# An Evaluation of the Smart Readiness Indicator proposed for Buildings

Vasiliki Varsami[1], Esfand Burman[1]
[1]Institute for Environmental Design and Engineering, The Bartlett School of Environment, Energy and Resources, University College London, London, UK

## Abstract

The European Commission (EC) recently introduced the smart readiness indicator (SRI) scheme. This framework evaluates the capacity of a building to use information and communication technologies (ICTs) to adapt to the needs of the occupants and the grid. Researchers and industry practitioners have carried out preliminary studies to examine its methodology and scope. This study aimed to complement previous work and analyse the new framework to identify its strengths, as an indicator that will enhance the performance of the building stock, and its improvement opportunities.

For this purpose, an evaluation was conducted, following a review of the current literature and the implementation of the proposed methods in two non-domestic buildings. The evaluation indicated that the SRI has the potential to offer multiple benefits, from improving occupants' health and wellbeing to increasing the energy efficiency of the European building stock and supporting the development of smart energy grids.

However, SRI is an indicator that in its current format, cannot address actual performance, and its assessment may not provide equal incentive for all the European Union's (EU) goals for 2050. Moreover, its simplified methodology was found to offer more favourable results when compared against the detailed methodology. Its checklist approach and lack of clear guidelines may also lead to subjective decisions during the assessment, resulting in inconsistent certifications.

By addressing these inconsistencies and by supporting the scheme with additional policy measures, the EU will benefit from a credible and fairer rating scheme.

**Keywords:**

Smart readiness indicator, SRI, framework evaluation, smart buildings, European policy.

## Key Innovations

- Critical review of the current litterature related to the new SRI scheme
- Detailed comparison between simplified and detailed SRI methodology

## Practical Implications

It is important to consider the appropriate methodology at the beginning of the assessment along with their implications (simplified vs. detailed). The accuracy of data collection will also affect the end result, thus conducting a thorough assessment during a site visit is advisable. Finally, the energy adjusted weighting method can offer more representative results for non-residential buildings, as it could be used for a more building-specific optimisation strategy.

## Introduction

Following the EU goals for climate neutrality, the Energy Performance of Buildings Directive (EPBD), was officially amended in May 2018 (Directive 2018/844/EU) and the concept of the "Smart Readiness Indicator" was first introduced. By introducing a framework to support the transition of the current building stock into a smart one, the EU is hoping to have more decentralised, user-adaptive, highly energy efficient buildings and utilize more renewables as the primary energy source (BPIE, 2017).

Two technical studies have been conducted by a consortium of experts, commissioned by the EC to support the development of SRI and its methodology. At the time of writing this paper, the EC is anticipated to release a finalised implementation act on the SRI, following the delegated regulation in October 2020.

Several researchers and industry practitioners have already attempted to contribute to the field and raised questions about the methodology and fair application of the SRI across all European members (Janhunen et al., 2019; Kurnitski and Hogeling, 2018). As an answer to the plethora of views on the SRI and the lack of a collective analysis, the paper attempts to analyse the framework and provide a detailed study on its methodology to identify the strengths and potential weaknesses of the framework. By doing so, the paper intends to potentially inform the process of continuous improvement of the scheme and recommend measures to maximise its impact.

## Background

### The Definition of SRI

The smart readiness scheme is a European policy initiative that aims to deliver a voluntary framework to measure how "smart-ready" the current building stock is (Wouters and Laustsen, 2017). The EPBD defines the term "smart readiness" as "the capacity of a building to use ICTs in order to adapt to the needs of the occupants and the grid", with an ultimate objective to improve their energy efficiency and overall performance (EC, 2020a). Therefore, the three key functionalities that SRI aims to assess are summarised below (Ibid.).

- Readiness to maintain energy performance and operation of the building through the adaptation of energy consumption, for example through use of energy from renewable sources
- Readiness to adapt its operation mode in response to the needs of the occupant while paying due attention to the availability of user-friendliness, maintaining healthy indoor climate conditions and the ability to report on energy use
- Readiness to adapt a building's overall electricity demand, including its ability to enable participation in active and passive as well as implicit and explicit demand response, in relation to the grid, for example through flexibility and load shifting capacities

### SRI Assessments

The Directive's objective was to establish a methodology that would be cost-effective, feasible in a short timeframe and without requiring in-depth expertise (Verbeke et al., 2020). The procedure should also be consistent, while allowing adequate flexibility across Member States (Ibid.).

As a result, the proposed methodology by the EPBD will follow a checklist, qualitative approach (Kurnitski and Hogeling, 2018). The assessment could be completed in a site visit where a series of smart ready services are to be inspected by a certified expert. Alternatively, an online self-assessment is proposed, though it will not be accompanied by an official certificate (EC, 2020a). The possibility of using building information models (BIM) instead of a site visit was also considered (Ibid.).

Currently, there is a simplified version of the assessment with 32 examined services and a detailed version with 54 services. These services can either be digital ICT (e.g. optimisation algorithms), physical equipment such as artificial lighting with daylight sensors or a combination of both (e.g. smart thermostats) (Verbeke et al., 2020). The two methodologies differ in complexity, with the detailed being mostly addressed towards non-residential buildings. The simplified method is recommended for residential or small non-residential buildings.

A performance-based, quantitative method of assessment has also been envisaged that would use measured data in order to quantify the smartness level of buildings in-use (EC, 2020a). However, this method is presented as a future development of the scheme.

### Current Views on the SRI

As the scheme is recently introduced, a significant amount of research on the field is still under development. Nevertheless, the existing papers reflect on SRI's scope, methodology and future development.

The literature suggests that SRI**,** being the first scheme to holistically address smart technologies, can create a form of benchmarking for smart buildings and technologies, and even promote investment in ICTs by making their added benefits more tangible to end users, thus supporting the modernisation and digitisation of the building stock (Verbeke et al., 2020). Moreover, SRI's methodology can be easily updated to account for innovations in a field of constant changes (Wouters and Laustsen, 2017).

Additionally, smart buildings can operate as highly efficient micro energy hubs that consume, produce, store and supply energy (BPIE, 2019). Therefore, the SRI can potentially lead to a more efficient building stock and support the decarbonisation of future energy systems. Furthermore, it can complement renovation initiatives by helping future-proof existing buildings (Ibid.). What is more, increasing energy savings is linked with lower fuel bills (BPIE, 2017). Additional benefits from an uptake of ICTs in the building sector, include improving user satisfaction and indoor environmental quality (IEQ) thus increasing occupant's health, well-being, productivity and quality of life (BPIE, 2019).

Many studies stress the lack of quantification in the existing methodology (Dakheel et al., 2020), especially for grid flexibility, which is one of the key functionalities of SRI (Vigna et al., 2020) and papers have already proposed technical methods for quantifying it (Märzinger and Österreicher, 2019). Furthermore, the scheme doesn't assess if services are functional and effective in-use; only their presence is examined. Thus, SRI can provide misleading results if a high smart-readiness score doesn't correspond to an efficient performance (Janhunen et al., 2019), or if the same services lead to different performances (Kurnitski and Hogeling, 2018). This lack of a quantified assessment can also minimise the incentive to invest in smart technologies during the design stage or during retrofitting projects and major renovations (Dakheel et al., 2020; Vigna et al., 2020). A performance-based approach could also be used during the monitoring stage of a building to help minimise the performance gap between design and actual operation (Vigna et al., 2020). Markoska et al. (2019) even propose an expansion of the SRI methodology in order to incorporate performance testing and minimise discrepancies between the design and operation of buildings.

The literature also identified that the current assessment leaves room for subjective decisions, which can minimise the credibility of the scheme (Märzinger and Österreicher, 2019, Janhunen et al., 2019). These discrepancies were highlighted by the work of Vigna et al. (2020), where the same building was assessed by two separate teams of experts, leading to different results in certain domains of up to 35% and a 13% difference in the final SRI scores.

Horák and Kabele (2019) suggested that some of the impact scores are insufficiently represented in the service catalogue. On the other hand, Kurnitski and Hogeling (2018) assert that the methodology discourages the use of passive systems, as they can potentially result in lower SRI scores, even though they can also adapt to user needs. Fokaides et al. (2020) also observed that buildings with building management systems (BMS) may receive more favourable results than smaller buildings that don't have a BMS. Another study by Janhunen et al. (2019) questioned the inclusivity of the scheme and if it addresses the needs of different climates, by focusing primarily on cold climate countries. Alternatively, Wouters and Laustsen (2017) propose that it would be beneficial to provide information on which updates would be more preferable and why, for each case building at the end of the assessment, by taking into account its use, climate and the availability of a smart grid.

Concerning the possibility of integrating SRI with the energy performance certificates (EPCs), Fokaides et al. (2020) support that further steps are needed in order to align the two certificates. It should, however, be noted that SRI is currently developed as a voluntary certification scheme, whereas EPCs are mandatory across the EU member states. EPCs were first introduced in 2002 by the EPBD and their intent is to provide information on a building's energy performance, in the form of rating and benchmarking, to prospective renters or buyers and include recommendations about cost-effective improvements (Directive 2002/91/EC).

## Methodology

The paper aims to evaluate the proposed framework by identifying its strengths and improvement opportunities.

Firstly, a literature review was conducted as part of a research study to gain an insight into the framework and gather valuable feedback on SRI. Consequently, the paper continued with an implementation study, by calculating the SRI of two selected case studies. The implementation study was conducted to provide an understanding of SRI's methodology and its benefits or barriers for the scheme.

As a final step, the paper provides the detailed evaluation of the SRI framework. The results of the evaluation were separated into Strengths and Improvement Opportunities. The scheme's strengths consist of factors of the SRI framework, including its definition, scope and methodology that enhance its ability to positively influence buildings' performance. These strengths can offer political, economic, social and technological benefits for the European built environment. On the contrary, improvement opportunities are factors of the SRI that may currently restrict the scheme's ability to enhance the built environment performance.

### SRI Methodology

The smart readiness score of the two case studies was calculated using both the simplified and detailed versions of the methodology. The calculation process followed the steps described in the final report of the technical study on SRI (Verbeke et al., 2020, pp. 129-132). Specifically, the assessment examines a list of smart services separated into nine domains as shown in figure 1. However, not all services are assessed. Following a triage process, any technical systems that are not present or are considered irrelevant for the specific case building by the assessor, can be omitted in order to not affect negatively the score of a building (Ibid.).

Subsequently, the level of smartness/ functionality level of each service was determined. Their functionality level can range from 0 to 4, with 4 being the highest level of smartness. Each functionality level corresponds to relevant impact scores over a series of seven criteria, shown in figure 2. Each impact score can range from -3 to 3, depending on how much the service contributes to each specific impact criterion. These seven impact criteria are derived from the three key functionalities of the SRI and contribute equally to the key functionality that they correspond (figure 2). Each key functionality represents one third of the final score.

After calculating the aggregated score of each domain over an impact criterion, weighting factors were applied. These domain weighting factors depend on the climatic zone (e.g. southern Europe) and the use of the building, which can either be residential or non-residential (EC, 2020a). Differentiation between the weighting factors to account for different types of non-residential buildings currently do not exist due to a lack of data, but it is a desirable future step (Ibid.). Lastly, the assessment leads to a single SRI score expressed as a percentage or as a smart-readiness class from A to G, describing the relative smartness of the examined case compared to a fully smart-ready building (Verbeke et al., 2020).

The smart readiness score was also calculated using the energy balance method. This method was developed by the technical studies on SRI to compensate for the fact that there are no weighting differentiations according to building type. Therefore, the technical study allows the assessor to adjust the weights of the domains heating, cooling, domestic hot water (DHW), controlled ventilation (CV), lighting and renewable electricity (for the impact criteria related to energy consumption (energy savings on site, maintenance and fault prediction, energy flexibility and storage). The weightings should be adjusted according to the energy balance derived from EPCs or any other available energy balance (Ibid.).

The weightings of the energy depended impact criteria were adjusted in the implementation study using the results of the EPCs' of the buildings and calculated with

*Figure 1. The nine domains of the SRI service catalogue (Adapted from Verbeke et al.,2020)*

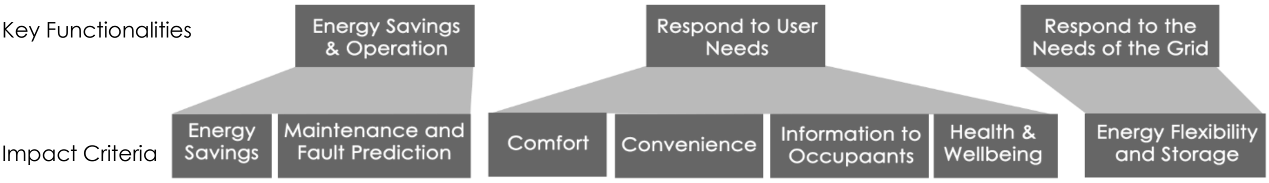

*Figure 2. The impact criteria of SRI and the key functionalities that they correspond (Adapted from Verbeke et al.,2020)*

the equation below, provided by the technical studies (Ibid, pg. 121):

$$\alpha_{\text{domain}} = \frac{Q_{domain}}{Q_{Total}} \quad (1)$$

*Where* $\alpha_{\text{domain}}$ *is the weighting of the adjusted domain,* $Q_{domain}$ *is the primary energy use of the specific building for a certain domain and*

$$Q_{Total} = Q_{HEAT} + Q_{DHW} + Q_{COOL} + Q_{VENT} + Q_{LIGHT} + Q_{RENEW}$$

*Where* $Q_{HEAT}$ *is the primary energy use for space heating,* $Q_{DHW}$ *for domestic hot water,* $Q_{COOL}$ *for space cooling,* $Q_{VENT}$ *for ventilation,* $Q_{LIGHT}$ *for lighting and* $Q_{RENEW}$ *is the renewable energy produced on site, expressed as primary energy.*

Lastly, an optimisation study of the two cases was also conducted, supported by a sensitivity analysis in order to introduce the most favourable services for each case. As proposed by Markoska et al., (2019), the optimisation process focused mostly on software updates of the smart measures, as they are easier to implement on existing buildings, less disruptive for the occupants, easier to improve in the future and usually more cost-effective.

### Case Studies

The two case studies examined, are non-residential buildings in the UK that were completed in 2015. Although they are not representative of the European building stock as a whole, being two common typologies in a temperate climate, they offer a variety of technical systems that were considered applicable in the majority of EU countries. Moreover, both buildings were awarded for their environmental performance and their innovative technical systems, therefore offering more opportunities to test the assessment. What is more, the first case study follows an active environmental approach while the second one mostly incorporates passive measures, thus further testing the inclusiveness of the SRI methodology.

Case study A is a 1950s secondary school in London, redeveloped in 2015. The campus can accommodate 2,000 students and 200 members of staff. Regarding its technical systems, the school has a biomass boiler supported by gas fired boilers that distribute the heat using a low temperature hot water (LTHW) system. The LTHW circuit is also feeding the DHW system, which is supported by solar panels. Cooling is available only in IT enhanced classrooms, while the whole building is mechanically ventilated (demand-controlled) with small operable windows. A central BMS is used to control and monitor the systems' operation.

Although the school complex was designed with contemporary, energy efficient systems, its operational performance failed to achieve its ambitious design. The inefficient centralised control of the buildings resulted in the operation of systems in unoccupied areas, while the low carbon biomass boiler wasn't utilised in practise. Additional construction and operational issues led to the very low operational ratings of F, as reported on the display energy certificate (DEC) of the school. It should be noted that DECs differ from EPCs, as they are required for public buildings or buildings frequently visited by the public (Great Britain. Department for Communities and Local Government, 2018). Additionally, DECs represent the actual annual energy consumption of a building over a period of 12 months (Ibid.).

Case study B is an office building, situated in Keynsham (Bristol) that can host 688 people. The building's design follows a "fabric first" approach, by utilising measures such as thermal mass, natural ventilation with centrally controlled openings and internal atria and PV panels, which provide around 200MWh of electricity each year. The building's form and orientation also complement its passive strategy. Additionally, the water to water heat pumps that are used for cooling the IT servers, provide any waste heat to the heating system, which is supplemented by gas fired boilers. Cooling is only available in meeting rooms by manually controlled, radiant cooling panels. All the systems are centrally monitored and controlled via the BMS.

The project aimed to achieve a DEC rating A, by following a two-year aftercare period (performance contract). The design had already attained an EPC rating of A but failed to reach its original target. The project's operational score was still high and acquired a DEC rating of B due to some technical and construction defects.

## Results

### Application of Detailed and Simplified Methods

According to the classification of the SRI, the case studies received an average SRI score (table 1), even though both buildings were constructed in the past six years and received awards of excellence for their design and environmental strategy. Case study A received a total SRI of 50.8% with the detailed methodology and 41 applicable services, while the score was 10% higher with the simplified method with only half (21) the services.

As with the educational building, in case study B, there was a nearly 10% improvement in the final score with the simplified method. The office building had an SRI of 47.6% using the detailed method with 39 applicable services, whereas 21 services were examined with the simplified method. However, case study B received a rating of D with both methods, providing a result that wasn't in line with its high EPC and DEC ratings.

The services related to electric vehicle charging (EV) weren't applicable in both case studies. Moreover, the office building was naturally ventilated in all spaces. Therefore, the domain CV was omitted as a whole, and the domain weighting factors were adjusted to account for its absence, by equally distributing the CV's weightings.

In all cases, energy savings and response to user needs had relatively high results ranging approximately between 60% and 70% with both methodologies. As the buildings were constructed recently, with state-of-the-art technical systems, it was expected that they would score highly in these two key functionalities. However, the buildings received a very low score in grid flexibility (17.7% and 18.7% respectively) with the detailed method. Grid flexibility accounts for one third of the total SRI score and it is the only functionality that the two methodologies had a large discrepancy. Specifically, the simplified method allowed for a 20 to 30% higher score.

The impact criteria scores followed the same pattern for both cases. Apart from grid flexibility, the rest of the six criteria had mostly insignificant differences between the two methods. Finally, the average domain scores were calculated, but no clear patterns could be found between the two methodologies were compared (figure 3). Overall, the simplified methodology allowed for a higher score in the heating domain but the average score in lighting and monitoring and control (MC) were much lower than with the detailed version.

### Energy adjusted weighting factors method

When the weighting factors were adjusted according to the results derived from the EPCs of the buildings, the difference between the simplified and detailed method followed the same pattern. In case study B, the difference between the two methodologies' ratings was slightly less, although its total SRI rating was still significantly lower compared to its EPC rating (table 1).

### Sensitivity Analysis

To ease the optimisation process and to introduce the most favourable services for each case's final score, a sensitivity analysis was carried out. The sensitivity and optimisation study were conducted using the detailed methodology, as it has a larger set of services for improvement (50% more) and it was the methodology that provided the lowest scores.

It should be noted that the contribution of each key functionality and impact criterion to the final score is independent of the weighting system. In contrast, the contribution of the domains heating, cooling, DHW, CV, lighting, and renewable electricity and storage to the energy related impact criteria, is affected by the weighting system of each climatic zone. The sensitivity analysis was conducted using the western Europe, non-residential weighting factors of the case studies. However, the final results are also affected, apart from the weighting factors, from the number of services and their impact scores attributed to each impact criterion, which are constant in all weighting systems.

Of the three key functionalities, energy demand flexibility had the lowest score in all cases, having more than 40% difference compared to the other functionalities. Thus, improving grid flexibility, which is the only criterion affecting this key functionality (figure 2), can significantly increase the cases' rating. Conversely, the four user responsive criteria are the least influencing, each representing 8.3% of the final score.

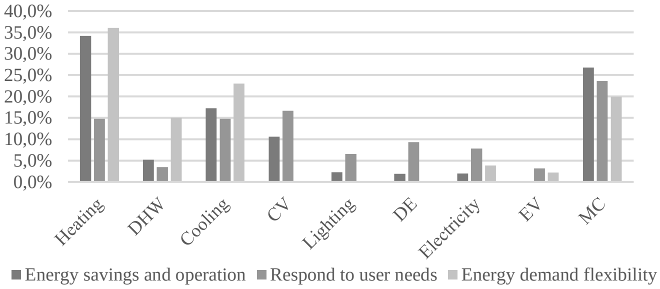

*Figure 4. The contribution of each domain to the score of each key functionality expressed as a percentage*

However, not all domains contribute to grid flexibility. From figure 4, it is obvious that heating offers the largest opportunity for improvement, followed by cooling, MC and DHW. In contrast, CV, lighting and dynamic building envelope (DE) don't affect demand flexibility.

Regarding the service domains, heating contributes the most to the final score, having the potential to increase SRI by 28% (figure 5). MC and cooling also represent a

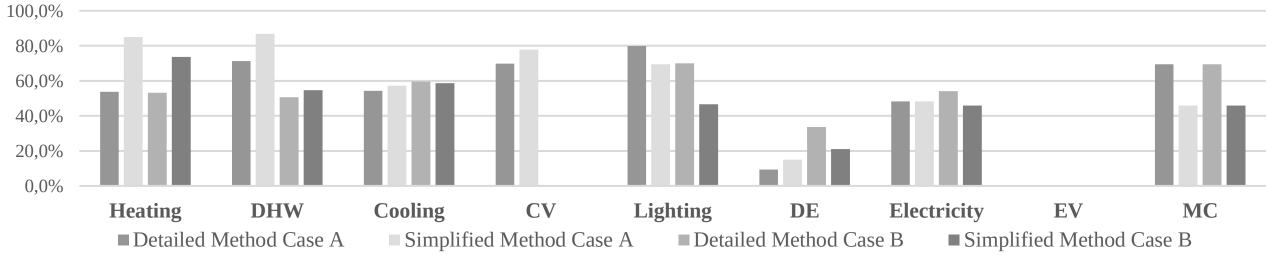

*Figure 3. The smart readiness score of each domain using the detailed and simplified methodology*

*Table 1. Summary of findings from the calculation of the smart readiness of the case*

| Case | Weighting System | Method | Functionality SRI Score | | | Total SRI Score | SRI Class | EPC Rating | DEC Rating |
|---|---|---|---|---|---|---|---|---|---|
| | | | Energy savings and operations | Respond to user needs | Energy Demand Flexibility | | | | |
| Case A | Non-adjusted | Detailed | 68.6% | 66.1% | 17.7% | 50.8% | D | B | F |
| | | Simplified | 69.1% | 69.1% | 49.0% | 62.4% | C | | |
| | | Optimised | 94.1% | 83.2% | 46.3% | 74.5% | B | | |
| | Adjusted | Detailed | 68.6% | 66.1% | 12.6% | 49.1% | D | | |
| | | Simplified | 66.4% | 69.8% | 46.4% | 60.9% | C | | |
| Case B | Non-adjusted | Detailed | 63.4% | 60.6% | 18.7% | 47.6% | D | A | B |
| | | Simplified | 71.1% | 62.1% | 38.0% | 57.1% | D | | |
| | | Optimised | 90.8% | 77.1% | 44.0% | 70.7% | C | | |
| | Adjusted | Detailed | 62.0% | 60.6% | 22.7% | 48.4% | D | | |
| | | Simplified | 70.5% | 62.1% | 35.7% | 56.1% | D | | |

large portion of the final score (23.4% and 18.3% respectively). These three domains are also the only ones that affect all seven impact criteria. Conversely, EV has the lowest contribution to the final score, even though clean mobility and buildings' interaction with electric vehicles are at the forefront of the EU's goals for 2050. The domain comprises 1.8% of the total SRI when all services are implemented at their highest functionality.

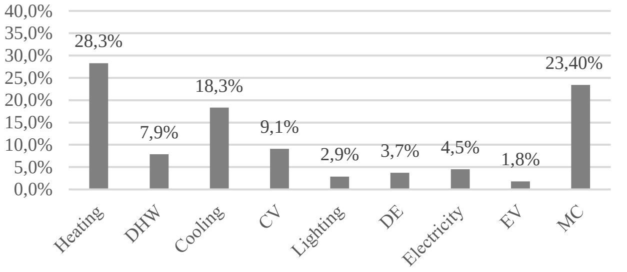

*Figure 5. The contribution in percentage of each domain on the total SRI score*

### Optimisation Study

The process started from the heating domain, which had the largest effect on the final score (figure 5) and followed the same logic for the rest of the applicable domains. Any services regarding grid flexibility were not applied. Despite being an option that could be implemented in the existing buildings and would offer significant benefits, it depends mostly on the condition of the local electricity market (e.g. dynamic tariffs and price signals) and less on the buildings' technical systems.

With the optimisation study, the case study A attained a B classification which differs from its DEC rating of F. In contrast, the office building utilises mostly passive measures and has a significantly higher operational performance rating of B. However, its SRI score was lower in all scenarios.

The services that were updated during the optimisation process included room temperature control linked to occupancy detection, fault detection, load predictive operation of the BMS and predictive control of systems such as HVAC, together with total interlock between heating and cooling. Motorised windows were avoided in the mechanically ventilated building as they offered only a 0.6% increase in the final score that wouldn't justify the installation of actuators. As a last step, EV charging stations where included, since they are expected to become a necessity in the near future, despite offering only a 0.7% rise in the score.

An important conclusion from the optimisation process is that an existing building can attain a higher SRI rating, up to 20%, by implementing mostly software upgrades and non-invasive measures. Additionally, a high SRI score can be achieved even in cases where grid flexibility options are not yet widely available in the electricity market, by implementing energy storage measures.

## Discussion

The evaluation results are presented in table 2. Regarding the strengths of the SRI, it is the first European scheme to address the subject of smart buildings. It is therefore expected to provide a credible pan-European framework that evaluates smart readiness using a common set of standards, thus having the potential to provide a basis for benchmarking of smart buildings (S1).

Concerning its three key functionalities, they are complementary to the amended EPBD and the EU goals for 2050. Specifically, user responsiveness can increase IEQ and user satisfaction (BPIE, 2017). Thus, SRI can potentially support the health and wellbeing of occupants (Verbeke et al, 2020) (S4), which is essential given that Europeans spend almost 90% of their time indoors.

Secondly, SRI evaluates energy efficiency. Smartly controlled and interconnected technical systems can sufficiently decrease energy consumption and operational costs of buildings (BPIE, 2017) (S5). These energy and monetary saving could potentially assist the reduction of fuel poverty, of which according to the EC (2020b), 50 million households in the EU suffer from. However, policy support and funding would be needed, as the cost of smart ready services may be prohibiting.

Lastly, SRI promotes grid responsiveness and the use of renewables and energy storage in the built environment (S3). The implementation study showed that both buildings received a relatively low SRI score with both methods, mainly due to the lack of grid responsive services. By emphasising on grid flexibility, the SRI's assessment could incentivise the wider adoption of grid responsive controls in buildings and become a driver for the provision of more dynamic tariffs in the electricity markets, which in both case studies were not available. Therefore, SRI assessment supports the EU goals for more modernised and decarbonised energy markets.

By advocating these benefits of smart ready technologies (SRTs), the scheme can potentially leverage investment in the field (S2). Additionally, SRI can provide a classification system for smart service providers as they could position each service in terms of SRI score benefits (Verbeke et al., 2020). This common evaluation method will provide extra transparency in the field of SRT and can increase the interoperability of smart systems (Markoska et al., 2019).

Regarding its methodology, its checklist approach provides a quick and easy assessment. Furthermore, it is modular and flexible (S6), thus the service catalogue can be easily updated in order to respond to any technological advances (Wouters and Laustsen, 2017). Furthermore, it allows for differentiations between EU countries by adjusting the weighting system in order to reflect any national needs (S7).

Despite its strong advantages, the implementation study detected some improvement opportunities in the current format of the assessment. Specifically, SRI's qualitative assessment is not synonymous to actual performance. A service needs to be available to be accounted for, but it doesn't need to be realised in practise. Even during the implementation study, services of case study A have been included in the assessment despite not properly functioning during the post-occupancy evaluation of the buildings. Therefore, SRI may contribute to the problem of the performance gap that other schemes (such as EPCs) face (IO4). What is more, there is an intention to link the two schemes (Verbeke et al, 2020). EPCs are addressing the energy performance potential of a building, thus there is a threat for misinterpreting smart readiness to smart operation and increased energy performance (IO6). Also, the current study of Fokiades et al. (2020) showed that the classification of the two schemes is not well aligned, which can potentially create additional confusion.

This inconsistency can also create confusion around the actual benefits of SRI. In contrast, an indicator derived from a technical and quantitative analysis of building systems could provide measurable and more credible results that are expressed into actual monetary and energy savings. Since these quantitative results are missing from the current assessment, SRI may not provide enough incentive for investment in SRTs (IO7). Additionally, a performance-based assessment can be valuable during the design phase, for simulating and comparing the benefits of different technical systems (Vigna et al., 2020).

Moreover, during the implementation and research study, a lack of guidelines was noted, for instance the provision of clear descriptions for each service. Especially, for the case of a missing domain or the installation of multiple heating solutions in the same building, as in the office building, the technical study didn’t offer any guidance. In the case of services that were partially implemented in the buildings, such as occupancy detection lighting and cooling, the assessors are left to decide if they should be considered or not. Therefore, subjective decisions were made not only during the triage process but also during the selection of functionality levels (IO2). Vigna et al. (2020) have also demonstrated that these subjective decisions can lead to different results for the same building between different groups of assessors. Consequently, the credibility of SRI, as a fair rating system for the smart readiness of buildings, could be at risk (Janhunen et al., 2019). Solutions such as a list of technical systems that are encompassed under each service and detailed documentation (e.g. conventions for determination of services and functionality levels in multi-zone, multi-service applications), could minimise confusions and make the calculation process more robust.

The results of the implementation study also showed a clear difference between the two methodologies, with the simplified method offering approximately 10% higher results (IO1). This difference between methods can render any comparisons between results misleading and create a preference towards the simplified method among assessors if a clear separation on their use is not provided. The energy balanced method could possibly offer safer results that could be later used to provide tailored optimisation strategies for each building.

What is more, the implementation study showed that the SRI methodology doesn’t appear to reflect equally all of the EU intentions for 2050. For example, services such as EV charging and electricity storage provided a very small increase in the final score when implemented in their maximum functionality (between 1.8% and 2%). Thus, the scheme may not provide enough incentive for investment in such costly measures, despite their clear benefits (IO5). Similarly, passive measures such as the centrally controlled natural ventilation in the office building, received overall a lower score, despite being more energy efficient.

As the technical study stresses, “the integrity and credibility of SRI are crucial for its success” (Verbeke et al, 2020). Hence, the potential improvement opportunities identified should be addressed at the early stages of the scheme’s adoption. A series of national regulations and incentives that promote SRTs and grid integration within the EU members (e.g. to promote more dynamic electricity markets), is even more essential as it would ensure the relevance of the indicator and uptake in the EU built environment (IO3).

### The role of building simulations on future of SRI

The SRI scheme in its current format, uses a qualitative

*Table 2. The evaluation results of the SRI framework*

| Strengths | Improvement Opportunities |
|---|---|
| S1 - SRI can create a common framework across Europe | IO1 –The two methods do not always provide consistent results, which may promote the use of the simplified method |
| S2 - SRI can leverage investment in smart technologies and potentially create a common classification across Europe for SRT providers | IO2 - The calculation process allows for subjective decisions, which together with the lack of clear guidelines lead to inconsistencies between assessors and thus can hinder the credibility of the framework |
| S3 - The SRI methodology promotes grid flexibility, keeping in line with the EU goals for 2050 | IO3 - If SRI is not properly supported by other national policies in each EU member, it may not be successful |
| S4 - SRI can potentially support the health and wellbeing of occupants | IO4 - The lack of quantitative results doesn’t support the reduction of the performance gap |
| S5 - Increasing the smart readiness of buildings can increase energy efficiency and thus lead to energy and monetary savings | IO5 - The methodology doesn’t create enough incentive for some smart services such as electric vehicle charging and may discourage the use of passive systems |
| S6 – The framework provides an easy and quick assessment that can be updated to account for new technologies | IO6-Smart-readiness may be confused with energy performance, especially if SRI is linked with EPCs |
| S7- The framework can be easily adapted to the needs of each EU country by promoting the domains or impact criteria that are more beneficial for built environment of each EU member | IO7 - A performance-based methodology can provide measurable results and increase the uptake and credibility of the scheme. It can also be helpful when selecting between different systems and may provide more incentive when investing in SRT |

methodology to measure the smart readiness of a building. However, many studies (Kurnitski and Hogeling,2018; Dakheel et al., 2020; Märzinger and Österreicher, 2019) have addressed the need for a performance-based assessment, which could use building simulation modelling, in order to provide quantitative results. Energy and indoor environmental modelling could be used to measure impact criteria such as energy savings and comfort, while the IEA (2019) EBC Annex 67 programme has developed several performance-based indicators to measure energy flexibility (Kurnitski and Hogeling, 2018). As a result, building simulations could possibly improve the credibility of SRI by providing objective and measurable results.

## Conclusion

As the SRI scheme is about to be introduced as an EU-wide framework, the paper conducted an analysis in order to identify the factors that may contribute to the widespread adoption of the scheme or hinder its success.

The scheme could act as a push-mechanism for smart technologies and offer several advantages for the built environment and the EU market, including increasing the energy efficiency and grid responsiveness of the building stock as well as improving IEQ and users' satisfaction.

However, despite its strengths, the format and methodology of the scheme have been found to entail several potential weaknesses. In particular, the indicator measures the smart capability of buildings and can fail to translate into actual performance, thus contributing to the performance gap that other performance certifications face. Also, the two separate methodologies that exist may lead to inconsistent certifications. Furthermore, the assessment may not provide enough incentive for measures, such as EV charging, which are essential for the accomplishment of the EU goals for 2050. Lastly, a lack of clear guidelines and subjective decisions during the evaluation, may lead to unreliable assessments. These inconsistencies can create confusion among end users and threaten the credibility and success of the framework. It is therefore important to address these issues at the early stages of the scheme's adoption in the member states.

## References

BPIE (2019). Future-proof buildings for all Europeans. A guide to implement the Energy Performance of Buildings Directive (2018/844). BPIE. Brussels (Belgium).

BPIE (2017). Is Europe ready for the smart buildings' revolution? Mapping smart-readiness and innovative case studies. BPIE. Brussels (Belgium).

Dakheel, J., A., Del Pero, C., Aste, N. and Leonforte, F., (2020). Smart buildings features and key performance indicators: A review. Sustainable Cities and Society 61, 102-328.

Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency.

Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings.

European Commission (2020a). Delegated Regulation of the European Parliament and of the Council by establishing an optional common European Union scheme for rating the smart readiness of buildings. European Commission.Brussels (Belgium).

European Commission (2020b). European Energy Poverty Observatory Leads the Way in Coordinating Action to Tackle Energy Poverty. EU Energy Poverty Observatory.

Fokaides, P.A.; Panteli, C.; Panayidou (2020), A. How Are the Smart Readiness Indicators Expected to Affect the Energy Performance of Buildings: First Evidence and Perspectives. Sustainability 12, 9496.

Great Britain. Department for Communities and Local Government (2018). Improving the energy efficiency of our buildings A guide to display energy certificates and advisory reports for public buildings.

Horák, O. and Kabele, K. (2019). Testing of Pilot Buildings by the SRI Method. Heating Ventilation Sanitation 6, 331-334.

International Energy Agency (IEA) (2019), Summary Report, Energy in Buildings and Communities Programme Annex 67 Energy Flexible Buildings.

Janhunen, E., Pulkka, L., Säynäjoki, A. and Junnila, S. (2019). Applicability of the Smart Readiness Indicator for Cold Climate Countries. Buildings, 9(4), 102.

Kurnitski, J. and Hogeling, J. (2018). Smart Readiness Indicator (SRI) for buildings not so smart as expected. REHVA 55 (4), 6-9.

Markoska E., N. Jakica, S. Lazarova-Molnar and M. K. Kragh, (2019). Assessment of Building Intelligence Requirements for Real Time Performance Testing in Smart Buildings, 4th International Conference on Smart and Sustainable Technologies (SpliTech), Split (Croatia), 18-21 June 2019.

Märzinger, T.; Österreicher, D. (2019). Supporting the Smart Readiness Indicator-A Methodology to Integrate A Quantitative Assessment of the Load Shifting Potential of Smart Buildings. Energies 12, 1955.

Verbeke, S., Aerts, D., Rynders, G., Ma, Y. and Waide, P. (2020). Final report on the technical support to the development of a smart readiness indicator for buildings.VITO NV. Boeretang (Belgium).

Vigna, I., Pernetti, R., Pernigotto, G. and Gasparella, A., (2020). Analysis of the Building Smart Readiness Indicator Calculation: A Comparative Case-Study with Two Panels of Experts. Energies, 13(11), 2796.

Wouters, P. and Laustsen, J. (2017). The smartness indicator. REHVA 54 (2), 19.