QUALICHeCK
Towards better quality and compliance

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Technology	*Aspects*	*Country*
All technologies	Quality of the works	Spain

QUALITY OF THE WORKS IN A SAMPLE OF BUILDINGS IN SPAIN

In Spain there is a general regulation, which pays attention to the quality of the construction process, from the design to the end of the construction process when the building is handed over to the owner: it is the Law 38/1999 of Building Management (LOE). It determines the requirements that the buildings must meet from the moment of its first concept until the end of its life cycle, covering all phases of the building process: design, construction, commissioning and maintenance. The complex process makes the quality of the works a matter of concern. The status of 19 buildings has been reviewed and the results are summarised here.

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

Context

In developed societies, the parameters of functionality, safety and habitability are increasingly demanded in all types of human and social activities. In the case of buildings, where people spend most of their time, performing all kinds of activities, the above parameters are especially relevant.

The building process, because of its direct impact on the configuration of spaces, always implies a commitment to functionality, economy, harmony and environmental balance of general relevance. As provided for in Directive 85/384/EEC of the European Union, in which it is stated that architectural design, the quality of buildings, their harmonious integration into the environment, respect for natural and urban landscapes and collective heritage and private, are of public interest.

Applied to the field of construction and considering the building as the final product of a complex industrial process, we could define the quality of the building in a very generic way as: "the series of conditions that a building must meet to fulfil the basic conditions for which it has been built."

These basic conditions are defined for the first time in Spain in article 3 of Law 38/1999 of Building Management (LOE), which determines the requirements that buildings must meet from the moment of their first concept until the end of their life cycle, covering all phases of the building process: design, construction, commissioning, and maintenance.

The lack of quality in the building is therefore the lack of compliance with these basic conditions, with the final consequences of non-compliance, in turn, with the parameters of functionality, safety and habitability required by the society.

The building process acquires greater and greater complexity in its elaboration and its components, and so the quality management of the same becomes increasingly complex. To this must be added the intervention of multiple actors and processes with different provenances and interests, which makes the monitoring of quality management one of the most important tasks of the building process.

The law makes mandatory to have several insurance contracts that cover all possible deficiencies that the construction could contain.

Several companies are specialized in checking the quality of the works done in the buildings. In this fact sheet the review work done by the authors in connection with one of these companies for analysing the status of 19 buildings is summarised.

Main causes of constructive deficiencies

Reference [1] makes a review and a classification of the different type of deficiencies detected in the different phases of the constructive process. It is summarized in Table 1.

PHASE OF THE PROCESS OR GENERIC SOURCE	CAUSES OF DEFICIENCIES
Deficiencies contained in the design of the building	✓ Inadequate constructive solutions. ✓ Sizing errors due to deficiencies in hypotheses or calculation systems in structures or installations. ✓ Absence or defective design of constructive details.
Inappropriate design of building foundations	✓ Inadequate foundation for construction type. ✓ Inadequate foundation due to calculation errors. ✓ Appearance of waterways due to watering holes or presence of groundwater level that alter ground conditions. ✓ Absence or defects in the geotechnical study. ✓ Corrosion of reinforcement due to presence of sulphates.
Deficiencies during the construction process of the building	✓ Poor implementation of the design. ✓ Alterations introduced in the design are not resolved on site. ✓ Lack of accuracy? in the execution of fundamental elements by the use of poor materials or low-skilled labor.
Damage generated by external agents	✓ Attacks of xylophages (e.g. wood worms, etc.). ✓ Natural disasters. ✓ Degradation of concrete structures, by carbonation or corrosion of reinforcement
Natural degradation due to the aging of materials	✓ Weathering factories or stone elements on facades. ✓ Arrows and deformations in woody structures. ✓ Water leaks due to defects in the facilities or misuse of the facilities. ✓ Presence of water from the outside by leaks, capillarity, evaporation, etc. ✓ Defects generally generated by misuse or lack of maintenance.
Degradation due to misuse and lack of maintenance	✓ Lack of preventive reviews of the use and maintenance of facilities. ✓ Absence or poor follow-up of the maintenance program. ✓ No immediate repair of damages that ends up degenerating the affected element.

Table 1: Causes of deficiencies.

Statistical data on the sources or causes of building defects are not very abundant, but after analyzing information from different insurance companies of this type of risk the following conclusions could be drawn presented as a graph in Figure 1. Most of the deficiencies appears in the execution of the works (40%), and in the design of the building (35%). Then follows maintenance problems (only 13%) and material problems (12%).

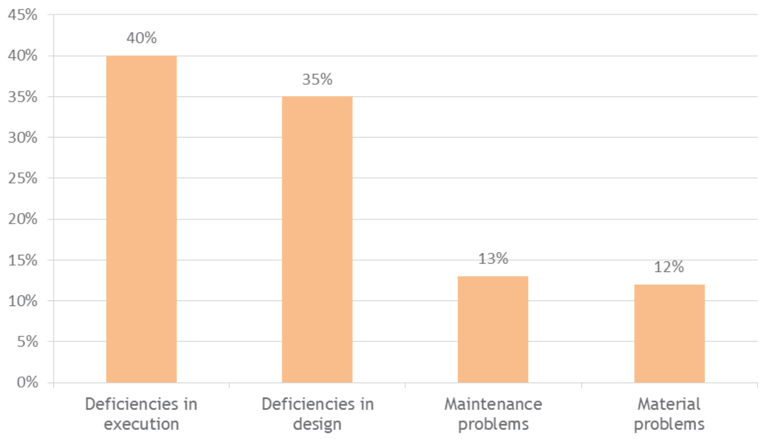

Figure 1: Distribution of deficiencies in building process. Source [1]

Objectives and problems addressed

The objective of this study is to reflect the most common deficiencies detected in the building process in Spain. For this, deficiency in the building is understood as any incidence in the building process that causes a difference between the designed and the actually executed building. Overall, deficiencies in buildings may be associated with three major periods of the life cycle of a building:

- ✓ Design.
- ✓ Construction and commissioning.
- ✓ Use of the building.

The study includes deficiencies detected in all three periods. Deficiencies contained in the design of the building and deficiencies during the construction and commissioning are usually detected by the installer or builder at the time of executing the project or by third parties contracted by the property for commissioning or quality control of the project works.

Deficiencies in the process once the building is finished are detected by the owners of the buildings when they start to use the building.

The deficiencies will be classified according to the system they affect:

- ✓ Envelope: deficiencies related to building materials, glasses, glazing gaps, etc.
- ✓ HVAC: deficiencies related to energy management systems, generators, distribution systems, emission systems, etc.
- ✓ DHW: deficiencies related to generators, distribution systems, etc.
- ✓ Lighting: deficiencies related to lamps, luminaires, auxiliary equipment, management and control systems, etc.
- ✓ RES: deficiencies relating to renewable energy systems: solar thermal installations, photovoltaic systems, biomass, geothermal energy, etc.

Approach to assess the quality of the works in the sample of buildings

Building sample

In order to achieve significant results, 19 buildings of different typologies have been analysed, located in different climatic zones, built in different construction periods and with different peculiarities in the installations.

The buildings are classified in:

	Type of building
Residential buildings	Single family house, Apartment, Residential block of apartments
Tertiary Buildings	Medium tertiary building, Large tertiary building

Table 2: Classification of buildings

Table 3 shows the generic data of the sample of buildings included in the study. The data used for conducting the study is strictly confidential, as it has been obtained under a commitment of non-disclosing the source of information. All the data related to the actual buildings has been deleted.

Id	Type of building	Atonomous Region	City	Climatic zone	Built área (m^2)	Year of construction
1	Single family house	Madrid	Madrid	D3	120	2015*
2	Residential block of apartments	Madrid	Madrid	D3	5.100	2007
3	Residential block of apartments	Madrid	Madrid	D3	23.611	2007
4	Residential block of apartments	Madrid	Madrid	D3	20.000	2015
5	Large tertiary building	Madrid	Madrid	D3	113.864	2009
6	Large tertiary building	Madrid	Madrid	D3	12.048	2017
7	Large tertiary building	País Vasco	Bilbao	C1	3.661	2012
8	Medium tertiary building	C. Valenciana	Valencia	B3	4.662	2015
9	Large tertiary building	Madrid	Madrid	D3	33.547	2003
10	Large tertiary buildings	Madrid	Madrid	D3	32.000	2003
11	Large tertiary buildings	Castilla La Mancha	Ciudad Real	D3	740	2016
12	Residential block of apartments	Castilla La Mancha	Toledo	C4	3.500	2011
13	Large tertiary buildings	Madrid	Madrid	D3	5.300	2013*
14	Large tertiary buildings	Castilla La Mancha	Ciudad Real	D3	9.100	2013
15	Residential block of apartments	Madrid	Madrid	D3	2.200	2016
16	Residential block of apartments	Madrid	Madrid	D3	1.600	2016
17	Residential block of apartments	Madrid	Madrid	D3	3.600	2016
18	Residential block of apartments	Madrid	Madrid	D3	10.300	2013
19	Medium tertiary building	Madrid	Madrid	D3	4.500	2011

(*) rehabilitation

Table 3: Analysed building sample

Results of the study

In this section we present and comment the results of the study carried out on buildings and their typology, as well as the classes of deficiencies detected.

Table 4 summarizes the identification data of the buildings and the incidents detected, the moment in which it was detected and its classification by type of system that is affected. There is an X mark for every problem detected. Buildings without any problem are not included in the table.

There is a complete report, prepared in the frame of QUALICHECK project, in which the reader can check the details of the problems of quality of the works observed in each of the buildings. You can access the report from the reference [2].

Id	Type of building	City	Climatic zone	Built area [m²]	Year of construction	Deficiencies detected in the design of the building	Deficiencies detected during the construction and commissioning process	Deficiencies detected in the use phase	Affected system					Result		
									Envelope	HVAC	DHW	RES	Lighting	Corrected design	Corrected building	Not corrected
2	Residential block of apartments	Madrid	D3	5.100	2007			X	X						X	
3	Residential block of apartments	Madrid	D3	23.611	2007			XX	XX			X			X	XX
4	Residential block of apartments	Madrid	D3	20.000	2015			XXXXX		XXXX	X				XX	XX
5	Large tertiary building	Madrid	D3	113.864	2009			X			X					X
6	Large tertiary building	Madrid	D3	12.048	2017		X						X			X
7	Large tertiary building	Bilbao	C1	3.661	2012		X						X	X		
9	Large tertiary building	Madrid	D3	33.547	2003			X				X				X
10	Large tertiary building	Madrid	D3	32.000	2003			X		X						X
11	Large tertiary building	Ciudad Real	D3	740	2016		X			X				X		
12	Residential block of apartments	Toledo	C4	3.500	2011			X				X				X
13	Large tertiary building	Madrid	D3	5.300	2013 (rehabilitation)		X			X				X		
14	Large tertiary building	Ciudad Real	D3	9.100	2013	X				X				X		
15	Residential block of apartments	Madrid	D3	2.200	2016		XXX			X	X	X		XXX		
16	Residential block of apartments	Madrid	D3	1.600	2016		XXX			X	X	X		XXX		
17	Residential block of apartments	Madrid	D3	3.600	2016		X					X		X		
18	Residential block of apartments	Madrid	D3	10.300	2013		XX			X	X			XX		

Table 4: Summary of detected deficiencies and their correction.

From the previous tables it can be observed that deficiencies were detected in 84% of the buildings. Only 11% of the residential buildings have no problems with the quality of the works, i.e. 89% of them have quality problems. For tertiary buildings the percentage of deficiencies is slightly lower.

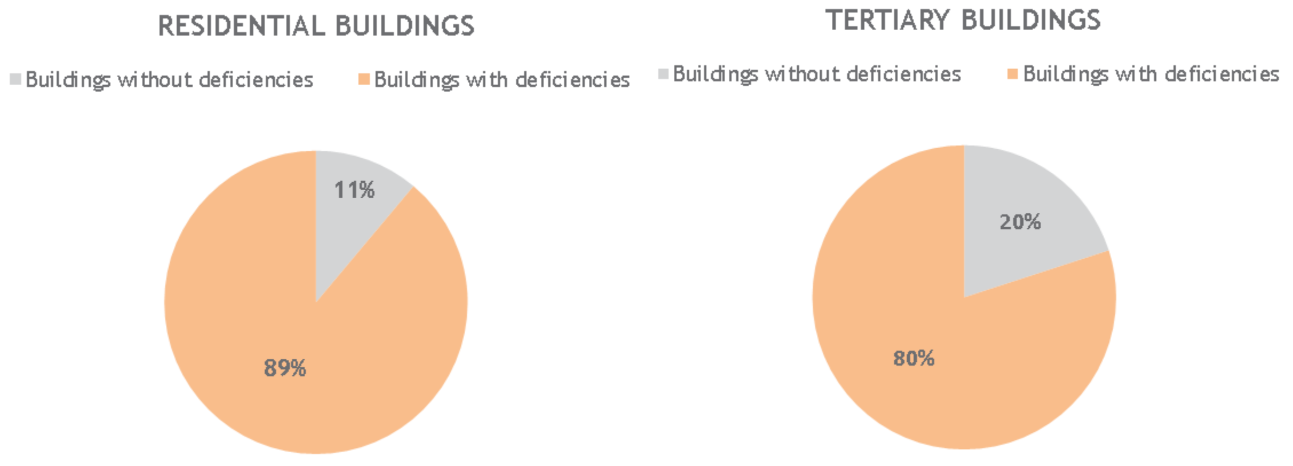

Figure 2: Percentage of residential and tertiary buildings with deficiencies

Analyzing the problems by the system affected, the distribution is different between residential and tertiary buildings. In the case of residential buildings, the number of deficiencies detected affects the HVAC, DHW and RES systems equally. In the case of tertiary buildings, half of the detected deficiencies occur in the HVAC system followed by the lighting system:

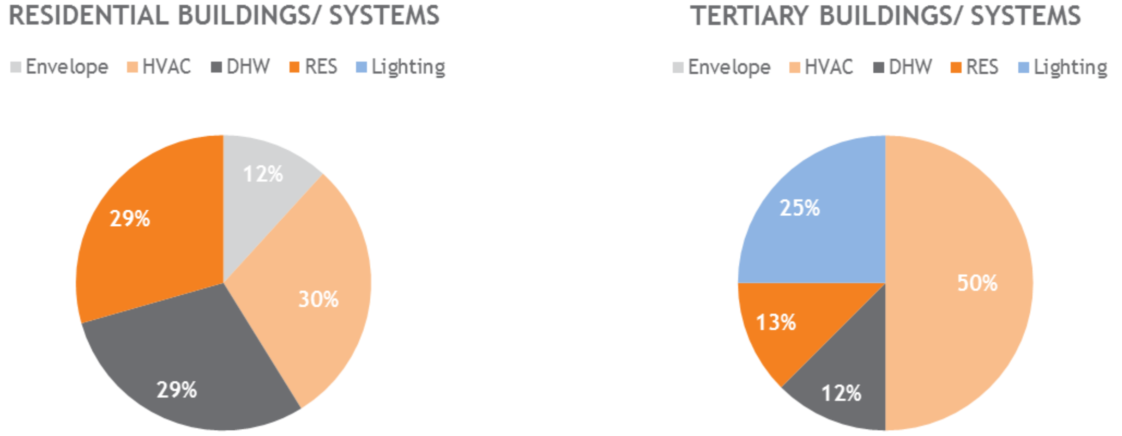

Figure 3: Deficiencies found in residential and tertiary buildings, per system

Correcting the deficiencies

An interesting fact observed is that most of the deficiencies are corrected. Two main actions are taken:

- ✓ The design of the building is corrected to match what is installed, for instance when the design had a mistake that was identified by the installer company.
- ✓ The problem detected is solved to match the design.

Most of the deficiencies were detected are in the HVAC system (41%), followed by DHW and RES facilities. All the deficiencies detected in HVAC, DHW, RES and Lighting, are solved either by modifying the design, or by correction of the works done in the building.

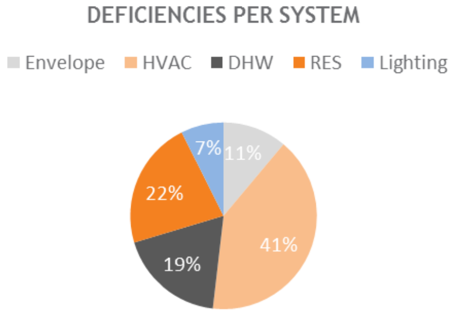

Figure 4: Deficiencies per system

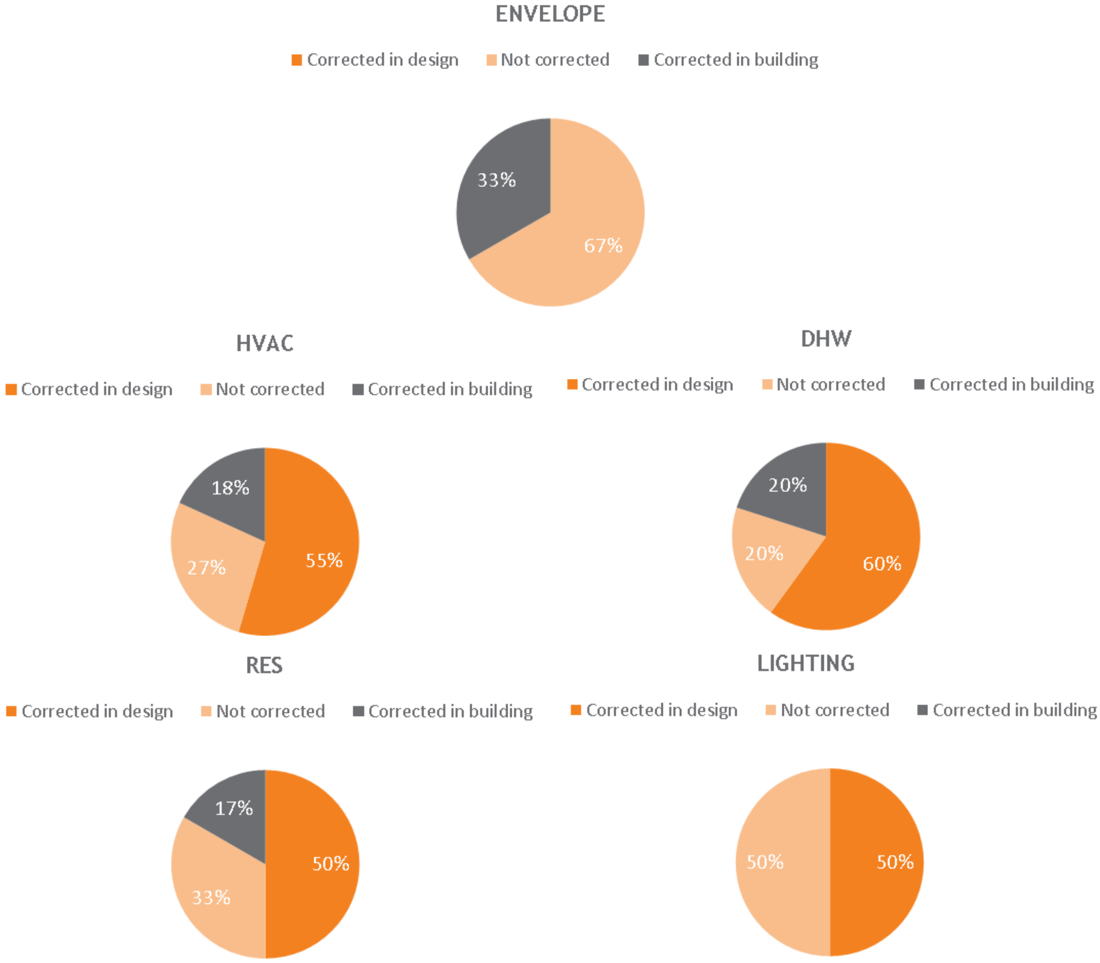

Figure 5: Details on when the deficiency was corrected per system

50% of the detected deficiencies are in the Construction/Commissioning phase, followed by 46% that were detected during the first days of use of the building.

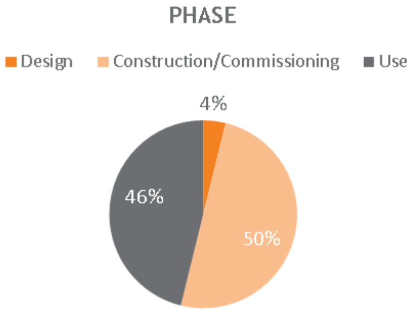

Figure 6: Details on when the incidence is discovered

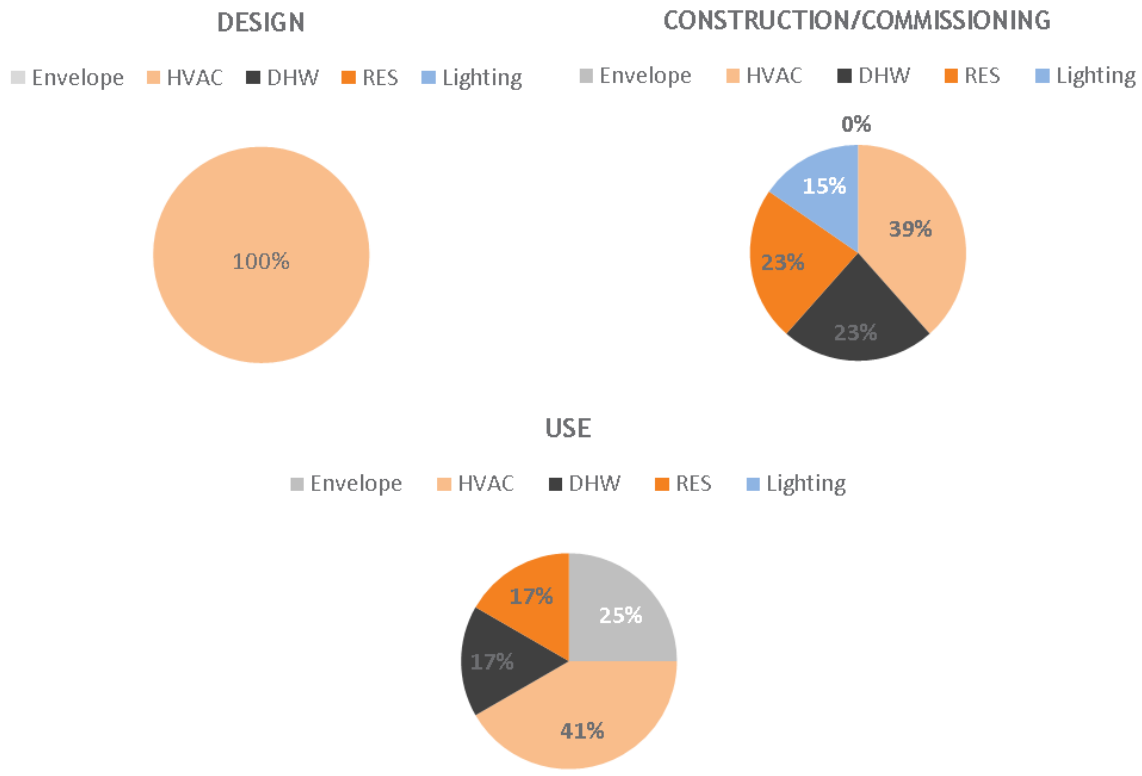

Figure 7: Details on when the incidence is discovered, and distribution per system

The percentage of deficiencies detected that are not finally resolved is 33%. The others are resolved by modifying the design (48%) or by making modifications in the building (19%).

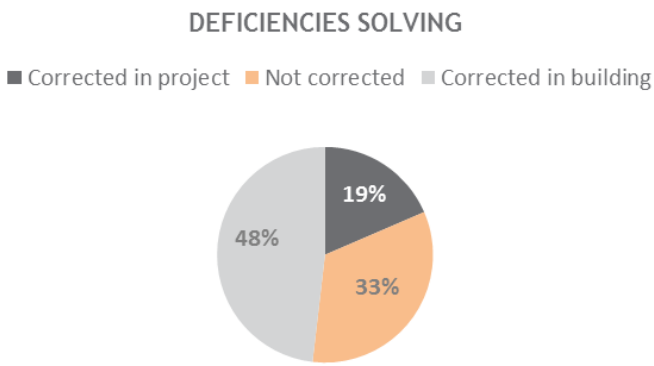

Figure 8: Resolution of deficiencies

Compliance concerns related to EP certificates

The analysis done on the sample of buildings, shows that following the prescriptions of the LOE law, the buildings being constructed or refurbished according a document of design, are very likely free of deficiencies.

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

Compliance concerns related to EP certificates (for more information about typical cases of non-compliance, see the QUALICHeCK "terms and definitions" document, available at www.qualicheck-platform.eu)

The mechanism of checking the quality during the execution of the building works allows the detection of problems in all phases of the construction of all buildings. As a result of this methodology, most of the final EPCs are showing the actual status of the building "as built".

Overall evaluation

We evaluate the quality control as most positive. Some *Pros* and *Cons* can be seen in table 5.

Pros	Cons
✓ Almost all of the buildings are finally lack of deficiencies	✓ The works of checking the quality of every stage must be done in a complex process
✓ In the buildings the "as built" EPC is always correct	✓ The quality control add costs to the process of building a building.

Table 5: Overall pros and cons of the approach

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

Prerequisites

There must exist a Law forcing to check the quality of the works during the construction of the building

There must exist companies specialized in doing that control of quality at the different stages of the process

Conclusions

From the analysis of the cases studied, in 84% of the cases, deficiencies in real estate were detected. The same number of buildings in the residential and tertiary sector are affected by the detection of deficiencies, and it is not possible to conclude whether the typology of buildings leads to a worse or better construction quality.

Most deficiencies are detected in the building construction process, followed by the use phase. In a few cases the deficiencies are detected in the design process. That most deficiencies are detected in the construction phase of the building may be due to the control processes established in the regulations or by additional services of this type contracted by the property.

Most deficiencies detected are found in HVAC installations, followed by RES and DHW. In 67% of the cases the deficiencies are solved either by modifying the design or by correction of the works done in the building. Thirtythree percent (33%) remain unsolved.

References

[1] Manual Patología de la edificación. Departamento de tecnología de la edificación (E.U.A.T.M). Universidad politécnica de Madrid.

[2] Qualicheck report: Quality of the works in a sample of buildings in Spain. University of Seville. JL. Molina, S. Álvarez, J.M. Salmerón.

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