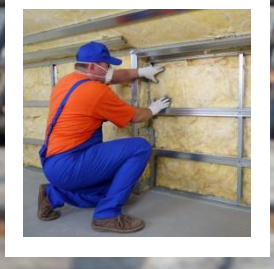
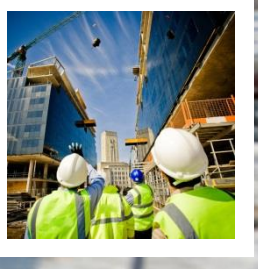
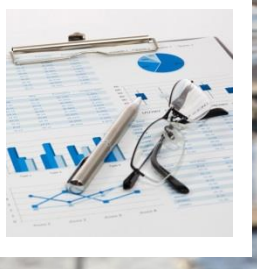
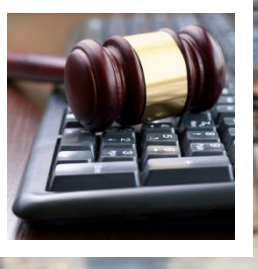
QUALICHeCK
Towards better quality and compliance

Source book on Guidelines for better enforcement of quality of the works

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How to read and use this source book

This source book can, of course, be read through from beginning to end. However, it has been conceived as a book that can be scanned based on the reader's interest in one particular issue or another. Its structure and clear chapter headings will allow the reader to go directly to the pages of his/her choice.

In addition, this report contains numerous references to other documentary resources, largely derived from the QUALICHeCK project. It is strongly recommended that the reader who wishes to go further in his/her reflection consults the cited reports, fact sheets, recorded webinars and slide presentations. All of these are available at www.qualicheck-platform.eu.

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Table of Contents

How to read and use this source book 2

EXECUTIVE SUMMARY 5

1. INTRODUCTION 6

2. CONTEXT OF THIS SOURCE BOOK 8

2.1. What is meant by quality of the works? 8
2.2. Achieving quality of the works: various conditions to be fulfilled 9
2.3. NZEB and quality of the works 9
2.4. Third party and second party control and enforcement frameworks 10
2.5. A third party control and enforcement framework is not always necessary 10
2.6. Governmental control and enforcement schemes are politically sensitive 11
2.7. Terminology 12
2.8. Structure of QUALICHeCK deliverables 12

3. OVERALL PHILOSOPHY REGARDING IMPROVED BOUNDARY CONDITIONS FOR BETTER QUALITY OF THE WORKS 14

3.1. Analysis of the reasons for lack of quality of the works in building construction 14
3.2. Practical experience with skills requirements and enforcement in relation to energy efficient buildings 19
3.3. Challenges and opportunities for the various actors 23
3.4. QUALICHeCK approach for obtaining better enforcement frameworks 24

4. CRITICAL SUCCESS FACTORS FOR EFFECTIVE QUALITY FRAMEWORKS 25

4.1. Overall approach 25
4.2. PART 1: Technical procedures to obtain and prove good quality of the works 25
4.3. PART 2: Robust procedures on how to decide on compliance and how to respond to non-compliance 30
4.4. PART 3: Operational framework for better compliance and effective penalties related to quality of the works 33
4.5. Examples of transmission characteristics 35
4.6. Examples of ventilation and airtightness 36
4.7. Examples of sustainable summer comfort technologies 37
4.8. Examples of renewables in multi-energy systems 38

5. DOCUMENTED SETS OF BEST PRACTICES PART 1: TECHNICAL PROCEDURES TO OBTAIN AND PROVE GOOD QUALITY OF THE WORKS 41

5.1. Clear description of work specifications 41
5.2. Clear description of the procedures to show evidence of compliance 43
5.3. Tracing procedures 44
5.4. Handling of innovative solutions 45
5.5. Consider simpler on-site compliance procedures for certain systems 46
5.6. Consider simpler on-site compliance procedures for certain companies 47
5.7. Rewarding good practice 48
5.8. Specific issues for existing buildings 49
5.9. Quality management approaches 50
5.10. Market surveillance and integrating lessons learned 51
5.11. Influence by European and national legislations and standards 52

6. DOCUMENTED SET OF BEST PRACTICES PART 2: ROBUST PROCEDURES ON HOW TO DECIDE ON COMPLIANCE AND HOW TO RESPOND TO NON-COMPLIANCE 54

6.1. Different types of non-compliance 54

6.2. Clear procedures to check the quality of the works 55
6.3. Types of penalties in case of non-compliance 59
6.4. Clear rules about liabilities and penalties 60
6.5. Consequences in terms of qualification, certification, labelling 62
6.6. Specific issues for (deep) renovations 64
6.7. Influence by European and national legislations and standards 65

7. DOCUMENTED SET OF BEST PRACTICES PART 3: OPERATIONAL FRAMEWORK FOR BETTER COMPLIANCE AND EFFECTIVE PENALTIES RELATED TO QUALITY OF THE WORKS 67

7.1. The willingness to check 67
7.2. The resources to check 68
7.3. Effective sampling schemes 69
7.4. Effective penalties 71
7.5. Handling of market complaints 72

8. ON INNOVATION 73

8.1. Simplified procedures are important but should not be a barrier to innovation 73
8.2. Need for a robust framework for assessing technologies not covered by the classic procedures 74

9. IMPORTANCE OF SOCIETAL SUPPORT FOR COMPLIANCE AND ENFORCEMENT 75

9.1. Effective enforcement is not possible without strong societal support 75
9.2. Raising societal awareness regarding reliability of EPC and quality of the works 75

10. ECONOMICS OF COMPLIANCE 77

10.1. An effective second or third party control and enforcement framework requires effort 77
10.2. Who pays the costs for control and enforcement schemes? 77
10.3. Are there no costs in case of no second or third party control and compliance framework? 77
10.4. Lower total cost? 78
10.5. Compliance checks and enforcement as means against unfair competition? 79
10.6. Cheap financing of stimuli for innovation? 79

11. CONCLUSIONS 80

12. ANNEXES 81

12.1. The meaning of 'quality' in the technical literature 81
12.2. List of QUALICHECK factsheets with relevance to quality of the works and compliance 85

Executive summary

The energy performance of buildings has become a major boundary condition for new buildings but, increasingly for existing buildings as well. At the European level, the EPBD has been the major driver. Whereas the original EPBD was not imposing to the Member States a requirement level to be achieved, the EPBD recast imposes cost-optimal requirements and for new buildings from 2019/2021 onwards the level nearly-zero energy buildings (NZEB).

Of course, one should aim for not only good energy performance but also good quality of the works, as good quality of the works is the precondition for high building energy performance. There can be many reasons for poor quality of the works. Within the context of the QUALICHeCK project, there was a strong focus on compliance frameworks and enforcement, but there might be much lighter and easier to implement approaches, which will also receive broader societal support.

In practice, various studies, including studies carried out in the framework of QUALICHeCK have highlighted that it is not evident to assume that the quality of the works is compliant with expected results. Often the declared EPC of a building is better than what is achieved in reality, due to faults during the construction process. This results in not only a loss of investments but also a decline in energy performance caused by poor quality of the works. To enforce the quality of the work is one of the low hanging fruits on the way to cost efficient high performance buildings.

In this context, this source book intends to analyse the conditions for compliance and the reasons for non-compliance of the quality of the works in buildings: how to make sure that the work on a building is compliant, and thus that the minimum energy performance requirements are met and/or that the owner or tenant is well informed.

To achieve a good compliance of the quality of the works, a three-step approach has been identified:

1. To obtain compliant quality of the works and to prove that they are compliant, there should be clear procedures to obtain and prove the quality of the works,
2. There should be clear (legal) procedures about how to decide on non-compliance of the quality of the works, and how to decide on related actions,
3. There should be effective control and sanctioning mechanisms to be applied in case of non-compliance of the quality of the works.

This source book describes this three-step approach with examples and references to other documents from the QUALICHeCK project, which provide more details.

Different ways to check compliance are described, together with the ways to define penalties so that they are effective, proportionate and dissuasive. The importance of political will and societal support is also emphasised. The way to handle innovative products and systems and the economic impact of compliance are also discussed.

The source book provides guidance and support for compliant quality of the works and will be useful to all stakeholders interested in improving energy performance of new and existing buildings.

1. Introduction

New buildings as well as the existing building stock must become much more energy efficient to reach the EU climate goals (Emissions from houses and office buildings can be almost completely cut – by around 90% in 2050, compared to 1990). Of course, one should aim for not only good energy performance but also good quality of the works, as good quality of the works is the precondition for high building energy performance. Various experiences show that there are cases where the quality of the works is a (major) issue of concern. An analysis of the additional costs in the German construction sector caused by faults during the construction process in 2014 identified approx. 10 Billion € or nearly 10% of the turnover of this sector. Comparable values have been reported from France.

This source book aims to act as guidance and support for persons and organisations that want to know if better enforcement of the quality of the works is needed. Moreover, if it is indeed needed or relevant, what are the possibilities and points for attention to implement a compliant quality of the works framework?

In this source book, we analyse reasons for quality of the works related to compliance and non-compliance to answer the following question:

How to make sure that the quality of the work in a building is compliant, and consequently that the energy performance is met as expected in the EPC and/or that the consumer is well informed?

In this regard, the focus of analysis is on construction processes, but not on the calculation procedure as such.

The EPBD imposes demanding energy performance requirements on the one hand, creating a strong need for the elimination of thermal bridges in the building envelope, for airtight construction, and for energy efficient ventilation systems, and the nearly zero energy building (NZEB) concept on the other hand, requiring the installation of on-site producing renewable energy systems. Therefore, focus of analysis in this report will also be on the technical areas mentioned above. It is important to address the quality of the works related to these technical areas (transmission characteristics, ventilation and air tightness, sustainable summer comfort technologies, renewables in multi-energy systems) in detail, in order to ensure compliance at the level of construction works. Compliance is demonstrated by fulfilling defined requirements at different levels, e.g. maximum allowed specific heat transmission losses, maximum U-values of the envelope elements, maximum annual heat demand for space heating and for cooling, maximum primary energy for operation of building systems (HVAC and lighting).

Often the declared EPC of a building is better than what is achieved in reality, caused by faults during the construction process. Not only a loss of investments but also a decline in energy performance caused by poor quality of the works. To enforce the quality of the work is one of the low hanging fruits on the way to cost efficient high performance buildings.

In order to achieve good compliance, societal support is important, meaning that stakeholders understand and accept the need for energy efficiency requirements, the need for compliance and the need to check and enforce compliance.

A three-step approach (Figure 1) has been identified for achieving good compliance:

1. There should be clear procedures explaining what must be done in order to obtain quality of the works,
2. There should be clear legal procedures on how to decide on non-compliance and related actions,
3. There should be effective control and sanctioning mechanisms to be applied in case of non-compliance.

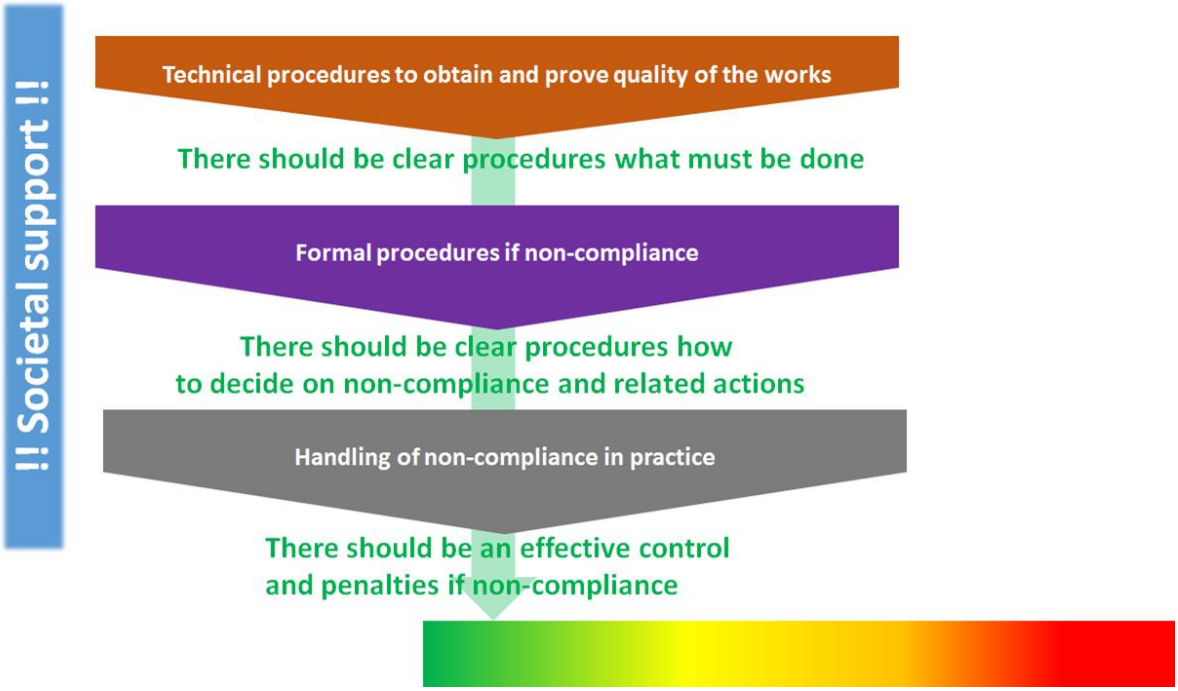


Figure 1: The three step QUALICHeCK approach to an enforcement framework for a better quality of the works

In Chapter 2, the context and scope of this source book is developed, with specific attention to various aspects of the quality of the works and its implementation (e.g. second party or third party control and enforcement frameworks).

Chapter 3 approaches the challenges related to the quality of the works in a global context, with the focus on assessing a certain context and identifying what kind of measures are needed or appropriate. Often, it is sufficient to focus on better specifications and training for acquiring the required competences. However, in some cases second or third party control systems (e.g. examinations by individuals up to on-site inspections) might be justified and or needed.

Chapter 4 is focusing on those cases where there must be second or third party control of the delivered works. The crucial elements for effective enforcement are briefly described in three parts.

The detailed description of these three parts is then discussed in Chapters 5, 6 and 7.

As innovation is a key element for progress, it is important that second and third party control and enforcement frameworks are not a barrier for innovation. This is discussed in Chapter 8.

For third party control and enforcement schemes, it often is crucial to have societal support, and this is covered in Chapter 9.

Control and enforcement schemes always introduce some extra costs, but are there also benefits? This is discussed in Chapter 10.

Finally, the conclusions are found in Chapter 11.

2. Context of this source book

The Energy Performance of Buildings Directive (EPBD) imposes on member states to raise the requirements regarding the energy performance of new and existing buildings. In parallel, there are also various voluntary energy performance frameworks related to minimum energy performance of buildings (active house, passive house, minergy house standard and others). These requirements create challenges in terms of building and system design as well as products and systems to be used. Moreover, they also often represent specific challenges regarding the quality of the construction and installation works.

While reading this source book which focuses on quality of the works in buildings, it is important to have a clear understanding of what is meant by quality of the works, the various aspects of attention and key issues of concern. This is discussed in this chapter.

2.1. What is meant by quality of the works?

Work can be defined as a physical or mental effort or activity towards the production or accomplishment of something. In the context of this book, work refers to all the activities directed to produce or refurbish a building.

In the most important quality standard ISO 9000:2015, quality is defined as “Totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs“. Needs are usually translated into characteristics with specified criteria. Needs may include, for example, aspects of performance, usability, dependability, safety, environment, economics and aesthetics. More information on quality related terms can be found in Chapter 12.1 and in the QUALICHeCK document ‘Terms and Definitions‘.

What is crucial in the context of this source book is that “quality of the works” for a given activity (e.g. installation of a PV system or insulation of an existing cavity wall) has to be clearly defined. As such, one can for the same activity come to a quite different set of specifications (“stated needs”) and, in order to minimise the risk of disputes, one should try to minimise the number of implied needs, as different parties might have a completely different view of the implied needs[1].

"Quality of the works" therefore refers to the potential gap between the works realised and the works expected to meet stated or implied needs. It has no absolute meaning, but is always linked to the stated (and implied) needs, i.e. one has to know the needs in order to judge the quality of the works. When looking specifically at how quality of the works impacts energy performance certificates, "quality of the works" may be further defined as a measure of the gap between the specifications of the works stated or implied to be consistent with the input values assumed to be used in the energy performance certificate, and the actual execution of the works. It is assumed that the desired levels of the corresponding input data are explicitly defined.

Therefore, quality of the works may be considered "good" or "compliant" if, for example:

- ✓ a system is installed according to the technical specifications agreed within a given context (e.g. technical prescriptions, a technical approval, rules of a professional association, etc.);
- ✓ products are installed according to the designer’s and manufacturer’s specifications in another context.

Errors in execution of the works are mistakes (intentional or not) made when implementing the works, taking as reference stated or implied specifications. The quality of the works depends on the size and nature of these errors.

[1] Implied needs are needs which are assumed to be evident. Once you identify and define an implied need, it becomes a stated need.

2.2. Achieving quality of the works: various conditions to be fulfilled

In order to achieve conditions where all parties involved will agree that in practice quality of the works has been realised, at least three conditions have to be met:

1. There must be an agreement about the specifications which have to be met by the works ("What is quality")
   - ➢ *Ideally, it requires a full inventory of the needs to be fulfilled AND clear written statements (in descriptive or performance based terms) of what has to be done.*
2. There must be the required knowledge/competence to design and execute the works according the specifications (The competence to deliver the required quality)
   - ➢ *In case of lack of knowledge and/or competence among part of the design team and workforce, it might be necessary to invest in training activities.*
3. There must be the will and resources to carry out the works according the specifications (The will and means to deliver the required quality)
   - ➢ *In case of concerns about the required will and resources, control and enforcement schemes might be necessary.*

2.3. NZEB and quality of the works

The various conditions to be fulfilled as listed in Chapter 2.2 should apply to all kind of works and therefore also to works in Nearly Zero-Energy Buildings (NZEB).

In practice, there are some specific challenges for NZEB in several Member States, e.g.:

- ✓ The available transition time to come to NZEB requirements is, in terms of the typical transition speed in the building sector, extremely short. In contrast with other industrial sectors, the European building sector is composed of a few hundred thousand architects and millions of construction workers, often working in SMEs.
- ✓ Meeting the NZEB requirements often represents a substantial extra investment cost. The pressure to save costs might result in not meeting these requirements.

1. **What is the required quality of the works for NZEB?**
   The tendency to move to NZEB typically requires for most components energy performances, which are much higher than in the past (better U-value, higher efficiencies, etc.). Moreover, there will be in most cases more care needed with respect to the connections between components (the building nodes, e.g. connection between walls and windows) and interactions between (components of) systems. In parallel with energy requirements, there can be other more stringent requirements (e.g. acoustics)
   In the transposition of the EPBD into national legislation, attention is paid to most product and system characteristics but rarely contains specifications dealing with other aspects of the quality of the works. Also, many incentive schemes or voluntary schemes dealing with energy efficiency and/or renewables mostly focus on the presence of the required components and systems, whereby very limited attention is given to other specifications, such as indoor climate.

2. **How to guarantee that there is the competence to deliver the required quality for NZEB buildings?**
   It is important to evaluate present learning and training programmes with respect to the evolution in specifications due to the NZEB requirements. If needed, one has to invest in adapting training programmes.
   The European BUILD UP skills programme has been focusing on these topics. More information can be found on www.buildupskills.eu.
   There are also various other EU and national projects specifically focusing on creating better conditions for learning.

3. **How to guarantee that there is the will and means to deliver the required quality?**
   In quite a lot of cases, designers and builders will apply the specifications if these specifications are clear and if the required competence is available. This is in particular the case if poor performance might introduce high liability costs, including financial risks. However, there are cases where it is not enough to have clear specifications and the required competence. Often, economic pressure is the major factor for not delivering the required specifications. If this kind of non-compliance is a major issue of concern, one should consider paying more attention to control and enforcement measures.

2.4. Third party and second party control and enforcement frameworks

The focus of this source book is on NZEB related projects whereby control and enforcement has to be considered.

Basically, there are two types of control mechanisms:

- **Second party control**:
  - ✓ In this type of control, it is the client (or its representatives) who carries out the control and enforcement activities.
  - ✓ In case of a building project, control issues can be realised by the owner, the architect, consulting engineers, a quality surveyor, etc.
  - ✓ It can also include internal control, by a quality assurance department in the same company for example.
  - ✓ The specifications are fully covered by the contract between client and supplier.
- **Third party control**:
  - ✓ In this type of control, a legally independent entity is taking care of the control mechanisms.
  - ✓ The third party control can be imposed by government, a public body, a social housing company, voluntary schemes, etc.. It can also be imposed by a private builder.

In addition, there is the concept of self-control, meaning that companies commit themselves to the framework of voluntary quality assurance schemes. However, this concept is not in the focus of this sourcebook.

Most of the content and points of attention raised in this source book are valid for both types of control mechanisms. In the case of second party control, several points of attention might be less crucial. This is in particular the case for societal support as it is the client who imposes the specifications. In contrast are third party control mechanisms that are imposed by government. In order to be effective and lasting, wide societal support is crucial and requires much more care in the preparation and implementation phase.

2.5. A third party control and enforcement framework is not always necessary

Second party control is in the hands of the client and/or its representative(s), whereby the level of control and related compliance measures have to be decided by them. This source book contains information and suggestions which can make such control and compliance actions more effective and acceptable by all parties involved.

A third party control is not always necessary. In particular in the context of energy legislation, incentive schemes, etc., it is important to evaluate if such a third party control scheme is necessary or if more simple measures can achieve a comparable level of quality. The reason is that

third party control and enforcement schemes introduce extra costs for the investor, whereby enforcement and penalties often lead to discussion.

In those cases where it is not clear whether the required level for the quality of the works is achieved, an effective third party compliance and enforcement scheme might be the right option. This source book aims to help the reader to better understand potential bottlenecks while providing suggestions for an effective approach.

This issue is developed in more detail in Chapter 3.

2.6. Governmental control and enforcement schemes are politically sensitive

Third party control and enforcement by governmental organisations (as part of legislation or in the context of incentive programmes), is in most countries politically very sensitive. In general, the building sector is not in favour of third party control schemes with strict enforcement schemes. In particular, some stakeholder organisations might react strongly if the enforcement scheme results in penalties

Therefore, and in order to come to a sustainable control and enforcement scheme, it is crucial to evaluate if such schemes are necessary and, if so, if the development of the scheme is done in close collaboration with the leading stakeholder organisations. By doing so, the stakeholders will probably better understand the reasons for such schemes, and can bring in considerations and suggestions for improvement and reflect the concerns by their members.

Additionally there are different roles the governments on all levels (EU-National-Local) can play, with clear added value to the improvement of the quality of the work:

- Reluctance of construction federations: very often construction or building federations are reluctant to set up appropriate certification or qualification frameworks. Here, both EU and national authorities could support setting up certification or qualification schemes (e.g. Art. 14.3 in Renewable Energy Directive, EU project Build Up Skills, various national qualification schemes). The final scheme has to be set preferably by the different stakeholders.
- Connect current or future instruments to quality frameworks (QF)
  - ✓ Obligation schemes, e.g. for EPC works, have to be executed in framework of a QF (as with airtightness in BE-Flanders)
  - ✓ Support schemes, to receive subsidies for certain EE measures, the government providing the subsidy could require the works to be executed under a certain QF (e.g. cavity wall insulation in BE-Fl).
- Communication with and awareness raising among consumers: final consumers have a high trust in governments to provide information (qualitative installers)
  - ✓ Information campaign on the added value of working with qualitative construction professionals (and why the upfront cost could be higher)
  - ✓ List of available/qualitative construction professionals
  - ✓ Supporting consumers through the process of renovation/new building (local level seems the most appropriate, e.g. Stuttgart, QUALICHeCK Factsheet 8).

2.7. Terminology

Compliance - Compliant

Compliance is defined as according with EPC procedures or with specifications of the works. Compliant is the adjective referring to something that is in accordance with EPC procedures or with specifications of the works.

Quality of the works

"Quality of the works" refers to the potential gap between the works realised and the works expected to meet stated or implied needs. When looking specifically at how quality of the works impacts energy performance certificates, "quality of the works" may be further defined as a measure of the gap between the specifications of the works stated or implied to be consistent with the input values assumed to be used in the energy performance certificate, and the actual execution of the works. It is assumed that the desired level(s) of the corresponding input data is (are) explicitly defined.

Therefore, the quality of the works may be considered "good" or "compliant" if, for example:

- ✓ a system is installed according to the technical specifications agreed within a given context (e.g. technical prescriptions, a technical approval, rules of a professional association, etc.);
- ✓ products are installed according to the designer's and manufacturer's specifications in another context.

Quality of the works has no absolute meaning, but is always linked to the stated (and implied) needs, i.e. one has to know the needs in order to judge the quality of the works.

Errors in execution of the works

Errors in execution of the works are mistakes (intentional or not) made when realising the works, taking as reference stated or implied specifications. The quality of the works depends on the size and nature of these errors.

2.8. Structure of QUALICHeCK deliverables

This report builds on the outcomes of QUALICHeCK (see Figure 1), namely:

- ✓ The **status on the ground report**, which includes the analysis of 31 specific studies addressing specific concerns on performance data from the field, the compliance of input data, the quality of the works, as well as feed-back from compliance frameworks.
- ✓ The **reports of each of the 10 field studies** conducted within QUALICHeCK in the nine focus countries of the consortium. These studies aimed at enriching the literature on quality and compliance issues with clear data. Each study investigated a sample of at least 25 buildings.
- ✓ The **report on documented examples of existing situations regarding quality of works** that describes a series of critical situations on the construction site that can result in poor quality, successful initiatives to overcome site implementation issues and examples in the context of regulatory frameworks, quality labels, self control or quality management procedures/guidelines, and training programmes.
- ✓ **59 factsheets** produced in total within QUALICHeCK, including 29 with a specific focus on quality of the works and compliance aspects (see also Annex 12.2).

All of these deliverables are available on the QUALICHeCK website.(www.qualicheck-platform.eu)

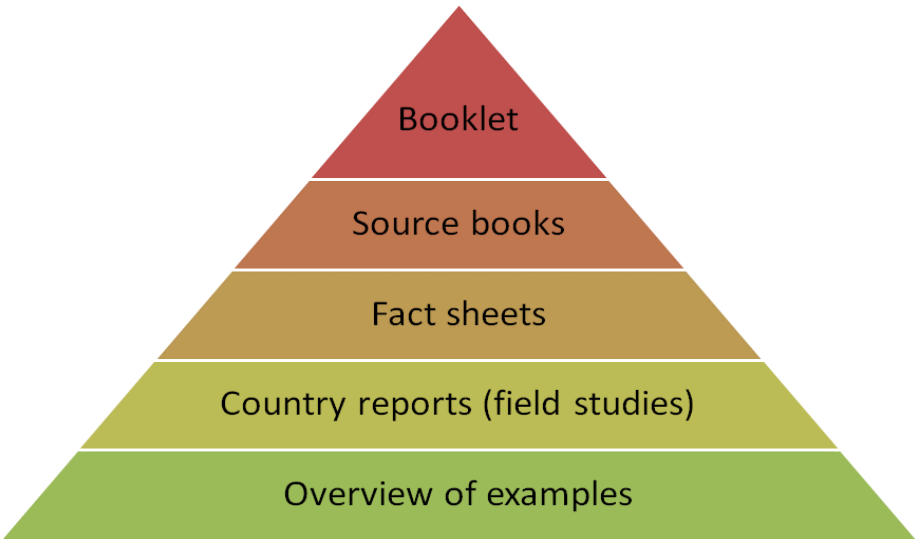


Figure 1: QUALICHeCK deliverables

3. Overall philosophy regarding improved boundary conditions for better quality of the works

There can be many reasons for poor quality of the works. Before deciding on any kind of corrective measures, it is important:

- ✓ to understand the reasons for the poor quality of the works
- ✓ to identify the most effective way for remediation.

Within the context of the QUALICHeCK project, there is a strong focus on compliance frameworks and enforcement, but there might be much lighter and easier to implement approaches, whereby these approaches will also receive a broader societal support.

Therefore, it is very important to understand reasons for problems with the quality of the works and possible ways for remediation. The analysis of these issues has already been partly done in the framework of the EPBD Concerted Action 3 and in close collaboration with BUILD UP Skills. This resulted in a report published in 2014[2].

Three of the four authors of this report are also participating in the QUALICHeCK project and this work has been further developed in the framework of this project.

Specific emphasis is put on the differences and synergies between capacity building in workers' skills and enforcement schemes. Both can be crucial elements to improve the building quality on site. The following aspects are described in the next chapters:

- ✓ Analysis of the reasons for lack of quality of the works in building construction (Chapter 3.1);
- ✓ Practical experience with skill requirements and enforcement in relation to energy efficient building (Chapter 3.2);
- ✓ Challenges and opportunities for the various actors (Chapter 3.3);
- ✓ QUALICHeCK approach for obtaining better enforcement frameworks (Chapter 3.4).

3.1. Analysis of the reasons for lack of quality of the works in building construction

Assuming that there is a common understanding of what is meant by good quality of the works, the following two requirements have to be met:

- ✓ The appropriate competence for achieving a good quality of the works.
- ✓ Effective use of this competence.

In the next paragraphs, these aspects are dealt with in more detail.

3.1.1. Lack of competence for achieving good quality of the works

There are problems regarding the quality of the works in several types of works related to energy efficiency and renewable energy in buildings. Often, this is due to a lack of competence, either in

[2]Marcello Antinucci, Susanne Geissler, Marianna Papaglastra, Peter Wouters (2014): CA EPBD Task Force on the interaction with BUILD UP Skills: Towards improved quality in energy efficient buildings through better workers' skills and effective enforcement. A view of the Concerted Action EPBD on Challenges and Opportunities. PUBLIC REPORT.
www.epbd-ca.org/Medias/Pdf/CA_EPBD_BUS_interaction_report.pdf

design, or in the execution of the works (and the latter is explained in the chapters below), or both:

3.1.1.1. Lack of competence regarding 'classical' works

Experience shows a lack of competence for several, rather well-known technologies, e.g.:

- ✓ poor placement of thermal insulation in walls, resulting in high energy losses;
- ✓ poor placement of windows, resulting in high air leakage losses, acoustical and other problems;
- ✓ poor execution of ventilation systems, resulting in wrong airflow rates, acoustical problems and maintenance issues.

Basic knowledge of good rules of workmanship, along with the appropriate training courses, technical publications, etc., can be very useful and should in principle already be available. Such training can be organised either by neutral training organisations, or by the supply industry or other organisations. In all cases, and in order to increase the credibility of the building workforce, it is important that such training is worked out in close collaboration with the representative professional organisations (for example, building associations).

3.1.1.2. Additional challenges for new technologies

To a large extent driven by the more strict energy targets, a whole range of new technologies have recently emerged in the market, e.g., heat pumps, photovoltaic installations, solar collectors, vacuum insulation, switchable glazing, multi-functional systems for heating, ventilation and domestic hot water and others. In parallel, for more classical aspects, like ventilation and airtightness, new solutions and components introducing higher complexity with much higher performance requirements are resulting in the need for additional skills in several countries. All in all, in order to improve the quality of the works, there is a need to develop appropriate training and course material. At the same time, and in particular for such new emerging technologies, for which there can be a very quick evolution in the market, the need for regular updating of the course material is crucial.

Also, close collaboration with the representative professional associations, and in particular with the representative branch organisations/federations of such innovative technologies, is important to guarantee up to date content and credibility of the information.

3.1.1.3. Important to guarantee that the required knowledge is effectively available

Assuming that a sufficiently wide offering of appropriate training is provided to the market, it is still not reasonable to expect that all relevant building workers will follow such training and effectively acquire this type of knowledge. In order to guarantee this, there is a need to create the relevant boundary conditions, e.g. mandatory training requirements and certification of persons who have successfully followed a course.

3.1.2. Effective application of the available knowledge

Is it correct to assume that acquiring knowledge will result in better workmanship?

In many cases, such an assumption is valid, also in the building sector. This may typically be the case for works where poor workmanship results in high risks of damage claims and/or security & health problems, e.g.:

- ➢ electricity and gas works;
- ➢ stability of buildings;
- ➢ works that result in (major) aesthetic or functional problems. e.g.:
  - ✓ condensation and mould growth problems due to thermal bridges;
  - ✓ corrosion of steel in concrete;
  - ✓ cracks in plastering;
  - ✓ damage to PV panels by heavy winds.

In various other cases, it is not correct to automatically assume that the acquired knowledge will be implemented. This may typically be the case for technologies where:

- ✓ good workmanship means extra efforts and/or costs, in terms of design, material and system costs and labour time AND
- ✓ whereby lower quality works do not often result in major claims.

Examples may be:

- ✓ **the installation of ventilation systems**, where controls often highlight problems regarding the air flow rates, the acoustical performances and/or energy efficiency features; however, there often is little risk that poor performance will result in actual damage claims;
- ✓ **building airtightness**: unless there are very strict compliance frameworks in place, there is a high probability that requirements will not be met in practice;
- ✓ **energy aspects of thermal bridges;** these performances are very difficult to detect and, if detected, are often not feasible to legally demonstrate a problem of compliance.

3.1.3. Step by step approach for combining capacity building with enforcement schemes

As illustrated in Figure 2 it is appropriate to use the following logic in order to make sure that capacity building will actually result in an energy efficient building (NZEB) on site:

STEP 1: Analyse if there is a sufficient availability of Vocational Education and Training (VET) and if the available VET is in line with the needs for NZEB buildings.

- ➢ If this is not the case, then there is a need for new VET, or to upgrade the existing VET to bring them in line with the NZEB needs.

STEP 2: Analyse if, despite the availability of appropriate VET, there is a substantial risk that workers are not following these trainings and/or not sufficiently acquiring the assumed competences.

- ➢ In case of a substantial such risk, several actions can be taken into consideration, e.g. mandatory courses, examinations, certification of successful training, obligation to have works executed by certified workers, etc..

STEP 3: Analyse if there is a risk that competent workers will not carry out the works accordingly, e.g. due to cost considerations, competition, difficulties at work, etc.

- ➢ In such cases, the following possibilities should be evaluated for more effective control:
  - ✓ **TYPE OF REQUIREMENTS**: These can range from the obligation to make use of certified workers, to random inspection of the works, up to inspection of each individual building site. This is further discussed in Chapter 3.1.3.1.
  - ✓ **DIRECT OR INDIRECT CHECKS OF THE QUALITY OF THE WORKS**: Checks may either focus on the competence of the worker, or on the final outcome of the work. This is further discussed in Chapter 3.1.3.2.
  - ✓ **FRAMEWORKS FOR IMPOSING QUALITY REQUIREMENTS**: The framework in place for such effective control is crucial and may vary from within a wide range of possibilities: imposed at the level of individual projects, imposed for a specific sector (e.g. social housing), imposed by insurance, imposed by governments (e.g. when applying for incentives), or even mandatory for all cases. This framework may also apply to voluntary schemes, managed by certification bodies for the certification of persons or companies. The topic is further discussed in Chapter 3.1.3.3.

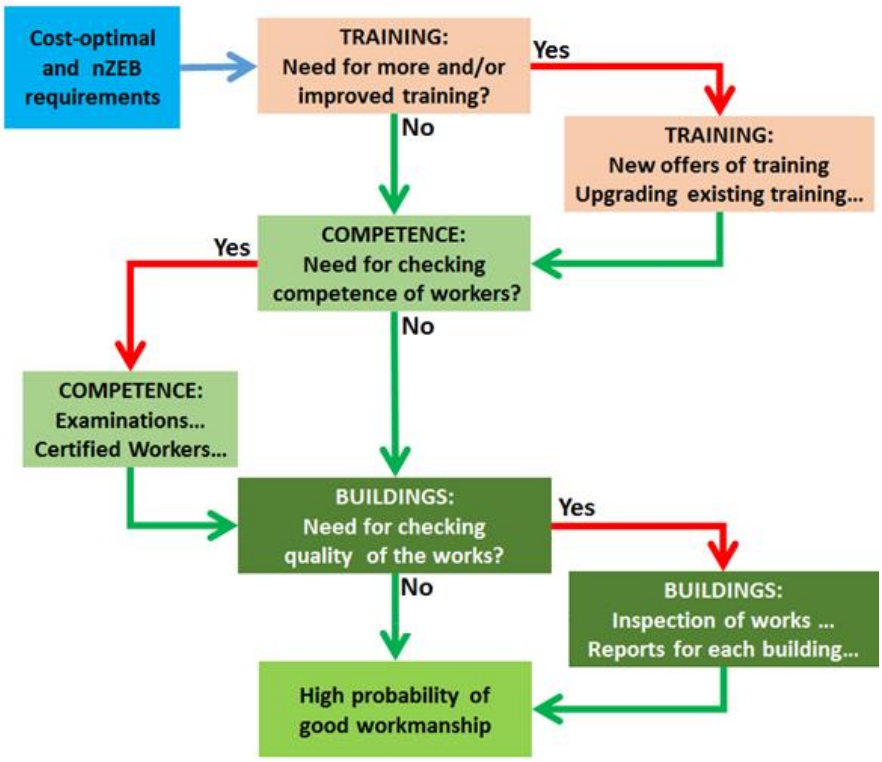


Figure 2: Step by step approach for combining capacity building with enforcement schemes

3.1.3.1. Type of requirements

In case there are strong concerns that poor workmanship will occur although there are no major barriers for acquiring the required competence, external drivers for increasing the probability of good workmanship may be considered.

Three common types of external control are briefly described in the next paragraphs and in Chapter 2.4.

Works to be performed by certified persons/companies

In this approach, the works must be performed by certified persons/companies, but without a direct follow-up action (such as reporting site-related performance features or inspection) of each building project.

Declaration of performance by a certified person for each building site

In this case, there is a specific action expected for each building project. This can include reporting of specific, site-related performance features. In some cases it is mandatory that such reporting is done by independent persons (e.g., airtightness reporting in France), whereas in other frameworks the reporting can be done by persons involved in the building project, but certified and controlled by a third party.

Systematic inspection of a building site by an independent person

The strictest form of control is **inspection**, whereby each building site or random samples is visited by an independent person. This can be quite costly and should therefore only be considered in cases where poor quality may result in major costs (in terms of energy losses, damage, or health & safety issues).

A typical example of such a control, for non-energy related works is the mandatory inspection of new electrical and gas installations prior to connecting to the grid. Major drivers in this example are health and safety risks.

3.1.3.2. Direct and indirect control of the quality of the works

Indirect checks: Focus on the effective competence of the workers

A direct check of the required performances (e.g. whether or not an existing cavity wall is completely filled with the appropriate density), may often be very costly and resource consuming. In such cases, an effective procedure might be to focus on the quality of the design and execution **competences**, in combination with random checks of the executed works.

Direct checks: Focus on the effective performances in practice

In several cases, a direct determination of key performances can be very effective. This is, for example, the common approach to quality checks of new electrical and gas installations mentioned above. In principle, everyone (including the do-it-yourself) can execute the works, as long as the final requirements are achieved. Such an approach is the case in many countries for the mandatory inspection of cars, for example.

In the area of energy efficiency of buildings, there are several examples of such direct performances (e.g. airtightness testing of building envelope and air distribution systems, air flow rates of mechanical ventilation systems, etc.).

Combinations of various types of checks

Often, it is not possible, and/or economically not feasible to perform a comprehensive check of all the direct performances (e.g. the U-value of an insulated wall, the effective output of a PV system, etc.). In practice, it can be very efficient and desirable to have a combination of direct and indirect checks. Such real life examples are the schemes used in Belgium and the UK for the insulation of existing cavity walls, whereby on one hand specific duties have to be carried out by workers that have completed a mandatory training and examination (indirect check), and on the other hand measurements (direct check) are performed on site, e.g. the width of the cavity, the area of insulated walls, etc..

In certain cases, different quality frameworks may co-exist in parallel. France has since 2012 a mandatory quality framework for building airtightness that comprises of either:

- ✓ direct checks: a direct measurement of the building airtightness of each building by certified testers; or
- ✓ indirect checks: a proven quality framework at the level of the building firm, allowing airtightness declarations without testing each building.

3.1.3.3. Frameworks for imposing quality requirements

The basic principle for a quality framework must be ‘voluntary if sufficient, mandatory if needed’. In practice, there is a wide range of frameworks for imposing quality of the works:

- ✓ **at the PROJECT LEVEL**: at the building or individual site, the building owner, architect or other can impose that the works are done under a specific quality framework;
- ✓ **at the SECTOR LEVEL**: a specific sector (e.g. association of external insulation, PV installers) can impose that all their members respect an agreed quality framework;
- ✓ **at the REAL ESTATE DEVELOPMENT LEVEL**: major real estate developers (e.g. in the social housing sector) can decide to impose that all their works respect an agreed quality framework;
- ✓ **at the INSURANCE COMPANY LEVEL**: insurance companies can impose compliance with a specific quality framework as a prerequisite for accepting certain works as part of the covered guarantee;
- ✓ **at the GOVERNMENTAL LEVEL**: governments can impose compliance with specific quality frameworks as a condition for incentives, or as a general quality requirement for all works.

Practice shows that imposing quality frameworks in not equally easy at all levels:

- ✓ at the project level it will be difficult to impose if the end user is not sufficiently aware, and subsequently sufficiently convinced of the added value of the quality framework;

- ✓ to convince sector associations to respect a given quality framework can be very challenging, in particular if the sector association is not covering the whole sector, e.g. if a part of the sector is applying lower quality standards.

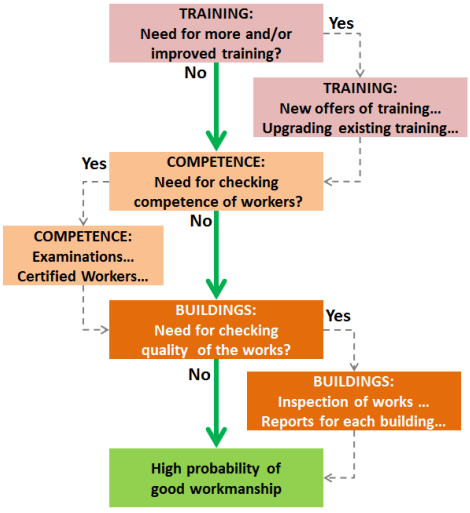
3.2. Practical experience with skills requirements and enforcement in relation to energy efficient buildings

In this section, a series of examples are given on how to deal with skill requirements and enforcement in relation to energy efficient building. The following aspects are described in the next chapters:

- ✓ market uptake of new energy efficient products without specific challenges for building workers;
- ✓ thermal bridges;
- ✓ renewables;
- ✓ insulation cavities in existing cavity walls;
- ✓ building airtightness;
- ✓ ventilation.

3.2.1. Market uptake of new energy efficient products without specific challenges for building workers

Surprisingly, a whole range of sometimes spectacular developments in terms of improvement of the energy performance of buildings often have nearly no impact on the required skills and needs for good workmanship. Such examples are the replacement of classical double-glazing by argon filled, low-e glazing, the replacement of boilers by products of the same technology with higher efficiency, etc..



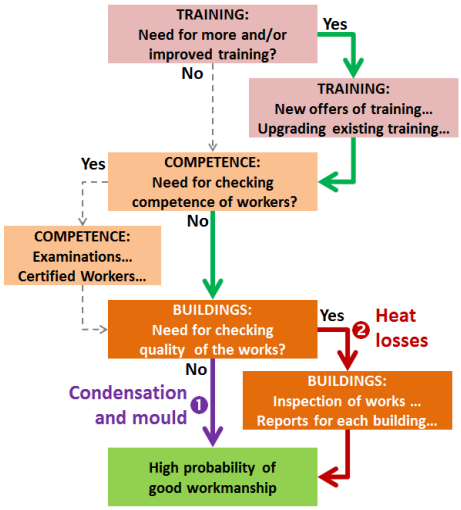
In such cases, the existing training schemes can continue to exist with only marginal updates. Of course, if there are already major quality concerns with the classic systems, there might be a need for better training and/or control, but this is then not linked to the introduction of new technologies.

3.2.2. Thermal bridges

The example of thermal bridges is an interesting one as it illustrates that the challenges regarding compliance and enforcement may differ for different aspects. Thermal bridges present two major issues of concern:

- ✓ increased energy losses;
- ✓ risk of condensation and/or mould problems.

Both aspects create a need for training (of designers, craftsmen) on how to minimise relevant problems. Improved and/or new training is crucial, in particular within the context of NZEB.



In terms of compliance and enforcement, there are fundamental differences between these two aspects:

- ✓ **Condensation and mould** problems will be detected by the users of the buildings. There can be multiple reasons for these problems, e.g. wrong building detail, poor execution of the works, excessive humidity production in the building, lack of ventilation, etc.. There are various mechanisms for dealing with non-compliance and enforcement (e.g. agreement for solution between building partners, decision by court case, etc.). Imposing a requirement (e.g. a minimum surface temperature) would require a lot of work (2D- and 3D- thermal bridge simulations) to assess the building envelope as well as to check the results.
- ✓ For **energy losses**, the situation is very different. It is in practice almost impossible for the building user to identify if there are (major) thermal bridges with high energy losses. It seems therefore useful to have a formal framework in place, allowing checks at building project level.

Example: Belgian approach for thermal bridges

A refined scheme is in place in Belgium for taking the **energy aspects** of thermal bridges into account in the Energy Performance of Buildings calculations. Five possibilities for compliance checks are allowed, the simplest approach being a default value (e.g. the U-value is increased by X W/m^2K) and the most complex being a detailed, 2- or 3-dimensional, calculation. The three intermediate options are based on the principles of 'approved building nodes', whereby a relatively small extra heat quantity has to be taken into account. There is no framework for certified 'calculators', but an assessment has to be done for each building. Indirectly, it is a major driver for craftsmen to pay attention to thermal bridges.

With respect to condensation and mould growth, it was an explicit choice not to impose requirements as part of the EPBD implementation.

3.2.3. Renewables

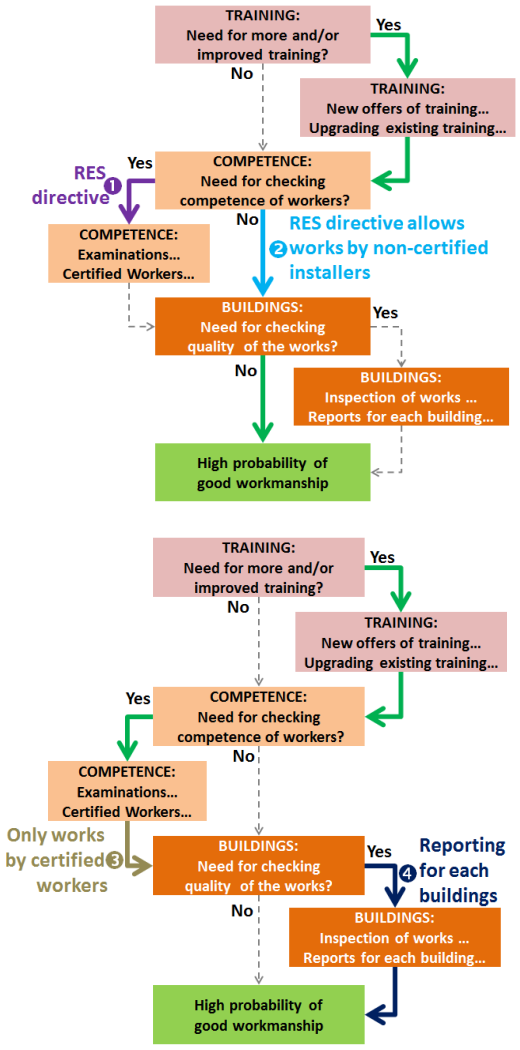
It is clear that technologies that are based on renewable energy sources (thermal solar systems, PV systems, heat pumps, etc.) represent for craftsmen new challenges, and there clearly is a need for new forms of training and/or refinement of existing training schemes.

The Renewable Energy Sources Directive (RESD) requires Member States to develop frameworks for the certification of RES installers. However, the same Directive (RESD) does not require that the works have to be done by a certified installer.

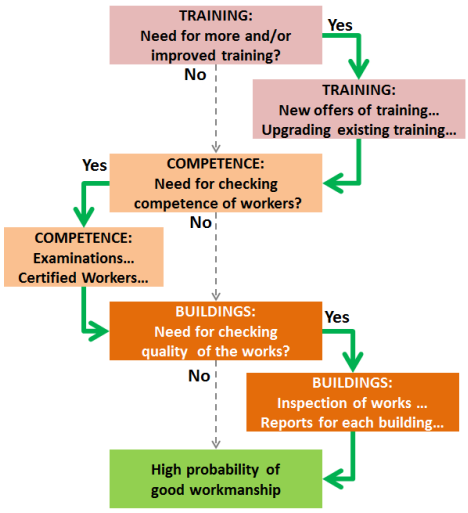
Poor design, system quality and/or poor workmanship may result in major problems in practice. Examples are major damages to solar systems installed on the roof during storms.

In practice, it is possible to go further than the requirements in the RES Directive:

- ✓ Member States, insurance companies, major builders, etc. can impose that the works have to be done by certified workers;
- ✓ moreover, Member States, insurance companies, major builders, etc. can impose that there is specific reporting for each building, as well as random controls, etc.



3.2.4. Insulation cavities in existing cavity walls



In some countries, e.g., the UK, Belgium and The Netherlands, it was in the past quite common to have non-insulated cavity walls. It is clear that such walls represent high heat losses. A potentially attractive technique to reduce heat losses is the post-insulation of the walls, by blowing-in or injecting cavity insulation. However, such works require the use of appropriate insulation systems and competent workers.

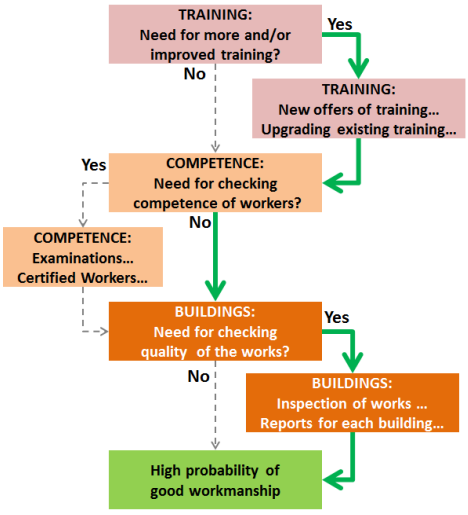
In the UK and, more recently also in the Belgian Flemish Region, quality frameworks with wide scale implementation have been set up to ensure that cavity insulation is properly implemented. These schemes require, at least for a certain part of the work, the involvement of certified persons, in conjunction with the use of proven insulation techniques. In addition, there is also a mandatory reporting at the building level.

Examples: Quality frameworks for cavity insulation of existing walls in the UK and the Belgian Flemish Region

The quality framework for cavity insulation by CIGA (Cavity Insulation Guarantee Agency - www.ciga.co.uk) has already been in operation in the UK for many years. In practice, more than 3 million dwellings have been insulated within the CIGA framework.

A rather similar framework has been in operation since mid-2012 in the Flemish Region of Belgium. By the end of 2013, more than 20,000 dwellings had been insulated within this quality framework in Belgium.

3.2.5. Building airtightness



Within the move towards NZEB, there is a fast-growing attention to building airtightness. Building airtightness is in many countries a rather new point of attention which clearly results in new training needs for designers and craftsmen. Of specific importance is the fact that nearly all building professionals have an impact on the overall building airtightness; it is of course difficult to impose that all works are done by certified workers. In principle, it is rather easy to measure the overall airtightness result with a pressurisation test and most EPBD-related calculation methods allow taking such measured values into account.

There are several issues of concern, in particular:

- ✓ Reliability of declared airtightness results: incorrect values may be reported as a result of testing without the appropriate competence, or in case of fraud. Several countries put schemes in place that require the use of certified testers in order to minimise such risk. Examples of such governmental schemes are found in France, the UK and Sweden.
- ✓ Long term performance: it is not evident to assume that initial airtightness levels will be maintained during the lifetime of the building. The potential risk can be minimised through appropriate building details, good workmanship and high quality procedures at the level of the building companies.

More information can be found on www.tightvent.eu.

Example: French quality framework for building airtightness

In the framework of the French RT2012 regulation, it is mandatory to assess the building airtightness. Two possibilities exist:

- ✓ a systematic testing of the airtightness of each building; such tests must be done by certified testers and the assessment also includes leakage detection;
- ✓ an overall quality framework at the level of the building companies involved; this approach requires the fulfilment of a series of procedures at the company level, in combination with testing of about 5% of all buildings.

3.2 6. Ventilation

In general, and most certainly in the context of improved attention to building airtightness, it is important to have buildings with the appropriate ventilation systems guaranteeing good indoor air quality. Moreover, in the context of the move towards NZEB, it is important that these ventilation systems are energy efficient.

Practice in many countries often shows problems in the design, execution and/or maintenance of the ventilation systems; the reasons often being a lack of competence and a lack of availability of broader training. In order to increase the likelihood for correct execution of the works, several countries created voluntary quality frameworks, including certification of installers of ventilation systems. However, it remains uncertain whether the market will automatically make use of such quality frameworks. This is illustrated by the experience in the Netherlands, where apparently only 2% of the installers are working according to such quality framework. An interesting positive example however is Sweden. Here, and for most building types, it is mandatory to let a certified person perform a check, both at the moment of delivery of the installation, as well as during the lifetime of the building. In France the voluntary labels Effinergie+ and BEPOS Effinergie 2013 require that a visual inspection of the ventilation system and the measurement of the ductwork airtightness are conducted after completion of the work; measurement of the ventilation airflow rates is optional. In the case of the Swedish and the French approaches, there is no need for proven competence of the installers. However, the fact that there is a strict control at the end of the works is a very strong driver for competence.

Examples: Inspection of ventilation systems in Sweden and France

In Sweden, the testing of ventilation systems has been mandatory for most building types for several years. Two types of certified testers exist. A control has to be done at the moment of delivery of the installation and also at regular intervals. These intervals (3, 6 or 9 years) are a function of the type of building.

In France, the Effinergie+ and BEPOS Effinergie 2013 labelling scheme impose a quality control of the ventilation system at the moment of delivery of the system.

3.3. Challenges and opportunities for the various actors

It is clear that an effective quality framework may have a substantial impact on the working conditions for the various actors in the building process. In the following paragraphs, some considerations are given for the supply industry, the contractors, the designers and the government.

3.3.1. The impact of an effective quality framework on the supply industry

For the supply industry, an effective quality framework will be a major push for improvement of the quality of the installed products. Moreover, and perhaps even more important, it may be a very strong driver for the development of new products and systems which optimise certain aspects of workmanship and the end result. This could lead to products that are easier to use and implement, as well as to systems that can be installed with less risk of error. This could also be a driver for the improvement of the instructions given to the workers about the implementation of the products and the installation of the systems: new training tools using modern information and communication technologies, improvement in the clarity of the instructions, new media for referring to these instructions on site, etc..

For example an appropriate quality framework for air distribution systems (with attention to good airtightness, low pressure losses, etc.) may be a strong driver for the supply industry to provide systems that are easy to correctly install and with low pressure drops. On the contrary, the use of high performance products in markets which show only a low quality focus will often be marginal. As a result, there will be limited interest in product development from the supply industry.

In economic terms the total investment cost is not necessarily higher when using better-conceived products and systems, as the extra product costs might be compensated by lower installation costs.

3.3.2. The impact of an effective quality framework on the contractors

In the context of an effective quality framework, contractors will have to deliver good quality of the works. Depending on the original market conditions, this may require a substantial effort for the building contractor sector. At the same time, an effective quality framework might be very positive for those contractors delivering good quality, as there will be much fairer competition with other contractors who had delivered poor quality.

In areas where there is a wide consensus that quality improvements are important, it is crucial to support these by providing the appropriate services and the relevant timing to raise the quality standards for the sector. If these are not in place, societal support for such changes might be lost

3.3.3. The impact of an effective quality framework on the designers

In the context of an effective quality framework, several changes might be needed for the design sector, and will affect architects, consulting engineers, etc. in the following ways:

- ✓ On the one hand, due to new procedures and requirements they may have to pay more attention to appropriate specifications for achieving good quality of the works, in particular where several types of contractors are involved. As an example, an effective quality framework will stimulate designers to provide sufficient space for technical installations for HVAC.
- ✓ On the other hand, an effective quality framework may facilitate acceptance of the delivered works. As an example, several countries have installed a quality control system to provide confidence in the quality of the works for cavity wall insulation in existing walls.

3.3.4. The impact of an effective quality framework on the government

Imposing governmental requirements is often not popular. In order to achieve the crucial societal support for such requirements (as part of incentives, general requirements, etc.), stakeholders' concertation is crucial and pragmatic implementation is important.

If successfully implemented, an effective quality framework will give better energy performance, reduce the risk of problems and increase societal support. It will also facilitate the achievements of the 20-20-20 targets according to the EU climate and energy package.

3.4. QUALICHeCK approach for obtaining better enforcement frameworks

In case the implementation of an enforcement framework is considered as an effective approach for a better quality of the works, the QUALICHeCK approach is based on a three step approach (see Figure 3)

PART 1: Technical procedures to obtain and prove good quality of the works

- There should be very clear technical procedures describing what is understood by good quality of the works, in order to minimise the risk of differences in interpretation in case of control.

PART 2: Robust procedures on how to decide on compliance and how to respond to non-compliance

- There should be very clear and enforceable procedures regarding the rules for identifying compliance, and sanctions and penalties in case of non-compliance.

PART 3: Operational framework for better compliance and effective penalties related to quality of the works

- There should be appropriate resources for carrying out monitoring and, if necessary, for an effective penalty.

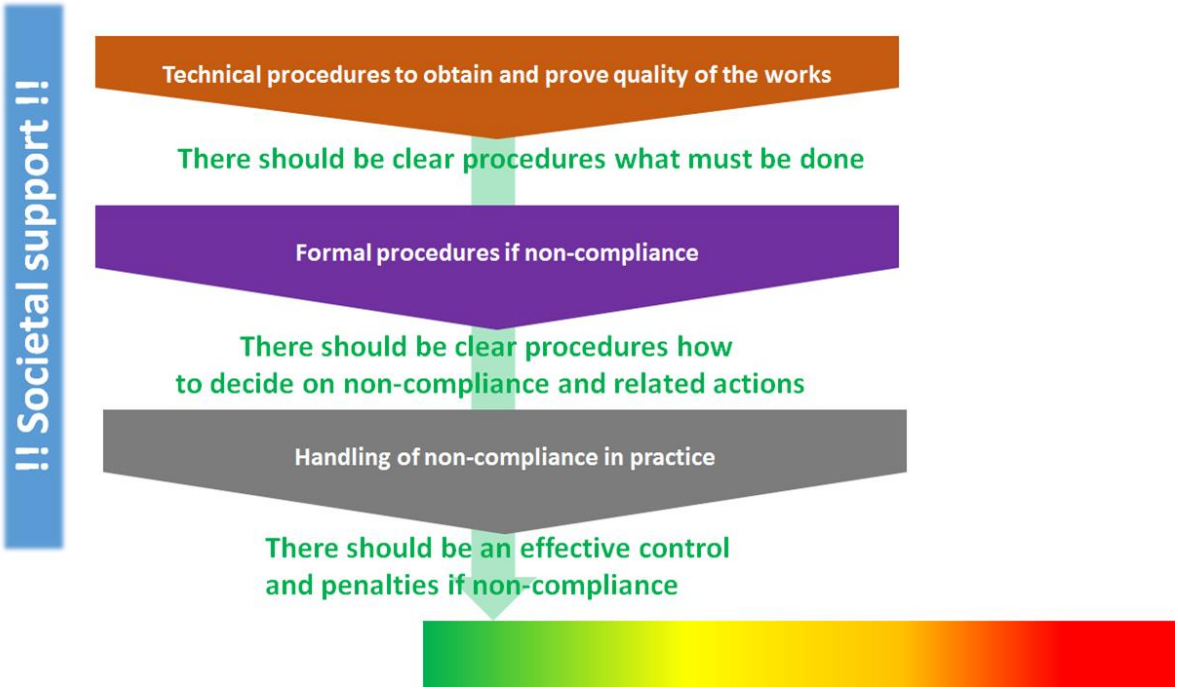


Figure 3: The three step QUALICHeCK approach to an enforcement framework for a better quality

4. Critical success factors for effective quality frameworks

The challenges regarding quality of the works in NZEB buildings were discussed in general in Chapter 3. In this chapter we focus on those circumstances whereby second or third party control schemes are considered appropriate and/or necessary to achieve large-scale quality of the works.

4.1. Overall approach

In order to achieve good compliance, societal support is important, meaning that stakeholders understand and accept the need for energy efficiency requirements, the need for compliance and the need to check and enforce compliance.

A three-step approach has been identified on how to achieve good compliance:

- ✓ There should be clear procedures on what requirements must be fulfilled in order to achieve good quality of the works (Part 1)
- ✓ There should be clear procedures on how to decide on compliance and related actions in case of non-compliance (Part 2)
- ✓ There should be effective control and penalties mechanisms to be applied in cases of non-compliance (Part 3)

The paragraphs below present the analysis of reasons for good and poor quality of the works allocated to each of the three steps. Each of these three steps will be discussed in more detail and in a structured way in Chapter 5, Chapter 6 and Chapter 7.

4.2. PART 1: Technical procedures to obtain and prove good quality of the works

The analysis of the construction practice illustrates that there are different ways to specify quality related procedural aspects:

- ➢ There can be specifications regarding competence of persons or companies:
  - ✓ Need to follow training,
  - ✓ Need to successfully pass theoretical exams,
  - ✓ Need to show competence in practice,
  - ✓ Need to be qualified and/or certified (e.g. linked to RES Directive).
- ➢ There can be specifications regarding techniques to be used and execution rules
  - ✓ Need to use approved systems and follow the related execution specifications.
- ➢ There can be specifications regarding checks on site
  - ✓ Measurement of airflow rates.
- ➢ There can be a combined set of requirements
  - ✓ PV installations: competence, system choice, checks on site.

Sometimes, there can be several paths in parallel and/or in progress at the same time.

This chapter presents an analysis of reasons for good and poor quality of works, taking into account the following aspects with regard to practical procedures:

- ✓ Clear description of work specifications
- ✓ Clear procedures to show evidence of compliance
- ✓ Tracing procedures
- ✓ Handling of innovative solutions
- ✓ Usability of the specifications in practice
- ✓ Giving benefits to systems that have a high probability to perform well
- ✓ Rewarding good practice
- ✓ Specific issues for existing buildings

- ✓ Quality management approaches
- ✓ Market surveillance and integrating lessons learned
- ✓ Interrelation with European and national legislation and standards

The chapters below briefly describe these aspects, and an overview of reasons for good and poor quality of the works is highlighted in Table 1. Detailed information about these aspects is available in Chapter 5.

4.2.1. Clear description of work specifications

In most of the building project tenders there is a comprehensive description of material and technologies to be mounted, but the quality description of the executed work is often not part of the construction contract and depends finally on the experiences and the philosophy of the contractor and craftsmen. Due to the complex influences of some technologies on the overall performance of the building, it is often not enough just to trust in a comprehensive installation guide of a single component manufacturer. It is necessary to define procedures on how to test and to guarantee the expected performance on site and also to ensure the qualification of the craftsmen for installing advanced and innovative technologies.

To ensure acceptance to meet requirements in practice, the specifications of the expected execution of the work have to be written clearly. The craftsmen have to understand what is expected from them, where possible problems can come up and how to avoid them.

- **Critical success factor:** The development of a unique and comprehensive work specification has to be done with the consensus of all the relevant players in the building process. Explicitly the interfaces between crafts have to be taken into consideration and the responsibility of each work step has to be mentioned.
  Specifications should be written as completely as possible and in simple language in just one document instead of using many cross-references to other information sources. A simple cross reference, like “Eurocode XYZ has to be considered”, will not help the craftsmen to understand where specific attention needs to be taken.

4.2.2. Clear procedures to show evidence of compliance

Beside a description of the work specification, a clear procedure is needed to show the evidence of compliance, in order to ensure a transparent process that has to be followed to prove the quality of work in practice.

- **Critical success factor:** The procedure should be referenced from the beginning of the process, so the contractor and the client have clear rules on how to proceed and at which milestones in the construction process or at which deadlines verification has to take place. Special attention must be paid to the implementation of intermediate controls at critical phases.

4.2.3. Tracing procedures

In addition to clear procedures to show evidence of compliance on the building site, it is advisable to establish a documentation system where all the relevant data gathered during the construction process are stored and are easily accessible for verification procedures. This kind of database could also be extended to a documentation of the work progress. In the future BIM (Building Information Modelling), a digital representation of the characteristics of a building and its systems, can significantly help to share information before and during construction, as well as during the use of the building and at the end of its life.

- **Critical success factor:** The acceptance of all involved parties to join this procedure is necessary to guarantee a comprehensive procedure.

4.2.4.Handling of innovative solutions

With the progressive movement towards a high energy-efficient building stock, more and more innovative technologies enter the market and displace the well known and mostly easy to handle conventional technologies. The craftsmen are often not trained to handle the new technologies, which can end in refusal by the contractor or lead to damages to the installed systems.

- **Critical success factor:** A training and qualification course for specialised craftsmen, which has to be periodically refreshed, can help to sort out such problems and ensure a high reliability of innovative solutions at the building site. The procedure has to be agreed by the whole trade sector, otherwise the associated costs will prevent the success of this approach on a broad level.

4.2.5. Giving benefits to systems that have a high probability to perform well

The simpler a technology to be applied on the building site is, the smaller the risk of faults in operation. Plug and play solutions are mostly more fail-safe than others assembled from pieces at the construction site. Therefore it can be expected that an easy to implement technology will perform in practice statistically better than comparable but complicated technologies that require experienced craftsmen for installation.

- **Critical success factor:** There has to be a benefit for both parties (investor and contractor). This benefit can be achieved in different ways in the process. The implementation of "in use factors" in the assessment method is one of the ways to promote plug and play solutions, while simplified test requirements for plug and play solutions is another way.

4.2.6. Rewarding good practice

Instead of sanctioning in case of poor quality of the works, one can also consider a more positive approach by explicitly rewarding good quality of the works. A useful instrument to motivate the craftsmen to deliver a good practice is to offer a gratification scheme. Such schemes could be developed on very different levels and directions, for example:

- ✓ Mentioning the company as a good practice craftsman's establishment on neutral advertising platforms
- ✓ Better result in the context of performance declarations, EPC, etc.
- ✓ Higher incentives
- ✓ Better loans from banks

- **Critical success factor**: There has to be an independent system installed, to set and prove the rewarding criteria.

4.2.7. Specific issues for existing buildings

Improving energy efficiency in existing buildings requires specific knowledge regarding the as-built situation of previous construction periods as well as up-to-date technical know-how to assess which energy efficiency measures are suitable in the specific building to be renovated. Sometimes problematic situations are hidden and cannot be detected during the initial survey. Damages have to be eliminated before renovation works can start. Therefore, staff working on-site must be qualified to identify critical situations when they become evident and react accordingly in order to achieve good quality of the works.

- **Critical success factor:** A tailor-made quality check procedure has to be developed to ensure quality of the works with limited additional costs. This procedure should ideally be applicable in the course of a deep renovation as well as in the course of a single renovation measure.

4.2.8. Quality management approaches

ISO 9000 introduces eight quality management principles on which quality management systems can be based. Concerning the improvement of the quality of work of high performance buildings, mostly Principle 4 (process approach) is applied, but also Principles 1 to 3 (customer focus, leadership and involvement of people) have great relevance. The principles are listed in Chapter 5.9.

- **Critical success factor:** Most critical for the acceptance of the implementation of quality management systems are the expected additional costs. The approaches of verifying the defined quality criteria are often directed to third party control, but also second party approaches can be found which are mostly more cost-efficient, but have to be organised in a transparent manner to ensure confidence. Some approaches are dynamic over time.

4.2.9. Market surveillance and integrating lessons learned

In practice, the work specifications (4.3.2) might in some cases not be sufficient to guarantee good quality of the works. It is important that there is some kind of procedure to handle complaints from practice, whereby this knowledge should then be used to improve the procedures (4.3.2).

Complaints can be of different nature, e.g.:

- ✓ Not strict enough requirements resulting, in some cases, in poor quality of the works
- ✓ Overly strict or excessive requirements resulting in excessively high and unnecessary costs.

- ➢ **Critical success factor:** If there are complaints about a building without an organisation involved that runs a quality framework, consumers will most likely contact the building owner and also the consumers' association for assistance. Therefore, consumers' associations might be valuable partners in assessing market complaints and developing elements of quality assurance frameworks.

4.2.10 . Interrelation with European and national legislations and standards

Design of quality frameworks is influenced by European and national legislation and standards. In this respect, the Services Directive, the Construction Product Regulation, the Public Procurement Directive, and the certification of qualified individuals according to EN ISO/IEC 17024 are important as well as national legislation, for example privacy legislation, building legislation, and national energy efficiency in building subsidy schemes.

- ➢ **Critical success factor:** Design of quality frameworks must respect various legislation.

4.2.11 . Overview of reasons for good or poor quality of the works

Table 1 summarises the aspects described above and presents an overview of reasons for good or poor quality of the works related to practical procedures.

Table 1: Overview of analysis of reasons for good or poor quality of the works

Aspects which are important for good quality of the works	Reasons for good quality of the works	Reasons for poor quality of the works
Clear description of work specifications	Target groups have clear instructions on how to install building and technical elements and what to consider	No consensus between target groups regarding responsibilities
Clear procedures to show evidence of compliance	From the beginning of the process a clear procedure is defined to show the evidence	Unclear what the criteria are and who checks them
Tracing procedures	Comprehensive, continuous documentation allows early recognition of faults	All documentation will be checked at the final stage only, which does not allow the craftsmen to react in time
Handling of innovative solutions	Continually trained and experienced craftsmen	Overstretched craftsmen who have not followed developments in the market
Usability of the specifications in practice	The craftsmen understand clearly what is expected of them and where possible problems are	Incomplete specifications written in difficult language
Offering benefits for systems that have a high probability to perform well	Ease of implementing technology in combination with other beneficial effects for the craftsmen	Technologies which need highly experienced craftsmen for installation and offer no benefits for the craftsmen
Rewarding good practice	High motivation of the craftsmen	No sanctioning in case of poor quality of the works
Specific issues for existing buildings	The specific challenges in existing buildings are taken into account	Quality frameworks are not sufficiently specific
Quality management approaches	Advantage of lower effort required for daily compliance procedures, if the company uses a collective compliance procedure	Excessive costs for the compliance procedures leads to failure to comply
Market surveillance and integrating lessons learned	An organisation running a quality framework was involved	Reasons can be different: loose requirements or excessive and unnecessary costs
Interrelation with European and national legislations and standards	Possible synergies are investigated and made use of	Limitations are not respected causing an appeal against the procedures, thus hindering implementation

4.3. PART 2: Robust procedures on how to decide on compliance and how to respond to non-compliance

In order to have a robust framework for deciding on dealing with non-compliances, second and third party quality frameworks related to quality of the works should have specifications regarding the following three aspects:

- **Qualification requirements** for persons or companies performing the works;
- **Reporting requirements:** e.g. declaration of performance by a certified person for each building site; reporting of specific, site-related performance features:
  - ✓ reporting must be done by independent persons, or
  - ✓ reporting can be done by persons involved in the building project, but certified and controlled by a third party;
- **Checking requirements:** e.g. systematic inspection of a building site by an independent person

Quality frameworks can address the whole building quality (e.g. voluntary green building rating schemes) or focus on well-known problematic situations (e.g. voluntary SWIGA Solid Wall Insulation Guarantee Agency scheme).

This chapter presents an analysis of the reasons for good and poor quality of works, taking into account the following aspects with regard to quality frameworks:

- ✓ Different types of non-compliance
- ✓ Clear procedures to check the quality of the works
- ✓ Types of penalties in case of non-compliance
- ✓ Clear rules about liabilities and penalties
- ✓ Consequences in terms of qualification, certification, labelling
- ✓ Specific issues for existing buildings
- ✓ Interrelation with European and national legislations and standards

The chapters below briefly describe these aspects, and an overview of reasons for good and poor quality of the works are highlighted in Table 2. Detailed information about these aspects is available in Chapter 5.

4.3.1. Different types of non-compliance

Not respecting the above requirements imposed by the quality framework corresponds with different types of non-compliance:

- ✓ Not respecting qualification requirements of persons or companies
- ✓ Not respecting reporting requirements
- ✓ Not respecting checking requirements

The quality framework will be effective and contribute to achieving good quality of the works if types of non-compliance are clearly defined, can be revealed by cost-efficient procedures and penalties are appropriate and proportionate.

- **Critical success factor:** Involved stakeholders (building owner, executing companies, authorised experts and other third-party entities) are aware of possible types of non-compliance and which penalties apply. In this context, awareness creation activities are important, not only regarding non-compliance with requirements imposed by quality frameworks but also regarding the need for quality frameworks in general.

4.3.2. Clear procedures to check the quality of the works

Quality frameworks can be voluntary (e.g. SWIGA Solid Wall Insulation Guarantee Agency scheme) or mandatory, e.g. to achieve public funding for proven quality of the works and thus better building performance. Quality frameworks can be governed by public authorities, companies authorised by the government or private organisations running third-party quality schemes. They can cover the entire building or focus on a specific problematic situation.

Clear procedures to check the quality of the works require the following decisions:

- ✓ What should be checked, based on what information and reported by whom?
- ✓ Who checks and which requirements must these individuals and / or companies meet?
- ✓ Are checks systematic or random, and how are samples for random checks selected?
- ✓ How is information processed and archived?
- ✓ What happens in case of detected non-compliances?

- ➢ **Critical success factor:** Acceptance of quality frameworks will be better if it is very clear that the quality framework aims to improve a serious weakness. Therefore, a good knowledge of critical situations in buildings caused by poor quality of the works is a precondition for designing problem-oriented and effective quality frameworks.

4.3.3. Types of penalties in case of non-compliance

There are different types of penalties in case of non-compliance, such as warning, obligation to correct the mistakes, attending additional trainings including examination, fines, loss of licence, and loss of financial support. First of all, penalties addressing poor quality of the works should not aim at punishment but try to achieve improvements on-site as well as permanent improvements, for instance by imposing additional trainings. In this regard, a step-wise penalty system including at least a step or warning will contribute to constant improvement while securing societal support.

- ➢ **Critical success factor:** Step-wise penalty schemes will effectively contribute to better quality of the works. In fact, there should be no need to apply penalties like fines, loss of licence, and prison, because the problem should have been solved during earlier steps of the penalty scheme. However, step-wise penalty schemes based on warnings have to be supported by administrative procedures (e.g. database with a rating option).

4.3.4. Clear rules about liabilities and penalties

An effective quality enforcement framework specifies penalties for non-compliance and whom they address. Entities governing quality frameworks should aim at making the rules and related penalties as clear as possible, in order to minimise debate afterwards and minimise the risk of loss of societal support.

Depending on the specifications of the contract with the third-party control and the defect detected, liability can lie with the building owner, the design team, the construction site supervisor, the executing company, and the companies commissioned for external quality assurance.

- ➢ **Critical success factor:** Commissioning routines at critical moments during the construction process are essential because they help to detect mistakes which would be hidden later on as construction works proceed (e.g. missing insulation of pipes mounted in the wall). Rules about liabilities should make clear that procedures aim at detecting the source of a quality problem, including responsibilities, with the objective to correct it.

4.3.5. Consequences in terms of qualification, certification, labelling

Qualification certification, labelling schemes and quality seals offered by governments or acknowledged and trustworthy organisations provide support for the implementation of cost-efficient quality frameworks aiming to improve quality of the works. They are an important element to ensure quality of the works delivered by the executing companies but also delivered by the competent persons in charge of self-checks or second/third-party checks.

- ➢ **Critical success factor:** Running accredited schemes or schemes complying with CEN/ISO standards can be very costly due to the procedures to be followed, and therefore sometimes organisations decide to offer their own quality schemes. If the operator of a quality framework wants to make use of existing certifications, labels and quality seals, it must be sure that organisations awarding them are acknowledged and trustworthy and that the requirements their schemes are based on are in line with the expectations of the manager of the quality framework addressing quality of the works. Rules must be transparent and limitations of

certifications, labels and quality seals must be clearly communicated (e.g. company label versus individual certification).

4.3.6. Specific issues for existing buildings

Regarding the building stock, there are two aspects to be taken into account:

- ✓ Improving energy efficiency in existing buildings requires specific knowledge, for example regarding the identification of hidden critical situations when they become evident during renovation works. A skilled worker will react accordingly in order to achieve good quality of the works.
- ✓ Depending on a country's building stock, specific standard renovation measures can be defined and tailor-made quality frameworks can be developed to ensure quality of the works. These frameworks can be applied in the course of a deep renovation as well as in the course of a single renovation measure.
- ✓ **Critical success factor:** Existing buildings can suffer from poor maintenance that adds unexpected cost to the renovation budget and thus increases the total cost of energy-related renovation measures. Financing of energy efficiency in existing buildings is a priority in many countries due to the fact that renovation rates are lower than expected. It will be essential to combine requirements addressing quality of the works with the availability of financing instruments and public funding in order to make progress in quality of the works in building renovation.

4.3.7. Interrelation with European and national legislations and standards

Design of quality frameworks is influenced by European and national legislations and standards. In this respect the Services Directive, the Construction Product Regulation, the Public Procurement Directive, the certification of qualified individuals according to EN ISO/IEC 17024 are important, as well as national legislation, for example privacy legislation, building legislation, and national energy efficiency in building subsidy schemes.

- ➢ **Critical success factor:** Design of quality frameworks must respect limitations and should make use of synergies.

4.3.8. Overview of reasons for good or poor quality of the works

Table 2 summarises the aspects presented above and presents an overview of reasons for good or poor quality of the works related to procedures.

Table 2: Overview of analysis of reasons for good or poor quality of the works related to procedures

Aspects which are important for good quality of the works	Reasons for good quality of the works	Reasons for poor quality of the works
Different types of non-compliance	Target groups are aware of different types of non-compliance and support the application of quality frameworks	No awareness among target groups
Clear procedures to check the quality of the works	Basic information about the way to check the quality of the works is available to develop clear procedures suitable to address critical issues	Procedures lack detail; Procedures are not well focused and do not sufficiently address critical issues
Types of penalties in case of non-compliance	Penalties are proportionate; The full range of possible penalties is used in a step-wise sanctioning scheme with the objective to contribute to constant improvement of the quality of the works	Possibility to bypass penalties; Penalties are pure punishment; No execution of penalties due to lack of societal support
Clear rules about liabilities and penalties	Rules include the definition of the right moments for commissioning and checking to detect the source of a mistake and oblige the responsible person/company to correct the mistake	Rules about liabilities are not sufficient to hold the person / company who caused the problem liable
Consequences in terms of qualification, certification, labelling	Requirements are clear and certifications, labels and quality seals are operated according to transparent rules	Limitations of certifications, labels and quality seals are not clearly communicated
Specific issues for existing buildings	The specific challenges in existing buildings are taken into account	Quality frameworks are not sufficiently specific
Interrelation with European and national legislations and standards	Possible synergies are investigated and made use of	Limitations in applications are not respected, causing an appeal against the procedures, thus hindering implementation

4.4. PART 3: Operational framework for better compliance and effective penalties related to quality of the works

This chapter presents an analysis of reasons for good and poor quality of works, taking into account the following aspects:

- ✓ The willingness to check/control
- ✓ The resources available for checking
- ✓ Effective sampling schemes
- ✓ Effective penalties
- ✓ Handling of market complaints

The chapters below briefly describe these aspects and reasons for good and poor quality of the works are highlighted in Table 3. Detailed information about these aspects is available in Chapter 6.

4.4.1. The willingness to check

The main reasons for the willingness to check the quality of the works are financial implications and public interest, depending on who is the manager running the quality framework. The willingness to check depends on the advantages or benefits gained from the checking procedure in relation to the resources and thus cost of the checking procedure.

- **Critical success factor:** The willingness to check might increase if building owners actively demand quality checks addressing critical situations, or at least are ready to tolerate or even support them.

4.4.2. The resources to check

The resources needed for checking determine whether a quality framework will be feasible on the one hand and meaningful and effective on the other hand.

Resources are necessary in terms of:

- ✓ Human resources: availability of qualified staff
- ✓ Time resources: sufficient time to carry out the work properly according to specifications
- ✓ Financial resources: availability of monetary budget to pay for quality checks

- **Critical success factor:** Irrespective of the type of control, checking is limited to critical situations and critical moments. Experience shows that the simple fact that a check could take place results in improved workmanship.

4.4.3. Effective sampling schemes

Development of sampling schemes deals with the decision on the sampling type and sampling size (e.g. problematic technology, inconsistencies in reporting of construction site supervisor, etc.), the method of choosing samples (e.g. execution companies marked with warnings, etc.), how to collect data and administer results, and whether systematic checks or random check should apply.

- **Critical success factor:** The sample size is as large as necessary and as small as possible. There is a clear method of evaluating results and a feedback loop to revise decision-making on sample sizes and choosing samples.

4.4.4. Effective penalties

There are several types of penalties, among others withdrawal of financial support. Financial support is crucial for improving the energy efficiency of new buildings, as well as of existing buildings. Therefore, combining requirements addressing quality of the works with access to financial instruments and public funding schemes has proven to be an effective penalty.

Other effective penalties address the qualification of executing companies directly, namely a warning including the obligation to improve the quality of the works according to the requirements and the obligation to attend mandatory training including evidence of passing the examination.

- **Critical success factor:** Whether penalties are effective or not depends on the market where a certain type of penalty is applied. If a penalty is too severe, stakeholders will look for a way to bypass the system, and acceptance will be low. In poorly developed markets, warnings may be appropriate to make stakeholders aware and make preparations, while infringements related to well-established technologies can be subject to harsher punishment.

4.4.5. Handling of market complaints

In practice, operation of quality frameworks can result in complaints, especially if rules and liabilities are not transparent and not clear. The manager of the quality framework must also run a unit managing complaints. It is necessary to plan resources accordingly, to ensure the effectiveness of this unit.

- **Critical success factor:** The complaints handling unit needs sufficient resources and a clear structure for individual complaint resolution. In addition, handling of market complaints should

be used to generate input to further develop the quality framework based on the weaknesses revealed through market complaints.

4.4.6. Overview of reasons for good or poor quality of the works

Table 3 summarises the aspects presented above and presents an overview of reasons for good or poor quality of the works related to aspects relevant to practical implementation.

Table 3: Overview of analysis of reasons for good or poor quality of the works related to operational issues

Aspects which are important for good quality of the works	Reasons for good quality of the works	Reasons for poor quality of the works
The willingness to check	Main reasons are financial implications of and public interest in quality of the works	Building owners do not support quality checks addressing critical situations
The resources to check	Allocation of human resources, time resources and budget for checking is sufficient	Checks are not efficient due to underestimation of effort required, resulting in insufficient or incomplete information
Effective sampling schemes	Schemes address critical situations with the appropriate method of choosing and checking samples	Choice of samples is not well motivated and sample sizes are too small to gain the necessary information
Effective penalties	Choice of penalties reflects the status of market development regarding the technologies subject to the quality framework	Choice of penalties is not tailor-made but transferred based on experience in other fields and thus might be suboptimal in contributing to improving the quality of the works
Handling of market complaints	Complaints handling succeeds in resolving individual complaints and in collecting and assessing complaints as a contribution to further developing the quality framework	Complaints handling is not well organised and hinders the effective implementation of the quality framework

4.5. Examples of transmission characteristics

In France, the national programme RAGE (Règles de l'Art Grenelle Environnement 2012) produced several professional recommendations for the implementation of walls, roofs, and facades using different construction products, but also on the implementation of different insulation techniques, thermal break systems and windows. These recommendations published in 2014-2015 are reference texts recognised by insurance companies. Fulfilling their requirements helps to improve the quality of the design, installation and maintenance works.

These documents are available for free at the website of the new French national programme PACTE (Programme d'Action pour la qualité de la Construction et la Transition Energétique - www.programmepacte.fr/catalogue), which will continue to publish such documents intended to improve the quality of the works.

More details are given in the QUALICHeCK Brussels workshop presentations on performance of thermal insulation in low energy buildings and advanced building renovation projects. The outcomes showed clearly that the trend towards Nearly Zero-Energy Buildings (NZEB) implies a

better execution of construction works and increased installation of advanced technologies, such as superinsulating materials, requiring specific skills in the workforce in order to reach quality and good performance of the installed systems.

4.6. Examples of ventilation and airtightness

In France, the national programme RAGE (Règles de l'Art Grenelle Environnement 2012) produced five professional recommendations on ventilation systems, published in 2014-2015. These recommendations are reference texts for design, dimensioning, implementation and maintenance that are recognised by insurance companies. Fulfilling their requirements helps to improve the quality of the design, installation and maintenance works.

The systems covered include:

- ✓ exhaust-only mechanical ventilation systems for renovation of houses,
- ✓ exhaust-only mechanical ventilation systems for renovation of apartment buildings,
- ✓ balanced ventilation systems for new houses,
- ✓ balanced ventilation systems for new apartment buildings,
- ✓ room exhaust mechanical ventilation systems for renovation.

Guides were also published for innovative systems such as ground-to-air heat exchangers (covering design and dimensioning, implementation, maintenance) and hybrid ventilation systems.

All these documents are available for free at the website of the new French national programme PACTE (Programme d'Action pour la qualité de la Construction et la Transition Energétique - http://www.programmepacte.fr/catalogue), which will continue to publish such documents intended to improve the quality of the works.

In Sweden, a system is well implemented to ensure the quality of the ventilation work. The system is based on:

- ✓ A clear description of work specifications: VVS AMA specifications
- ✓ A clear procedure to show evidence of compliance: OVK compulsory ventilation checks
- ✓ A qualification for ventilation testers: KIWA certification for OVK compulsory ventilation checks.

In Belgium, a professional guide was published in 2015. This document (Figure 5) gives practical recommendations to the designers and to the workers on building airtight buildings. It is mainly based on technical details. (Note d'information Technique Etanchéité à l'air des bâtiments - Technische voorlichting Luchtdichtheid van gebouwen)

Figure 4: Belgium guidelines with practical recommendations for designers and workers

More details are given in the QUALICHeCK Lund workshop presentations on Voluntary and Regulatory Frameworks to Improve Quality and Compliance of Ventilation and Airtightness.

4.7. Examples of sustainable summer comfort technologies

In **France**, the national programme RAGE (Règles de l'Art Grenelle Environnement 2012) produced two professional recommendations on metal solar shading systems for new and renovated buildings, published in 2014. These recommendations are reference texts recognised by insurance companies. Fulfilling their requirements helps to improve the quality of the design, installation and maintenance works.

These documents are available for free at the website of the new French national programme PACTE (Programme d'Action pour la qualité de la Construction et la Transition Energétique - www.programmepacte.fr/catalogue), which will continue to publish such documents intended to improve the quality of the works.

The European Cool Roofs Council was founded in 2011 to develop scientific knowledge and research in relation to "cool roof" technology and to promote the use of cool roof products and materials in Europe, including developing a product-rating programme for such products and materials. The participating companies provide lists with trained workers to ensure the proper application of cool roof materials. Additionally training courses on "Cool materials and heat island mitigation methods" were implemented in Greece, with the cooperation of the Greek partners of the MED-MAIN project (www.med-main.eu/).

The courses were co-organised by the Athens Chamber of Small and Medium Industries (ACSMI), the Institute of Accelerating Systems and Applications (IASA) and the Municipality of Acharnes. The targeted audience was: technical staff, such as experienced installers, technicians, construction managers, manufacturers, etc. who are able to provide support in the decision making process; designers, engineers, architects, etc., who are meant to provide calculation support and can quantify the impact of cool materials on energy performance and comfort.

More details are given in the AQUALICHeCK Athens workshop presentations on voluntary and regulatory frameworks to improve quality and compliance of solar control, cool roofs and ventilative cooling.

4.8. Examples of renewables in multi-energy systems

Setting up new professional recommendations in France

In **France**, the national programme RAGE (Règles de l'Art Grenelle Environnement 2012) produced 42 professional recommendations on systems using renewable energy sources, published in 2014-2015. These recommendations are reference texts recognised by insurance companies. Fulfilling their requirements helps to improve the quality of the design, installation and maintenance works.

They refer to domestic solar thermal water heaters, solar heating systems, heat pump water heaters, air-to-air heat pumps, air-to-water heat pumps, geothermal heat pumps, and for commercial heat pumps (air-to-water and water-to-water). There are five recommendations for each of these systems that cover:

- ✓ design and dimensioning of new installations,
- ✓ design and dimensioning of installations for renovation,
- ✓ implementation and commissioning of new installations,
- ✓ implementation and commissioning of installations for renovation,
- ✓ maintenance works.

One recommendation deals with all these aspects for heat pump combination heaters.

For solar water heaters in apartment buildings (with a centralised storage or with individual storage tanks), three recommendations for each of these systems cover:

- ✓ design and dimensioning,
- ✓ implementation and commissioning,
- ✓ maintenance works.

Guides were also published for innovative systems such as hybrid heat pumps/hybrid boilers (i.e. systems combining a heat pump and a boiler), as well as a practical guide for workers on air-to-water heat pumps.

All these documents are available for free at the website of the new French national programme PACTE (Programme d'Action pour la qualité de la Construction et la Transition Energétique - www.programmepacte.fr/catalogue), which will continue to publish such documents intended to improve the quality of the works.

Below, a harmonised procedure of the certification of workers implemented in France is presented:

From September 2014, the label RGE (Reconnu Garant de l'Environnement) has been implemented in **France** to certify the skills of workers and companies specialized in energy renovation and installation of systems using renewable energies. From 1 September 2014, only the works done by companies with the RGE label can be funded through zero-interest loans. From 1 January 2015, this also applies to the tax credit for certain energy renovation works and installation of certain systems using renewable energies.

The display of this voluntary sign of quality allows its holder to strengthen its relationship of trust with customers. RGE holders are referenced on a website targeted at individuals: www.renovation-info-service.gouv.fr. They are also listed by the advisors in the "Points renovation information service" where individuals can get advice.

Labels are given by several organisations: QUALIBAT, QUALIFELEC, QUALIT'ENR, CERTIBAT, CEQUAMI. For energy renovation, the labels can be:

- ✓ RGE Eco-artisan
- ✓ RGE Les Pros de la performance énergétique
- ✓ RGE Qualibat
- ✓ RGE Qualifelec
- ✓ RGE Certibat Rénovation énergétique

✓RGE NF HABITAT

✓RGE NF HABITAT HQE

For the installation of systems using renewable energies, the labels can be:

✓RGE QualiSol

✓RGE QualiPV

✓RGE QualiPac

✓RGE QualiBois

A key module of the **Austrian** KlimaAktiv guideline is the commissioning protocol in the form of a three-page checklist (see Figure 5) which must be signed by both the planner of the solar thermal system and the installer who mounted the solar thermal system. The name of the company who did the professional adjustment of the solar thermal system must also be provided.

The fact that the checklist also asks for the control number issued for the collectors by the institute carrying out the standard testing reminds the stakeholders of the importance of high quality products.

Thanks to the checklist-oriented structure, filling in the commissioning protocol does not take much time. Due to the fact that it is evident what will be checked, planners and installers pay specific attention to critical aspects that correspond with the criteria of the checklist.

The criteria include:

- ✓ Checks for damaged frame and glass, checks for tightness
- ✓ Checks for completeness of insulation, whether insulation is damaged, whether outdoor insulation reaches the minimum thickness of 30 cm
- ✓ Function checks of control elements, temperature sensors, pressure reading and heat meter
- ✓ Circulation pump settings have to be documented: Is a high efficiency pump adapted to the system, is the built-in situation of the circulation pump satisfactory, is the function checked?
- ✓ Is the system connected to existing lightning protection device?
- ✓ Hydraulic balancing has to be carried out in case of parallel connected collectors or different supply-line lengths

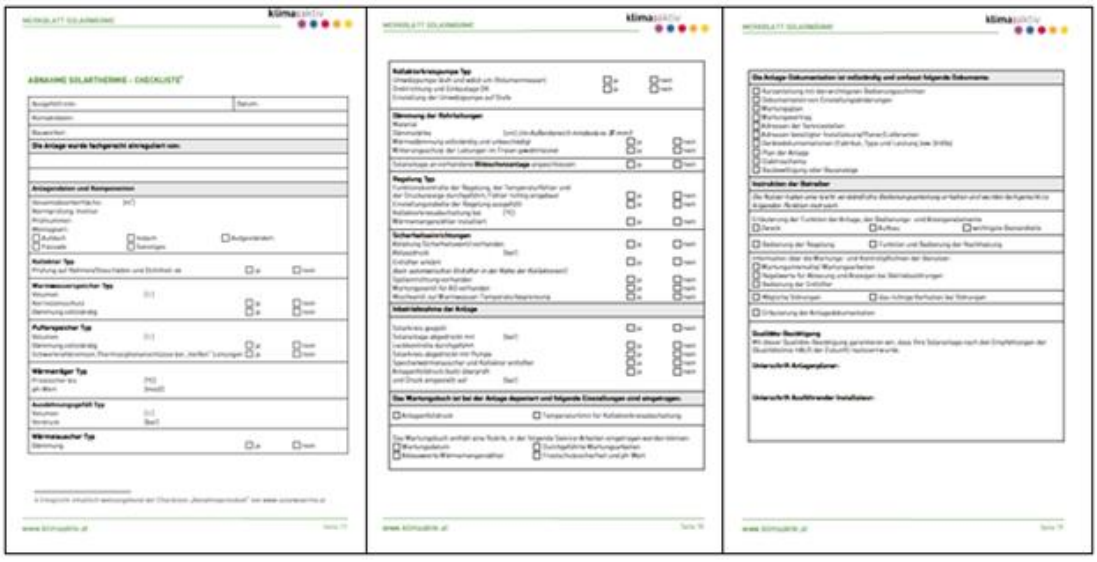


Figure 5: Commissioning checklist of the Austrian KlimaAktiv guideline

The commissioning checklist asks for the complete documentation of the system, consisting of the following elements:

- ✓ Short user guidelines explaining the operation
- ✓ Documentation of changes applied to the setting
- ✓ Maintenance plan
- ✓ Maintenance contract
- ✓ Addresses of service providers
- ✓ Addresses of all companies involved in planning and execution including product suppliers
- ✓ Documentation of products (type, capacity, size, etc.)
- ✓ Installation diagram
- ✓ Electrical circuit diagram
- ✓ Building permit or notification

The commissioning checklist requires that the operator of the solar thermal systems must have received an explanation of the documentation described above. In addition, information must be provided about other important aspects such as:

- ✓ Functioning principles of the solar thermal system
- ✓ Possible reasons for system failures
- ✓ How to respond to system failures

Further frameworks and approaches are presented in the QUALICHeCK Lyon workshop presentations on securing the compliance of product data and the quality of installed systems, to reach high levels of energy performance.

5. Documented sets of best practices PART 1: Technical procedures to obtain and prove good quality of the works

5.1. Clear description of work specifications

Context and motivation

In most of the building project tenders there is a comprehensive description of material and technologies to be mounted, but the quality description of the executed work is often not part of the construction contract and ultimately depends on the experiences and the philosophy of the contractor and craftsmen. Often phrases such as “acknowledged rules of technologies have to be applied” or “all relevant standards have to be considered” are integrated to fix the competence requirements of the executor but this results in non-uniform requirements of the quality of work in practice.

In order to enforce the quality of work it is necessary to have a uniform and comprehensive work specification available for reference in the building tender, which ideally is developed in consensus with the relevant players in the building process. This specification should, in addition to technical specifications, also contain the following quality elements:

- ✓ Requirements that can be verified;
- ✓ Training or competence requirements, if applicable;
- ✓ Certification, qualification, labelling requirements of persons, companies or products (if applicable);
- ✓ Tracing procedures, types of checks, and checking procedures.

Due to the complex influences of some technologies on the overall performance of the building, it is often not enough just to trust in a comprehensive installation guide for a single building or technical system component manufacturer. It is necessary to ensure procedures on how to test and guarantee the expected performance on site and also to ensure the qualification of the craftsmen for installing advanced and innovative technologies.

The specifications (as discussed above) should be clear in order to allow an effective second or third party control. This is a minimum requirement but, in particular for compliance frameworks imposed by third parties such as a government, and given the fact that works are often done by small and medium enterprises or one person companies, it is important that the specifications are sufficiently simple for all potential workers. This can be done by, for example, having various possibilities for meeting the specifications, such as performance based specifications (typically more abstract and requiring more knowledge from the parties involved) and descriptive specifications.

Examples of problematic situations

- ✓ PV systems: The wind resistance of PV systems is an important aspect. In practice, storm damage has been reported several times. It is not appropriate to use as a requirement a generic description such as “the PV system should resist storms”. It is important to describe the requirements in performance or descriptive criteria that can be verified, i.e. by making use of standards. See also Chapter 5.5.
- ✓ Glazing and solar gains: The installation of the glazing in a window frame sometimes causes problems at the building site, as the craftsmen do not consider which side of the glazing has to be mounted on the inner (room) side and which on the outer side. This is not important for the visibility, the air- and water tightness, the heat losses or the acoustics, but can influence the solar gains, depending on the position of the IR coating. Therefore the installer has to be trained to be sensitive to this issue and to find out and document the right position of the installed glass.
- ✓ Requirements: The development of different requirements in Eurocodes was an important step to harmonise and standardise procedures all over Europe, but the Eurocodes are mainly written in a more general standardisation language, which will often not allow the reader to apply

them directly to the national situation. Therefore a national transposition is necessary before they can be applied to practical construction work. A simple cross reference, like "Eurocode XYZ has to be considered" will not help the craftsmen to understand where specific attention is needed.

Procedural considerations

It is highly desirable, and in particular if there is a government-imposed third party control scheme, that the work specifications are developed with the consensus of all the relevant players in the building process, explicitly the overlapping responsibilities of different crafts have to be taken into consideration and the responsibility at each work stage has to be mentioned.

Approaches relevant to this topic

- ✓ The German STLB-Bau specification system (Standardleistungsbuch für das Bauwesen) is a library of specification texts for standard construction works. It enables the building owner or planner to dynamically build up a specification text from various passages. The work is organized in one of the three steering committees of the "German Committee for construction contract procedures" under the umbrella of the German Federal Ministry for Environment and Building. Among its members are the federal government building departments, central organizations of the building and construction technology industries, public building authorities, central municipal organisations, associations of architects and engineers and professional associations. They support the work by sending honorary members to its approximately 100 working groups free of charge. The equal appointment of committee members results in an acceptable arrangement for all parties. Thus, neutrality and acceptance of the results are guaranteed. The work results are published by DIN (Deutsches Institut für Normung e.V.).
- ✓ Another example is from the Swedish building industry. Since 1950, Svensk Byggtjänst (the Swedish Building Centre) publishes the general material and workmanship specification system AMA. AMA is specified in tenders and then has to be applied by the contractor.
- ✓ An example based on an industry initiative is the German Gütegemeinschaft Fenster und Haustüren e.V., an association of manufacturers of windows, front doors, facades and winter gardens, that requires of itself outstanding product and installation quality. In order to prove this quality the products are subject to strict quality control. The qualified products receive the RAL-Gütezeichen, a quality certificate. In addition the association publishes a guideline for installation of the high quality products. This guideline includes the accepted rules of technology for installing windows and front doors. The part 'Fixation and sealing' deals on the one had with statics and on the other with the preparation of the components before sealing, the different levels of sealing, the sealing functions, where to place the sealing system within the seam, the preferable seam size, and different sealing systems, and presents exemplary installation technologies for different types of window systems and situations. Additionally the association developed a quality of work procedure, for which each manufacturer has to collect a standardized checklist of installation details for each window or door that they have produced and has been installed by an installer, which has to be filled in and signed by the installer. The ift Rosenheim institution randomly checks that these checklists are available for each product and each installer that holds the RAL certificate.

References

- ✓ 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 QUALICHeCK project. 2016.
- ✓ AMA – General material and workmanship specifications – Paula Wahlgren - QUALICHeCK Fact Sheet #09, February 2016
- ✓ The German STLB-BAU specification system (www.gaeb.de/en/about-us/)

5.2. Clear description of the procedures to show evidence of compliance

Context and motivation

Beside a clear description of the work specification (Chapter 5.1), a clear procedure is needed on how to show evidence of compliance in the case of second and third party control or in a self-check procedures by the worker or the company. For example, it is necessary to define what kind of verification procedure or measure has to be applied, to what content and complexity, at which construction phase and scale and who is authorised to acknowledge this proof.

The procedure should be referenced from the beginning of the process, so that all parties involved (contractor; client, etc.) have clear rules on how to proceed and at which milestones in the construction process or at which deadlines verification might take place.

Examples of problematic situations

In particular in case of second and third party control, it is problematic if there is no clarity about precisely what has to be provided as proof for showing compliance with the works specifications (Chapter 5.1). If there are no clear rules on how, for example, competence must be proven in practice, about the specific materials used, etc., it might lead to disputes and/or lack of support for the overall quality approach.

Procedural considerations

In general, and in particular in case of third party control schemes, it is highly desirable that the development of comprehensive proof procedures is done with the consensus of all relevant players in the building process, explicitly the overlapping responsibilities of different crafts have to be taken into consideration and the responsibility at each work stage has to be clarified.

Approaches relevant to this topic

- ✓ In Belgium, technical specifications for the renovation of existing cavity walls by adding insulation to the cavity have been adopted (STS 71.1 and regional legislation in case of subsidy scheme). The quality assurance organisation has set up an IT environment that has to be used at all critical steps of the process.
- ✓ In the French RT 2012 regulation, it is mandatory to prove the airtightness of new constructions. An alternative approach to the systematic measurement is foreseen to show evidence of compliance. Instead of direct measurements on the building site, the construction company can compile a catalogue of “high quality” details, document that only qualified persons are appointed for construction work and document a certain sample of realised buildings, to provide evidence that the required result will most likely be realised. In this case no measurements at the building site are needed.
- ✓ One focus area of the Swedish general material and workmanship specification system AMA is ductwork airtightness specification and verification. The duct airtightness is specified to meet a certain air tightness class, which means that there is a permissible air leakage to be met, and if required, verified according to a given test procedure. The contract is not approved unless the contractor can state, or if required, prove that the requirements are met. The builder can ask for a compliance test for a part of the ventilation duct work and the contractor has to prove the air tightness according to a given test procedure described in AMA (measurements of allowed air leakage at a specified static pressure).

References

- ✓ SPF Economie: STS 71.1 “Na-isolatie van spouwmuren door insitu vullen van de luchtspouw met een nominale breedte van ten minste 50 mm“. 2012
- ✓ Centre Scientifique des Techniques du Batiment, CSTB, on behalf of the Ministry of Sustainable Development and Energy: Réglementation Thermique - RT2012
- ✓ Building regulations can foster quality management – the French example on building airtightness – François Rémi Carrié - QUALICHeCK Fact Sheet #01, January 2015

- ✓ Regulatory compliance checks of residential ventilation systems in France – François Rémi Carrié, Sandrine Charrier, Adeline Bailly - QUALICHeCK Fact Sheet #06, November 2015
- ✓ Building airtightness in France – regulatory context, control procedures, results – Sandrine Charrier, Adeline Bailly, Carrié, François Rémi Carrié – QUALICHeCK Fact Sheet #07, December 2015
- ✓ AMA – General material and workmanship specifications – Paula Wahlgren - QUALICHeCK Fact Sheet #09, February 2016
- ✓ The Swedish Sveby scheme - standardise and verify the energy performance of buildings - Pär Johansson - QUALICHeCK Fact Sheet #11, May 2016
- ✓ Romanian qualification schemes for installers of opaque building elements and/or window systems - Horia Petran – QUALICHeCK Fact Sheet #52, February 2017
- ✓ Ductwork airtightness in France: Regulatory context, control procedures, results – Sandrine Charrier, Adeline Bailly Mélois, François Rémi Carrié - QUALICHeCK Fact Sheet #54, February 2017

5.3. Tracing procedures

Context and motivation

Besides clear procedures to show evidence of compliance at the building site, it is advisable to establish a documentation system where all the relevant data gathered during the construction process are stored, and are easily accessible for verification procedures, though they might also be useful afterwards, e.g. post intervention dossiers, etc. This kind of database could also be extended to documentation of the work progress.

Examples of problematic situations

For strict airtightness requirements and/or in order to guarantee very good airtightness results, it might be effective to carry out intermediate airtightness tests (at critical phase of the works) and/or identify leakage paths. In case of second and third party control schemes, it is important to avoid very general descriptions (e.g. 'the airtightness has to be tested at critical phases of the work and leak detection must be done'), but instead have precise specifications regarding such tasks, e.g.:

- ✓ At which stages of the work leak detection must be done (e.g. after the installation of the windows, after installation of the ventilation system, etc.)
- ✓ What kind of leakage detection must be done, what has to be reported, etc.
- ✓ Are there specifications regarding those who carry out these tasks?

PROCEDURAL CONSIDERATIONS

It is clear that modern communication means (tablets, cloud, etc.) offer new and interesting possibilities for achieving powerful tracing procedures. Examples:

- ✓ storage of all relevant data in the cloud
- ✓ coupling between applications, e.g. in the case of EPC declarations, between the EPC tool and the quality framework; in case of incentives schemes, direct data exchange with the organisation providing incentives
- ✓ long term access to collected data, e.g. by giving owners unique and secure access to data, so that the information remains available long after the works are complete.

Approaches relevant to this topic

The use of a central database for the documentation of compliance results can have the advantage that specific information (like air tightness test results), even if anonymised, can be linked to a central database system of associations that allows a good benchmark for the current practice.

In the future BIM (Building Information Modelling), digital representation of the characteristics of a building and its systems can significantly help to share information before and during construction, as well as during the use of the building and at the end of its life

References

- ✓ The Swedish Sveby scheme - standardise and verify the energy performance of buildings - Pär Johansson - QUALICHeCK Fact Sheet #11, May 20165.4 Handling of innovative solutions

5.4. Handling of innovative solutions

Context and motivation

As explained in Chapter 5.1 a clear description of the work specifications is important, in particular in case of second and third party control afterwards. It is important that all existing good quality technologies are covered by these procedures. New technologies are regularly introduced, with potential benefits as better performance, lower cost, etc.

In case such new technologies are not in line with the technical specifications or if already existing technologies are not covered, it might be that the second and third party control will identify non-compliance with the specifications. In practice, it means that an effective control scheme may be a major barrier for innovation.

In order to avoid this, it is necessary to consider appropriate procedures allowing new technologies of similar quality to be applied.

Examples of problematic situations

Renewable energy systems (PV or solar thermal) on flat roofs: if the technical procedures (see Chapter 5.1) to prove wind resistance foresee only mechanical ballast as an acceptable physical protection, it is clear that mechanical fixing methods cannot be used. Nor can combinations of mechanical ballast and mechanical fixing. Also, if the technical specifications only allow wind analysis at the level of single arrays, innovative concepts might be blocked.

Demand controlled ventilation: in case the technical procedures specify that the airflow rates have to be measured on site under nominal conditions, this might be problematic for humidity controlled ventilation, for example, unless there is a possibility to by-pass the humidity control. Appropriate procedures for such technologies might be necessary.

Procedural considerations

The development of a robust framework for avoiding barriers to innovation has different aspects:

- ✓ The use of performance-based procedures (instead of or in parallel with descriptive procedures) typically give more possibilities for covering systems not thought of when developing the procedures.
- ✓ Ideally, there should be from the beginning organisational procedures set up to handle systems not covered by the procedures. Aspects to cover include which formal procedure to be followed, who can develop and approve an alternative procedure, etc.

Approaches relevant to this topic

The examples below are illustrations of quality frameworks that impose regular training and, in that sense, make people aware of new innovative developments:

- ✓ A qualification system “QualiSol” for installation companies of solar thermal systems has been applied in **France** to improve the quality of work. The system is managed by the French association “QualitEnR”. An audit has to be applied every three years to continue the voluntary certification of the installation company. The association established a journal to publish failures found during the audit procedures. More than 12,000 companies have already been certified.

- ✓ Following the positive experiences from the **French** thermal solar initiative, comparable procedures have been implemented for solar PV systems (QualiPV), domestic wood boiler (QualiBois) and heat pump installations (QualiPac).
- ✓ Another approach is the **European**-wide applied vocational education and training programme "Solarteur". It is an additional training for engineers, technicians, craftsmen and skilled workers from related trades. The course structure emphasises practice-orientated training. Solarteur is a certified program across the trades (HVAC and electric) for renewable energy professions according to the EU guideline EG 2008/29.
- ✓ In **France,** a national programme called RAGE (Règles de l'Art Grenelle Environnement 2012) led to 42 new professional recommendations on systems using renewable energy sources (often innovative or not well known solutions), published in 2014-2015. These reference texts include requirements that help to improve the quality of the design, installation and maintenance works. They are recognised by insurance companies.

References

- ✓ Increasing the expertise of building professionals for a better quality of construction: The French programme PACTE – Julien Thomas, Slyvain Mangili, François Durier - QUALICHeCK Fact Sheet #51, February 2017

5.5. Consider simpler on-site compliance procedures for certain systems

Context and motivation

The efforts and costs related to second or third party compliance checks depend strongly on the frequency of controls to be carried out and the type and number of checks to be done for the works. The simplest approach is to have the same procedure for all kinds of systems. In practice, there might be systems with a higher probability for non-compliance than other systems. A differentiation in approach as a function of the risk assessment might lower the costs, increase the societal support for the system and it can in some cases even increase the quality of the works.

Examples of problematic situations

- ✓ Ductwork airtightness: It is technically possible to meet good airtightness requirements with circular and rectangular ductwork. In the case of circular ductwork, there are systems on the market with specific fittings that do not require additional actions (taping, etc.). In case of a moderate airtightness requirement, there are systems that systematically will meet the requirement. In such cases, it is redundant to systematically carry out an on-site test. Therefore, specific procedures allowing no test or a lower test frequency can be very relevant. However, care is needed with such approach, for example, specifying that no or fewer tests is allowed for circular ducts is not acceptable, as it might result in products which are of lower quality but without the need for on-site testing.
- ✓ External insulation systems: there is a whole range of external insulation systems. Several suppliers offer systems which are pre-designed, with specific attention paid to ease of execution, appropriate accessories and guidelines for installation. In parallel, there are systems that are assembled on a case-by-case basis. Applying the same set of control procedures can be costly and also counterproductive.

Procedural considerations

- ➢ The criteria for allowing simpler compliance procedures for specific types of works have to be carefully selected and have to be robust. Criteria which may play a role are:
  - ✓ the probability that a given system will meet the specifications
  - ✓ the importance of not imposing system specifications that are in conflict with national and European legislations, e.g. the Construction Product Directive.

Approaches relevant to this topic

- ✓ External insulation systems with technical approval

- ✓ Ventilation kits with technical approval
- ✓ Pressure compensated ventilation grills
- ✓ Sweden: Circular ductwork

References

- ✓ BuildE – A method for quality assurance of energy efficient buildings – Paula Wahlgren – QUALICHeCK Fact Sheet #26, September 2016
- ✓ Wouters, P. et al.: QUALICHeCK Webinar. Interesting and innovative approaches for improved building envelope performances. 2017. http://qualicheck-platform.eu/events/webinars

5.6. Consider simpler on-site compliance procedures for certain companies

Context and motivation

If there is sufficient evidence that the probability of a good quality of the works is higher for companies and persons with proven compliance criteria at the company level, it might be appropriate to have simpler compliance checks at the building site and/or a lower frequency of compliance checks.

Examples of problematic situations

In daily practice several companies give sub-contracts to cheaper companies to reduce their costs, and they may not comply with the criteria. A scheme has to be developed to cover such cases.

Procedural considerations

No specific example available.

Approaches relevant to this topic

In France, there are two possible approaches for assessing the building airtightness level in the context of RT2012.

- ✓ One procedure requires systematically testing each building by a certified airtightness tester. In this case, there is no requirement with respect to the companies who did the building works.
- ✓ There is an alternative procedure (Annex F), whereby companies who follow a certain set of rules (building details, trained workers, etc.) can use a fixed airtightness value with only testing typically 5% or 10% of all buildings.

References

- ✓ Building regulations can foster quality management – the French example on building airtightness – François Rémi Carrié - QUALICHeCK Fact Sheet #01, January 2015
- ✓ Regulatory compliance checks of residential ventilation systems in France – François Rémi Carrié, Sandrine Charrier, Adeline Bailly - QUALICHeCK Fact Sheet #06, November 2015
- ✓ Building airtightness in France – regulatory context, control procedures, results – Sandrine Charrier, Adeline Bailly, Carrié, François Rémi Carrié – QUALICHeCK Fact Sheet #07, December 2015
- ✓ Building airtightness in France – regulatory context, control procedures, results – Sandrine Charrier, Adeline Bailly, Carrié, François Rémi Carrié – QUALICHeCK Fact Sheet #07, December 2015
- ✓ Increasing the expertise of building professionals for a better quality of construction: The French programme PACTE – Julien Thomas, Slyvain Mangili, François Durier - QUALICHeCK Fact Sheet #51, February 2017
- ✓ Romanian qualification schemes for installers of opaque building elements and/or window systems - Horia Petran – QUALICHeCK Fact Sheet #52, February 2017

5.7. Rewarding good practice

Context and motivation

The energy performance level in the European construction sector has significantly increased during the last decades and will continue during the next. This usually results in higher construction costs, which may be compensated by lower operating costs. To ensure these lower operating costs in the long run, the quality of the construction and the realised work is substantial. Instead of sanctioning in case of poor quality of the works, one can also consider a more positive approach by explicitly rewarding good quality of the works.

A useful instrument to motivate the craftsmen to deliver a good practice is to offer a gratification scheme. Such schemes can be developed on very different levels and in different directions, for example:

- ✓ Mentioning the company as a good practice craftsman's firm on neutral advertising platforms
- ✓ Better result in the context of performance declarations, EPC, etc.
- ✓ Higher incentives
- ✓ Better loans from banks

Examples of problematic situations

No specific example available.

Procedural considerations

In case good quality of the works is rewarded, one has to evaluate if the other works can be accepted. Assume that a PV system's good workmanship is rewarded. Is it acceptable that those works carried out not according good workmanship principles are allowed? If not, it means that those works should be sanctioned and that, in a certain way, there is no longer a need for positive reward.

There are surely applications where it makes sense to have a 'minimum' quality level and a 'higher' quality level, whereby a 'second-tier' reward could be envisaged.

Approaches relevant to this topic

In the French RT 2012 regulation, it is mandatory to prove the airtightness of new constructions. An alternative approach is foreseen to show evidence of the compliance. Instead of direct measurements on the building site, the construction company can collect details they usually apply, document that only qualified persons are appointed for the construction work and document a certain sample of realised buildings, to provide evidence that the required result will most likely be realised. In this case no measurements on the building site are needed.

References

- ✓ Centre Scientifique des Techniques du Batiment, CSTB, on behalf of the Ministry of Sustainable Development and Energy: Réglementation Thermique - RT2012
- ✓ Building regulations can foster quality management – the French example on building airtightness – François Rémi Carrié - QUALICHeCK Fact Sheet #01, January 2015
- ✓ Quality control of Stuttgart's retrofit standard realised by the city's energy consultancy office – Sarah Doster, Heike Erhorn-Kluttig, Hans Erhorn, Ulrich König - QUALICHeCK Fact Sheet #08, December 2015
- ✓ WE-Qualify project: Improving the Cypriot work-force skills – Marina Kyprianou Dracou - QUALICHeCK Fact Sheet #29, December 2016
- ✓ Erhorn, H.. et al.: QUALICHeCK Webinar. Certification schemes for installers. 2016. http://qualicheck-platform.eu/events/webinars

5.8. Specific issues for existing buildings

Context and motivation

Various Member States have set financial schemes to stimulate deep energy renovations. This stresses the relevance of qualification and quality control targeting the specific challenges encountered in the major renovation of existing buildings and to ensure that the grants are not used as economic subsidy fraud.

Improving energy efficiency in existing buildings requires specific knowledge regarding the as-built situation in the past as well as up-to-date technical know-how to assess which energy efficiency measures are suitable in the specific building to be renovated. Sometimes problematic situations are hidden and cannot be detected during the initial survey. Damages have to be eliminated before renovation works can start. Therefore, staff working on-site must be qualified to identify critical situations when they become evident and react accordingly in order to achieve good quality of the works.

Depending on the building stock of a country, specific standard renovation measures can be defined (see example on cavity wall insulation below) and a tailor-made quality framework can be developed to ensure quality of the works. These frameworks can be applied in the course of a deep renovation as well as in the course of a single renovation measure.

Examples of problematic situations

Specifically during a single renovation measure (like replacement of windows) the craftsmen need to have an overview of what other construction issues might be influenced and therefore which damages (e.g. mould) could result.

Procedural considerations

The contractor should be experienced enough so that he can address possible subsequent damages.

Approaches relevant to this topic

In Germany the city council of Stuttgart established a quality seal to reward good quality for craftsmen specialized in renovation. The contractor who applies for the seal has to agree that his staff participate in continuous further vocational training and that the city's independent energy consultant centre (Energieberatungszentrum Stuttgart) checks a random sample of construction sites of this contractor. The contractor can use the seal in advertising campaigns and he will additionally be listed as an experienced company on the website of the city's energy consultant centre.

References

- ✓ Quality control of Stuttgart's retrofit standard realised by the city's energy consultancy office – Sarah Doster, Heike Erhorn-Kluttig, Hans Erhorn, Ulrich König - QUALICHeCK Fact Sheet #08, December 2015
- ✓ Scheme of vocational qualifications in Cyprus „I have the qualifications. I certify!" - Marina Kyprianou Dracou – QUALICHeCK Fact Sheet #22, June 2016
- ✓ WE-Qualify project: Improving the Cypriot work-force skills – Marina Kyprianou Dracou - QUALICHeCK Fact Sheet #29, December 2016
- ✓ Increasing the expertise of building professionals for a better quality of construction: The French programme PACTE – Julien Thomas, Slyvain Mangili, François Durier - QUALICHeCK Fact Sheet #51, February 2017
- ✓ Romanian qualification schemes for installers of opaque building elements and/or window systems - Horia Petran – QUALICHeCK Fact Sheet #52, February 2017

5.9. Quality management approaches

Context and motivation

ISO 9000 introduces eight quality management principles on which quality management systems can be based, which are:

Principle 1 – Customer focus

Principle 2 – Leadership

Principle 3 – Involvement of people

Principle 4 – Process approach

Principle 5 – System approach to management

Principle 6 – Continual improvement

Principle 7 – Factual approach to decision making

Principle 8 – Mutually beneficial supplier relationships

Concerning the improvement of the quality of the work of high performance buildings, mostly Principle 4 is applied, but also Principles 1 to 3 have great relevance. Although it is most common to apply sanctions in case of not complying with expected quality criteria, a few approaches that reward good practices can also be found in the EU Member States. The approaches of verifying the defined quality criteria are often directed to third party control, but also second party approaches can also be found that are mostly more cost-efficient, but have to be organised in a transparent manner to ensure confidence. Also some approaches are dynamic in the course of time.

Examples of problematic situations

No example available.

Procedural considerations

The procedure to apply a quality management system is well described in ISO 9000.

Approaches relevant to this topic

In **Belgium** a three step approach to proof of the execution of internal insulation systems was developed:

- ✓ 2016: subsidies are only possible if the design and monitoring is done by an architect,
- ✓ 2017: subsidies are also possible if the work is done by an approved contractor,
- ✓ 2019: subsidies are only possible if a combination of approved techniques and competence proof of certain activities are available.

This dynamic approach, which moves from a third party to a second party approach during a time span of three years, was developed to motivate the craftsmen to gather experiences within a year and get approval of the proven competence to offer on the market in parallel with architects.

The financing scheme of the **German** KfW Bank on "Energy-efficient construction and home ownership" targets private persons, landlords and housing companies and promotes the construction of particularly energy-efficient homes. Since 2014 the grant can only be claimed if the owner of the building involves an independent consultant during the design and the construction process. This consultant has to certify that the design was carefully realised and the implementation complies with all requirements, before the KfW Bank transfers the grant to the client. The cost of the consultant is funded by the bank. Additionally, the bank performs an internal quality insurance system to check the quality of the independent consultant using three random sample controls including an on-site inspection. The bank also advises the clients that the detailed specification of expected performance and responsibilities are as important as the quality control and should be carefully contractually fixed before the assignment: Only specifications that have been set out in writing can be claimed at a later stage.

References

- ✓ The quality assurance system of the German reconstruction loan corporation (Kreditanstalt für Wiederaufbar, KfW) in the field of energy-efficient construction and retrofitting (residential buildings) – Linda Lyslow, Heike Erhorn-Kluttig - QUALICHeCK Fact Sheet #44, January 2017
- ✓ The list of energy-efficiency experts for German federal funding programmes – Linda Lyslow, Heike Erhorn-Kluttig, Hans Erhorn - QUALICHeCK Fact Sheet #57, February 2017

5.10. Market surveillance and integrating lessons learned

Context and motivation

In practice, the work specifications (5.1) might in some cases not be sufficient to guarantee good quality of the works. It is important that there is some kind of market surveillance and/or procedures to handle complaints from practice, whereby this knowledge should then be used to improve the procedures (5.1).

Complaints can be of different nature, e.g.:

Loose requirements resulting in some cases of poor quality of the works

Overly strict or excessive requirements resulting in excessive and unnecessary costs

If there are complaints about a building where no organisation running a quality framework was involved, consumers will most likely contact the building owner and also the consumers' association for assistance. Therefore, consumers' associations might be valuable partners in assessing market complaints and developing elements of quality assurance frameworks.

Specific attention should be given to situations where companies try to blame users for deficiencies, such as mould. Mould in apartments can appear due to incorrect user behaviour; however, in specific cases it might not be the user's fault but lack of quality of the works causing this problem.

Examples of problematic situations

A procedure for complaint management is published but not respected in practice, e.g. due to lack of resources.

Procedural considerations

Not applicable.

Approaches relevant to this topic

In the UK, a voluntary programme operated by CIGA (Cavity Insulation Guarantee Agency) provides 25 years guarantee for insulations fitted by registered installers respecting the organisations' quality frameworks including qualification and training requirements and control procedures. CIGA runs a transparent consumer complaints scheme which is publicly available: www.ciga.co.uk/consumer-complaints/

References

- ✓ QUALICHeCK study Belgium – Assessment of the Belgian quality control framework for installation of thermal insulation in existing cavity walls – Arnold Janssens - QUALICHeCK Fact Sheet #13, June 2016
- ✓ Quality control frameworks for cavity wall insulation - Arnold Janssens – QUALICHeCK Fact Sheet #47, February 2017

5.11. Influence by European and national legislations and standards

Context and motivation

Although the Services Directive has been implemented by all EU countries as of 28 December 2009, the construction business is still dominated by local companies executing the work. Trade regulation takes place at the national level and conditions for practising specific jobs vary among Member States, strongly influencing the actual knowledge level of skilled trades. The Services Directive aims at creating a legal framework to ensure the freedom of establishment and the free movement of services between the Member States. However, this Directive does not affect the freedom of Member States to define, in conformity with Community law, what they consider to be services of general economic interest, how those services should be organised and financed, in compliance with the government aid rules, and what specific obligations they should be subject to. Freedom of establishment for providers must be guaranteed, but authorisation schemes will be possible if the authorisation scheme does not discriminate against the provider in question. In terms of mandatory qualification requirements and quality frameworks requiring authorisation, this means that authorisation schemes must be non-discriminatory, justified by an overriding reason relating to the public interest; proportionate to that public interest objective; clear and unambiguous; objective; made public in advance; transparent and accessible (Article 10).

The **Construction Product Regulation** imposes the free circulation of construction products in the EU's Single Market, meaning that products have to be tested only once according to a harmonised European standard or European Assessment Document. This has to be taken into account when setting rules on how to check the quality of the works.

The Public Procurement Directive supports the life-cycle costing approach (Article 68) and thus also employment of qualified workforce. In addition it says: "Furthermore, with a view to the better integration of social and environmental considerations in the procurement procedures, contracting authorities should be allowed to use award criteria or contract performance conditions relating to the works, supplies or services to be provided under the public contract in any respect and at any stage of their life cycles from extraction of raw materials for the product to the stage of disposal of the product, including factors involved in the specific process of production, provision or trading and its conditions of those works, supplies or services or a specific process during a later stage of their life cycle, even where such factors do not form part of their material substance."

Certification of qualified individuals according to EN ISO/IEC 17024 (e.g. certified heat pump installers, certified solar thermal installers, certified PV installers, certified ventilation installers) can be an option to enhance qualification. However, certification according to EN ISO/IEC 17024 requires the establishment of a body operating the certification and the respective certification scheme. The procedure takes time and is costly.

Besides relations with EU legislation and standards, there are also links with national legislation, for example:

- ✓ National privacy legislation: It is not allowed to inspect a building unit in use after building completion, thus limiting the possibilities to check quality of the works during building utilisation.
- ✓ National building legislation: There are no obligations regarding commissioning and inspection to ensure the quality of the works although standards and voluntary systems are available.
- ✓ National energy efficiency in buildings subsidy scheme: a quality framework is imposed and is a condition to receive financial support.

Examples of problematic situations

The effort needed to design functioning quality frameworks is underestimated: Quality frameworks are designed without thorough discussion of pros and cons with all affected parties and without sufficient legal expertise, resulting in cancellations, and as a consequence, also resulting in a loss of societal support.

Procedural considerations

To be in line with EU Directives, quality frameworks addressing qualification and quality of the works must be transparent and non-discriminatory.

Approaches relevant to this topic

BUILD UP Skills: Towards improved quality in energy efficient buildings through better workers' skills and effective enforcement.

References

- ✓ Marcello Antinucci, Susanne Geissler, Marianna Papaglastra, Peter Wouters (2014): CA EPBD Task Force on the interaction with BUILD UP Skills: Towards improved quality in energy efficient buildings through better workers' skills and effective enforcement. A view of the Concerted Action EPBD on Challenges and Opportunities. PUBLIC REPORT. www.epbd-ca.org/Medias/Pdf/CA_EPBD_BUS_interaction_report.pdf
- ✓ Official Journal of the European Union L 376/36 EN, 27.12.2006: Directive 2006/123/EC of the European Parliament and of the Council of 12 December 2006 on services in the internal market
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- ✓ EN ISO/IEC 17024 Conformity assessment – General requirements for bodies operating certification of persons

6. Documented set of best practices PART 2: Robust procedures on how to decide on compliance and how to respond to non-compliance

6.1. Different types of non-compliance

Context and motivation

In practice, there have been multiple examples of poor quality construction works not meeting the standard, or even worse, causing serious damage. The situation is worsened by the transposition of the EPBD into ambitious building legislation leading to regulations being one step ahead of professional skills. This demonstrates the need for further training and qualification of the workforce and the need for application of the acquired skills in practice to actually meet energy performance requirements.

In this regard third party quality frameworks addressing qualification and quality of the works are essential, specifying requirements regarding:

- Qualification requirements of persons or companies performing the works
- Reporting requirements: e.g. declaration of performance by a certified person for each building site; reporting of specific, site-related performance features:
  - ✓ reporting must be done by independent persons, or
  - ✓ reporting can be done by persons involved in the building project, but certified and controlled by a third party
- Checking requirements: e.g. systematic inspection of a building site by an independent person

Different types of non-compliance refer to elements of the third party quality framework in place, irrespective of whether they are mandatory or voluntary:

- Not carrying out the work according the procedures in terms of staffing, e.g. not respecting the requirement that works must be performed by certified persons or companies.
- Not following the set procedures in terms of e.g. documentation or reporting or not respecting the requirement of declaring the performance by a certified person for each building site.
- Not following the procedures in terms of systematic inspection, e.g. not respecting the requirement of systematic inspection of a building site by an independent person.
- Not carrying out the work according to the procedures in terms of technical quality

While the first three types of non-compliance refer to requirements regarding qualification of staff for execution works and quality assurance procedures carried out by qualified staff and subject to third party control, the last type of non-compliance relates to the technical terms of the contract.

However, the pre-condition for consequences in both cases is that there is awareness of possible types of non-compliance. While clients are aware of contractual quality aspects such as window-frame material, there is little awareness that invisible mistakes due to lack of qualification and poor quality of the works cause leakages and thermal bridges and this will result in energy losses during building operation.

Another pre-condition for consequences in both cases is that the non-compliance can be detected. Therefore, clear procedures to check the quality of the works are necessary (for more information on clear procedures to check the quality of the works see next chapter).

Examples of problematic situations

- ✓ In general no awareness of energy-related non-compliance and thus no demand for quality assurance.
- ✓ No awareness about the cost implication of energy-related non-compliance during the building life cycle.

Procedural considerations

✓ Not applicable.

Approaches relevant to this topic

✓ Not applicable.

References

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6.2. Clear procedures to check the quality of the works

Context and motivation

Clear procedures for checking the quality of the works are necessary for checking compliance with the requirements, for example those related to subsidies and quality labels, and imposed by third party control.

The following aspects are crucial in the context of developing clear procedures to check the quality of the works:

- ✓ To identify quality problems: focus is on specific problematic issues.
- ✓ To develop effective methods to ensure quality and compliance: quality frameworks impose criteria to be respected and which can be checked.
- ✓ To define appropriate procedures on how to check compliance with requirements: procedures define roles, responsibilities, and consequences.
- ✓ To determine who is entitled to check compliance and what the conditions are: check by government administration, authorised company or independent expert, voluntary or mandatory check.

Table 4 shows a brief overview of examples regarding potential quality problems, methods on how to ensure quality, and approaches to how to check compliance.

Table 4: Overview of potential quality problems and procedures on how to address them

Potential quality problems	Examples of how to ensure quality (requirements imposed by qualification frameworks)	Examples of how to check compliance (procedures)
Products / components built in the wrong way	Employ qualified workforce (certified / trained workers) and / or quality coach (BUILD UP Skills); Provide sufficiently clear execution details including the requirement of measured performance	Check the reporting of an independent expert; Check the declaration of performance by a certified person; Systematic inspection by an authorised person
Information gaps between skilled trades which result in worse performance	Employ cross-trade qualified workforce; Commissioning dates including measurements in between trades (time schedule); Construction book for documentation	Check the standardised commissioning checklist forms on product / component level signed by the responsible professional; Check reporting document (e.g. construction book)
Overall adjustment of building services systems does not take place	Standardised commissioning checklist forms on product / component and performance level (evidence of what is actually built in and whether systems are working properly)	Check standardised commissioning checklist forms filled in and signed by qualified person

There are several options regarding the organisation that can carry out controls and the control procedures to be applied, and the most suitable choice, taking national conditions into account.

Possible organisations that can carry out control and check quality of the works are:

- The Government and organisations / individuals acting on behalf of the government (mandatory control, e.g. as part of a public subsidy scheme)
  - ✓ Government administration, e.g. the local administration in charge of building permits and permits to use the building
  - ✓ Public authorities such as a regional energy agency
  - ✓ A designated third party: accredited companies (requirements to be specified)
  - ✓ A designated third party: certified individuals (requirements to be specified)
  - ✓ Specified self-control: authorised professionals (e.g. authorised by professional license), subject to control by an authorised party
- Third party control (voluntary, e.g. as part of a green building rating scheme)
  - ✓ Certified companies and individuals (requirements to be specified, e.g. by national Green Building Councils)
- Self-check (voluntary, e.g. as part of a self-declaration building assessment programme; independent commissioning unit within a big company)
  - ✓ Building assessment programme randomly checks self-declaration by qualified company staff
  - ✓ Independent commissioning unit in a big company checks quality of the works carried out by qualified company staff

Possible control procedures (archive based on on-site checks, sample checks or full checks depending on the size and complexity of the project) must be effective and preferably low cost. Examples of on-site checks are given below:

- ✓ **Check of human resource policies of companies involved** compared with voluntary and / or mandatory requirements (such as regular in-house training for craftsmen to update technical know-how): e.g. by means of on-site interviews with a few workers
- ✓ **Check of on-site quality assurance procedures** compared with voluntary and / or mandatory requirements (such as a few hours on-site training for craftsmen prior to a crucial implementation phase, specific tasks to be performed by the site supervisor such as filling and signing commissioning checklists, etc.): e.g. by means of on-site interviews with a few workers
- ✓ **Check of qualification certificates of involved craftsmen on-site:** all documentation required according to tender specification and / or mandatory requirements has to be available on-site for random check
- ✓ **Check of time schedule and execution plan, including visits to construction site during critical periods** and check whether execution complies with voluntary and / or mandatory requirements (visual check)
- ✓ **Check of reporting documents, commissioning checklists and measurement protocols** (for example airtightness testing protocol) regarding compliance with voluntary and / or mandatory requirements (functional check)

Examples of problematic situations

- ✓ Procedures are not problem-oriented and not specific enough.
- ✓ There are no minimum requirements defined which refer to installation rules for building elements and that can be easily checked.
- ✓ Requirements regarding qualification of the workforce are not sufficiently specified, giving opportunity to companies submitting offers with dumping prices and using a less qualified workforce.
- ✓ Certain aspects regarding qualification are not sufficiently covered by the requirements, and therefore it can be problematic to procure based on the cheapest offer.
- ✓ Reporting documents needed for checking are not well specified, and standard formats are not available.
- ✓ Hand-over procedures do not include verification checks.
- ✓ Commissioning is only done at the point of handing-over, there is no commissioning at critical stages, and therefore mistakes cannot be corrected at reasonable costs.
- ✓ Authorised experts entitled to check the quality of the works do not actually have the technical knowledge to perform their work according to expectations.

Procedural considerations

- ➢ It is not the objective to introduce third party control for as many elements of the construction process as possible, but for those that are crucial and pose a serious problem.
- ➢ Requirements should be detailed to also address building elements, especially those that are crucial for building energy performance, and should be formulated in a way that they can be checked easily. They become even more important taking into account the development towards nearly zero energy buildings or even plus-energy buildings.
- ➢ In many countries it is the usual procedure that the supervising engineer (construction site supervisor) verifies that the building is built in accordance with the plans and specifications and also verifies the quality of the construction. These duties can be extended to also include energy aspects (self-check). In general, self-checks increase the level of quality and thus reduce the necessary number of costly third party checks.
- ➢ Timing of on-site check: What are the best moments to control the as-built situation (self-check by construction site supervisor and third-party check of site supervisor)?
- ➢ Development of procedures has to carefully deal with the qualification requirements inspectors and authorised experts allowed to check the quality of the works must fulfil.

- Development of procedures should consider and assess the advantages and disadvantages of the following options in the specific national or regional context:
  - ✓ Archive versus on-site checks,
  - ✓ Mandatory versus voluntary checks,
  - ✓ Systematic checks versus sample-based checks,
  - ✓ Self-checks versus third-party checks,
  - ✓ Visual checks versus functional measurements (performance).

Approaches relevant to this topic

- **Quality assurance procedure in Ireland:**
  - ✓ The owner must appoint an inspector for the construction process.
  - ✓ The authority only checks that the prescribed process has been followed, not compliance with the requirements.
  - ✓ The designer must sign off that the design complies with the requirements.
  - ✓ At completion, the builder must sign off that the building is constructed according to the design and in accordance with the requirements and the drawings submitted to the authority. The builder must be competent (in the legal meaning, i.e. have the necessary education or skills), however is allowed to lean on competent sub-contractors, e.g. plumber, electrician etc.
- **Measurements after completion in France:** Enforcement of airtightness requirements was introduced in the requirements as a first step towards introduction of NZEB requirements. This is seen as a way to ensure better contractor skills and increase focus on airtightness. There are two ways to demonstrate compliance with the requirements:
  - ✓ Measurements in the building after completion;
  - ✓ Management of a quality assurance procedure in the construction company.
- **Commissioning checklists for self-control in Austria:** The klimaaktiv programme is funded by the government and provides a green building self-declaration scheme including supporting material such as detailed checklists for systems commissioning to ensure quality of the works and thus energy efficiency.

References

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- ✓ BUILD UP Skills Austria: http://buildupskills-crosscraft.at/moodle/?lang=en
- ✓ Voluntary green building assessment paves the way for better as-built quality – Susanne Geissler, Peter Wallisch - QUALICHeCK Fact Sheet #28, November 2016
- ✓ klima**aktiv** quality requirements for building services systems as part of the klima**aktiv** green building self-declaration: www.klimaaktiv.at/publikationen/bauen-sanieren/qualitaetslinien.html
- ✓ Building air leakage rate in energy calculation and compliance procedures - Kalle Kuusk, K. et al. – QUALICHeCK Fact Sheet #33, December 2016

6.3. Types of penalties in case of non-compliance

Context and motivation

Penalties in case of non-compliance with requirements regarding qualification and quality of the works target executing companies, developers, and companies commissioned with quality assurance activities. The following are types of non-compliance:

- ✓ Executing companies violating the requirements of quality frameworks addressing qualification of the workforce
- ✓ Executing companies not carrying out the work according to the procedures in terms of technical quality
- ✓ Developers not respecting the reporting requirements
- ✓ Developers not respecting the inspection requirements
- ✓ Quality assurance companies not respecting qualification requirements
- ✓ Quality assurance companies making mistakes and delivering defective work

The following types of penalties are possible, depending on the framework applicable to quality frameworks, the conditions regulating the activities, rights and obligations (licence) of professions in the Member States, and the culture prevailing in the Member States:

- ✓ Warning and no further consequence
- ✓ Warning and publication of companies marked with warnings in terms of quality of the works
- ✓ Warning and obligation to correct the mistake within a given period
- ✓ Warning and counting the warnings; after a certain number of warnings an administrative fine will apply, and several fines will result in the withdrawal of permit to execute this type of activities
- ✓ Requirement for (additional) training/examination of the workforce within a given period of time
- ✓ Requirement to carry out additional activities before works can be approved/delivery of attestation
- ✓ Administrative fine
- ✓ Prison
- ✓ Withdrawal of permit to execute this type of activities
- ✓ Finally, the building owner will be liable for the lack of building performance resulting from poor quality of the works. Aspects of EPBD compliance are dealt with in the Qualicheck Source book for improved compliance of Energy Performance Certificates (EPCs) of buildings, while compliance with other requirements (e.g. imposed by green building certification schemes, financing schemes) is tackled in this report. Penalties addressing the building owner will be, for example: obligation to correct the mistake, loss of financial support, loss of green building certificate.

Examples of problematic situations

Possibilities to bypass penalties, for example: Green building certification schemes usually offer design certificates and completion certificates for the same building. It happens quite often that building owners only commission the design certificate and also use it for the completed building, although the design certificate does not reflect the (defective) as-built situation. In some cases, the “loss of certificate” penalty would have to apply but cannot take place.

Procedural considerations

- ✓ First of all, the types of penalties chosen should contribute to constantly improving the quality of the works rather than represent a pure punishment.
- ✓ Penalties must be designed in a way that they are proportionate and effective.
- ✓ Execution of penalties must be feasible from the administrative point of view.
- ✓ A step-wise penalty-system (warning – fine – withdrawal of licence) requires a database to collect and administrate building-related as well as company-related information about quality of the works.

Approaches relevant to this topic:

In **Austria (province of Lower Austria)**, an effective quality framework was applied in the course of granting additional financial support for energy efficient buildings exceeding energy performance minimum requirements. Several on-site visits were carried out and in case of mistakes solutions were suggested and discussed with the responsible executing companies. Companies had to follow the advice because otherwise the building owner would have lost financial support. In this regard, the penalty "Warning and obligation to correct the mistake within a given period" was used to raise awareness of quality of the works. The penalty "Loss of financial support" addressing the building owner was never applied because detected mistakes were used as an opportunity to train the executing companies and to achieve the energy minimum requirements at the same time. The program was very effective but also costly because technically up-to-date experts had to be employed to carry out meaningful inspections and on-site advice for executing companies.

REFERENCES

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- ✓ Belgium/Flemish Region control and penalty scheme of the energy performance legislation: Checking procedure and fines – Clarisse Mees - QUALICHeCK Fact Sheet #48, February 2017

6.4. Clear rules about liabilities and penalties

Context and motivation

Growing awareness of quality of the works is translated into more emphasis on qualification and training of the workforce and also on third party quality frameworks, sometimes focusing on competence of workers and in other cases on the execution quality on the building site, or both. Quality of the works involves liability issues and a potential cost increase, and therefore remains a very sensitive issue requiring a careful approach.

An effective quality enforcement framework specifies penalties in case of non-compliance, and whom they address. Entities governing quality frameworks should aim at making the rules and related penalties as clear as possible, in order to minimise debate afterwards and minimise the risk of loss of societal support.

Depending on the infringements detected during voluntary or mandatory control, e.g. in the framework of financing schemes, liability can be with the building owner, the design team, the construction site supervisor, the executing companies, and the companies commissioned for external quality assurance.

Roles and responsibilities are, for example:

- ✓ Design team is responsible for breaking down requirements at the level of executing trades (detailed design, execution planning)
- ✓ Design team is responsible for marking crucial stages for the construction site supervisor and third party control to pay special attention to (interfaces between trades, e.g. those relevant to achieve an airtight building envelope)
- ✓ Executing companies are responsible for respecting the requirements regarding qualification of the workforce
- ✓ Executing companies are responsible for carrying out the work according to the procedures in terms of technical quality
- ✓ Executing companies are responsible for respecting the commissioning and reporting requirements

- ✓ Developers representing the client are responsible for respecting the reporting requirements
- ✓ Developers representing the client are responsible for respecting the inspection requirements
- ✓ Construction site supervisor representing the client is responsible for internal quality control according to requirements (self-checks subject to third party control)
- ✓ Third party control (company commissioned for quality assurance or independent commissioning unit in a big company) is responsible for carrying out the agreed checks and measurements according to specification
- ✓ Third party control (company commissioned for quality assurance or independent commissioning unit in a big company) is responsible for fulfilling the qualification requirements regarding their own staff

Clear rules and related penalties in case of non-compliance help to set up the contracts between the parties affected by the quality framework in a way that there are clear roles between partners, resulting in clear responsibilities for the quality of the works depending on the type and the complexity of the project.

In case of disputes taking place during a project subject to a quality framework, the entity governing the quality framework can be the first contact point trying to mediate the dispute prior to making use of established procedures according to civil law.

Procedures in case of disputes should be transparent and publicised, including penalties and whom they will address if there is a violation of requirements.

Examples of problematic situations

- ✓ Execution planning does not pay sufficient attention to interfaces between trades in terms of commissioning dates: e.g. installation of heating system with insulated piping flush-mounted fitting (in-wall mounted), and therefore responsibilities are not clear and penalties cannot be applied.
- ✓ Specification is not detailed enough regarding qualification of staff in order to justify penalties: some employees of the company hold the required certificate, but staff involved in the project do not.
- ✓ Task descriptions for the construction site supervisor are not sufficiently detailed, and therefor he or she cannot be held liable.

Procedural considerations

- ✓ Penalties must be specified by the entity running the respective quality framework.
- ✓ Penalties must address the responsible actor who is in the position to correct the mistake at the source of the problem.
- ✓ Standardised commissioning checklists and other supporting material for carrying out checks should be provided by the entity governing the quality framework.

Approaches relevant to this topic

- ➢ **In Belgium / Flemish region**, the "Enforcement framework for cavity wall insulation of existing buildings" allows a quality approach based on the certification by an accredited organisation.
- ➢ This enforcement framework can also serve as an example for similar approaches to be considered for other technologies (internal insulation, external insulation, installation of windows and doors, etc.), for ventilation systems and heat pumps, as well as for renewable energy technologies (PV, solar hot water, etc.).
- ➢ **In Austria**, the national climate protection programme klimaaktiv (funded by the government) issues quality guidelines for heating systems, heat pumps, solar thermal systems, PV systems, airtight building envelope, ventilation systems, lighting, and district heating systems in the framework of the voluntary green building self-declaration scheme called klimaaktiv. Quality guidelines include execution checklists specifying responsibilities among trades, e.g. what to consider during execution to achieve a building envelope meeting the airtightness requirements, as shown below:

- ✓ A time schedule for accompanying checks and airtightness measurements during the construction period is available
- ✓ Visual check of executed connections, intersections and penetrations; check of materials used, steam breaks and foils glued
- ✓ Airtight installation of windows and doors according to ÖNORM B 5320; responsible party: window installer (commissioning of the works)
- ✓ Solid construction: airtight interior plaster completed; responsible party: builder (commissioning of the works)
- ✓ Light weight construction: airtightness layer completed; responsible party: carpenter (commissioning of the works)
- ✓ Plastering the chimney; responsible party: builder (commissioning of the works)
- ✓ Plastering of brick walls behind chimneys and built-in components such as sewage systems; responsible party: builder (commissioning of the works)
- ✓ Airtight integration of electrical installations; responsible party: electrician (commissioning of the works)
- ✓ Empty conduits / tubing are sealed to the outside (e.g. for solar thermal system, electric wiring, etc.); responsible party: plumber, electrician (commissioning of the works)
- ✓ Airtightness measurement completed, n50, etc.

The construction site supervisor representing the client is responsible and subject to random control carried out by the klimaaktiv programme management. This programme applies the penalty "loss of certificate": If the airtightness measurement does not comply, the klimaaktiv label will not be awarded.

References

- ✓ QUALICHeCK study Belgium – Assessment of the Belgian quality control framework for installation of thermal insulation in existing cavity walls – Arnold Janssens - QUALICHeCK Fact Sheet #13, June 2016
- ✓ klimaaktiv quality guidelines including checklists: www.klimaaktiv.at/publikationen/bauen-sanieren/qualitaetslinien.html
- ✓ Mikk Maivel, Kalle Kuusk, Raimo Simson, Jarek Kurnitski, Targo Kalamees (2015): Overview of existing surveys on energy performance related quality and compliance. QUALICHeCK Report.

6.5. Consequences in terms of qualification, certification, labelling

Context and motivation

Accredited certification schemes for individuals, **certification schemes for individuals operated by acknowledged and trustworthy organisations, and seals of quality awarded to companies (related to products, systems, quality of the works)** by acknowledged and trustworthy organisations can play an essential role in ensuring quality of the works. The relevant work can be delivered by executing companies but also delivered by the competent persons in charge of self-checks subject to third-party checks or actual third-party checks. However, rules must be transparent and limitations of certifications, labels and quality seals must be clearly communicated (e.g. company label versus individual certification).

In terms of staff of executing companies, in-house trainings as well as **product specific trainings** are often considered an appropriate and cheaper alternative compared with trainings resulting in certificates, in order to ensure qualification and achieve good quality of the works. However, experience shows that fluctuation of staff (promotion of successful workers in the company and better opportunities outside the company) can compromise in-house qualification efforts. Product specific trainings are necessary but not a substitute for trade specific further education either. Sufficiently qualified craftsmen need to understand the relation of their own trade to the other ones and their position in achieving the objective of an energy efficient or nearly zero energy building.

Therefore, **on-site trainings resulting in qualification certificates** can be feasible options in terms of coping with the trade-off regarding cost.

Examples of problematic situations

- ✓ Certification schemes exist, but the certification of qualification is not a requirement due to concerns regarding higher cost and thus lack of acceptance.
- ✓ Certification schemes exist, but in many countries they are limited to installers dealing with renewable energy technologies because this has been a consequence of implementing the RES-Directive. Similar schemes are necessary for ventilation installers and trades responsible for delivering an airtight building envelope (trades dealing with insulation, windows, facade, roof), but are not available yet.
- ✓ Unclear information leads to confusion regarding liability and non-compliance, e.g. the company holds a qualification certificate, but there is no evidence that requirements are met regarding the individual workers on-site.

Procedural considerations

- ✓ Evidence of qualification must be available in a form allowing the translation into requirements imposed by quality frameworks.
- ✓ Evidence of qualification must be available in a form allowing for compliance checks.

Approaches relevant to this topic

- ✓ Examples of trainings and certified qualifications showing how they could be used in quality frameworks:
- ✓ In Romania, the BUILD UP Skills QualiShell project (IEE) focuses on the development of qualification schemes for building envelope insulators and insulated window system installers to ensure the execution of high performance building envelopes.
- ✓ In Slovenia, the Chamber for Crafts and Small Business Slovenia developed this pilot initiative: Because there were no guidelines for the installation of ETICS, companies (manufacturers of ETICS, approximately 18 ETICS companies offering ETICS facade systems on the Slovenian market) have organised their own trainings targeting installers. The number of ETICS façade certified installers was about 800 in 2014.
- ✓ In Austria, accredited certification schemes are available for photovoltaic systems installers, solar thermal systems installers, heat pump installers, and airtightness testers. Other certification schemes (operated by programs, companies, associations or research institutions) are available for ventilation installers, builders, biomass heating systems installers. There is a seal of quality for companies targeting installers and providers of solar thermal systems. In Austria, the company and training provider Sonnenplatz offers training across trades on passive house technologies. In the context of this training craftsmen acquire theoretical knowledge of the passive house technology, complimented by practical exercises and study topics across the trades. Target audience: craftsmen in the building industry, foremen, masons, (construction) carpenters, ventilation technicians, roofers, tinsmiths, plumbers, electricians, manufacturers and installers of windows, etc.
- ✓ In Malta, on-site-training is considered beneficial for improving the quality of the work while maintaining the cost for the contractors at very low levels (the time spent on training is during actual construction works). The suggested process requires all workers to become fully trained and certified while working on projects where financial incentives are being granted. This process is expected to gradually increase the numbers of trained workers.

References

- ✓ Mikk Maivel, Kalle Kuusk, Raimo Simson, Jarek Kurnitski, Targo Kalamees (2015): Overview of existing surveys on energy performance related quality and compliance. QUALICHeCK Report
- ✓ klimaaktiv programme, the Austrian national climate protection programme: www.klimaaktiv.at/
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6.6. Specific issues for (deep) renovations

Context and motivation

Member States have set action plans to stimulate **deep energy renovations**. This stresses the relevance of qualification and quality control targeting the specific challenges encountered in the major renovation of existing buildings (see example from Austria below).

Improving energy efficiency in existing buildings requires specific knowledge regarding the as-built situation in the past as well as up-to-date technical know-how to assess which energy efficiency measures are suitable in the specific building to be renovated. Sometimes problematic situations are hidden and cannot be detected during the baseline study. Damages have to be eliminated before renovation works can start. Therefore, staff working on-site must be qualified to **identify critical situations when they become evident and react accordingly** in order to achieve good quality of the works.

Depending on the building stock of a country, **specific standard renovation measures** can be defined (see example on cavity wall insulation from Belgium below) and a tailor-made quality framework can be developed to ensure quality of the works. These frameworks can be applied in the course of a deep renovation as well as in the course of a single renovation measure.

Examples of problematic situations

Cost increases and additional cost caused by quality control: energy related payback times are often not realistic due to the rebound effect and the influence of user behaviour in general, as well as hidden damages that have to be eliminated or repair works that turn out to be necessary before energy measures can be implemented derail the planned budget. There is not much support for accepting additional costs for quality assurance although this will pay off in the long run.

Procedural considerations

Effort needed to attain the formal qualification requirements (course attendance and examination) must be proportionate to business opportunities opening up for companies meeting the qualification requirements.

Cost of a voluntary quality framework must be acceptable for the client or it must be made mandatory to create equal conditions on the market.

Approaches relevant to this topic

In **Belgium / Flemish region**, the "Enforcement framework for cavity wall insulation of existing buildings" allows a quality approach based on certification by an accredited organisation and targeting a specific renovation measure:

- ✓ This approach foresees that accredited organisations can approve insulation techniques meeting well-defined specifications in combination with the certification of installers who meet the criteria.
- ✓ Regular inspections are done regarding the various procedural aspects.
- ✓ The installers have to follow two training courses, i.e. one by the supplier of the insulation technology and one by a neutral body (including examination).

In **Austria**, the platform of qualified companies active in building renovation "Traumhaus Althaus" under Energieinstitut Vorarlberg, the regional Energy Agency of Vorarlberg represents a network of more than 60 companies specialised in building renovation. Members are committed to continuous

further education and training and high quality ecological and energy standards for successful renovations. The energy agency checks interested companies applying for membership whether they comply with the rules set by the energy agency. During membership, training is mandatory and member companies are checked on an annual basis. Training offered by the platform is free for members. Training is not limited to a specific area of expertise but addresses all relevant issues regarding high quality renovations.

References

- ✓ EPBD Concerted Action www.epbd-ca.eu/
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- ✓ Platform of qualified companies active in building renovation "Traumhaus Althaus", platform governed by Energieinstitut Vorarlberg, the regional Energy Agency of Vorarlberg in Austria: www.energieinstitut.at/unternehmen/partnerbetriebe-traumhaus-althaus/mitglied-werden/

6.7. Influence by European and national legislations and standards

Context and motivation

Although the **Services Directive** has been implemented by all EU countries as of 28 December 2009, the construction business is still dominated by local companies executing the work. Trade regulation takes place at the national level and conditions for practising a specific job vary among Member States, strongly influencing the actual knowledge level of skilled trades. The Services Directive aims at creating a legal framework to ensure the freedom of establishment and the free movement of services between the Member States. However, this Directive does not affect the freedom of Member States to define, in conformity with Community law, what they consider to be services of general economic interest, how those services should be organised and financed, in compliance with the government aid rules, and what specific obligations they should be subject to. Freedom of establishment for providers must be guaranteed, but authorisation schemes will be possible if the authorisation scheme does not discriminate against the provider in question. In terms of mandatory qualification requirements and quality frameworks requiring authorisation, this means that authorisation schemes must be non-discriminatory, justified by an overriding reason relating to the public interest; proportionate to that public interest objective; clear and unambiguous; objective; made public in advance; transparent and accessible (Article 10).

The **Construction Product Regulation** imposes the free circulation of construction products in the EU's Single Market, meaning that products have to be tested only once according to a harmonised European standard or European Assessment Document. This has to be taken into account when setting rules on how to check the quality of the works.

The **Public Procurement Directive** supports the life-cycle costing approach (Article 68) and thus also employment of qualified workforce. In addition it says: "Furthermore, with a view to the better integration of social and environmental considerations in the procurement procedures, contracting authorities should be allowed to use award criteria or contract performance conditions relating to the works, supplies or services to be provided under the public contract in any respect and at any stage of their life cycles from extraction of raw materials for the product to the stage of disposal of the product, including factors involved in the specific process of production, provision or trading and its conditions of those works, supplies or services or a specific process during a later stage of their life cycle, even where such factors do not form part of their material substance."

Certification of qualified individuals according to EN ISO/IEC 17024 (e.g. certified heat pump installers, certified solar thermal installers, certified PV installers, certified ventilation installers) can be an option to enhance qualification. However, certification according to EN ISO/IEC 17024 requires the establishment of a body operating the certification and the respective certification scheme. The procedure takes time and is costly.

Besides relations with EU legislation and standards, there are also **links with national legislation**, for example:

- ✓ National privacy legislation: It is not allowed to inspect a building unit in use after building completion, thus limiting the possibilities to check quality of the works during building utilisation.
- ✓ National building legislation: There are no obligations regarding commissioning and inspection to ensure the quality of the works although standards and voluntary systems are available.
- ✓ National energy efficiency in building subsidy schemes: a quality framework is imposed and is a condition for receiving financial support.

Examples of problematic situations

The effort needed to design functioning quality frameworks is underestimated: Quality frameworks that are designed without thorough discussion of pros and cons with all affected parties and without sufficient legal expertise, resulting in cancellations, and as a consequence, also resulting in a loss of societal support.

Procedural considerations

To be in line with EU Directives, quality frameworks addressing qualification and quality of the works must be transparent and non-discriminatory.

Approaches relevant to this topic

BUILD UP Skills: Towards improved quality in energy efficient buildings through better workers' skills and effective enforcement.

References

- ✓ Marcello Antinucci, Susanne Geissler, Marianna Papaglastra, Peter Wouters (2014): CA EPBD Task Force on the interaction with BUILD UP Skills: Towards improved quality in energy efficient buildings through better workers' skills and effective enforcement. A view of the Concerted Action EPBD on Challenges and Opportunities. Public report. www.epbd-ca.org/Medias/Pdf/CA_EPBD_BUS_interaction_report.pdf
- ✓ Official Journal of the European Union L 376/36 EN, 27.12.2006: Directive 2006/123/EC of the European Parliament and of the Council of 12 December 2006 on services in the internal market
- ✓ Official Journal of the European Union L 94/65, 28.3.2014: Directive 2014/24/EU of the European Parliament and of the Council of 26 February 2014 on public procurement and repealing Directive 2004/18/EC
- ✓ Official Journal of the European Union L 88/5, 4.4.2011: Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC
- ✓ EN ISO/IEC 17024 Conformity assessment - General requirements for bodies operating certification of persons
- ✓ EN ISO/IEC 17024 Conformity assessment - General requirements for bodies operating certification of persons

7. Documented set of best practices PART 3: Operational framework for better compliance and effective penalties related to quality of the works

7.1. The willingness to check

Context and motivation

The willingness to check quality depends on the advantages or benefits gained from the checking procedure in relation to the resources and thus cost required for the checking procedure.

The willingness to check refers to:

- ✓ the government willing to check the quality of the works to boost energy efficiency and to support the establishment of new technologies necessary for the realisation of nearly zero energy buildings,
- ✓ entities operating quality assurance schemes which are a precondition to achieve access to financing schemes,
- ✓ entities operating quality assurance schemes which address companies seeking an edge over the competitors on the market,
  companies committing themselves in the framework of voluntary quality assurance schemes (self-control).
- ✓ The willingness to check might increase if building owners actively demand for quality checks addressing critical situations, or at least are ready to tolerate or even support them.

Examples of problematic situations

Not applicable

Procedural considerations

Not applicable

Approaches relevant to this topic

- ✓ **Willingness to check due to financial implications: In the UK**, a voluntary programme operated by SWIGA (Solid Wall Insulation Guarantee Agency) provides a 25 years guarantee for insulations fitted by registered installers respecting the organisations' quality frameworks including qualification and training requirements and control procedures. Requirements and control procedures are transparent and publicly available at: : www.swiga.co.uk/wp-content/uploads/2012/08/2.1LV-SWIGA-Members-Rules-of-Conduct.pdf.
- ✓ **Willingness to check due to public interest:** In **Spain**, the process of quality control during construction includes mandatory execution control. The entity control will create a schedule of visits according to the characteristics of the work, to check elements of the thermal envelope, aspects relating to thermal bridges, and the facilities including renewable energy technologies. A variable number of visits to examine the quality of the works are carried out depending on the type, complexity and size of the building. After each inspection, there is a report that presents the results obtained during the inspection, especially of those aspects in need of improvement. The report contains photographs and necessary measurements. The final report contains all results of the realized visits. The modifications of the presented project will be reflected so that the above-mentioned information can be used in crosschecking the EPC.

References

- ✓ Mikk Maivel, Kalle Kuusk, Raimo Simson, Jarek Kurnitski, Targo Kalamees (2015): Overview of existing surveys on energy performance related quality and compliance. QUALICHeCK Report
- ✓ Heike Erhorn-Kluttig, Hans Erhorn, Sarah Doster (2014):"Documented examples of existing situations regarding quality of works". QUALICHeCK Report. 2016
- ✓ SWIGA (Solid Wall Insulation Guarantee Agency): www.swiga.co.uk/

7.2. The resources to check

Context and motivation

Irrespective of whether checks are mandatory or voluntary, resources needed for checking should be distinguished:

- Human resources: availability of qualified staff
- Time resources: sufficient time to carry out the work properly according to specifications
- Financial resources: availability of monetary budget to pay for quality checks
- Depending on the type of check, resources needed to check will be different:
- From the client's perspective (the one who is checked):
  - ✓ Third party checks require qualified in-house staff, time for carrying out defined procedures to comply with requirements, and budget to commission the authorised company/expert to check.
  - ✓ Third party checks should provide an additional benefit for the one who is checked, e.g. demonstration of trustworthiness by awarding a certificate, a label, or granting access to a financing scheme, in order to justify the effort.
- From the scheme operator's perspective (the one who checks):
  - ✓ Systematic checks are more expensive than sample-based checks.
  - ✓ Systematic checks must be well justified, for example if a specific weakness in quality of the works is prevalent and region-wide improvement will be necessary.

Examples of problematic situations

- ✓ Allocation of human resources and budget is not realistic: The time pressure at the construction site and the cost pressure in general contradict the amount of time theoretically allocated to checking.

Procedural considerations

- ✓ Usually there is a construction site supervisor (supervising engineer) with the duty to verify that the building is built in accordance with the plans and specifications, and also with the duty to verify the quality of the construction. The task description could be extended to cover energy-related aspects, as well (self-checks). Self-checks can reduce the number of third-party checks needed and thus reduce cost.
- ✓ Visual checks are less costly than functional checks (measurements). However, they are not interchangeable but complement each other.
- ✓ Provided that a well-developed database is in place, archive checks can be much cheaper than on-site checks, but they are also more prone to fraud: ideally, both are combined and systematic archive checks are used to select the samples for the on-site check.

Approaches relevant to this topic

Initiatives to increase the quality of the works and to limit the resources needed for third-party checks at the same time:

- ✓ In Belgium, the OPTIVENT (2010 – 2013) project found that ventilation installations are often incorrectly adjusted: excessive flow rates in some spaces and too low rates in other ones. It was concluded that recommendations and tools for installers are necessary, and they are now available on the website www.optivent.be and will be soon published as a Technical Note of the Belgian Building Research Institute (BBRI). This tool enables the sizing of the ducts, the selection of the fans and also describes a set procedure. In addition, guidelines for airflow rate measurements are proposed (type of methods, conditions of measurement, etc.) in order to support installers in compliance checking.
- ✓ The UK responds to the challenge of poor ventilation installations by, among other things, producing a freely available flow measurement guide.
- ✓ In Austria, the independent platform called Komfortlüftung offers certified trainings and information such as the quality criteria framework for good ventilation installations, including installation guidelines and specific requirements (60 requirements) also allowing checking of

the built-in situation. Material is available for single-family buildings, multi-unit residential buildings, offices, schools and kindergartens. (www.komfortlüftung.at/fileadmin/komfortlueftung/MFH/60_QK_Komfortlueftung_MFH_V_2.0_mit_Erlaeuterungen.pdf)

References

- ✓ Detailed analysis of regulatory compliance controls of 1287 dwellings ventilation systems. Proceedings of the 34th AIVC - 3rd TightVent - 2nd Cool Roofs' - 1st venticool Conference , 25-26 September, Athens 2013. www.aivc.org
- ✓ Quality of ventilation systems in residential buildings: status and perspectives in the UK. Air Infiltration and Ventilation Centre (AIVC) International Workshop Proceedings 18-19 March 2013. www.aivc.org/
- ✓ Professional centre offering information material for tender specification, installation guidelines and requirements for checking: www.komfortlüftung.at/proficenter/
- ✓ Mikk Maivel, Kalle Kuusk, Raimo Simson, Jarek Kurnitski, Targo Kalamees (2015): Overview of existing surveys on energy performance related quality and compliance. QUALICHeCK Report
- ✓ French quality label for renewable energy systems installation companies: www.qualit-enr.org/professionnels/audit/

7.3. Effective sampling schemes

Context and motivation

Effective sampling schemes for control differ depending on how error-prone a technology is, the impact of faulty installations, and the respective qualification level of the workforce. Samples can refer to buildings, technologies, companies, and individuals.

Sampling schemes can be based on random samples or targeted samples addressing a specific subsample.

Effective sampling schemes operate with dynamic sample sizes: at the beginning when a new technology is introduced, there will be the need to control more buildings and craftsmen, in order to gain better insight and learn about the reasons for problems with quality of the works. The appropriate response, e.g. targeted qualification measures, may result in improvements and sample sizes may be reduced. Therefore, evaluation and feedback loops are part of effective sampling schemes.

Sampling of well-established technologies advocates sampling schemes equivalent to those applied for EPC control, which are usually between 1% and 5%. Other technologies such as ventilation systems installation are crucial for building performance and still problematic in terms of quality of the works and may require larger samples.

Experience shows that the simple fact that a check could take place (random check by government or voluntary quality assurance programme or measurement requested by client) results in improved workmanship.

Examples of problematic situations

- ✓ There is not much information available about the quality of installations on the market, which makes it difficult to design an effective sampling scheme.
- ✓ The sampling scheme is not well developed and feedback loops for constant improvements are not clear. Thus, it is not effective and societal support will be lost.
- ✓ There are several sampling schemes targeting companies and individuals in terms of qualification and technologies in terms of installation quality; the schemes are not well synchronised and cost saving potentials are not utilised.

Procedural considerations

- ✓ Methods to decide on the sampling type and sampling size: e.g. problematic technology, inconsistencies in reporting of construction site supervisor, etc..
- ✓ What is the right moment to control the chosen sample, and how to collect the relevant information
- ✓ Methods to choose samples: e.g. execution companies marked with warnings, etc.
- ✓ Methods of data collection and administration of results
- ✓ Methods of evaluating results and feedback loops to revise decision making on sampling size and choosing samples

Approaches relevant to this topic

Governmental schemes, targeted samples:

- ✓ 5% sample of one crucial element: In Denmark, the airtightness of new buildings is a mandatory requirement. To check, the pressure test is mandatory for 5% of new buildings. The local authority selects the houses to be tested. The owner pays for the test. In this way, craftsmen increase their awareness of air tightness.
- ✓ 100% sample of one crucial type of installation: For several years, the testing of ventilation systems has been mandatory for most building types in Sweden. Two types of certified testers exist: a control must be done at the moment of delivery of the installation and also at regular intervals. These intervals (three, six, or nine years) are defined depending on the type of building. This scheme serves on the one hand to ensure good quality installations, and on the other hand to ensure that quality is maintained during operation. Health concerns might be at least as important as the motivation to improve energy efficiency.
- ✓ No sampling scheme: In Germany, since 2009 every craftsman has to declare that the quality of the works for each building is in compliance with the energy saving regulations. The "craftsmen declaration" leads to fewer infringements because of increasing awareness and responsibility. The building owner has to retain the contractor's declaration for at least five years. The building owner has to present the declaration to the responsible authority on request.

Voluntary schemes, targeted samples:

- ✓ Full control: The French non-governmental voluntary quality label Effinergie+ plans to reinforce ventilation controls, introducing ventilation airflows and duct leakage measurements at commissioning. In France, ventilation commissioning is considered a necessary step to ensure well working installation upon receipt, with in-use performance corresponding to the planned one.
- ✓ Random control: The French association Qualit'EnR governs voluntary quality labels for companies installing solar thermal systems, PV systems, wood boiler installations and heat pumps. Qualit'EnR has developed check-up files helping the installer to control the quality of the own work. A hotline is available for technical advice. The quality of installations actually carried out is checked regularly (at least once in three years).

References

- ✓ The German contractor's declaration: supporting compliance with minimum energy performance requirements – Heike Erhorn-Kluttig, Hans Erhorn, Sarah Doster – QUALICHeCK Fact Sheet #02, March 2015
- ✓ Mikk Maivel, Kalle Kuusk, Raimo Simson, Jarek Kurnitski, Targo Kalamees (2015): Overview of existing surveys on energy performance related quality and compliance. QUALICHeCK Report

7.4. Effective penalties

Context and motivation

Not meeting the requirements for qualification of staff working on-site and quality of the works in general should be subject to penalties.

For implementation, clear definitions must be available regarding:

- ✓ the expected and accurately specified quality of the works and / or qualification;
- ✓ methods to determine the specified quality and / or qualification;
- ✓ on what parameters the penalty will be based;
- ✓ the conditions of execution.
- ✓ These aspects should be highlighted in the presentation of the respective quality framework to make affected parties aware of the conditions.
- ✓ Financial support is crucial for improving the energy efficiency of new buildings as well as of existing buildings. Therefore, withdrawal of financial support is a very effective penalty.
- ✓ Other effective penalties include:
- ✓ Obligation to improve the quality of the works according to the requirements
- ✓ Mandatory training.

Examples of problematic situations

- ➢ Only a few companies respond to a voluntary quality framework because requirements and penalties are considered too strict.
- ➢ Tenders are unreasonably expensive because companies calculate a risk premium to cover possible penalties in case of defective quality of the works identified by third-party checks.
- ➢ Lack of credibility due to non-execution of penalties:
  - ✓ Penalties are defined but there is no actual execution due to lack of procedures or excessive administrative effort.
  - ✓ Penalties are defined but there is no actual execution due to obviously problematic consequences for the relevant individuals or companies (e.g. attitude of professional associations: “we protect our weakest member”).

Procedural considerations

- ✓ The timing of introducing the appropriate penalties must be well chosen: qualification levels must be already high region-wide, if severe penalties such as fines and loss of licence are suggested, otherwise there will be a lack of societal support and penalties will not be effective. If qualification levels are still low, effective penalties will be warnings and mandatory trainings.
- ✓ The monetary amount must we well chosen: if too small, companies might take the risk of paying it without improving the quality of the works; if too high, this will act as a deterrent resulting in the attempt to bypass the penalty.
- ✓ Professional associations are important stakeholders and could be involved by working with them on the integration of aspects addressing quality of the works and related penalties in model contracts.

Approaches relevant to this topic

In **France**, several certifications of equipment installers/contractors have been implemented (QUALIBAT, Qualit’EnR, QUALIFELEC, ECO Artisan, Les Pros de la Performance Energétique) to secure the quality of the works. They generally cover quality requirements for the company and for the individual persons that operate the works. They may rely on dedicated training and requirements for the organization and the tools/equipment that have to be used by the company. These certifications are voluntary, but they are required in order for the building owner to benefit from public funding or subsidies.

References

No references available

7.5. Handling of market complaints

Context and motivation

Market complaints arise as a by-product of applying quality frameworks. Complaints may for example emerge from building owners doubting the result of the third-party control procedure, from installers detecting weaknesses in the control procedure, or from authorised experts excluded from the quality framework for specific reasons. While individual complaints have to be resolved, complaint resolution efforts should also be regarded as one element of the quality assurance process and as a chance to improve the effectiveness of third-party quality control frameworks. To make use of this potential at the level of organisations operating quality frameworks, market complaints have to be collected, processed, and evaluated.

Examples of problematic situations

A procedure for complaint management is published but not respected in practice, e.g. due to lack of resources

Procedural considerations

The following points have to be clarified at the level of organisations operating quality frameworks:

- ✓ Who is the contact point for market complaints;
- ✓ How to reach the contact point (e-mail, telephone, operating hours, etc.);
- ✓ How to differentiate between complaints (serious and unjustified, classification by type of complaint, etc.) and how to deal with the different types of complaints;
- ✓ How to organise the follow-up procedure to come up with specific solutions;
- ✓ How to organise the follow-up procedure to feed in relevant information into the feedback loop for constant improvement of the quality framework;
- ✓ What are the resources needed to operate the unit handling market complaints.

Complaint management procedures should be transparent and published.

Approaches relevant to this topic

No example available.

References

- ✓ EPBD Concerted Action www.epbd-ca.eu/

8. On innovation

Over the last decade, substantial progress has been achieved in terms of product and system performances regarding energy efficiency and renewable energies. The type of progress can take different forms, e.g.:

- ✓ Better energy efficiency of systems (e.g. heat recovery, efficiency of heat pumps, etc.)
- ✓ New technologies (e.g. vacuum insulation panels, LED lighting, deep geothermal energy, etc.)
- ✓ Cost reductions for various types of energy efficient technologies and renewable energies.

Energy performance regulations should correctly assess all kinds of technologies and, as a result also stimulate and/or allow the market uptake of innovative technologies.

Some thoughts about the current technology development in the building sector that affect energy use are:

- ✓ The role of electricity is changing, due to the German Energiewende. Looking at the national economy, it can be useful to consume electricity from renewables
- ✓ Building integrated renewable energy technologies for self-sufficiency
- ✓ Energy optimisation at the neighbourhood level, not at the building level
- ✓ Building as a whole is used to store energy
- ✓ Demand response and trading of electricity demand flexibilities

The following will not change, and therefore it should be the focus:

Transmission characteristics and thermal bridges are the most crucial parameters because good U-values and avoiding thermal bridges are preconditions for building energy efficiency in all European climates.

8.1. Simplified procedures are important but should not be a barrier to innovation

The availability of simplified procedures is often considered a major element for market acceptance. At the same time, it is important that innovation is not blocked due to oversimplification in the national assessment process.

In practice, there are various possibilities for correctly dealing with better performing products and it is crucial to provide for at least one of these possibilities.

Examples:

- ➢ Existing technology: condensing boiler
  - ✓ The use of a fixed value for the efficiency of condensing boilers does not stimulate the use of more energy efficient condensing boilers. A possibility to spur innovation is to allow the use of specific product data, whereby it still is possible to have a default value when using a condensing boiler.
- ➢ New technology not covered by the standard procedure: shower with heat recovery
  - ✓ In case such technology is not covered in a given country, and if considered a relevant technology, it is important that the legislation includes a procedure for handling such technologies.
- ➢ Very innovative building designs
  - ✓ In case specific and rather unique design concepts are implemented, it might be necessary to include the possibility of a project specific assessment method, if not innovation will be blocked.

For more information, see Chapter 5.4

8.2. Need for a robust framework for assessing technologies not covered by the classic procedures

8.2.1. Points of attention

In order to have legislation that allows compliance checks and effective enforcement, it is important that there are robust legal and technical procedures for assessing concepts and technologies not covered in the standard procedure.

There is a whole range of points of attention, i.e.:

- Technical assessment
  - ✓ It is important that there is a sufficient amount of transparency in the magnitude of the impact to be expected by an innovative technology in the EPC context.
  - ✓ This is in some cases far from evident (is the expected savings large or marginal?) and it might require a substantial effort and time to come to a robust procedure.
  - ✓ In case the procedure is not transparent, it is for industry not logical to develop and optimise innovative technologies
- Legal procedures
  - ✓ It is important that the legislation foresees a framework for assessing innovative products and concepts.
  - ✓ It is important that the legislation is in line with various EU legislation.
- Consistency between assessments of technologies
  - ✓ It is important that there is consistency between the assessments of different types of technologies. This seems evident, but in practice it is sometimes very difficult to find a straightforward method for comparing, in particular when the assumptions to be made for various systems are in different areas.
- Time for assessment
  - ✓ It is important that the time required to assess an innovative concept is still moderate, if not there is no market for an innovative approach. This aspect becomes more important in case there is a strict compliance and enforcement framework.
- Costs of assessment
  - ✓ It is important to pay attention to the costs for the industry of the assessment of the innovative approaches.

8.2.2 . Possible solutions

In general terms, the solution is to provide for in the legislation one or more alternative ways to deal with systems and projects that are not covered by the standard assessment procedure. In practice, one finds approaches allowing assessment of specific technologies independent of the building to which it is applied. Other approaches are focusing on the application of a specific technology (or combination of technologies). For more information, see Chapter 5.5.

9. Importance of societal support for compliance and enforcement

9.1. Effective enforcement is not possible without strong societal support

As already indicated above, it is unsuccessful in most countries for governments to have (strict) enforcement schemes regarding EPC and quality of the work compliance (including penalties) if such enforcement is criticised by a (substantial) part of the market. The political motivation for setting strict enforcement rules might be weak without societal support. In case there are enforcement rules, there is a very high risk that enforcement measures will be diminished or cease once there is strong market opposition against enforcement and penalties.

Therefore, it is very important to work on the required societal support, which involves various activities, including:

- ✓ Active involvement of stakeholders in the development phase of the procedures, whereby they have a good understanding of the pro and cons of various approaches and whereby they hopefully support the choices which are made
- ✓ Involvement and/or dialogue in the implementation and enforcement phase, whereby it is important that they understand the reasoning behind the enforcement measures and whereby they can provide inputs in case of criticism from the market.

9.2. Raising societal awareness regarding reliability of EPC and quality of the works

In general, and this is not surprising, there often are negative reactions in case someone or a part of the market is sanctioned in case of non-compliance. The reactions might be “this is not fair”, “The procedure is too burdensome and/or too costly”, “the procedures are not clear” etc..

Therefore, it is very important that all relevant stakeholders’ organisations have the opportunity to be involved in the preparation process of compliance and enforcement procedures.

The objectives for such stakeholders involvement can be:

- **Before implementation:**
  - ✓ To inform them about the motivations for an enforcement framework, e.g. by sharing experiences of problems with the EPC and quality of the works (EPC is not available, incorrect information in the EPC, etc.)
  - ✓ To discuss the procedures for determining the EPC and quality of the work(PART 1 – See Chapter 5), which will allow them to assess the complexity, the type of technologies covered/not covered, etc.
  - ✓ To discuss the principles of the legal framework for compliance and enforcement (PART 2 – See Chapter 6)
- To discuss the principles for practical implementation of enforcement (PART 3 – See Chapter 7)
- **During implementation:** regular evaluation if the procedure is well balanced and/or if improvements are needed, e.g.
  - ✓ Is there a need for modification of the procedures for determining the EPC and quality of the work (PART 1 – See Chapter 5);
  - ✓ Is there a need for modification of the principles of the legal framework for compliance and enforcement (PART 2 – See Chapter 6)
  - ✓ Is there a need for modification of the principles for practical implementation of the enforcement (PART 3 – See Chapter 7)

Experience shows that it requires substantial efforts for the stakeholders to obtain the overall picture and therefore it often is time consuming to achieve the required support. Moreover, it is important to acknowledge that many stakeholders’ organisations have a multi-layer approach,

whereby it is for issues as compliance and enforcement often important that there is a broad support at different levels, including:

- ✓ Individual members
- ✓ One or more committees dealing with issues related to quality of the works
- ✓ Some organisations have a permanent staff which is assumed to represent the views of the stakeholders

Productive interaction requires time but can have various substantial advantages:

- ✓ Identification of opportunities for improvement
- ✓ Increased credibility of the overall approach in case there is support from the stakeholders
- ✓ Better understanding by the stakeholders of the reasons for certain choices and therefore more support in case of negative reactions from market players

In the Flemish Region a comprehensive evaluation of the EPB regulation is provided for every two years. Stakeholders participate in this process, and quality issues are brought up. If necessary, legislation is adapted or actions such as communication or adaptation financial incentives are foreseen.

Real estate agents belong to a crucial stakeholder group because they are the ones presenting the energy performance of a building to customers interested in buying or renting a building or a building unit. It is paramount that they promote the quality of the work issues as a useful process and not as an additional burden

10. Economics of compliance

The cost issue is often a potentially critical issue in the context of second and in particular third party control and enforcement schemes. The cost debate has various dimensions and this is further discussed in this chapter.

10.1. An effective second or third party control and enforcement framework requires effort

Organising control and, in case of non-compliance, setting up enforcement actions requires various investment and staffing costs. These costs will depend on various elements, e.g.:

- ✓ The type of control: desktop, on site, etc.
- ✓ The frequency of control
- ✓ The intensity of control
- ✓ The frequency of non-compliance and the number of enforcement actions
- ✓ IT environment
- ✓ Consultation process, legal advices, etc.

10.2. Who pays the costs for control and enforcement schemes?

Overall scheme

In case of second party control and enforcement frameworks, the costs have to be covered by the parties involved and, at the end, by the client.

In case of third party control and enforcement schemes, this remains the same if the initiative is taken by the client. In case it is linked to a governmental initiative (EPC, incentives, etc.), it is a decision of the initiator (government, organization which is setting up incentive scheme; etc.) to decide who has to pay for the overall costs.

In case of governmental schemes, the cost of control and enforcement is covered by the budget for public administration. Specific taxes related to energy efficiency or fines due to violation of regulations can be used to sustain the budget. In the end, it is the public who pays and especially those not complying with the regulations.

Additional costs in case of non-compliance

In case of non-compliances and the need for additional controls, corrective measures, etc., these extra costs have to also be covered by one or more parties involved in the process.

10.3. Are there no costs in case of no second or third party control and compliance framework?

There is no doubt that the installation and operation of a second or third party control framework generates costs. Is the alternative, i.e. no control and enforcement framework, therefore cheaper?

The absence of a second or third party control and enforcement framework might result in a (much) higher degree of non-compliance. If this is the case, this can result in various types of direct or indirect costs, e.g.:

- ➢ **At the individual level:**
  - ✓ Overly positive EPC declarations caused by poor quality of the works will result in incorrect information about the building energy performance and typically higher costs for operation and improvement, thus misleading potential buyers and tenants during the decision making process, but also building owners if they plan to use the building themselves.

- ✓ A compliant EPC will act as a level playing field for investors, designers, contractors and the supply industry and will allow fair competition. In case it is easy to use incorrect data in the EPC, the risk of fraud will substantially increase.

➢ **At the member state level:**

- ✓ Not meeting the energy requirements as imposed by the Energy Efficiency Directive (EED) and the Renewable Energy Directive might cause infringement procedures due to violating the European legal framework, resulting in additional workload for civil servants and fines. It will probably have a negative impact on climate protection obligations, because usually energy efficiency in buildings is a condition for achieving CO2-reduction targets. Missing CO2-reduction targets causes penalties as well.
- ✓ No reporting will require additional efforts in substituting information otherwise provided by EPCs, e.g. for reporting according to Article 5 EED or to meet other reporting obligations. If EPCs are not available, data collection studies will have to be carried out to provide the necessary information. In the long run, expenses for these studies might be higher than the cost of implementing and running a successful compliance scheme.

➢ **At the global level**

- ✓ CO2 emissions from fossil fuels cause external costs related to climate change. These are costs paid by the society instead by the polluter. CO2 emissions contribute to climate change, and damages caused by climate change are enormous: floods and droughts, and as a consequence destruction of infrastructure and crop failures, fights for resources, migration, etc. These costs must be avoided. Therefore, when striving for cost transparency, it is necessary to declare correct CO2-emissions on the building level, to develop targeted policy instruments for a reduction of CO2-emissions.

10.4. Lower total cost?

Often, energy efficiency in buildings is motivated by lower Life Cycle Costs (LCC). However, in practice, this is often not true. The reason is that the Standard on LCC (ISO 15686-5:2008) allows a broad range of interpretations: Similar to Life Cycle Assessment (LCA, ISO 14044:2006), LCC also starts with the scoping and definition of objectives. Crucial parameters dominating the calculation result such as interest rate, intensity of maintenance and repair, and lifespan of products and systems can be defined by the person carrying out the analysis.

Apart from these crucial parameters, the following choices for calculation may lead to unrealistic results:

- ✓ Additional cost for energy efficiency is calculated instead of total renovation cost;
- ✓ Cleaning cost is neglected although it is important in energy efficient buildings due to extensive application of glass in order to making use of solar gains;
- ✓ Assumed energy consumption used for calculation is not realistic due to prebound and rebound effect or poor quality of the works;
- ✓ User needs and user behaviour might change over time and are not taken into account.

However, being aware of the possible traps, the Life Cycle Cost approach can facilitate new forms of cooperation (e.g. based on alliance contract models) and new business models (e.g. total cost of ownership), offering great potential for increasing energy efficiency in buildings.

In any case, it is crucial to start discussions at the same level of information, and thus to avoid troubles resulting from the utilisation of incorrect terms. In this regard it is useful to refer to ISO 15686-5:2008, defining the terms as follows:

- ✓ Life Cycle Cost (LCC) comprises of construction cost, maintenance cost, operation cost, occupancy cost, and end of life cost.
- ✓ Whole Life Cost (WLC) comprises of Life Cycle Cost, non-construction cost, income, and externalities.

10.5. Compliance checks and enforcement as means against unfair competition?

Compliance checks and effective enforcement create a level playing field for all actors involved in the project. This can substantially contribute to avoiding unfair competition.

10.6. Cheap financing of stimuli for innovation?

EPC and quality of the works legislation with possibilities for market uptake of innovative systems in combination with compliance checks and effective enforcement can be a major driver for product and system innovation. If industry achieves cost effective, energy efficient systems, there is in such context a very good chance for market uptake.

11. Conclusions

The energy performance of buildings has become a major boundary condition for new buildings but, increasingly for existing buildings as well. At the European level, the EPBD has been the major driver. Whereas the original EPBD was not imposing to the Member States a requirement level to be achieved, the EPBD recast imposes cost-optimal requirements and for new buildings from 2019/2021 onwards the level nearly-zero energy buildings (NZEB).

Of course, one should aim for not only a good energy performance but also good quality of the works, as good quality of the works is the precondition for high building energy performance. There can be many reasons for poor quality of the works. Within the context of the QUALICHeCK project, there was a strong focus on compliance frameworks and enforcement, but one has to evaluate for each context if there might be lighter and easier to implement approaches that might receive broader societal support.

In practice, various studies, including studies carried out in the framework of QUALICHeCK have highlighted that it is not possible to assume that the quality of the works is meeting the expectations. Often the declared EPC of a building is better than what is achieved in reality, due to poor execution or faults during the construction process. This results in not only a loss of investments but also a decline in energy performance caused by poor quality of the works. Surveys conducted in the German and French construction sectors identified additional costs of nearly 10% of the sector's turnover caused by poor execution. To enforce the quality of the work is one of the low hanging fruits on the way to cost efficient high performance buildings.

At the same time, there are various experiences that show that continuous high quality of the works is possible when certain conditions are met. The QUALICHeCK reports and factsheets describe such experiences. From the analysis of good and bad experiences in terms of quality of the works compliance, it has become clear that in many cases compliant quality of the works requires controls and the possibilities of sanctions.

In order to come to an effective compliance and enforcement framework, QUALICHeCK has identified three major steps. First of all, the technical procedures to obtain and prove quality of the works must meet a number of requirements. Secondly, there must be a robust legal framework for action in case of non-compliance and, finally, there is the application in practice, with an accompanying set of challenges.

Practice shows that it is possible to develop frameworks with adequate answers to these three parts of an effective compliance and enforcement framework. Depending on the context, there might be substantial differences in the details of implementation but this is not a problem. One has to take into account the starting point in a given country, the building tradition and culture, etc. A potentially country specific philosophy and approach, in addition to individual initiatives may be necessary for overall success at the level of the works.

A crucial element is achieving societal support for an effective compliance and enforcement framework. As a matter of fact, it is unsuccessful for a government to impose sanctions for poor quality if stakeholders strongly criticise such a sanction scheme. If developed in close consultation with stakeholders, an effective compliance and enforcement framework can be an opportunity instead of a threat for the various partners involved in the process (owners, architects, consultants, supply industry, contractors, etc.).

Finally, is a compliance and enforcement framework justified as it introduces extra costs? In case the compliance and enforcement framework is well developed, we believe that the benefits are in most cases much greater than the costs.

12. ANNEXES

12.1. The meaning of 'quality' in the technical literature

For industry, the notion of 'quality' has received increased significance. Quality management is a key issue for many sectors and companies and, therefore, there is a lot of literature focusing on quality related issues.

In the framework of this source book, the most important document is probably ISO 9000:2015 (See Figure 7 and Figure 8), whereby the following terms are of specific relevance for this source book:

- ✓ quality,
- ✓ entity,
- ✓ requirements for quality,
- ✓ requirements of society,
- ✓ customer, process,
- ✓ product,
- ✓ organisation,
- ✓ supplier,
- ✓ quality assurance.

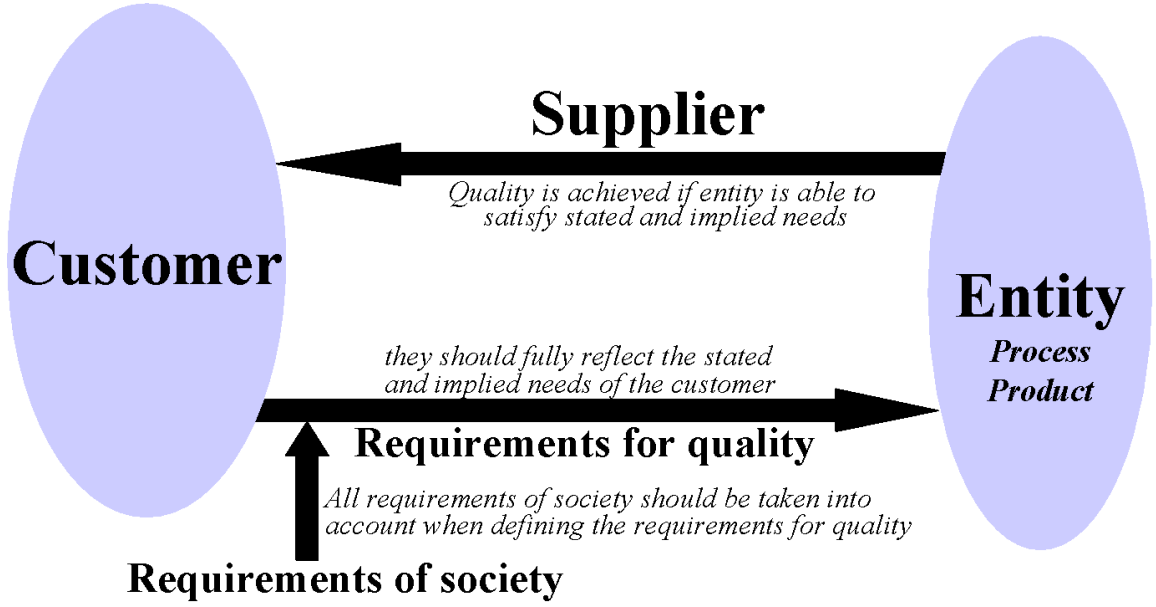

Figure 6: Quality related aspects (terms in bold are explained in text)

'Quality' *is defined as:*

'Totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs

Note :

1. In a contractual environment, or in a regulated environment, such as the nuclear safety field, needs are specified, whereas in other environments, implied needs should be identified and defined.
2. In many instances, needs can change with time; this implies a periodic review of requirements for quality.
3. Needs are usually translated into characteristics with specified criteria (see requirements for quality). Needs may include, for example, aspects of performance, usability, dependability, safety, environment (seee requirements of society), economics and aesthetics.
4. The term 'quality' should not be used as a single term to express a degree of excellence in a comparative sense, nor should it be used in a quantitative sense for technical evaluations.

To express these meanings, a quantifying adjective should be used. For example, use can be made of the following terms :

- ✓ 'relative quality' where entities are ranked on a relative basis in the degree of excellence or comparative sense;
- ✓ 'quality level' in a quantitative sense (as used in acceptance sampling) and 'quality measure' where precise technical evaluations are carried out;

5. The achievement of satisfactory quality involves all stages of a quality loop as a whole. The contributions to quality of these various stages are sometimes identified separately for emphasis; for example, quality due to definition of needs, quality due to product design, quality due to conformance, quality due to product support throughout its lifetime.
6. In some references, quality is referred to as 'fitness for use' or 'fitness for purpose' or 'customer satisfaction' or 'conformance to the requirements'. These represent only certain facets of quality, as defined above.'

'Entity' is defined as:

'That which can be individually described and considered.'

Note: An 'entity' may be for example:

- ✓ An activity or process,
- ✓ a product,
- ✓ an organisation, a system or a person,
- ✓ any combination thereof'

'Requirements for quality' is defined as:

'Expression of the needs or their translation into a set of quantitatively or qualitatively stated requirements for the characteristics of an entity to enable its realisation and examination.'

Notes :

- ✓ It is crucial that the requirements for quality fully reflect the stated and implied needs of the customer.
- ✓ The term 'requirements' covers market-based and contractual as well an organisation's internal requirements. They may be developed, detailed and updated at different planning stages.
- ✓ Quantitatively stated requirements for the characteristics include, for instance, nominal values, rated values, limiting deviations and tolerances.
- ✓ The requirements for quality should be expressed in functional terms and documented'.

'Requirements of society' are defined as:

'Obligations resulting from laws, regulations, rules, codes, statutes and other considerations.

Notes :

- ✓ 'Other considerations' include notably protection of the environment, health, safety, security, conservation of energy and natural resources.
- ✓ All requirements of society should be taken into account when defining the requirements for quality.
- ✓ Requirements of society include jurisdictional and regulatory requirements. These may vary from one jurisdiction to another'.

'Customer' is defined as:

'Recipient of a product provided by a supplier'.

'Process' is defined as:

'Set of inter-related resources and activities which transform inputs into outputs'.

Note : Resources may include personnel, finance, facilities, equipment, techniques and methods.

'Product' is defined as:

'Result of activities or processes

Notes :

- ✓ A product may include service, hardware, processed materials, software or a combination thereof.
- ✓ A product can be tangible (e.g. assemblies or processed materials) or intangible (e.g. knowledge or concepts), or a combination thereof.
- ✓ A product can be either intended (e.g. offering to customers) or unintended (e.g. pollution or unwanted effects).

'Organisation' is defined as:

'Company, corporation, firm, enterprise or institution, or part thereof, whether incorporated or not, public or private, that has its own functions and administration'.

'Supplier' is defined as:

'Organisation that provides a product to the customer'.

'Grade' is defined as:

'Category or rank given to entities having the same functional use but different requirements for quality'

Notes :

- ✓ Grade reflects a planned or recognised difference in requirements for quality. The emphasis is on the functional use and cost relationship.
- ✓ A high-grade entity (e.g. a luxurious hotel) can be of unsatisfactory quality and vice versa.
- ✓ Where grade is denoted numerically, the highest grade is usually designated as 1, with the lower grades extending to 2, 3, 4, etc.. Where grade is denoted by a point score, such as a number of stars, the lowest grade usually has the least points or stars'.

'Quality assurance' is defined as:

'All the planned and systematic activities implemented within the quality system and demonstrated as needed, to provide adequate confidence that an entity will fulfil requirements for quality.

Notes:

- ➢ There are both internal and external purposes for quality assurance :
  - ✓ Internal quality assurance : within an organisation, quality assurance provides confidence to the management;
  - ✓ External quality assurance : in contractual or other situations, quality assurance provides confidence to the customers or others
  - ✓ etc.
  - ✓ Unless requirements for quality fully reflect the needs of the user, quality assurance may not provide adequate confidence'.

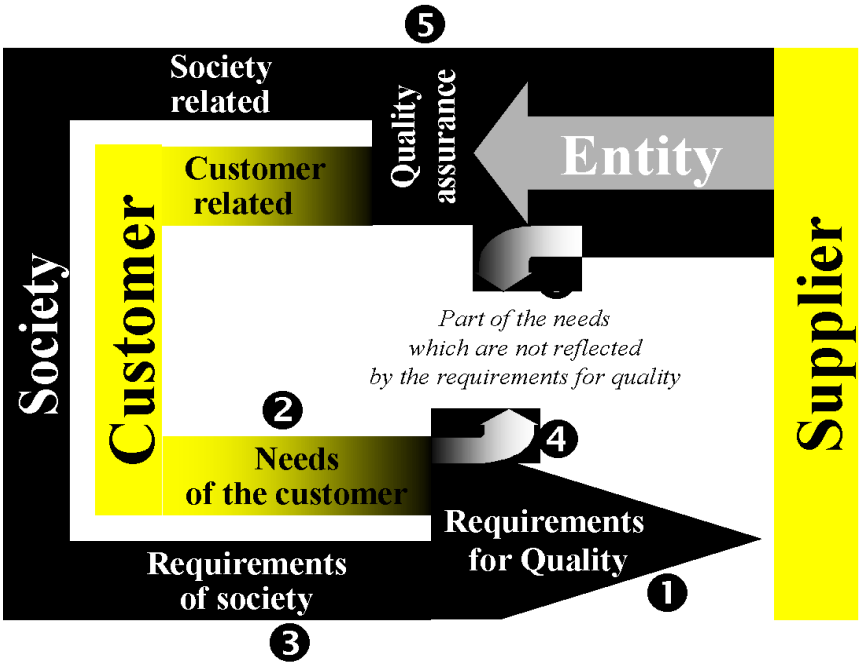

Figure 7: Relation between requirements for quality, requirements of society and customer needs

12.2. List of QUALICHeCK factsheets with relevance to quality of the works and compliance

- ✓ Building regulations can foster quality management – the French example on building airtightness – François Rémi Carrié - QUALICHeCK Fact Sheet #01, January 2015
- ✓ The German contractor's declaration: supporting compliance with minimum energy performance requirements – Heike Erhorn-Kluttig, Hans Erhorn, Sarah Doster – QUALICHeCK Fact Sheet #02, March 2015
- ✓ Regulatory compliance checks of residential ventilation systems in France – François Rémi Carrié, Sandrine Charrier, Adeline Bailly - QUALICHeCK Fact Sheet #06, November 2015
- ✓ Building airtightness in France – regulatory context, control procedures, results – Sandrine Charrier, Adeline Bailly, Carrié, François Rémi Carrié – QUALICHeCK Fact Sheet #07, December 2015
- ✓ Quality control of Stuttgart's retrofit standard realised by the city's energy consultancy office – Sarah Doster, Heike Erhorn-Kluttig, Hans Erhorn, Ulrich König - QUALICHeCK Fact Sheet #08, December 2015
- ✓ AMA – General material and workmanship specifications – Paula Wahlgren - QUALICHeCK Fact Sheet #09, February 2016
- ✓ The Swedish Sveby scheme - standardise and verify the energy performance of buildings - Pär Johansson - QUALICHeCK Fact Sheet #11, May 2016
- ✓ QUALICHeCK study Belgium – Assessment of the Belgian quality control framework for installation of thermal insulation in existing cavity walls – Arnold Janssens - QUALICHeCK Fact Sheet #13, June 2016.
- ✓ 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 – Theoni Karlessi – QUALICHeCK Fact Sheet #18, June 2016
- ✓ Quality framework for reliable fan pressurisation tests – Clarisse Mees, Xavier Loncour - QUALICHeCK Fact Sheet #21, June 2016
- ✓ Scheme of vocational qualifications in Cyprus „I have the qualifications. I certify!" - Marina Kyprianou Dracou – QUALICHeCK Fact Sheet #22, June 2016
- ✓ BuildE – A method for quality assurance of energy efficient buildings – Paula Wahlgren – QUALICHeCK Fact Sheet #26, September 2016
- ✓ The Austrian building certification system IBO OEKOPASS – Christina Florit, Susanne Geissler - QUALICHeCK Fact Sheet #27, October 2016
- ✓ Voluntary green building assessment paves the way for better as-built quality – Susanne Geissler, Peter Wallisch - QUALICHeCK Fact Sheet #28, November 2016
- ✓ WE-Qualify project: Improving the Cypriot work-force skills – Marina Kyprianou Dracou - QUALICHeCK Fact Sheet #29, December 2016
- ✓ Critical situations on the construction site and ideas for quality assurance procedures – The German perspective - Heike Erhorn-Kluttig, Hans Erhorn - QUALICHeCK Fact Sheet #30, December 2016
- ✓ Building air leakage rate in energy calculation and compliance procedures - Kalle Kuusk, K. et al. – QUALICHeCK Fact Sheet #33, December 2016
- ✓ Voluntary control scheme developed by the province of Salzburg: Building service systems declaration based on as-built characteristics – Susanne Geissler - QUALICHeCK Fact Sheet #34, December 2016
- ✓ Improving energy efficiency: Labelling schemes and their role in building related compliance frameworks – Susanne Geissler - QUALICHeCK Fact Sheet #37, December 2016
- ✓ Voluntary quality assurance systems for retrofitting multi-unit residential buildings based on self-commitment – Susanne Geissler - QUALICHeCK Fact Sheet #39, January 2017
- ✓ The quality assurance system of the German reconstruction loan corporation (Kreditanstalt für Wiederaufbar, KfW) in the field of energy-efficient construction and retrofitting (residential buildings) – Linda Lyslow, Heike Erhorn-Kluttig - QUALICHeCK Fact Sheet #44, January 2017

- ✓ Quality control frameworks for cavity wall insulation - Arnold Janssens – QUALICHeCK Fact Sheet #47, February 2017
- ✓ Belgium/Flemish Region control and penalty scheme of the energy performance legislation: Checking procedure and fines – Clarisse Mees - QUALICHeCK Fact Sheet #48, February 2017
- ✓ Increasing the expertise of building professionals for a better quality of construction: The French programme PACTE – Julien Thomas, Slyvain Mangili, François Durier - QUALICHeCK Fact Sheet #51, February 2017
- ✓ Romanian qualification schemes for installers of opaque building elements and/or window systems - Horia Petran – QUALICHeCK Fact Sheet #52, February 2017
- ✓ Ductwork airtightness in France: Regulatory context, control procedures, results – Sandrine Charrier, Adeline Bailly Mélois, François Rémi Carrié - QUALICHeCK Fact Sheet #54, February 2017
- ✓ Belgian/Flemish evaluation scheme for ventilation systems – Samuel Caillou, Paul Van den Bossche - QUALICHeCK Fact Sheet #55, February 2017
- ✓ The list of energy-efficiency experts for German federal funding programmes – Linda Lyslow, Heike Erhorn-Kluttig, Hans Erhorn - QUALICHeCK Fact Sheet #57, February 2017
- ✓ Quality of the works in a sample of buildings in Spain – José L. Molina. Servando Álvarez, José M. Salmerón – QUALICHeCK Fact Sheet #59, February 2017

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