(CT6)
Smart Buildings
Status in 2020

AUTHORS
Xavier Loncour, Peter D'Herdt, *Belgian Building Research Institute*

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1. Introduction

The concept of 'smart buildings' and the references to 'smart technologies' are new parts of Directive 2018/844/EU amending the EPBD, published in 2018. They support two complementary objectives, namely to accelerate the renovation of existing buildings by 2050 and to enhance the modernisation of all buildings with smart technologies and a clearer link to clean mobility[1].

In the context of a strong digitalisation trend and the rapid development of related markets, smart building technologies as well as information and communication technologies can drive energy efficiency in buildings and improve the living and working conditions of building users. This modernisation and digitalisation of buildings, including automation and smart appliances, could therefore place consumers at the centre of the energy market, and support the transition to smarter, renewable-energy-intensive grids.

Smart technologies in buildings can help to reap the benefits of the clean energy transition which comes with new opportunities such as smarter metering of energy, the use of on-site renewable energy and the self-consumption of energy. From this perspective, smart technologies and smart buildings can be seen as key contributors to the energy transition (see §3.1).

There is, however, no commonly accepted definition of 'smart buildings' or even 'smart technologies' in the regulatory context, though several initiatives are working on these definitions. Even if the concepts are not yet well defined and the reference to smart technologies is relatively recent in the regulatory context, some of the underlying principles, such as the use of Building Automation and Control Systems (BACS) and their interaction with Technical Building Systems (TBS), are well known and already largely integrated into energy performance regulations (see §3.2).

The amending EPBD foresees that an optional common EU scheme for rating the smart readiness of buildings, the Smart Readiness Indicator (SRI), will be established. The SRI scheme includes the calculation methodology and technical modalities for effective implementation, including possible links with Energy Performance Certificates (EPCs) (see §3.3).

The amending EPBD also introduces new requirements for the installation of self-regulating devices and BACS in buildings where specific conditions are met. These requirements will require specific implementation activities at the national level (see §3.4).

2. Objectives

The objectives of the Central Team 'Smart Buildings' are to follow the uptake of the concept of 'smart buildings', clarify the references to 'smart technologies' and identify the best ways to integrate them in the regulatory or broader voluntary context in order to support the energy transition.

The main topics addressed are the development and roll-out of the Smart Readiness Indicator (SRI) and the new requirements on Technical Building Systems (TBS) and Building Automation and Control Systems (BACS). The existing energy performance regulations and their evolutions are evaluated to identify the smart technologies already taken into account, and to explore the possibilities and opportunities to extend their uptake.

3. Analysis of Insight

3.1 Smart technologies and smart buildings as key contributors to the energy transition

Smart technologies are identified as a key contributor to achieve the ambitions of the European Green Deal for the European Union[2]. 'The clean energy transition should involve and benefit consumers. Renewable energy sources will have an essential role. The **smart integration** of renewables, energy efficiency and other sustainable solutions across sectors will help to achieve decarbonisation at the lowest possible cost.'

Smart buildings are increasingly becoming a reality. The digitalisation and connectivity of energy systems is rapidly changing the energy landscape, from the better integration of renewables to smart-ready buildings and smart grids. Energy generation from Renewable Energy Sources (RES) is becoming more and more decentralised, and in order to increase the balance between intermittent energy generation and demand, the use of overall smart energy systems to improve energy flexibility is necessary. Smart grids can provide new opportunities and tackle certain challenges in the current management of the grid and the energy market. In this context, smart buildings can be a key contributor to achieve decarbonisation and will play a central role in improving the efficiency of overall energy use.

3.1.1 The application of the 'smart' concept to buildings

One of the EPBD objectives is to support the modernisation of all buildings with smart technologies and provide a clearer link to clean mobility. Many current concepts are called 'smart': smart homes, smart technologies, smart ready systems or smart meters. In the current European legal framework, there is no real definition of what 'smart' exactly means, but proposals for such a definition are being developed outside the legal framework, e.g., in studies supporting the development of the Smart Readiness Indicator (SRI, see §3.3). The main and most important characteristic of smart technologies seems to be that they can communicate in a bi-directional way, exchange information and use that information to inform (e.g., fault detection) and/or undertake action (e.g., correct or improve functions or actions). In buildings, this supports the optimisation of building performance and overall energy use.

3.1.2 Smart technologies can enable synergies between energy-related policy areas

Smart technologies can help achieve the 2030 European targets. They can improve energy efficiency, optimise the integration of Renewable Energy Sources and enable synergies between the different policy areas that apply to them. Synergies among them have been addressed in January 2020 during a joint workshop of three Concerted Action initiatives from three different policy areas: the energy performance of buildings, renewable energy sources and energy efficiency. The workshop participants – 64% of them – largely recognised that smart technologies could be a key element for some aspects of the energy system of the future or could even form an essential interface to make the connection between all levels of this system. A further 14% thought that the role of smart technologies is not yet clear and should be further investigated. The primary barriers to the roll-out of smart technologies in the context of the transition to a smart energy system were identified to be related to user acceptance (22%), cyber-security and privacy issues (17%), and interoperability issues (15%).

Part of the discussion focused on the possibility of enlarging the scope of the regulation from building to district, or even to the city level, and how this could be done.

Highlights of 3.1	Many currently discussed concepts are called 'smart': smart homes, smart technologies, smart ready systems or smart meters. The definition of 'smart' is not yet clear, but the main and most important characteristic of smart technologies in the building context seems to be that they can communicate and exchange information in a digitalised way, and use that information to optimise the building performance and overall energy use.
	Smart technologies can help to achieve the 2030 European targets by enabling synergies between three different policy areas: energy performance of buildings, renewable energy sources and energy efficiency. Smart technologies are recognised as possibly being a key element for some aspects of the energy system of the future or having the potential to become an essential interface that makes the connection between all levels of this system.

Main Outcomes of 3.1
Even though it is not yet clearly stated what is considered 'smart', some essential characteristics are identified: the possibility to exchange information (two-way communication) and to act accordingly. Possible synergies with the uptake, the further introduction of renewables and the improvement of energy efficiency can be identified and should be further investigated.

3.2 Smart technologies and smart buildings – recent concepts relying on various well-known underlying technologies

Though the use of the term 'smart' in the context of building regulation is relatively recent, it relies on various, often already well-known technologies, implemented in various services with different levels of controlling possibilities (functionality levels) (see §3.3.2 for additional explanations). Certain Building Energy Management Systems (BEMS) already contain an important degree of 'smartness'. The amending EPBD (Directive EU 2018/844), for instance, promotes the use of Building Automation and Control Systems (BACS) and digital monitoring in Technical Building Systems (TBS) which are examples of implementing smart technologies.

3.2.1 Smart technologies are often already considered in energy performance regulations and standards

As they can have an impact on the energy performance of buildings, many control functions and aspects related to building automation are already considered to some extent in the existing national building energy performance calculation procedures and the European standards related to the energy performance of buildings.

Examples of services[3] in a specific technical domain like the heating of buildings are the control of heat emission, distribution pumps or heat generators. Many of these services are described in European standards, e.g. EN 15232-1[4], even if sometimes a slightly different terminology is used. The services in the standard served as a basis for many of the more than 110 smart-ready services that figured in the original catalogue of smart-ready services developed in the study for the SRI (see §3.3). The standard offers a long and comprehensive list of the most common BACS functions that can have an impact on the energy performance of buildings. For each function, different levels of complexity (functionality level) are mentioned, and a reference is made to other European standards. Reference is made to other European standards in which the possible impact of the systems can be quantified.

3.2.2 Smart receptiveness of the energy performance regulations

The European standard EN 15232-1 and more specifically the description of the services and the functionality levels offer a good starting point to assess to what extent BACS functions are or can be taken into account in existing building regulations and/or the energy performance calculation method of a Member State. In a way, the number of services that are covered in a national energy performance calculation method and the functionality level that can be valorised are a reflection of the extent to which 'smart technologies are already covered by the considered energy performance legislation' or 'how smart-compatible' the legislation actually is. The concept of 'smart receptiveness' was therefore introduced in the CA EPBD discussions. It was suggested that the minimum level of "smart receptiveness" should be that every type of service must be taken into account in the calculation method, although not necessarily always up to the most advanced functionality level. The functionality level which can be valorised in the legislation can be lower or higher than the most advanced level, as a function of the importance of the considered service or possible impact on the energy performance. Possibilities must be kept open for innovative systems, for instance, by adding services and/or functionality levels to take into account the potential of those systems. A survey in ten countries showed that, in general, the smart receptiveness of the national energy performance calculation methods is moderate to high and showed that it is often underestimated by the administrations responsible for the development of these regulations. Their regulations are actually covering more control possibilities than they would estimate before performing a deeper analysis of their calculation method. However, the degree of implementation varies from service to service and from country to country, and the most advanced functionality levels are not always considered.

A challenge concerning the potential of smart systems is that the exact impact of a control system at the time of the commissioning of the building as well as later in the lifetime of this building can be very difficult to quantify. Because it is too difficult to accurately predict the actual use or performance (impact of user behaviour, maintenance, etc.), some Member States therefore choose not to implement very advanced control systems in their calculation methods. A check that systems are working properly could potentially be integrated into the building energy audit/inspection.

The possibilities to follow up, control and regulate the functioning of these (smart-ready) services (see §3.3) are key to their optimal functioning and the performance of the building.

Highlights of 3.2	Quite often, certain control functions are already taken into account in energy performance calculations. Dealing with (the impact of) control is, however, one of the most difficult elements in a calculation procedure. Some Member States choose not to implement very advanced control systems in their calculation methods because it is too difficult to assess their impact in an accurate way. A check that systems are working properly could potentially be integrated into the building energy audit/inspection.

Main Outcomes of 3.2
In the building context, many functions and aspects related to building automation are already considered to some extent in the existing national energy performance calculation procedures, as they can have an important impact on the energy performance of buildings. A survey in ten countries showed that, in general, the smart receptiveness of the national calculation methods is moderate to high and often underestimated by the administrations responsible for the development of these regulations. Their regulations are actually covering more control possibilities than they would estimate before performing a deeper analysis of their calculation method. However, the degree of implementation varies from service to service and from country to country, and the most advanced functionality levels are not always considered.

3.3 Development of the Smart Readiness Indicator (SRI)

The amending EPBD (Directive EU 2018/844) introduces the concept of a 'Smart Readiness Indicator' (SRI). The legal acts describing the SRI have been officially adopted at the end of 2020. The first act[5] establishes an optional common European Union scheme for rating the smart readiness of buildings, while the second[6] details technical modalities for the effective implementation of the scheme.

The SRI will allow for the rating of the smart readiness of buildings, i.e.: the capability of buildings (or building units) to adapt their operation to the needs of the occupant; the optimisation of energy efficiency and overall performance; and the adaptation of their operation in reaction to signals from the grid (energy flexibility).

The SRI should raise awareness amongst building owners and occupants about the added value offered by building automation and electronic monitoring of Technical Building Systems (TBS).

3.3.1 Studies related to the SRI

Two technical studies, started in February 2017 and finalised in June 2020, commissioned by the European Commission services, provided technical support to feed the discussions on the SRI. The studies focused on the calculation methodology, investigated possible implementation arrangements and performed a quantitative evaluation of possible impacts of the SRI. The results are available online at https://smartreadinessindicator.eu/.

Extensive stakeholder concertation was organised during these two studies, including several interactions with the CA EPBD.

3.3.2 Smart-ready services, functionality levels, domains and impact criteria

The first technical support study proposed an SRI methodology based on the inspection of the '**smart ready services**' available in a building. Such services are enabled by (a combination of) smart-ready technologies, but defined in a technologically neutral way, e.g., the ability to 'control the distribution pumps in heating networks'. The SRI assessment procedure is based on the establishment of an inventory of the smart-ready services which could be available in a building, and an evaluation of the possibilities they can offer. Each of the services can be implemented with various degrees of smartness, referred to as '**functionality levels**'. In the example of distribution pumps, this can range from 'no control' to the simple implementation of 'on/off control' or to more elaborate control methods such as 'variable speed pump control based on internal estimation' or even 'based on external demand signal'.

The services within a building operate in multiple domains (e.g., heating, lighting, electric vehicle charging, etc.), inducing various kinds of impacts (e.g., energy savings, comfort improvement, increased flexibility towards the energy grid, etc.). The consolidated methodology considers nine (9) technical domains and seven (7) impact criteria. In order to cope with this multitude of domains and impact categories, a multi-criteria assessment method was proposed and developed as the underlying methodology for calculating the SRI.

3.3.3 Developing a demand-driven market for the SRI

It is essential to consider the voluntary nature of the SRI to create a demand-driven market for this new evaluation tool and to take this specificity into account during the development of the calculation procedure. For instance, the level of complexity according to the building type (residential vs. non-residential) and aspects such as the average time and costs necessary to deliver the SRI were identified as important elements and were taken into account when evaluating the method for implementing the SRI. The countries indicated that the SRI needs to be adapted according to the function of the different segments of the market (e.g., simple vs. complex buildings, professional building manager vs. private building owner, etc.) in order to be successful. As different buildings and people will have different needs or expectations from the SRI, there should be different methods with varying levels of complexity in order the fulfil those needs. This element was taken into account by proposing two levels of evaluation: a simplified online self-evaluation and a third-party evaluation by an expert.

3.3.4 Implementation pathways

The new SRI scheme is voluntary for Member States. Member States that decide to implement the SRI scheme may choose from a variety of modalities. For example, Member States may couple the SRI scheme with their energy performance certification scheme and/or with their scheme for the inspection of heating, air-conditioning and combined heating/air-conditioning and ventilation systems. If such a coupling is realised, the EPBD obligations regarding the Energy Performance Certificates and the inspection remain applicable. The introduction of the scheme can be organised via a test phase.

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Highlights of 3.3	A new optional Smart Readiness Indicator (SRI) is developed. This SRI for buildings provides information on the technological readiness of buildings to interact with their occupants and the energy grids, and on their capabilities for more efficient operation and improved performance through the use of ICT technologies.
	The SRI assessment procedure is based on the establishment of an inventory of the smart-ready services which could be available in a building and an evaluation of the possibilities they can offer. Each of the services can be implemented with various levels of functionality.

Main Outcomes of 3.3
The development of the new optional Smart Readiness Indicator (SRI) for buildings was organised via the development of two legal acts. Two technical studies provided technical support to feed the discussions on the SRI. Extensive stakeholder concertation including several interactions with the CA EPBD was organised. The necessity to develop a demand-driven scheme which offers the possibility to apply a different approach in function of the type of building or other aspects was taken into account by developing a simplified (self-assessment) and a more complete SRI evaluation (SRI certification). These alternatives should guarantee that the various user's needs are always met.

3.4 New requirements on self-regulating devices and on Building Automation and Control Systems (BACS) for buildings

Building Automation and Control Systems (BACS) and their use in Technical Building Systems (TBS) can integrate many smart technologies and services (§3.2).

The amending EPBD (Directive EU 2018/844) introduces new requirements on the installation of self-regulating devices and BACS in buildings when specific conditions are met. The aim is to improve the management of energy consumption while limiting costs and guaranteeing a good indoor environmental comfort and quality.

Requirements on TBS are not new and were already imposed earlier through Article 8 of the EPBD recast (Directive 2010/31/EU). Member States will have to extend their national regulations with the new provisions of the amending EPBD.

3.4.1 New requirements for countries

In practice, Member States must require the installation of self-regulating devices for the regulation of the temperature where technically and economically feasible as well in new buildings as in existing buildings when heat generators are replaced (Article 8(1)). They must also require, by 2025, the installation of BACS in all (existing and new) non-residential buildings with an effective rated output for heating, air-conditioning, ventilation or combined systems of more than 290 kW (Articles 14(4) and 15(4)) where technically and economically feasible. This is because BACS lead to significant energy savings as well as improved management of the indoor environment and, as such, are beneficial to both building owners and users of large non-residential buildings in particular.

The European Commission published a recommendation document[7] to support Member States in applying the provisions of these articles.

3.4.2 The challenge of the enforcement

Member States were asked to assess the success of their existing regulations for TBS in general, and specifically regarding aspects of TBS mentioned in the EPBD: overall energy performance, proper installation, appropriate dimensioning and the possibility of adjustment and control. For all these aspects, most of the Member States evaluate the success of their regulation as being rather average. The scores for dimensioning, adjustment and control are somewhat lower than for the other aspects concerning TBS. Regarding compliance and control, most of the Member States evaluate the efficiency of their approach as more or less average and none of the Member States judge their compliance and control systems as being excellent.

The challenge to enforce the requirements for TBS is to develop effective supervision and control of compliance. In 2015, the conclusions of this topic[8] mentioned that 'even if TBS are clearly defined by the EPBD, for a long period, MSs have given little attention to this part of the EPBD'. An open-ended question on best practices regarding the successful implementation of TBS requirements or on the way to guarantee compliance was asked in 2019, but very few Member States found they had best practices to share.

Highlights of 3.4	The amending EPBD (Directive EU 2018/844) introduces new requirements on the installation of self-regulating devices and Building Automation and Control Systems (BACS) in buildings when specific conditions are met. The European Commission published a recommendation document to support Member States in applying the provisions of these articles. Requirements for Technical Building Systems (TBS) are not new and were already imposed earlier; the new provisions could trigger extensions to the existing regulations.

Main Outcomes of 3.4
The main challenge to enforce the requirements for Technical Building Systems (TBS) is to develop effective supervision and control of compliance. Regarding this aspect, most Member States also evaluate the efficiency of their legislation as more or less average and very few found they had best practices to share at that moment.

4. Main Outcomes

Topic	Main discussions and outcomes	Conclusion of topic	Future directions
3.1	The definition of 'smart' is not yet clear, but the main and most important characteristic of smart technologies in the building context seems to be that they can communicate and exchange information in a digitalised way, and use that information to optimise	Smart technologies are recognised as possibly being a key element for some aspects of the energy system of the future or having the potential to become an essential interface that makes the connection	The role of smart technologies in the energy-related policy areas should be further investigated.

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Topic	Main discussions and outcomes	Conclusion of topic	Future directions
	the building performance and overall energy use.	between all levels of this system.	
3.2	In the building context, many functions and aspects related to building automation are already considered to some extent in the existing national energy performance calculation procedures, as they can have an important impact on the energy performance of buildings.	Dealing with (the impact of) control is, however, one of the most difficult elements in a calculation procedure. Some Member States choose not to implement very advanced control systems in their calculation methods because it is too difficult to assess their impact in an accurate way.	The proper working of these systems is crucial to obtain the expected performance and maintain it. A check that systems are working properly could potentially be integrated into the building energy audit/inspection.
3.3	A new optional Smart Readiness Indicator (SRI) is developed. The SRI assessment procedure is based on the establishment of an inventory of the smart-ready services which could be available in a building and an evaluation of the possibilities they can offer. Each of the services can be implemented with various levels of functionality.	The necessity to develop a demand-driven scheme which offers the possibility to apply a different approach in function of the goals or needs of the owner of a specific building was taken into account by developing a simplified (self-assessment) and a more complete SRI evaluation (SRI certification). These alternatives should guarantee that the various user's needs are always met.	The Member States each have to decide on the concrete implementation and roll-out of the tool. Most MS still have to formally decide if they will implement this new scheme. A test phase will be organised in some countries. A follow-up of these test phases and the rest of the decision process and exchange of ideas on the different approaches will support the uptake of the SRI throughout Europe.
3.4	The amending EPBD introduces new requirements on the installation of self-regulating devices and Building Automation and Control Systems in buildings when specific conditions are met. Requirements for Technical Building Systems are not new and were already imposed earlier; the new provisions could trigger extensions to the existing regulations in the MS.	The main challenge to enforce the requirements for Technical Building Systems is to develop effective supervision and control of compliance. Regarding this aspect, most Member States evaluate the efficiency of their legislation as average and very few found they had best practices to share.	Several new requirements like the ones on BACS still have to be implemented in practice. The control and compliance aspects could still be improved. The practical implications of these requirements and their consequences for the systems and the technologies in buildings still have to be tested.

5. Lessons Learned and Recommendations

The use of the term 'smart' in the context of building regulation is relatively recent. Even though it is not yet clearly defined, two essential characteristics of what can be considered as smart are the ability to exchange information (two-ways communication) and the ability to act on any issues which arise from this exchange.

It is expected that smart technologies will help to achieve the 2030 European targets by enabling synergies between three different policy areas: energy performance of buildings, renewable energy sources and energy efficiency.

In the building context, the concept of 'smart' relies on various technologies, often already well known, like the Building Automation and Control Systems (BACS), implemented in various services with different levels of control possibilities.

A survey undertaken among ten (10) Member States showed that their existing energy performance regulations are already taking into account many control possibilities, even though the most advanced levels of control are not always considered, sometimes on purpose. Most of the existing national regulations can be considered as 'smart receptive'.

From a policy point of view, several developments are ongoing:

- The implementation of the voluntary Smart Readiness Indicator (SRI) scheme. This new indicator provides information on the technological readiness of buildings to interact with their occupants as well as the energy grids, and on their capabilities for more efficient operation and improved performance through the use of ICT technologies.
- A significant development of the integration of BACS is also expected in the coming years with the implementation of the requirements in the amending EPBD in this field.

Future work will cover the futher implementation of the SRI, the opportunities and challenges that come with extending the scope from smart buildings to smart districts and beyond, and the extent to which existing systems can respond to the aims of the EPBD.

6. Endnotes

1. The aspects related to electromobility and charging infrastructure are handled by a different Central Team.
2. The European Green Deal, COM(2019) 640 final
3. The terminology used in this report makes the distinction between 1. 'Technical domains', e.g. heating, cooling, domestic hot water, etc.; 2. 'Services' in a 'technical domain', e.g. for heating systems the control of heat emission; and 3. 'Functionality levels', describing for every 'service' the level of control complexity from the simplest to the most advanced ones – extract from Commission Delegated Regulation (EU) 2020/2155
4. EN 15232-1 – Energy Performance of Buildings – Part 1; Impact of Building Automation, Controls and Building Management
5. Commission Delegated Regulation of 14.10.2020 supplementing Directive (EU) 2010/31/EU of the European Parliament and of the Council by establishing an optional common European Union scheme for rating the smart readiness of buildings
6. Commission Implementing Regulation of 14.10.2020 detailing the technical modalities for the effective implementation of an optional common Union scheme for rating the smart readiness of buildings
7. Commission Recommendation (EU) 2019/1019 of 7 June 2019 on building modernisation
8. Implementing the Energy Performance of Building Directive - Inspections - OVERVIEW AND OUTCOMES - AUGUST 2015 - cited on page 32 – ISBN 978-972-8646-32-5

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