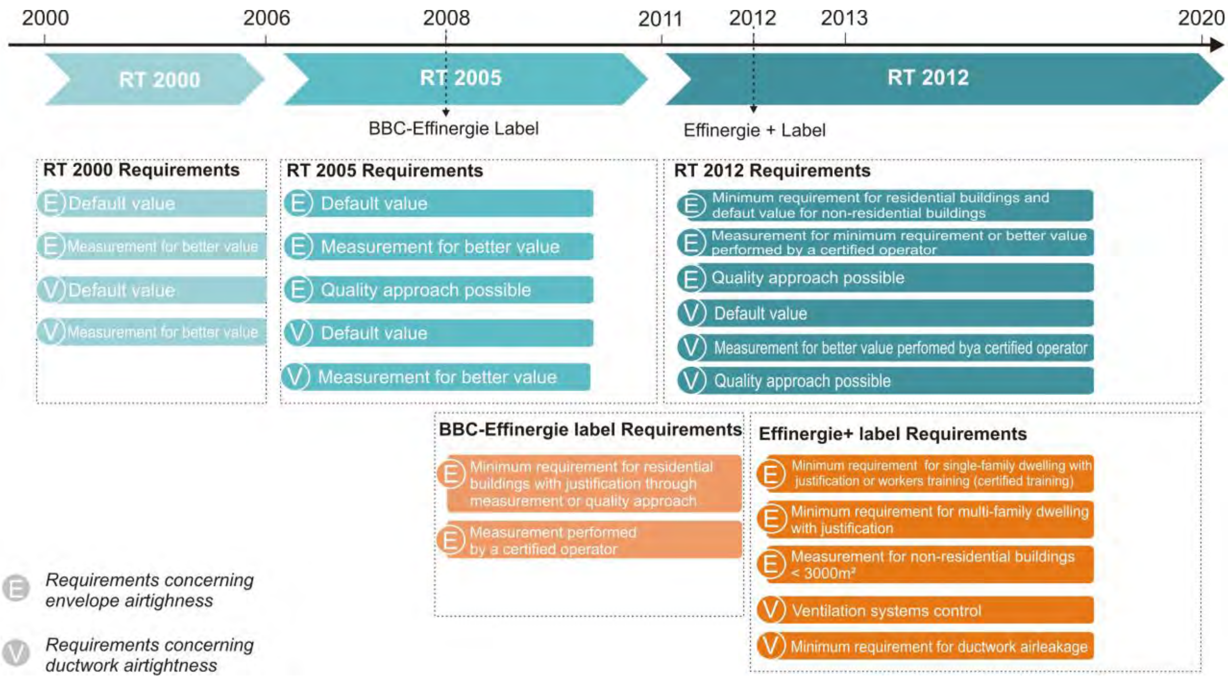


Figure 1: Evolution of French requirements on envelope and ductwork airtightness since 2000 for residential and non-residential buildings

Justification of airtightness level with competent testers

The current French EP regulation gives two options to justify using a ductwork airtightness class different from the default value as input in the EP calculation. The class achieved can be justified:

- ✓ Either with a ductwork airtightness measurement, performed by a certified tester;
- ✓ Or by the application of a certified quality management approach (QMA) on ductwork airtightness, that allows to test only a sample of buildings. Although a similar QMA option is popular for envelope airtightness (see fact sheet #01, [4]), it was never used in practice for ductwork airtightness and is under revision; therefore, it will not be developed in this fact sheet.

In both cases, ductwork airtightness tests must be performed by a third-party tester, qualified by the certification body Qualibat. To be qualified, a tester has to:

- ✓ Undergo a qualifying State approved training;
- ✓ Pass the training examination (the theoretical part, with a State-approved multiple choice questionnaire; and the practical part, with a test performed in situ with a certified tester),
- ✓ Justify sufficient testing experience.

Once qualified, every tester is subjected to yearly follow-up checks, organised by the certification body. The follow-up checks include an analysis of some reports to verify its compliance with applicable standards and guidelines.

The certification body can control the testers based on the documentation sent every year, but also on site, in particular, in case of complaints or doubts about their work. Those checks can lead to de-qualification.

The competent tester scheme started in 2014. As of January 2017, 49 testers have been qualified by Qualibat.

Test protocol and reporting

Tests have to comply with the European standards EN 12237, EN 1507, EN 13403 and EN 12599, and the French technical report FD E 51-767. For the Effinergie labels, testers have to comply with the Effinergie measurement protocol as well, and soon the Promevent protocol [6]. Whenever a test is performed, either for a certified QM approach or for a systematic test, it must be performed after any works that could impact the final ductwork airtightness. FD E 51-767 specifies the reporting format. The report specifies if the ductwork airtightness complies with the input class used in the EP calculation. A new version of FD E 51-767, modified to ease the measurement and avoid damage to the ductwork when preparing the section under test, should be soon published.

Note that qualified testers are required to fill in a database with all test results and provide this database to the certification body every year for the follow-up of their certification.

Market acceptance of the approach

As of January 2017, around 172 multi-family buildings (representing more than 550 dwellings), 9 non-residential buildings and 423 single-family dwellings have obtained an Effinergie+ label, and there are even more running for it. This label seems to drive an important part of the ductwork airtightness measurement market. Around 30% of the measurements collected in a database through the competent tester scheme (see Figure 2) were marked "Effinergie+". The share of Effinergie+ label building in this database may be actually greater since for more than half of the measurements, this field is not filled. For both single-family houses and multi-family buildings, most measured ductwork meet leakage class A (respectively 64% and 54%), but few meet a better class (see Figure 3). Non-residential buildings ductwork systems seem tighter: 48% of them meet class B. In summary, the results collected show a slow but clear drift towards better performance compared to previous measurement campaigns [1][3].

Note, however, that there are two significant differences with the approach to envelope airtightness, which might influence the impact of this approach to ductwork airtightness:

- ✓ The link between the required fan flow rate and fan performance to meet the required airflow rate at the air terminal device despite leakage has to be done manually. If not properly done, the reward for a better-than-default class can be in some cases significantly underestimated
- ✓ There are at present no central government subsidies to encourage the adoption of the label Effinergie+ or BEPOS requirements.

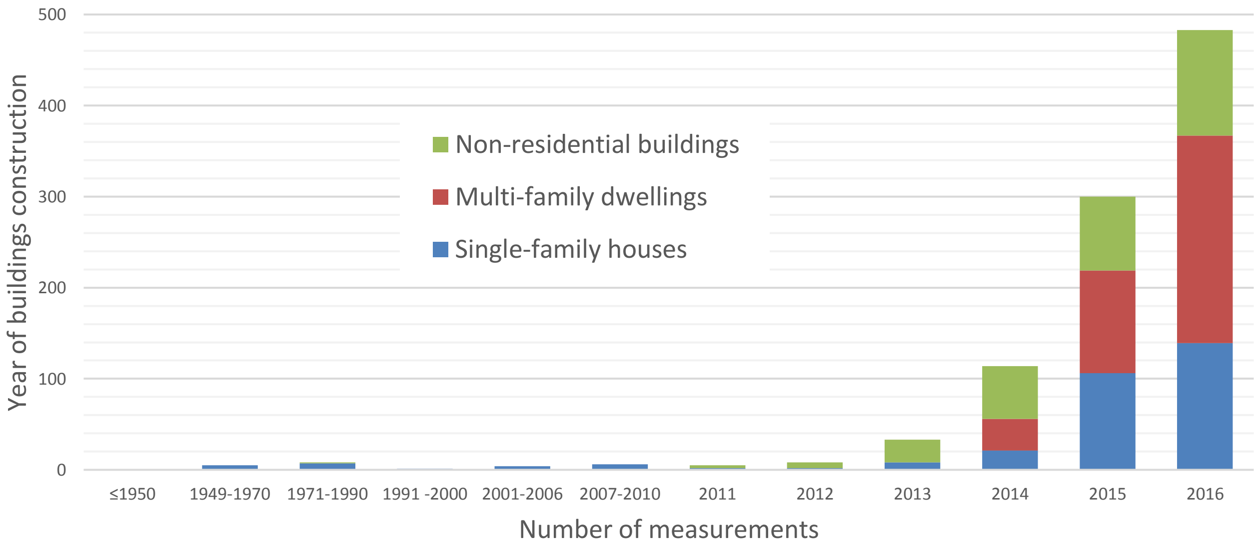


Figure 2: Number of ductworks airtightness measurements depending on the construction year and the use of the building

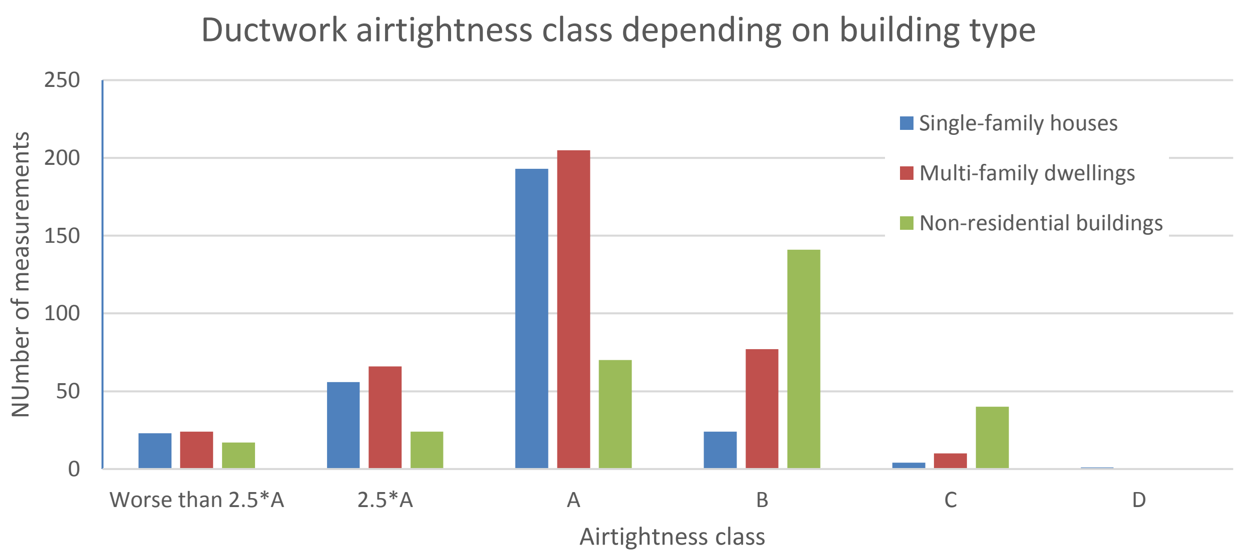


Figure 3: Specific ductwork airtightness measured class depending on the building type

Pros and cons of possible options

This part summarizes options that could or that have been considered, related to ductwork airtightness. They are similar to those presented in QUALICHeCK fact sheet #07 for envelope airtightness. Nevertheless, this analysis should be read bearing in mind that we have limited feedback from the field on the implementation of this approach.

Default class versus mandatory requirement for justification

For envelope airtightness, the BBC-Effinergie label gave a limit value and imposed a justification for residential buildings (see Figure 1), which has induced better envelope airtightness values in the field. As presented in fact sheet #07 [7], trends between periods requiring testing only when choosing a better-than-default value versus a minimum requirement are difficult to analyse given the relatively small samples. Furthermore, the context is quite different for ductwork airtightness because of the lack of subsidies and reward in case of better-than-default class. Nevertheless, the French State decided to duplicate the same approach for ductwork airtightness, and the preliminary assessments of the market acceptance and field data are positive, although the trends need to be confirmed and amplified.

Compel airtightness justification with better-than-default class

Justifying better-than-default class is likely sensible in all contexts to ease compliance checks. If this is not required, to check this input data, the control body would have to test by itself that the claimed ductwork airtightness level is actually achieved.

Qualification required for testers

Justifying ductwork airtightness (whether on systematic testing or partly on sample testing) raises the issue of the reliability of the measurement. To address this question, the French government decided to set up a competent tester scheme and to require testers to be qualified for the test to be acceptable for justification. This process applied for envelope airtightness and it was found useful given the success rate of applicants [7] and improvements observed in the testers' practice. Relying on existing standards alone without a specific scheme to train and follow-up testers seems risky.

Third-party check versus self-control

The present French approach requires third-party testing both for systematic tests and for tests performed with a QMA. Although it seems legitimate to have trust in the result, several issues should be considered:

- ✓ it implies extra costs for the owner;
- ✓ the tester is under pressure to please his client;
- ✓ this "third-party" requirement can be by-passed by creating a testing company which is legally independent, although under the authority of the same person(s) in reality;
- ✓ it requires enough independent testers available to match the demand.

In addition, experience on envelope airtightness has shown that professionals have made significant progress by implementing self-check procedures.

Private or public scheme owners

Should schemes be managed by private bodies or by public authorities? The answer will of course strongly depend on the context, including financial and human public resources available. In the French context, the schemes developed to certify testers and quality management approaches were first managed by public authorities to allow the government to test the schemes and make them evolve to meet their needs before transferring them to private bodies, when the number of applications became incompatible with public resources. Although successful in the French context, this approach may not be relevant in other regions.

Regulation requirement versus label requirement

The success of BBC-Effinergie label on envelope airtightness was based on the fact that the label was a) firmly based on the EP regulation; b) set as a pre-condition for subsidies; and c) a strong point for marketing lower energy bills and lower environmental impacts. These three aspects were likely key in the success of the label, although voluntary, with candidates often willing to do their best to obtain good results. This experience has been a strong basis to set the 2012 EP regulation requirements. For ductwork airtightness, conditions b) and c) are not as strong drivers because there is at present no national subsidy scheme and because some limitations in the EP calculation underestimate in many cases the energy impact of poor ductwork airtightness. Nevertheless, although the scheme is recent, the first market feedback shows a positive trend which need to be confirmed and amplified.

Option	Pros	Cons
✓ Default class (versus minimum requirement)	✓ Easier acceptance by stakeholder	✓ Better-than-default class are not rewarded enough in the EP calculation
✓ Compel airtightness justification with better-than-default class	✓ Pre-condition to undertake compliance checks	✓ Cost of the justification
✓ Mandatory qualification for testers	✓ Increases reliability of airtightness test results	✓ Cost for testers ✓ Cost scheme development and operation
✓ Measurement by an independent third-party (versus self-control)	✓ Increases confidence in test results	✓ Cost for the building professionals/owner ✓ Professionals learn with self-checks ✓ Need to have a matching number of independent testers available ✓ Testers may be independent on paper but not in practice
✓ Label requirement (versus regulation requirement)	✓ Enables experimenting new types of requirements and market acceptance.	✓ Regulation compels professionals to adapt and comply with requirements with no learning period
✓ Private scheme owner (versus public scheme owner)	✓ Easier to deal with human and financial resources to match large demand	✓ Beginning by a public entity enables to test the process and to make it evolve progressively, with experience ✓ Applications through public entity can be free of charge

Table 1: pros and cons of various options

Compliance concerns related to EP regulation

No reporting ☑	Wrong reporting ☑	Not meeting the performance requirements ☑

Compliance concerns related to EP regulation (see QUALICHeCK terms and definitions)

In the French EP calculation, ductwork airtightness is an input data as a leakage class. In the calculation kernel, it is converted into an airflow rate, which enters into account for the heating and cooling needs and for the fan energy use calculation.

The qualification scheme reduces the risk of wrong reporting in the EP calculation due to unintentional mistakes (lack of competence). The compliance checks based on the requirements of the energy regulation further reduce this risk, together with the risk of no reporting or not meeting the airtightness performance requirements.

Overall evaluation

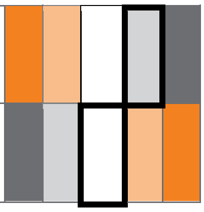
The ductwork airtightness scheme in the French EP regulation has just started in 2014 to put more emphasis on the significant impact of duct leaks on the energy performance and indoor climate, and thereby avoid negative effects of building airtightness improvements without appropriate ventilation provision.

The approach developed firmly builds on the success of the regulatory and voluntary approach to building airtightness requirements reported in previous fact sheets, yet with significant differences. The approach to ductwork airtightness is based on:

- ✓ a voluntary option to value ductwork airtightness in the EP rating, with a default value in the calculation software which can be changed to a better-than-default value;
- ✓ the requirement to justify for a better-than-default ductwork airtightness value either with systematic testing or with the implementation of a certified quality management approach;
- ✓ the development of a competent tester scheme, to secure appropriate testing and reporting;
- ✓ the development of scheme for quality management approaches as alternate ways to justify for a given ductwork airtightness level. Unlike for envelope airtightness, this scheme was never used in practice for duct systems and is under revision.

Preliminary feedback for the application of this approach shows a positive trend, with a clear shift of ductwork systems towards tighter classes. This trend needs to be confirmed and amplified.

Level of complexity (dark orange = simplest)	**Prerequisites**
Potential for replication (dark orange = best)	Strong political will to improve ductwork airtightness



Hints	Pitfalls
✓ Detail and consolidate technical standards ✓ Encourage (subsidies, reward in the EP calculation) the better-than-default-class ✓ Gradual introduction of the requirements: first in a label, and then in regulation ✓ Gradual introduction of the control processes: first headed by authorities, and then by better-dimensioned private bodies	✓ Resources to define specify the measurement standards to ease their application ✓ Resources for processes ✓ Resources to specify and control processes (reliability of the scheme), including ways of justification

Table 2: Overall hints and pitfalls to avoid when developing such an approach

References

[1] Andersson, J. 2013. Quality of ventilation systems in residential buildings: status and perspectives in Sweden. In edited proceedings of the AIVC- TightVent international workshop, Brussels, 18-19 March 2013, ISBN 2-930471-43-3, INIVE, Belgium. pp. 159-166.

[2] Arrêté du 24 mars 1982 relatif à l'aération des logements. Official Journal of the French Republic of 27 March 1982, modified 15 novembre 1983.

[3] Carrié, F. R., Andersson, J., Wouters, P. 1999. Improving ductwork—A time for tighter air distribution systems. Air Infiltration and Ventilation Centre, Coventry, UK. 126 p. ISBN 1 902177 10 4.

[4] Carrié, F.R. and Charrier, S. 2015. Building regulations can foster quality management – the French example on building airtightness. QUALICHeCK fact sheet # 01, available at http://qualicheck-platform.eu/wp-content/uploads/2015/02/QUALICHeCK-Factsheet-01.pdf

[5] Carrié, F.R., Charrier, S., and Bailly, A. 2015. Regulatory compliance checks of residential ventilation systems in France. QUALICHeCK fact sheet # 06, available at http://qualicheck-platform.eu/wp-content/uploads/2016/03/QUALICHeCK-Factsheet-06.pdf

[6] Carrié, F.R., and Dervyn, Y. 2016. The Effinergie approach to ease transitions to new regulatory requirements. QUALICHeCK fact sheet # 45, available at http://qualicheck-platform.eu/wp-content/uploads/2017/02/QUALICHeCK-Factsheet-45.pdf

[7] Charrier, S., Bailly, A., and Carrié, F.R. 2015. Building airtightness in France: regulatory context, control procedures, results. QUALICHeCK fact sheet # 07, available at http://qualicheck-platform.eu/wp-content/uploads/2016/03/QUALICHeCK-Factsheet-07.pdf

[8] Charrier, S., Ponthieux, J., Huet, A. 2014. The Airtightness Quality Management Approach in France - Assessment after more than Five Years of Operation. International Journal of Ventilation. ISSN 1473-3315. Vol. 13(2), pp. 125-140.

[9] Effinergie +. 2014. Règles Techniques applicables aux bâtiments neufs faisant l'objet d'une de demande de label Effinergie+, Validées par le CA du 3 juin 2014. (http://www.effinergie.org/images/BaseDoc/1066/20140603_r%C3%A8gles_techniques_Effinergie+_V5.pdf)

[10] Effinergie +. 2015. Protocole de contrôle des systèmes de ventilation des bâtiments demandant le label effinergie +, Version 3 - Mai 2015. (http://www.effinergie.org/web/images/permea/20150512_protocole_contrôle_ventilation_V3.pdf)

[11] RT 2012. 2010. Arrêté du 26 octobre 2010 relatif aux caractéristiques thermiques et aux exigences de performance énergétique des bâtiments nouveaux et des parties nouvelles de bâtiments. Official Journal of the French Republic of 27 October 2010.

[12] RT 2005. 2006. Arrêté du 24 mai 2006 relatif aux caractéristiques thermiques des bâtiments nouveaux et des parties nouvelles de bâtiments, Official Journal of the French Republic of 25 May 2006.

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Technology Ventilation	*Aspect* Compliance frameworks	*Country* Belgium

BELGIAN/FLEMISH EVALUATION SCHEME FOR VENTILATION SYSTEMS

Since many years, several monitoring studies have shown that the quality and compliance of installed ventilation systems can be low. The recently developed Evaluation scheme in Belgium tries to tackle this problem, thanks to the mandatory Ventilation Performance Report of all new ventilation installations, to be delivered by a Ventilation Reporter recognised by a Third-Party control organisation. This factsheet describes the approach of this scheme, including the penalty scheme and the role of the actors involved.

Residential buildings ☑	Non-residential buildings ☐	Specific buildings: ……
New buildings ☑	Existing buildings ☐	

Context

The installation of a ventilation system has been mandatory for new dwellings in Belgium since many years (since 1996 in the Walloon Region and since 2006 in the Flemish Region). The Energy Performance of Buildings (EPB) regulation includes minimum requirements in terms of installation of ventilation systems and in terms of minimum ventilation flow rates in order to ensure good indoor climate for the occupants of dwellings. This ventilation system can be naturally and/or mechanically driven, leading to 4 possible systems: natural supply and exhaust (system A), mechanical supply and natural exhaust (system B), natural supply and mechanical exhaust (system C), and finally mechanical supply and exhaust (system D). A minimum supply air flow rate of outdoor air is required for the living spaces such as the living room and the bedrooms; and a minimum exhausted air flow rate is required in the service spaces such as the kitchen, the bathroom, the toilet, and the laundry. However, the quality of the installed ventilation systems is often rather poor as shown by several monitoring projects. Moreover, the level of non-conformity is particularly high for ventilation in the EPB regulation.

On site monitoring showed for example too low ventilation flow rates, ventilation devices missing, too high electrical power consumption due to high pressure drops, noise production by mechanical ventilation systems or noise transfer from the outside environment by natural ventilation openings, etc..

In the context of the EPB regulation in Belgium, an as-built report of the finalised building is required. The last years, there are still a few percent of new Flemish buildings receiving fines due to non-conformity to the requirements [2]. Most of the time, these non-conformities concern the ventilation systems. Examples of non-conformities of the ventilation systems are: missing transfer devices, missing supply or exhaust devices in some spaces, or too low flow rates.

This poor quality of the ventilation systems in dwellings could be explained, at least partially, because many people, professionals as well as clients, are not yet convinced of the need to ventilate. In contrast to the thermal comfort for example, the human perception is largely less sensitive to the indoor air quality. Therefore the need for a ventilation system is felt lower than the need for a heating system for example. Therefore, the investment in a ventilation system (natural as well as mechanical), in first order to ensure a good indoor climate and comfort, is perceived less directly useful and profitable compared to the investment in a heating system (clearly considered as necessary for the comfort) and in the insulation of the building (clearly considered necessary to limit energy use and cost).

To improve both the compliance and the quality of the installed ventilation systems, a scheme has been recently developed in the Flemish Region of Belgium in the context of the EPB regulation. This ventilation evaluation scheme is based on a reference document, describing performance criteria for the quality of ventilation systems, the STS-P 73-1 [1]. This scheme recognises Ventilation Reporters which are authorised to evaluate ventilation systems and who are recognised by a Third-Party control organisation.

The present document describes the principles of this scheme developed in Belgium, with its advantages and its pitfalls for possibly further implementation of similar schemes in other countries.

Objectives and scope of the scheme

Main objectives

This ventilation evaluation scheme addresses objectives at 2 different stages in the construction process.

- ✓ Before the construction works, this scheme provides the possibility to prescribe (e.g. in a tender) the performance criteria of the ventilation system, according to the reference document STS-P 73-1. These performance criteria can be requirements of the EPB regulation which are mandatory, but also criteria for higher quality levels which are not mandatory. See step (1) in Figure 1.
- ✓ After the construction works, this scheme imposes the evaluation of the ventilation system and the reporting of the real performances according to the reference document STS-P 73-1. This report is used as part of the EPB as-built report and can also be compared to the performance criteria prescribed before the works. This evaluation is carried out by a Ventilation Reporter who is recognised by a Third-Party control organisation. See step (2) in Figure 1.

Scope of the ventilation evaluation scheme

This evaluation scheme is mandatory in the Flemish Region in Belgium in the context of the EPB regulation for all new dwellings with building permit submission after January 1st 2016 (Phase I).

In this first Phase of the scheme, the reporting of all the performance criteria related to requirements in the EPB regulation and to input data for EPC calculation is required. It is planned to extend this mandatory scheme in the future to all the performance criteria described in the reference document STS-P 73-1 (thus also those for which there are no requirements in the EPB regulation, see below), but there is no concrete timing at the moment.

Beside this mandatory evaluation scheme of ventilation systems after completion of the works, the approaches and procedures available in this scheme can eventually be used in other context within a voluntary framework.

- ✓ The reference document STS-P 73-1 is public and available for free on the federal website. It can be used to prescribe, on a voluntary basis, the performance criteria for ventilation systems in any construction contract for dwellings.
- ✓ Moreover, a client or a contractor can eventually call a Ventilation Reporter recognised in this scheme to carry out the evaluation of a ventilation system outside the mandatory scope of the scheme. Comparison between the requirements in the tender or contract and the final performances as reported, can be used to evaluate the fulfilment of the contract.

Final objectives of the scheme

This scheme and the applied principles and approaches allow finally fulfilling the following more general objectives in the context of the EPB regulation:

- ✓ Checking the conformity of the installed ventilation systems according to the ventilation requirements in the EPB regulation (see above);
- ✓ Improving the compliance and the accessibility of input data for the Energy Performance Certificate (EPC), product and system data (thermal efficiency of heat recovery devices) as well as data related to the building execution (measured electrical power on the installed system), necessary for the EPC calculation (see also [3]). This is related to the specific control and penalty scheme of the EPB regulation in Belgium (see [5]).
- ✓ Improving the quality of the works providing the possibility to set performance criteria before the works and to evaluate them after the works thanks to objective performance criteria described in the reference document STS-P 73-1, for criteria not related to mandatory requirements.

Approach and procedure

Reference document STS-P 73-1

The reference document STS-P 73-1 on which this ventilation evaluation scheme is based defines and describes performance criteria for ventilation systems in dwellings (residential applications), but this document doesn't set any minimum requirements on them.

These criteria can be expressed in the format of a quantitative parameter or in the format of different classes corresponding to different quality levels.

- ✓ Example of quantitative parameter: the thermal efficiency for heat recovery devices expressed in percent and measured in accordance to the measurement method described in this reference document (and referring in this case to the measurement method required in the EPB regulation).
- ✓ Example of classes: the acoustical performances of the mechanical systems is described using the following classes (class 5 is the highest level of quality):
  - Class 5: High comfort according to the NBN S 01-400-11 (evaluation measurement)
  - Class 4: Normal comfort according to the NBN S 01-400-1 (evaluation measurement)
  - Class 3: Normal comfort according to the NBN S 01-400-1 (calculation)
  - Class 2: Conform to the criteria of the simplified determination method described in the STS-P 73-1
  - Class 1: Limited risk of discomfort according to the simplified prescriptions in the STS-P 73-1
  - Unclassified: Potential risk of discomfort

The criteria of this reference document include those related to the requirements in the PEB regulation (e.g. conformity to the required flow rates) and to the input data necessary as input for the EPC calculation (e.g. thermal efficiency of heat recovery devices). But there are also additional quality criteria for which there are no mandatory requirements, such as criteria related to the acoustical comfort (due to mechanical and natural ventilation systems), to the indoor air quality of the air intake, to the cleanliness of the system and ductworks, to the information for the users, etc..

It is particularly important to emphasise that the reference document STS-P 73-1 doesn't set any requirement as such. Examples:

- ✓ For the thermal efficiency of heat recovery devices, the document describes the definition, the measurement method and the way to express the performance, but no requirement, no minimum level is set forward for this performance criterion.
- ✓ For the acoustical performance of the mechanical systems, the document defines the classes, describes the criteria related to each classes, the methods of measurement and/or calculation if applied, but no requirement, no minimum class is required for this criterion.

The STS-P 73-1 also contains an annex about the organisation of the control scheme by a Third-Party organisation. This annex describes the objectives and requirements for the control scheme such as:

- ✓ To ensure the reliability of the performances reports of the ventilation installations;
- ✓ To ensure the confidence in the control scheme regarding all the parties involved in the construction process and regarding the authorities.
- ✓ In other words, the organisation of the scheme has to be carried out with the support and after consultation of all the stakeholders involved in the market including the authorities themselves.

Organisation of the control scheme by BCCA

The Belgian Construction Certification Association (BCCA) has developed such a control scheme for ventilation systems, based on the STS-P 73-1 and its annex about the organisation of the control scheme. BCCA is a Third-Party control organisation recognised by BELAC (Belgian Accreditation Body). The control scheme developed by BCCA has been carried out with the support and consultation of many stakeholders in the Belgian market such as associations of building contractors, associations of ventilation manufacturers, associations of EPB rapporteurs, regional authorities, etc.

BCCA is the Third-Party control organisation responsible for the organisation of the scheme described in this factsheet. The scheme described in the following paragraphs refers to those developed by BCCA based on the EPB requirements and on the STS-P 731.

[1] Belgian standard on acoustics in dwellings

Ventilation Reporter recognised by BCCA

To insure the reliability of the evaluation of ventilation systems, these have to be carried out in this scheme by recognised Ventilation Reporters.

To become a Ventilation Reporter, the candidate must pass an exam organised by the Third-Party control organisation. The theoretical exam takes place online and concerns the knowledge of the general principles of ventilation of dwellings, the content of the reference document STS-P 73-1, the EPB regulation and the EPC calculation, etc.. A second part of the exam is practical and concerns the capability to measure the mechanical ventilation flow rates and the electrical power.

The competences and the reliability of a Ventilation Reporter as an evaluator are inspected on a regular basis by BCCA within the scheme. These inspections by the Third-Party occur randomly for around 10 % of the evaluations carried out by the Ventilation Reporter. In practice, the Ventilation Reporter has to use a web application (currently under development) for the follow-up of all the evaluations he carries out.

- ✓ The date and place of a planned flow rate measurement of a ventilation system carried out on site have to be encoded in advance through the web application (currently under development).
- ✓ At the end of the flow rate measurement, the Ventilation Reporter has to send an SMS to the Third-Party. On a random basis, the Third-Party can come on site shortly after this SMS communication to inspect the work of the Ventilation Reporter.

If the correct work of the Ventilation Reporter cannot be confirmed during these random inspections by a Third-Party, consequences apply for this Ventilation Reporter (from increased inspection frequencies to discarding from the system, see below).

There are no pre-requirements to apply as Ventilation Reporter, but the candidate has to pass an exam (see above). Different kind of professionals can apply to become Ventilation Reporter, such as architects, ventilation installers, “EPB rapporteurs” (the person responsible for delivering the Energy Performance Certificate, see [5] for more details), etc. Neither there are requirements related to the independence between the Ventilation Reporter and the other professionals involved in a given project. The Ventilation Reporter for a given project can be the ventilation installer or the architect for the same project, provided that this Ventilation Reporter is recognised within this scheme. The capacity of the Ventilation Reporters should be ensured by the exams and the Third-Party inspections described above rather than by a requirement about the independence (which is very difficult to define).

Design of ventilation installation

A prerequisite for a high quality ventilation system is the availability of a proper design. A start to this design is the setting forward of the requirements, to which the installation should comply. These requirements are already partly provided into the pre-calculation of the EPC (e.g. ventilations system type, design flow rates, …), required prior to the demand for a building permit. In the ventilation evaluation scheme, some additional information must be mentioned on the building permit plans, such as the position of the ventilation openings and the ductworks. The aim of requesting this information at the moment of the building permit is to raise awareness of the Building Contractor on the importance of the design of the ventilation system.

The overall scheme provides also the possibility, on a voluntary basis, to the Building Contractor to set additional performance criteria, according to the reference document STS-P 73-1, before the construction works start. The aim is here to set the desired criteria in an objective way and to fix them contractually between the Building Contractor and the ventilation installer.

Comparison between the requirements in the tender or contract and the final performances as reported, can be used to evaluate the fulfilment of the contract.

Ventilation Performance Report

The Ventilation Performance Report (VPV, Ventilatie Prestatie Verslag in Dutch) is the key element of this ventilation evaluation scheme (Figure 1).

This Ventilation Performance Report is mandatory in the EPB regulation (see above) and has to be delivered with the EPC (as-built performance) after the completion of the construction works.

The Ventilation Performance Report has to be carried out by an authorised Ventilation Reporter recognised within the scheme. This Ventilation Performance Report can be completed directly and on line via the web application (currently under development) within this scheme. This Ventilation Performance

Report is then used automatically by the “EPB Rapporteur” of this project (see [5]) to complete the EPC with the appropriate EPC input data. Within the EPC scheme in Belgium, there are then automatic control of the EPB requirements and automatic calculation of the penalties in case of non-conformity (see [5] for more details). This is also the case for ventilation aspects: e.g. non conformity of airflow rates may influence the EPC level or may lead to fines.

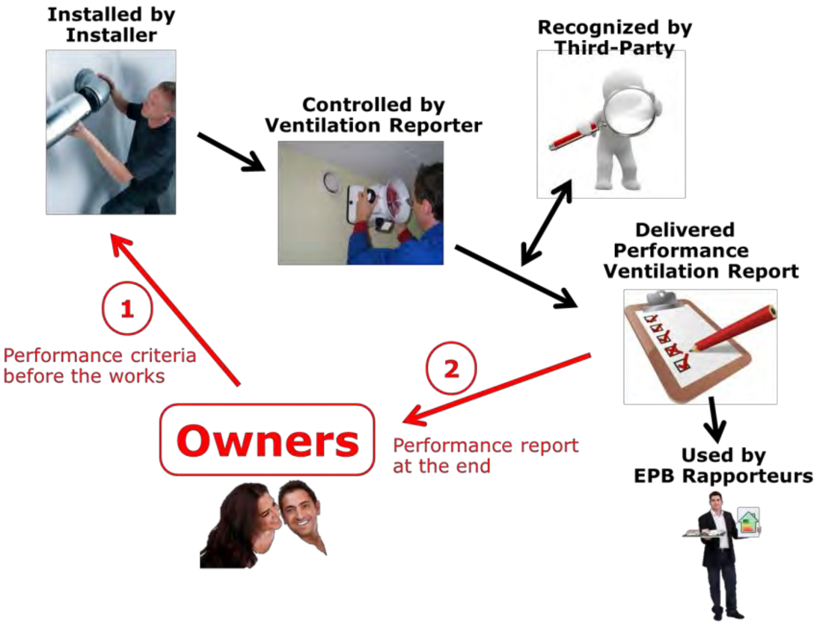

Figure 1: Principles of the evaluation scheme for ventilation in Belgium

Penalty scheme

Penalty to the Building Contractor

In case the Ventilation Performance Report (see above) reveals some non-conformities related to EPB requirements or to EPC calculation, there are penalties and fines foreseen for the Building Contractor (see [5]). In case the Building Contractor doesn’t provide a Ventilation Performance Report at all, it is considered in the EPB regulation that there is no ventilation system in this project, which leads to a lot of non-conformities, and important fines. As explained in another factsheet [5], there is a specific control and penalty scheme for the EPB regulation in Belgium.

Penalty to the Ventilation Reporter

In case the random inspections of the Ventilation Reporters by the BCCA reveal some lack of reliability of the Ventilation Reporter because of incorrect ventilation evaluations and reports, some consequences apply to the Ventilation Reporter. Firstly, he or she is asked to correct the fault ventilation report and will be inspected for additional ventilation reports (increase of inspection frequency). Finally, in some cases, the Ventilation Reporters not delivering reports according to the defined quality can be excluded from the scheme: they are no longer recognised and they can no longer carry out evaluations of ventilation systems on site and deliver Ventilation Performance Reports.

Market acceptance of the approach

Because this scheme has been developed only recently, it is difficult to evaluate the market acceptance of this scheme.

The following elements could lead to better market acceptance of the scheme:

- ✓ This scheme focuses on the recognition of the Ventilation Reporters and on the report of all installed ventilation systems. In contrast to schemes focusing on the recognition of the installers themselves, this scheme is lighter and simpler, leading to a better acceptance by the professionals, at least the installers.
- ✓ Because the scheme is open to several professionals (installers, architects, EPB Rapporteurs, etc.), this scheme is quite open and not limited to certain professionals, leading to higher acceptance by the market.

- ✓ The criteria on which this scheme is based (described in the STS-P 73-1) are performance based criteria instead of descriptive criteria related to the means used. These performance based criteria give the freedom to the designers and installers of ventilation systems to choose the means they want to use to achieve the performance.

However, this evaluation scheme could lead to additional direct and indirect costs for the installation of ventilation systems by the Building Contractor, which could affect the market acceptance of the scheme.

In order to increase the market acceptance of the scheme, the development of this scheme has been carried out in constant consultation with the building sector. At each stage of the development (publication of the STS-P 73-1, development of the approach for the inspections by a Third-Party, etc.), a large number of stakeholders has been consulted thanks to regular meetings.

Pros and cons of possible options

This evaluation scheme, with the mandatory Ventilation Performance Report to be done by Ventilation Reporters recognised by BCCA, can be seen as an intermediate approach between these 2 more extreme alternatives:

- ✓ Recognition of competent installers in order to ensure higher quality and compliance of installed ventilation systems, thanks to for example training and exam of the installers;
- ✓ Inspection of the conformity of all the installed ventilation system by a Third-Party control organisation or by the authorities themselves.

Compared to these alternatives, the developed scheme in Belgium presents several advantages as listed in Table 1.

To some extent, this scheme presents similarities with the Quality framework for reliable fan pressurisation tests described in another factsheet [4].

Option	Pros	Cons
Recognition of competent installers	✓ Higher skills of the installers could lead to higher quality of the installed systems. ✓ The effort is not only focused on the end result but also on the improvement of the competence of the professionals and quality of the works at short term.	✓ Higher skills of the installers cannot be a guarantee of higher quality of the final result if there are no performance based evaluations at the end. ✓ The recognition of the installers can be a big challenge and it can take time to increase the skills of all the professionals. ✓ Such scheme is nearly not possible in a mandatory evaluation scheme; and equivalent voluntary schemes in other countries have shown low to very low penetration of the market.
Inspections of all the installed systems by Third-Party	✓ The reliability of the inspections could be the highest in such scheme because of the higher competence, reliability and independence of Third-Party control organisations such as Notified Bodies. ✓ 100 % of the installed systems are inspected.	✓ The most important disadvantage of such scheme is the higher operational costs for all the parties involved: inspection of 100% of the installed systems by a Third-Party control organisation requires higher costs for qualifications of these organisations and for these inspections.
Mandatory evaluation by recognised Reporters (the scheme developed in Belgium)	✓ Performance based evaluation of the end result. ✓ Lower cost compared to inspection of 100% of installed systems. ✓ See below for more details	✓ No direct guarantee of improvement of the quality and compliance of the works.

Table 1: Description of pros and cons of different options

Compliance concerns related to EP regulation

The following table shows whether the described scheme avoids or limits some of the most typical cases of non-compliance.

No reporting ☑	Wrong reporting ☑	Not meeting the performance requirements ☑

Compliance concerns related to EP regulation

Financial aspects

In this scheme, there are direct costs to be supported by the Ventilation Reporter to be recognised in the scheme:

- ✓ Cost for the exams (theoretical and practical);
- ✓ Annual fixed costs: 200 EUR per company and 50 EUR per recognised person;
- ✓ Variable costs: 70 EUR per delivered Ventilation Performance Report.

But this scheme involves also indirect costs for the Building Contractors:

- ✓ The Building Contractor has to engage a Ventilation Reporter to carry out the mandatory evaluation of the ventilation system and the delivery of the Ventilation Performance Report;
- ✓ As a function of the desired performances and quality of the ventilation system, additional costs can apply for the design and installation of the system. Higher quality requires a higher price.

Overall evaluation

The pros and cons of the described scheme are summarised in Table 2. Overall, the scheme is considered clear and effective.

Pros	Cons
✓ The global scheme as well as the technical criteria are performance based. The means used to design and install the ventilation systems can be chosen freely.	✓ There is no direct guarantee to increase the quality and conformity of the installed systems, because there are no minimum requirements but only a report of the actual performances (good or bad).
✓ The scheme is a compromise between the schemes presented above, namely the recognition of competent installers and the evaluation of all installations by the authority itself or an independent Third-Party.	✓ There is no absolute guarantee that all the installed systems are correctly evaluated and reported because only a sample of the Ventilation Performance Reports are controlled randomly by BCCA.
✓ The principles of the scheme are simple and clear.	✓
✓ The scheme emphasises the responsibility of the different parties: the Building Contractor is free to pay for higher quality or not, the installers are free to propose higher quality of the works based on the common performance criteria, the recognised Ventilation Reporter is only responsible for the correct reporting not for the quality and compliance of the installed system itself.	✓
✓ The scheme should lead indirectly to higher quality and conformity of the installed systems, because the correct evaluation based on clear criteria can help the market to ask for higher quality and compliance.	✓

Table 2: Overall pros and cons of the approach

Level of complexity (dark orange = simplest)	Prerequisite: The scheme is closely related to the specific control and penalty scheme of EPB regulation in Belgium (see [5] and is maybe difficult to replicate without such scheme.
Potential for replication (dark orange = best)	

A summary of hints and pitfalls for developing and implementing a control system including penalties is shown in Table 3.

Hints	Pitfalls
✓ The approach prevents fraud because the procedure is such that the Ventilation Reporter cannot take any advantage from a wrong reporting.	✓ Focus on the real technical performances and not too much additional administrative load.
✓ Coupling of the scheme with the EPB regulation and EPC: the Ventilation Performance Report is mandatory in EPB regulation and the fines in EPB regulation can apply.	✓ Integration of the different schemes and reportings (EPB, Ventilation, etc.): avoid the multiplication of the reports and reporting tools.
✓ Constant consultation of the sector is necessary to ensure the market acceptance of such scheme.	✓ Administrative load, complexity of the organisation of the scheme.
✓ Limited cost of the scheme thanks to random inspection (10% of the reports) and recognition of the reporters by Third-Party.	✓ Choice between a unique or several types of Ventilation Reporters (one per ventilation component: natural supply, transfer devices, mechanical system, etc.).
✓ Non-compliance regarding the EPB requirements leads to fines, but there are no obligations to correct the installation to make it conform.	✓ Timing of the inspections of the Ventilation Reporter on site by the Third-Party.

Table 3: Overall hints and pitfalls to avoid when developing such a scheme

References

[1] STS-P 73-1 Systèmes pour la ventilation de base dans les applications résidentielles / Systemen voor basisventilatie in residentiële toepassingen http://economie.fgov.be/nl/modules/publications/sts/sts_73_1.jsp

[2] VEA: Cijferrapport 10 jaar energieprestatieregelgeving 2006-2015, 2016

[3] Samuel Caillou: Voluntary scheme and database for compliant and easily accessible EPC product input data in Belgium. QUALICHeCK Factsheet #05, 2015

[4] Clarisse Mees, Xavier Loncour: Quality framework for reliable fan pressurisation tests. QUALICHeCK Factsheet #21, 2016

[5] Clarisse Mees: Belgium/Flemish region control and penalty scheme of the Energy Performance legislation: Checking procedure and fines. QUALICHeCK Factsheet #48, 2017

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Technology All Technologies	*Aspect* Compliant and easily accessible EPC input data	*Country* Sweden

CERTIFICATION OF EXPERTS FOR THE ISSUANCE OF EPCS IN SWEDEN

Certification of energy experts who issue the building energy performance certificates (EPCs) is a way to ensure a high quality of EPCs. In the following, a description of the role and certification of energy experts in Sweden is provided.

Residential buildings ☑	Non-residential buildings ☑	Specific buildings: ……
New buildings ☑	Existing buildings ☑	

Context

Energy performance certificates (EPCs) in Sweden are based on on-site measurements on occupied buildings (either new, or existing for many years), and in rare cases on calculations, and are valid for ten years. Certified energy expert issues EPCs. They can also check the compliance with the requirements on energy use and insulation if a municipality asks for it because a lacking in competence of a builder is suspected. The certification is personal and is issued by a certification body. The certification bodies are accredited by Swedac (Swedish national accreditation body). Boverket (National Board of Housing, Building and Planning) formulated the regulations for certification of energy experts and collects the EPCs into a database filled in by the energy experts.

Objectives and problems addressed

A Swedish EPC must contain the following information:

- ✓ energy performance of the building (usually measured/operational specific energy use, rated class A to G),
- ✓ floor area,
- ✓ description of the heating system,
- ✓ description of the ventilation system,
- ✓ information if radon and OVK (mandatory ventilation control) measurements have been made (and results of radon measurements if existing),
- ✓ and specific energy use for a reference building (for comparison).

In addition, recommended measures to decrease the energy use of the building must be included.

Issuing a complete EPC involves many steps and requires extensive knowledge. Therefore the EPC can only be issued by an energy expert who is educated and certified.

Until 2014, it was enough that one person (in a leading position) within an accredited company was an energy expert in order for other personnel within the same company to be able to issue EPCs, but this was considered as an insufficient requirement. A certification applying to energy experts as persons was defined and implemented.

Approach to overcome identified problems

In order to become an energy expert, several requirements need to be fulfilled and there are two levels of competence: Normal (for simpler buildings, i.e. residential buildings with low complexity) and Qualified (for complex buildings) [1]. The independence of the energy expert is required.

The energy expert needs to have a proper educational background with a general technical knowledge. Professional degree or higher education on relevant topics is required, such as building technology, building energy systems or building services engineering. There is also a requirement concerning practical experience described as at least five years' work within the building or real estate sector and whereof two years should be close to the field of energy use and indoor environment (for the appropriate building type, complex or simple).

There are also several requirements on the actual competence of the person, such as:

- ✓ knowledge about indoor factors affecting health and comfort,
- ✓ knowledge about building components and building materials,
- ✓ knowledge about systems (from different time periods) for heating, ventilation, domestic hot water, heat producing units (i.e. heat pumps, solar panels), electricity,
- ✓ knowledge about energy balance of a building including the influence of user behaviour,
- ✓ knowledge about energy efficiency measures (taking into account indoor air quality and prevention of moisture damage),
- ✓ knowledge about calculation of energy use and energy savings, with the ability to use at least one energy calculation program for buildings and ability to use the EPC registration tool,
- ✓ insight on that architectural and cultural values of buildings are affected by energy efficiency measures,
- ✓ and an understanding for the environmental impact of different energy sources.

In addition, there are requirements on the knowledge about regulations and advice, in particular the Swedish planning and building regulations (PBL, BBR) but also about European standards and directives.

The competences that are needed to become a Qualified energy expert (i.e. for complex buildings) are even higher and in more details, both for calculation skills and understanding of for systems, methods and regulations.

The certification includes training (optional but usually a prerequisite) and an exam. The training duration ranges from one day to a few days and is followed by the exam. The exam includes performing a test EPC. The results from the exam are submitted to the certification body to which the person that wants to be certified sends an application. There are currently four accredited certification bodies for energy experts in Sweden and Boverket is the regulatory body.

If the person fulfils the requirements, the certification is granted and is valid for five years. It can be renewed after performing a simplified exam (unless there are special reasons). When the energy expert is certified, his/her name appears at the web site of Boverket and he/she is granted access to the EPC database managed by Boverket, being then able to register EPCs in the database. In addition, the energy expert reports every year on his/her activity (which EPC he/she has performed and what further training he/she has taken).

The certification can be recalled by the certification body if the expert provided incorrect information or if the energy expert has proven to be inappropriate for the task (for example incompetent).

Market acceptance of the approach

Compared to the previous accreditation scheme (before 2014), the current system requires that the person performing the EPC is certified. Earlier, it was the company that had to be accredited. This led to some problems [2, 3], for example, a lack in independence between energy expert and property developers.

In the year of 2010, there were 952 experts at companies that were authorized to perform EPCs in Sweden and in January 2017 there were a total of 830 certified energy experts (persons) [4].

Pros and cons of possible options

There are different pros and cons for the options of having a personal certification and a company accreditation.

Since Sweden is a large European country with respect to area and not densely populated, there can be some difficulty to find an expert in a given area. With the previous accreditation scheme, finding a person that can perform an EPC as a member of an accredited company was probably easier, with only one expert required in the company and not certified staff being able to perform the EPC. With the current scheme of certification of persons, the travel cost can become high for someone who needs an EPC if the expert has to travel far.

It is also possible that the cost for an EPC can be higher for the system using certification of persons, since assistants can no longer participate in the execution of the EPC.

For the accreditation body Swedac, it was easier to monitor and control companies than individuals.

Option	Pros	Cons
✓ Certified energy experts as persons instead of accredited companies	✓ Higher quality of EPCs. ✓ Each person performing an EPC has a high level of competence. ✓ For small companies performing EPCs the cost can be less. ✓ Increased competition can decrease the cost for EPCs.	✓ It can be difficult to find a person for a remote area. ✓ Higher cost for education of staff at companies performing EPC (more people have to be thoroughly educated). ✓ Systems for quality assurance and follow-up are more difficult to maintain and improve for individual experts than the accreditation of the whole company. ✓ Easier to monitor and control for the accreditation body. ✓ Risk for higher cost for EPCs since assistants cannot participate in the work.

Table 1: Pros and cons for certified energy experts (persons) versus accredited companies.

Compliance concerns related to EP certificates and to the QM approach

No reporting ☐	Wrong reporting ☑	Not meeting the performance requirements ☑

Compliance concerns related to EP certificates (see QUALICHeCK terms and definitions)

Since performing a complete EPC involves many steps and requires extensive knowledge, the level of competence of the person in charge is important. Two different approaches have been tried in Sweden: accredited companies (which required one leading energy expert at the company), and certification of persons (energy experts). Both approaches aims at maintaining a high competence. However, it has been judged that a personalized certification assures a higher level of competence and thus more compliant EPCs [5].

Financial aspects

In preparation for the change from accredited companies to certification of persons, the cost for the two different options were calculated (in 2010).

Cost for the accreditation of a company: yearly cost for the accreditation (to Swedac and documentation) 26 000-80 000 SEK (2600-8000 €) + yearly fee app. 30 000 SEK (3000 €) + initial cost in order to conform to ISO 17020. The latter amount depends largely on the starting point of the company, i.e. how developed the company is in terms of, for example, quality assurance work.

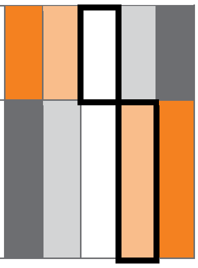
Cost for the certification of an energy expert: training (usually three days) app. 15 000 SEK (1500 €) + time and cost for exam, 2000 SEK (200 €) + yearly fee almost 1000 SEK (100 €). The certification is renewed every fifth year.

Overall evaluation

Certification of energy experts is important. In Sweden, two approaches have been used over the time: accredited companies (which required one leading energy expert at the company) until 2014, and personalized certification of energy experts since then. The overall evaluation is that the current certification of persons is well functioning.

Pros	Cons
✓ Higher quality of EPCs (due to higher requirements about the competence of the energy expert).	✓ Systems for quality assurance and follow-up are easier to maintain and improve in companies.
✓ Facilitates for smaller companies if persons are certified since personal certification means a smaller initial cost for the company.	✓ Easier to monitor and control companies for the accreditation body. ✓ There might be a risk for lack of capacity (energy experts) at times when many EPCs expire. In Sweden, this will occur during 2018-2019.)

Table 2: Overall pros and cons of the approach with certification of individual persons.

Level of complexity (dark orange = simplest)	
Potential for replication (dark orange = best)	

Prerequisites

Prerequisites are: an accreditation body, certification bodies (to certify the energy experts), regulations and a regulatory authority for control. A database for EPCs is valuable but not mandatory.

Hints	Pitfalls
✓ The independence of the certified energy expert need to be ensured. ✓ Requirements on education are important to provide the prerequisites for a good quality. ✓ A certain flexibility in the requirements on education and experience would add value to the system. ✓ Simplified recertification should be possible if the energy expert has shown good results during the certification period of five year.	✓ The EPCs can be costly if only very qualified persons can operate the work. ✓ Less control of how the experts work when the certification is personal compared to when the company is certified. ✓ Might be a risk for lack of capacity (energy experts) at times when many EPCs expire.

Table 3: Overall hints and pitfalls to avoid when developing a system for certification of energy experts.

References

[1] Boverkets föreskrifter och allmänna råd för certifiering av energiexpert, CEX, BFS 2007:5 med ändringar till och med BFS 2016:15, Boverket, 2016.

[2] Regeringens proposition 2012/13:171, Kompetens och oberoende vid upprättandet av energideklarationer, government proposition 2012/13:171, 2013, (http://www.regeringen.se/49bbbd/contentassets/7d8128a3eef34150a0e77a6b6e114c85/kompetens-och-oberoende-vid-upprattandet-av-energideklarationer-prop.-201213171)

[3] Konsekvensutredning med anledning av ändringar i Boverkets föreskrifter och allmänna råd (2007:5) för certifiering av energiexpert, Dnr: 1191-4101/2013, Boverket, 2013

[4] Finding certified energy experts : http://www.boverket.se/sv/om-boverket/tjanster/hitta-certifierade/

[5] Regeringens proposition 2011/12:120, Vägen till mer effektiva energideklarationer, government proposition 2011/12:120, 2012, (https://data.riksdagen.se/fil/269EE8AE-794C-4461-8ED1-69D116958705)

All references are in Swedish.

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Energy Technology Network

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