European Commission

FINAL REPORT ON THE TECHNICAL SUPPORT TO THE DEVELOPMENT OF A SMART READINESS INDICATOR FOR BUILDINGS

Summary

Summary of the final Report
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Waide
Strategic Efficiency Europe

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Directorate-General for Energy
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2020

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EXECUTIVE SUMMARY

Smart technologies in buildings can be a cost-effective means to assist in creating healthier and more comfortable buildings with a lower energy use and carbon impact and can also facilitate the integration of renewable energy sources in future energy systems. One of the focal points of the Energy Performance of Buildings Directive (EPBD) is to better tap this potential of smart technologies in the building sector. As part of this focus, the EPBD sets out provisions to establish a **"Smart Readiness Indicator" (SRI)** as an instrument for rating the smart readiness of buildings. This optional common EU scheme will assess the technological readiness of buildings to interact with their occupants, to interact with connected energy grids and to operate more efficiently. The aim of the SRI is to raise awareness of the benefits of smarter building technologies and functionalities and make their added value more tangible for building users, owners, tenants, and smart service providers. It seeks to support technology innovation in the building sector and create an incentive for the integration of cutting-edge smart technologies in buildings.

The European Commission services (DG ENERGY) commissioned and supervised two studies with the aim of providing technical support to feed into the discussions on a common methodology and potential implementation pathways of this indicator. The outcomes are structured to help guide the establishment of the SRI by the European Commission and Member States and inform the development of related delegated and implementing acts, in accordance with the provisions of the EPBD. A first technical study proposed a definition and draft methodology for the SRI. The second technical support study has built further on the available knowledge to deliver the technical inputs needed to refine and finalise the definition of the SRI and the associated calculation methodology. Both technical studies have been carried out in close collaboration with the stakeholder community, e.g. through open consultations, five plenary stakeholder meetings, surveys, and collection of written feedback on draft reports, and via input received from three topical stakeholder working groups.

The technical study team has observed a broad consensus among stakeholders on the key principles and methodological choices of the SRI. A beta version of the methodology was tested on a voluntary basis during an open public testing phase, which resulted in 112 assessments being conducted by interested actors across the EU. This provided confirmation of the viability of the approach and led to further improvements of the consolidated methodology. Furthermore, the studies explored various options for the implementation of the SRI in order for the Commission Services and Member States to be informed of the possible arrangements for an effective implementation of the SRI scheme and the associated potential impacts. The EU impact analysis indicates that significant net beneficial benefits can result from implementing the SRI instrument across the European Union.

In conclusion, the technical support studies have developed and tested a viable definition and assessment methodology for the SRI. The proposed approach is aligned with the objectives set out in the EPBD, produces acceptably consistent results, can be readily implemented and has been shown to provide useful information to building users. It has been extensively reviewed and appears to enjoy broadly-based support across a wide range of stakeholders, suggesting that it could be an adequate basis to support an effective implementation of the SRI including, where relevant, further testing at Member State level.

1 SUMMARY OF CONTENTS

A first technical study to support the establishment of the SRI was launched in March 2017 and conducted by a consortium consisting of VITO NV, Waide Strategic Efficiency, Ecofys and Offis[1]. A second technical support study - conducted by a consortium consisting of VITO NV and Waide Strategic Efficiency Europe - started in December 2018 and concluded in June 2020.

This summary provides a resumé of the main findings and conclusions discussed in the full report of the second technical support study, which also integrates the outcomes of the first technical support study. Specifically, this document presents a summary of the main conclusions concerning:

- a consolidated proposal for the SRI calculation method and its main components, including the service catalogues of method A and method B
- a proposal of weighting factors for the multi-criteria analysis on impact and domain level
- suggestions on the SRI assessment procedures
- suggested implementation pathways for the SRI
- findings on SRI formatting and value to the respective users
- an overview of the main interactions with stakeholders and member state representatives
- results from the EU-level impact analysis of the SRI instrument.

2 WHY A SMART READINESS INDICATOR FOR BUILDINGS IS NEEDED

There is a clear need to accelerate building renovation investments and leverage smart, energy-efficient technologies in the building sector across Europe. Smart buildings integrate cutting edge ICT-based solutions to optimise energy-efficient control of technical building systems and enable energy flexibility as part of their daily operation. Such smart capabilities can also effectively assist in creating healthier and more comfortable buildings, which adjust to the needs of both the user and the energy grid while reducing building energy consumption and carbon impacts.

A greater uptake of smart technologies is expected to lead to significant, cost-effective energy savings, while also helping to improve indoor comfort in a manner that enables the building to adjust to the needs of the user. Smart buildings have also been identified and acknowledged as key enablers of future energy systems for which there will be a larger share of renewables, distributed supply, and demand-side energy flexibility.

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[1] "Support for setting up a Smart Readiness Indicator for buildings and related impact assessment - final report"; August 2018; Brussels. Authors: VITO: Stijn Verbeke, Yixiao Ma, Paul Van Tichelen, Sarah Bogaert, Virginia Gómez Oñate; Waide Strategic Efficiency: Paul Waide ; ECOFYS: Kjell Bettgenhäuser, John Ashok, Andreas Hermelink, Markus Offermann, Jan Groezinger ; OFFIS: Mathias Uslar, Judith Schulte

In the **Energy Performance of Buildings Directive** (EPBD)[2], one of the focal points is to improve the realisation of this potential of Smart Ready Technologies in the building sector. Therefore, the revised EPBD requires the development of **a voluntary European scheme for rating the smart readiness of buildings: the "Smart Readiness Indicator" (SRI)**. The SRI aims to make the added value of building smartness more tangible for building users, owners, tenants, and smart service providers. The present technical study was commissioned to support the development of this indicator.

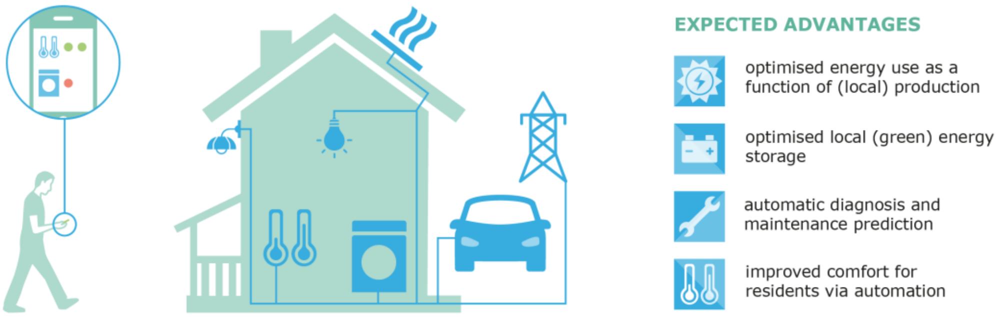


Figure 1 – Expected advantages of smart technologies in buildings

The SRI-scheme is intended to **raise awareness** about the benefits of smart buildings - in particular, from an energy perspective - and thereby **stimulate investments** in smart building technologies and **support the uptake of technology innovation** in the building sector. It is also within the scope of the SRI to enhance synergies between energy, buildings and other policy segments, in particular in the ICT area, and through this contribute to cross-sectorial integration of the buildings sector into future energy systems and markets.

In this work, the following definition of smartness of a building is used:

> "*Smartness of a building refers to the ability of a building or its systems to sense, interpret, communicate and actively respond in an efficient manner to changing conditions in relation to the operation of technical building systems or the external environment (including energy grids) and to demands from building occupants.*"

[2] Directive 2010/31/EU on the energy performance of buildings as amended by Directive (EU) 2018/844.

A Smart Readiness Indicator for buildings therefore 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 using ICT technologies.

For building occupants, owners and investors of both existing and new buildings, the SRI is designed to provide information on the smart services the building could deliver. Valuable information on the smartness level of the building - and potential improvements - could steer investment decisions. A transition towards ‘smarter’ buildings will induce multiple benefits to the users of the buildings, such as better energy efficiency, health and wellbeing, comfort and convenience. Facility managers will also be an important audience for the SRI as they may operate the smart systems and may influence the investment decisions. The other important audience for the SRI will be service providers, including network operators, manufacturers of technical building systems, design and engineering companies and many others. The SRI can help them to organise and position their service offering by providing a neutral and common framework wherein the capability of their smart services can be directly compared with those of their competitors including the incumbent non-smart services.

By providing a common language for all main stakeholders, the SRI can help boost the market uptake of smart ready technologies through the establishment of a credible and integrated instrument.

Figure 2 – Three key functionalities of smart readiness in buildings

3 TECHNICAL SUPPORT STUDIES

3.1 OUTCOMES FROM THE FIRST TECHNICAL STUDY

The first technical support study proposed an SRI methodology according to a set of guiding principles (see list below) and implemented via 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 power of artificial lighting*". 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 functionalities they can offer. Each of the services can be implemented with various degrees of smartness, referred to as **'functionality levels'**. In the example of lighting control this can range from the simple implementation of "*manual on/off control of lighting*" to more elaborate control methods such as "*automatic on/off switching of lighting based on daylight availability*", or even "*automatic dimming of lighting based on daylight availability*".

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, flexibility towards the energy grid, etc.). 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 smart readiness indicator.

The methodology is flexible with regard to the choice of assessment method, e.g. through on site-inspections by external SRI assessors, self-assessment by building owners, a blend of checklists and self-reporting by intelligent equipment, etc. To demonstrate the methodology, two in-field case studies were carried out. These follow a simple checklist process filled-in by third-party assessors who made site visits to the premises to conduct the SRI assessments and compute the scores.

Principles which have guided the development of the SRI methodology

The SRI:

- *Creates a technology-neutral level playing field for market actors through the definition of functional capability rather than the prescription of certain technological solutions.*
- *Is consistent with the goal of having a simple, expressive, and easy to grasp indicator which conveys transparent and tangible information.*
- *Balances the desire for a sufficiently detailed and reliable assessment with the desire to limit the time and cost requirements of assessing the smartness of a building.*
- *Allows for the incorporation of multiple distinct domains (e.g. both heating services as well as electric vehicle charging capabilities, etc.) and multiple distinct impact categories (e.g. energy efficiency, energy flexibility and provision of information to occupants, etc.).*
- *Is designed to be able to adapt to relevant contextual factors, which include variations by building type, climate, culture, and the collective impact these have on the demand for certain services.*
- *Is flexible enough to allow regular updates to support innovation in line with the rapidly changing landscape of policies and commercially available services.*

3.2 STRONG INVOLVEMENT OF EUROPEAN STAKEHOLDERS

During both technical support studies, the consortium partners have conducted extensive consultations of relevant stakeholders in an open and inclusive process. The feedback gathered has informed and deepened the analysis being undertaken and helped to build awareness and consensus over both the project aims and the most viable approaches to realise them.

During the technical studies, the dissemination and written consultation open to the public was managed via a public website[3]. The draft reports, interim deliverables and other relevant documents have been published regularly. At the end of the second technical support study, 813 people were registered as stakeholders and signed up to receiving updates. In total, five large plenary stakeholder consultation meetings were organised, with an average attendance of over 80 stakeholders in Brussels as well as the numerous stakeholders who followed the web-stream.

During the second technical support study, three dedicated thematic stakeholder working groups were set up specifically to enter into in-depth discussions with compact and well-balanced expert groups of approximately 30 members, representing different sector organisations and Member States, as follows:

- topical group A focused on the SRI value proposition and implementation
- topical group B focused on the consolidation of the SRI methodological framework, including the selection of services and the definition of weighting factors and impacts
- topical Group C was added in autumn 2019 and focusses on future developments of the SRI.

Both study teams have set up structured surveys to request feedback on interim deliverables. In addition, the Commission's DG Energy set up a targeted consultation on its website, to collect further feedback from stakeholders on some key issues related to the SRI. This consultation opened from 9 August 2019 to 11 October 2019. The consultation resulted in the collection of detailed feedback from 93 respondents located in 21 countries. This feedback was processed by the study team to inform the developments on the SRI methodology and implementation pathways.

Furthermore, 55 position papers were sent in by stakeholders and analysed and processed by the study teams. These position papers covered a wide set of topics, ranging from a general appreciation of the SRI concept to feedback on very specific technical suggestions.

Finally, stakeholders were also given the opportunity to test a draft version of the SRI calculation framework on buildings of their choice. In total, 112 complete and unique calculation sheets were received, constituting a rich source of information to assess the viability of the approach and finetune the proposed SRI methodology.

[3] This website was set up for the purpose of the study and is bound to be taken offline when this summary and related report are published by the Commission.

Main conclusions drawn from the public SRI beta testing

- *During the public testing, 112 assessments were performed, covering 81 unique buildings from 21 member states. For 31 buildings, both the simplified methods A and the more detailed method B were applied to the same building.*
- *Based on the analysis of the calculation sheets and the received feedback, the study team concludes that the SRI calculation methodology is generally well-received. Results were generally in line with the expectations, and the results were found to be insightful. The formatting and communication on the SRI will play an important role in creating a reference frame for the results. Additional (default) recommendations could strengthen the role of the SRI as an informative tool.*
- *It is concluded that objectively the results for both methods A and B are generally well-aligned. Furthermore, issues of comparability will not likely arise since in practice only one of the two methods would be applied to a given building. Nevertheless, both service catalogues were updated to harmonize the methods. It is suggested to include a clear reference to the method used in the communication on the SRI of a particular building.*
- *From a practical perspective, the assessment typically took less than one hour for method A, whereas most assessments with method B did not take more than 4 hours. This is in line with the expectations. In general, sufficient information was available to perform the assessment. To facilitate the assessment, the guidance document should include more detailed definitions of the functionality levels and provide additional examples or guidelines for complex systems. The role of the facility manager as a source of information was highlighted.*

4 IMPLEMENTATION ASPECTS OF THE SRI SCHEME

4.1 IMPLEMENTATION PATHWAYS

When considering the implementation of the SRI it is important to recognise that there is a tension between the notion of a centrally managed and coordinated SRI and that of subsidiarity where each EU Member State may seek to implement the SRI as they see fit. The legal framework for the SRI in the EPBD clearly sets out the applicable legal basis, so this is beyond discussion, however, practically, it is still important to consider the implications for the efficacy of the SRI of a more or less harmonised methodology. While the methodology needs to be flexible enough to adequately reflect local specificities such as climatic and building type variations it also needs to be sufficiently unified for it to leverage the power of the Single Market for goods and services. In particular, this implies an approach which is common in the manner in which the smart functionalities of goods and services are classified so that their providers can position their offers in a common way across the Single Market and avoid the need (and associated extra cost) of developing separate offers for each local implementation of the SRI. The discussion of implementation, beginning with the prospective pathways, builds on this understanding of the necessary trade-offs between harmonised and locally flexible approaches.

The investigation of the prospective pathways for the effective implementation of the SRI in the EU involved the following three elements:

- identification of the schemes and initiatives on which the SRI could build on, or connect to, to facilitate its implementation
- identification and analysis of the potential options for implementing the SRI at EU-level and at Member States-level
- definition of a set of robust and flexible implementation pathways for the roll-out of the SRI in the EU.

4.1.1 RELEVANT SCHEMES FOR THE SRI TO BUILD ON

An extensive review was conducted of available schemes at both EU and national level that the SRI could connect to (e.g. Energy Performance Certificate schemes). One of the key factors to assess with regard to the schemes reviewed was to evaluate how they have set about building engagement and stimulating adoption, which will be one of the key success factors for the SRI. The study team undertook a structured analysis of the barriers to adoption that these schemes (and the SRI) confront and the mechanisms they have used to overcome them. Their relative success in doing so has been evaluated to derive relevant lessons for the implementation of the SRI. In so doing it is recognised that engagement rates are related to the inherent value propositions of the initiatives and the legal frameworks that apply to them and so these have been considered too.

4.1.2 OPTIONS FOR IMPLEMENTING THE SRI AT EU-LEVEL AND AT MEMBER STATES-LEVEL

The identification and analysis of the possible options for implementing the SRI at EU-level and at Member State-level involved the examination of equivalent frameworks as possible templates for the SRI's adoption. In principle, the SRI's governance will require a final decision-making body, supported by technical group(s) with mechanisms for stakeholder input.

Some models of other initiatives which are instructive for the SRI's governance include the Ecolabelling scheme, and CEN/CENELEC standardisation bodies. Each of these initiatives involves oversight, review and maintenance and incorporates Member State representation with technical support just as the SRI will need to. However, the explicit governance structure that will best suit the needs of the SRI will need to be formally linked to the EPBD's governance and also needs to combine routine review and maintenance functions, with the ability to respond quickly to potentially rapid innovations. This last aspect implies the possible relevance to have a fast track decision making pathway in addition to the conventional review and maintenance functions.

4.1.3 DEFINITION OF A SET OF ROBUST AND FLEXIBLE IMPLEMENTATION PATHWAYS FOR THE ROLL-OUT OF THE SRI

The definition of a set of robust and flexible implementation pathways for the roll-out of the SRI in the EU entailed extensive consultation with SRI stakeholders, including regular physical or virtual meetings with the Topical Group A concerned with *SRI value proposition and implementation*.

This consultation process led to the development of the following set of potential implementation pathways:

A. linkage of the SRI to the EPC (energy performance certificate) (potentially in a mandatory way) so an assessment would be offered each time an EPC is conducted
B. linkage of the SRI to new buildings and major renovations so that each time a new build/or renovation is undertaken it would be a requirement
C. a market-based voluntary scheme where self-assessment is supported by on-line tools and 3rd party certified assessment is offered to those willing to pay for it
D. as option C. but with 3rd party assessments supported, or subsidised, by the state and/or utilities seeking to roll out flexibility, energy efficiency, electromobility and self-generation measures
E. linkage to the BACS (building automation and controls systems) and TBS deployment trigger points in Articles 8, 14 & 15 in the EPBD
F. linkages of the roll-out of smart meters
G. a mosaic of the above noting that Member States have subsidiarity in how they may choose to implement the SRI, so they could choose any of these options – also combinations of A/B/C/D/E/F are possible within any single Member State.

In the case of option E, the trigger points in the recast EPBD include:

- Article 8 provisions regarding the installation, upgrade, and replacement of technical building systems (TBS) and measures to encourage the deployment of automatic temperature regulation and zoning
- Articles 14 (heating inspections) and 15 (cooling inspections) which require all non-residential buildings with equivalent rated capacity > 290 kW to have BACS by 2025.

In principle, SRI deployment could be linked to any one or all of these trigger points.

In reflecting on these it is first important to appreciate that the SRI is expected to exert an influence on the market adoption of smart services and technologies through:

- a **"market pull"** impact of SRI assessments on property investment decisions that encourages the adoption of SRTs
- a **"market push"** impact of SRT and service providers self-organizing and promoting their service offers in line with the SRI criteria.

The market *pull* effect is driven by the impact that SRI assessments on properties have on the deployment of smart services and technologies, through raising awareness among stakeholders in the value chain at the property level. In this regard its impact could be expected to be rather similar to the impact effect associated with EPCs on building energy performance. The SRI impact is rather broader than the EPC's, however, because it also provides a common organisational framework within which the purveyors of smart technologies and services can identify and market the functionality and value proposition of their product and service offerings on a common basis across the EU. This "*market push*" effect will often operate at the Single Market level and hence has more in common with the organisational impacts of say, Ecodesign information requirements, than is the case of EPCs.

The duality of the SRI in this regard is important to appreciate because it implies that at one level (the *push* level) it needs to operate as a harmonised EU-level scheme to maximise impact whereas at the other level (the *pull* level) it could follow the same subsidiarity rationale as is applied to EPCs. Nonetheless, the leading implementation pathways mapped out above are necessarily all orientated to the *pull* level because they address how Member States could choose to implement the SRI. In this context option C would appear to be a common, lowest, dominator because it implies an entirely voluntary engagement with the SRI that in principle could be served by a common EU platform (an on-line SRI assessment and information tool made available in all EU languages). Member states and interested market actors could potentially choose to promote this in whatever way suits their concerns and the Commission could support this by the creation of a common interactive platform; however, while such a platform would provide value to any implementation pathway option C gives the least stimulus to SRI assessment and hence is the most passive pathway.

4.2 FORMAT OF THE SRI

4.2.1 APPROPRIATE FORMAT

The determination of the most appropriate format that the SRI should take needed to consider factors such as:

- Should the SRI be presented in the form of a physical certificate, as a virtual certificate, as a label, or in some other way?
- What information is to be conveyed? SRI scores, guidance on improvement options, or both?
- Should the format vary as a function of the target audience e.g. facility managers, building occupiers, and building owners?
- Should the format vary as a function of the building type e.g. non-residential (medium-large), non-residential (small), and residential?
- What scoring information should be presented? An aggregate overall score or rating, smartness scores for each impact criterion (e.g. energy, flexibility, etc.), smartness scores for each domain (e.g. heating, cooling, lighting etc.), combinations of, or all, of the above?

To help answer these questions an extensive stakeholder consultation process was undertaken. From this the following observations can be made. The most appropriate form of the SRI could depend on the implementation pathway and target audience – but it is likely that some blend of a physical and virtual certificate/platform would add most value. In principle, a virtual platform could be structured in hierarchical layers permitting users to assess the information they are interested in at the level they are interested in and thus could accommodate a spectrum of needs and interests. This can also support transparency which is important for the scheme's integrity. A physical certificate, if it is assessed by a third party, is also useful as it allows the ratings to be readily demonstrated. Most stakeholders surveyed favour allowing the SRI rating (scoring) information to be presented at both the sub-score level (e.g. at the impact criteria and domain level) and the overall level (a whole building rating). Most stakeholders would prefer that improvement guidance be included.

4.2.2 SRI LOGO AND DESIGN

From a design and communication perspective there is another discussion about whether, or not, the SRI should make use of mnemonics and/or a logo to support communication and branding. Mnemonics are used to simplify the processing and retention of information. The most famous example in the energy sector is the energy label that ranks appliance efficiency from A to G and is reinforced by colour coding (Green to Red). Other examples of mnemonics used to simplify rankings are the number of stars e.g. a 5-star hotel. Stakeholders have been asked if:

- mnemonics should be used for the SRI? And does the answer depend on the target audience?
- mnemonics should be used in combination with numerical scores or as a replacement?
- some form of A to G and/or colour-coded mnemonic should be an option, or does it risk confusion vis a vis energy labelling and EPCs?
- other mnemonic scales could/should be considered?

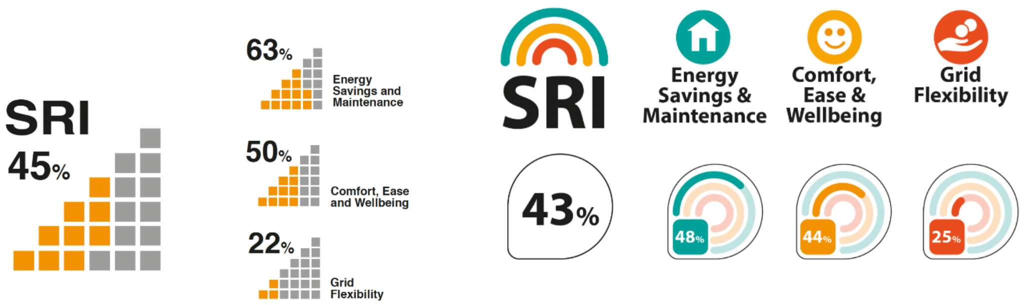
To help answer these questions a professional graphic designer was hired to develop a set of trial SRI design concepts which were subsequently tested in consumer focus groups held in Madrid and Budapest. The designs combined a blend of the following:

- conventional logos
- simple mnemonics which apply a single simple mnemonic scoring system to convey the aggregate performance (e.g. Figure 3)
- more complex, tri-partite mnemonics which apply a mnemonic scoring system for each of the three pillars mentioned in the EPBD text and also for an aggregate score (e.g. Figure 4)
- a comprehensive scoring matrix that includes scores per domain and per impact criterion as well as aggregate scores per impact criterion and the overall SRI aggregate score (Figure 5).

To test the SRI concepts consumer focus groups with a representative set of members of the public were conducted in Madrid and Budapest by a professional market research company (Kantar Millward Brown) and WSEE in state-of-the-art market research premises using professional moderators and best practice methods.

Example 10A Example 10D

Figure 3 – Examples of single mnemonics to convey the overall SRI score and/or rank



Example 20A Example 20E

Figure 4 – Examples of Tri-partite mnemonics to convey the overall SRI score/rank and sub-score/ranks for the three SRI "pillars"

IMPACTS

DOMAINS	Energy efficiency	Maintenance and fault protection	Comfort	Convenience	Health and well-being	Information to occupants	Energy flexibility & storage	SRI
Total	39%	18%	60%	71%	48%	59%	0%	42%
Heating	32%	18%	62%	55%	24%	74%	0%	
Sanitary hot water	17%	0%	45%	70%	67%	83%	0%	
Cooling	65%	51%	78%	72%	61%	55%	0%	
Controlled ventilation	41%	0%	55%	60%	34%	44%	0%	
Lighting	85%	14%	90%	100%	83%	15%	0%	
Dynamic building envelope	10%	0%	31%	56%	22%	46%	0%	
Electricity	10%	0%	-	-	-	68%	0%	
Electric vehicle charging	-	38%	-	82%	-	84%	0%	
Monitoring and control	52%	43%	62%	72%	45%	64%	0%	

Figure 5 – Matrix showing SRI scores by domain and impact criterion, aggregate scores per impact criterion and the overall SRI score

4.2.3 DATA MANAGEMENT AND CROSS-CUTTING ISSUES

The importance of ensuring data protection and confidentiality has been highlighted as a critical factor that would severely weaken the SRI were it to compromise these factors. GDPR requirements therefore need to be respected as a minimum, including ensuring that only legally mandated actors should have access to the SRI information pertaining to any specific property.

It is equally essential that SRI assessments should not cause any increase in cybersecurity risk and that if/where possible the SRI should be structured to enable information on the cybersecurity status of the smart services and devices being assessed to be reported to the SRI recipient. As it will not be actionable to have an on-site inspection of cybersecurity aspects, the SRI will have to rely on other data sources, e.g. the EU's voluntary cyber-security label which might become available for specific TBSs used within buildings in the future. This could feature on the SRI and its accompanying documents as additional information in addition to other relevant information such as the EC *broadband-ready label*[4] of a building when this information is available from trusted sources.

Additionally, the SRI or accompanying documents could also feature information on the cross-cutting issues of interoperability. It is suggested to take interoperability inexplicitly into account in some of the services which deal with interaction of various systems (e.g. the provision of preventing simultaneous heating and cooling in building zones requires some form of interoperability). Optionally, the SRI and its accompanying documents could report on the standards and communication protocols used by the technical building systems or introduce a simplified metric to indicate interoperability for each of the technical domains. The latter is likely to be more of a longer-term objective than a near term reality, as currently it is particularly challenging to determine the interoperability status of technologies from on-site (or other) assessment.

[4] See Article 8 of Directive 2014/61/EU of the European Parliament and the Council of 15 May 2014 on measures to reduce the cost of deploying high-speed electronic communications networks.

STUDY TEAM CONCLUSIONS ON FORMATTING

- *An SRI format that combines a mnemonic graphic design such as those shown in Figure 3 or Figure 4 at the top with the matrix shown in Figure 5 somewhere beneath would seem to be viable and address most users' needs – it seems to work well for consumers and professional users. This would combine a whole building score and ranking (which many users have indicated is important) with the detailed information on the scores by domain and impact criterion in a manner that is readily accessible. It would also ensure that users can see how the whole score is comprised from the sub-scores and provide the richness of information that many users desire without putting off those that simply want a whole-building score/ranking. The mnemonic ranking complements the percentage score as it gives a more easily retainable and comparable reference. It is suggested to use this approach for all building types and user segments.*

- *With regard to the set of media used to such an approach (i.e. a top-line mnemonic ranking/score with a matrix of sub-scores beneath) could be presented via a certificate and/or report with the option to access more details through an on-line tool. Such a tool could be accessible via a QR code and/or weblink and could potentially include the option for the user to enter (and/or retrieve) their building details so they could examine how they could improve its smart readiness in detail. The on-line tool could combine the functionalities of: explaining the SRI purpose and calculation to users; explain the higher levels of SRT functionality that are available and their benefits; and being able to calculate SRI scores from raw input data while allowing users to see how improved SRTs would improve their building's overall score and sub-scores.*

- *The use of an on-line platform would provide a solid and flexible foundation for the SRI's informational needs and be most responsive to the range of user needs. It could help to: facilitate SRI assessment, enable interactive determination of the impact of prospective changes in a building's smartness, manage evolutions in the SRI, manage evolutions in the data for any specific property, support data exchange with other service platforms whenever appropriate permissions are granted. Critically, the use of such a platform, if arranged to be in a navigable hierarchical manner, would avoid the need for the scheme to have to present the information in a single condensed format based on assumptions about user needs, as users would be able to readily find the information they are most interested in.*

- *Whatever media and graphic design format is chosen it will be important to ensure that additional explanation is provided which clearly clarifies what it does and does not address if confidence in the scheme is to be established and to protect it from accusations of being misleading. Distinct versions, where calculation methods have evolved, will need to be clearly communicated.*

- *There seems to be no obstacle in terms of user comprehension or perception to integrating the SRI within an EPC or to implementing them jointly. The same is probably true of other building rating, labelling or certification schemes.*

- *There seems to be no obstacle to using a common EU graphical design format for the SRI providing text used within it, such as in the matrix of Figure 5, can be communicated in the local language. It is probably acceptable to use the English acronym SRI as part of a common EU brand providing there is explanation of what the scheme is about offered in the local language.*

- *Information on cybersecurity and interoperability can be communicated together with the SRI and its accompanying documents. Some elements of interoperability are also implicitly integrated in the SRI calculation methodology, thus attributing to the overall score.*

4.3 ASSESSMENT PROCEDURE

The assessment time is strongly linked to the degree of complexity of the SRI definition. At least two different SRI assessment types could be envisioned: a light version with a limited set of services and a detailed version. Differentiating between a light version and a detailed version would allow the costs to be brought down for simple buildings, which in turn could increase the uptake. At the same time, the detailed version would permit validation of the added value of advanced systems in complex buildings. On the downside, differentiation may bring confusion, which could hamper the communication of the SRI. Finally, there is also a demand amongst certain stakeholders to take the SRI a step further by basing it on actual performance data of in-use buildings. From consideration of these aspects, the study team has investigated the three potential SRI assessment methods depicted below:

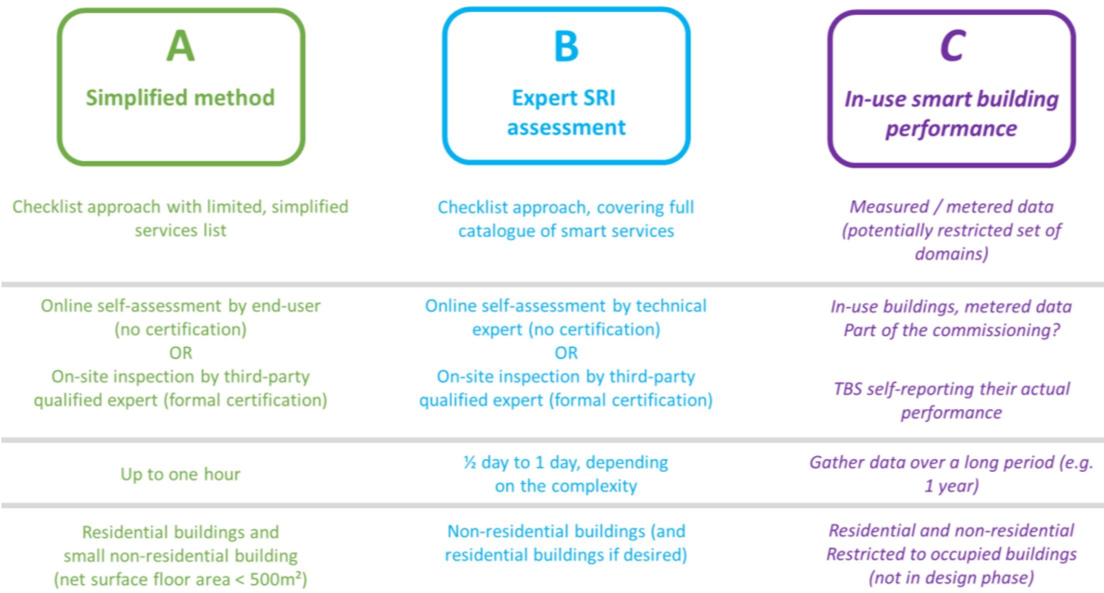


Figure 6 - Three potential assessment methods

- Method A could be a simplified quick scan, focusing mainly on residential buildings and small non-residential buildings. The method could be based on a check-list approach with a limited or simplified services list. It could be a fast method, taking less than one hour for a single-family home. The method could allow (online) self-assessment in addition to a formal third-party expert assessment. Only a third-party expert assessment would issue a formal certification.
- Method B could be a detailed SRI assessment, focusing mainly on non-residential buildings. The assessment could take ½ day to 1 day, depending on the size and complexity of the building. By default, it would require an on-site inspection by a third-party qualified expert. The method could potentially allow self-assessment by a non-independent expert (e.g. facility manager). Only a third-party expert assessment would issue a formal certification.
- Method C could be a metered/measured method. In the long run, Technical Building Systems (TBS)/ Building Automation and Control Systems (BACS)

might be able to self-report functionality levels, assisting methods A and B. Method C goes beyond this, and quantifies the actual performance of in-use buildings. Method C will require benchmarking to assess how much savings, flexibility, comfort improvements, etc. are delivered as a result of smart technologies. Alternatively, the scope could be broadened beyond the scope of the current SRI to become an assessment of actual performance, rather than solely focusing on smart controls. Method C is currently considered to be a potential future evolution of a certification approach for a commissioned building. Many practical and legal implications would hamper a fast roll-out. Therefore, it will not be treated in detail in this technical study but rather considered as a potential future evolution of the SRI.

Transparent processes will be needed to support the evolution of the SRI once it is established. The SRI method may need to be adapted over time to include additional domains, services, functionality levels or impact categories. Transparent frameworks and procedures will have to be defined and set up to manage this process in close interaction with relevant stakeholders.

As the SRI scheme becomes more established, it may evolve into a more sophisticated and less intrusive - thus less costly - assessment process(es). Potential options for this could include the use of Building Information Models (BIM) to facilitate the assessment process, self-reporting of smartness by BACS and the emergence of some form of standardised labelling on (packages of) smart-ready products. The full report discusses several important considerations that should be addressed in the implementation of the SRI scheme or could assist in a practical assessment on-site.

The SRI assessment can be linked to other assessment schemes and voluntary labels. This approach could potentially allow engagement of voluntary schemes introduced by some industry and service sectors that go into greater depth for specific smart services. Potential linkages to various schemes and initiatives are discussed in the full report.

The full report also discusses various approaches to deal with smart services that are only present in a part of the building. By introducing inspection thresholds or defining representative rooms in a building, the assessment efforts can be reduced significantly.

CONSOLIDATED APPROACH ON THE SRI ASSESSMENT METHODS

- *There is strong stakeholder support for distinguishing between a simplified approach (Method A) and a detailed approach (Method B). Method A, the simplified method, is mainly oriented towards small buildings with low complexity (single family homes, small multi-family homes, small non-residential buildings, etc.). The checklist method could be made accessible for non-experts, such as individual homeowners. Method B, the detailed method, is oriented towards buildings with a higher complexity (typically large non-residential buildings, potentially large multi-family homes).*

- *While in principle Method B is mainly oriented to more complex buildings, there is a greater richness of information in Method B and hence the study team are of the view that it should always be presented as an option even for building segments where Method A is the more common choice. Nonetheless, the manner in which this is executed would naturally be dependent on the implementation pathway adopted by each implementing authority.*

- *To support this approach, two separate service catalogues have been developed by the study team in consultation with the stakeholder community: a simplified service catalogue A and a detailed service catalogue B. Both methods have been subject to the public beta test which led to further finetuning and harmonisation of both methods. The consolidated service catalogues are distributed as annex C and annex D of the full report.*

- *For either method self-assessment could be made available. In this case it should be strictly framed as an informative tool that does not issue a formal certificate.*

- *The SRI needs to be a dynamic instrument. Within the framework of the current method, elements such as smart ready services and their scores and functionality levels will need to be adapted over time to keep in line with innovations available on the market. Furthermore, novel assessment methods (e.g. focussing on actual in-use performance) could be introduced. Various initial options for future evolutions of the SRI scheme have been canvassed and discussed with the dedicated topical stakeholder group C. While the outcomes of the technical support study mainly focused on an actionable first version of the SRI which can readily be implemented, the study team suggests that in parallel a process is set-up to discuss and facilitate future updates to the SRI in close collaboration with relevant stakeholders and Member States.*

5 Technical aspects of the SRI scheme

5.1 The catalogues of smart ready services

The proposed SRI methodology builds on the assessment of the **smart ready services** present in a building. Services are enabled by (a combination of) smart ready technologies, but are defined in a technology neutral way, e.g. '*provision of temperature control in a room*'. To support this, two catalogues of smart ready services has been compiled: a detailed method (method B) and a simplified method (method A). Each catalogue lists the relevant services and describes their main expected impacts towards building users and the energy grid. Many of these services are based on international technical standards. In accordance with the requirements from the revised EPBD, three key functionalities of smart readiness in buildings have been taken into account when defining the smart ready services in the SRI catalogue:

1. The ability to **maintain energy efficiency performance and operation** of the building through the adaptation of energy consumption - for example through use of energy from renewable sources.

2. The ability to adapt its operation mode in **response to the needs of the occupant**, paying due attention to the availability of user-friendliness, maintaining healthy indoor climate conditions and ability to report on energy use.

3. The **flexibility of 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.

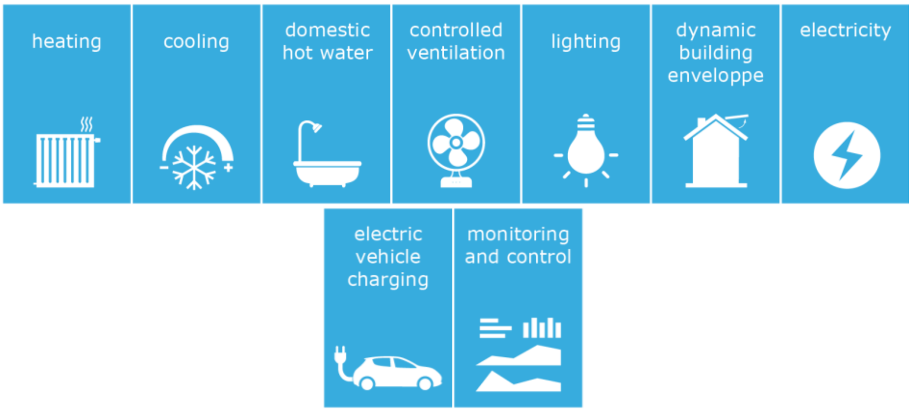


Figure 7 – Domains structuring the SRI catalogue

In the SRI service catalogues developed, services are structured within nine **domains**: heating, cooling, domestic hot water, controlled ventilation, lighting, dynamic building envelope, electricity, electric vehicle charging and monitoring and control.

The detailed service catalogue (method B) and the simplified service catalogue (method A) have been thoroughly reviewed based on various stakeholder feedback, a review session with members of Topical Group B and feedback from the public beta testing. The final consolidated proposal for a detailed service catalogue (method B) consists of 54 services, the simplified (method A) of 27.

For each of the services, 2 to 5 **functionality levels** are defined. A higher functionality level reflects a "smarter" implementation of the service, which generally provides more beneficial impacts to building users or to the grid compared to services implemented at a lower functionality level. The functionality levels are expressed as ordinal numbers, implying that ranks cannot be readily compared quantitatively from one service to another.

5.2 IMPACT SCORES OF SMART READY SERVICES

A smart ready service can provide several impacts to the building, its users, and the energy grid. In the proposed approach, a set of seven impact criteria is evaluated, but scores can potentially be aggregated along the three key functionalities mentioned in the EPBD.

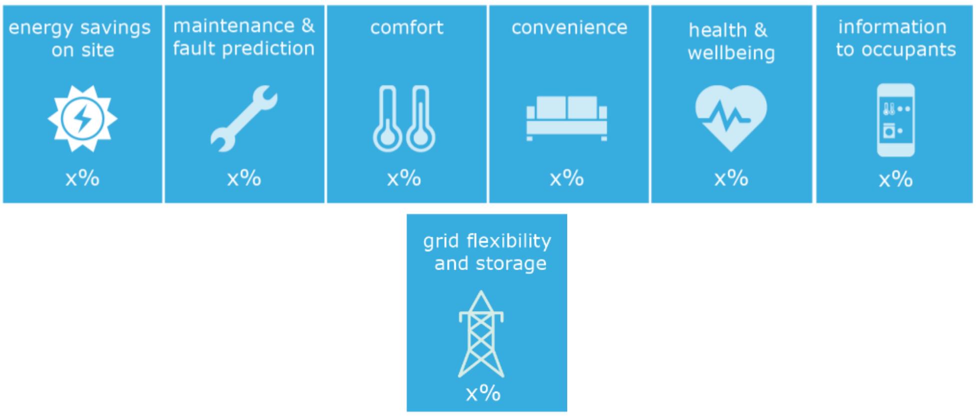


Figure 8 – Smart service impact criteria

The impact criteria are:

- **Energy savings on site**
  This impact category refers to the impacts of the smart ready services on energy saving capabilities. It is not the whole energy performance of buildings that is considered, but only the contribution made to this by smart ready technologies, e.g. resulting from better control of room temperature settings.
- **Flexibility for the grid and storage**
  This impact category refers to the impacts of services on the energy flexibility potential of the building. The study proposes to not solely focus on electricity grids, but also include flexibility offered to district heating and cooling grids.
- **Comfort**
  This impact category refers to the impacts of services on occupant's comfort. Comfort refers to conscious and unconscious perception of the physical environment, including thermal comfort, acoustic comfort, and visual performance (e.g. provision of sufficient lighting levels without glare).

- **Convenience**
  This impact category refers to the impacts of services on convenience for occupants, i.e. the extent to which services “make life easier” for the occupant, e.g. TBS requiring fewer manual interactions.
- **Well-being and health**
  This impact category refers to the impacts of services on the well-being and health of occupants. For instance, smarter controls can deliver an improved indoor air quality compared to traditional controls, thus raising occupants’ well-being, with a commensurate impact on their health.
- **Maintenance and fault prediction**
  Automated fault detection and diagnosis has the potential to significantly improve maintenance and operation of technical building systems. It also has potential impacts on the energy performance of the technical building systems by detecting and diagnosing inefficient operation.
- **Information to occupants**
  This impact category refers to the impacts of services on the provision of information on building operation to occupants.

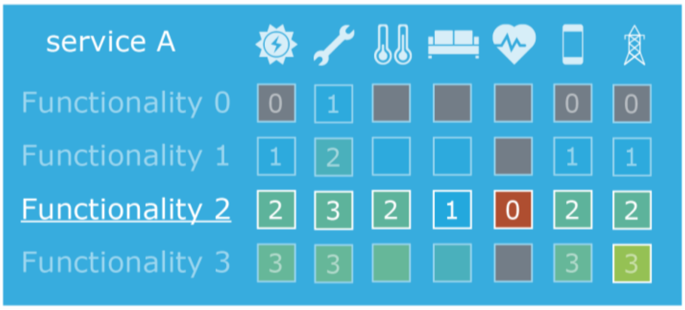


Figure 9 – Matrix displaying the impact scores for the seven impact categories of a fictitious "service A". Functionality level 2 is assumed to be present in the building, which has the following impact scores listed: “2” for energy savings, “2” for flexibility and storage, “2” for comfort, etc.

For each of the smart ready services in the catalogue, provisional impact scores have been defined for their respective functionality levels according to a seven-level ordinal scale. While most of the impacts are positive, the scale also provides the opportunity to ascribe negative impacts.

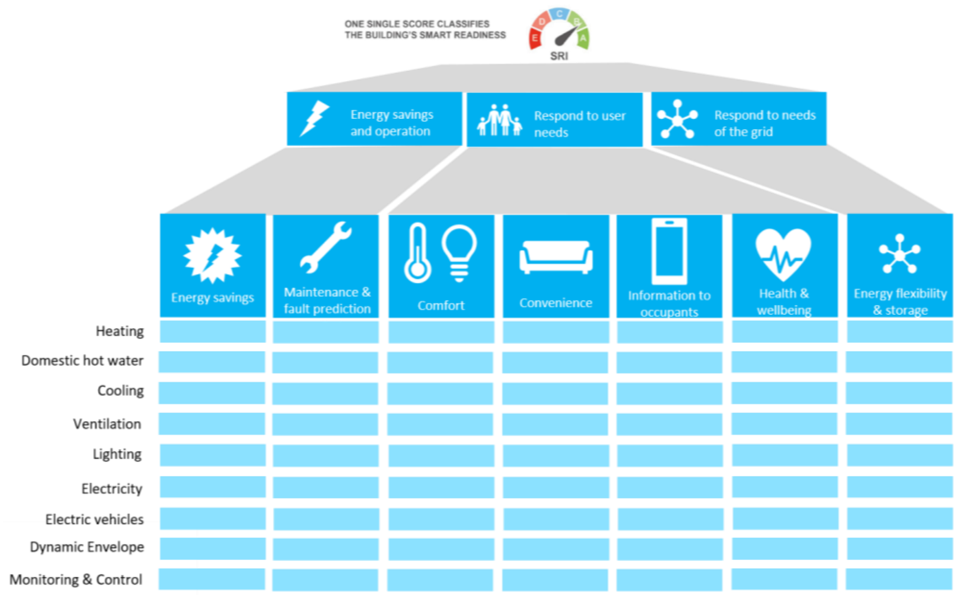


Figure 10 – Proposed structure of domains and impacts criteria

5.3 MULTI-CRITERIA ASSESSMENT METHOD

Under the proposed SRI methodology, the smart readiness score of a building is a **percentage** that expresses how close (or far) the building is to maximal smart readiness. The higher the percentage is, the smarter the building. The percentage can also be converted to another indicator, e.g. star rating or alphabetical score (A, B, C, etc.). This has been further tested through the development of graphical designs and market surveying with selected consumer focus groups.

An aggregated score can be derived as follows:

- The process starts with the assessment of **individual smart ready services**. Services available in the building are inspected and their functionality level is determined. For **each service**, this leads to an **impact score** being ascribed for each of the impact criteria considered in the methodology**.**

- Once all these individual services impact scores are known, an aggregated impact score is calculated for each of the domains considered in the methodology. This **domain impact score** is calculated as the ratio (expressed as a percentage) between individual scores of the domains' services and theoretical maximum individual scores.

- For each impact criterion, a total impact score is then calculated as a weighted sum of the domain impact scores. In this calculation, the weight of a given domain will depend on its relative importance for the considered impact.

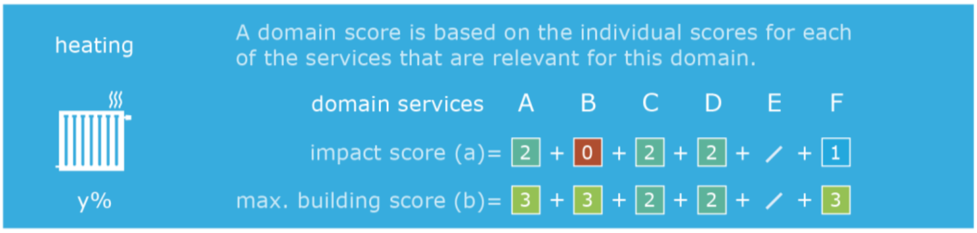


Figure 11 - The domain score is based on the individual scores for each of the services that are relevant for this domain

The SRI score is thus based on a weighted sum of the 7 total impact scores. In this multi-criteria assessment, the **weighting factors** can be attributed to both domains and impact criteria to reflect their relative contributions to an aggregated overall impact score. An aggregated SRI score indicates the overall smartness level of the building, while sub-scores allow to assess specific domains and impact categories. Conceptually, three approaches for the derivation of the domain and service level weighting factors can be envisioned: equal weighting, predicted impact approach and energy balance approach.

The weighting factors for domains will be derived from an energy balance whenever possible. This approach reflects the differences in relative importance with respect to regional differences. By using weightings from an energy balance, the heating domain would gain importance in northern areas of Europe, whereas the relative importance of the cooling domain would increase in southern areas of Europe. For those domains where no direct link with an energy balance can be made (e.g. monitoring & control, dynamic building envelope), a weighting factor can be defined based on the estimated impact of that domain. The methodology also foresees a differentiation in weighting factors for the individual impact criteria.

The proposed methodology provides default weighting factors which are differentiated by building type and climate zone. Figure 12 and Figure 13 provide an overview of the proposed weighting scheme which consist of a blend of fixed weights, equal weights, and energy balance weights, depending on domain and impact.

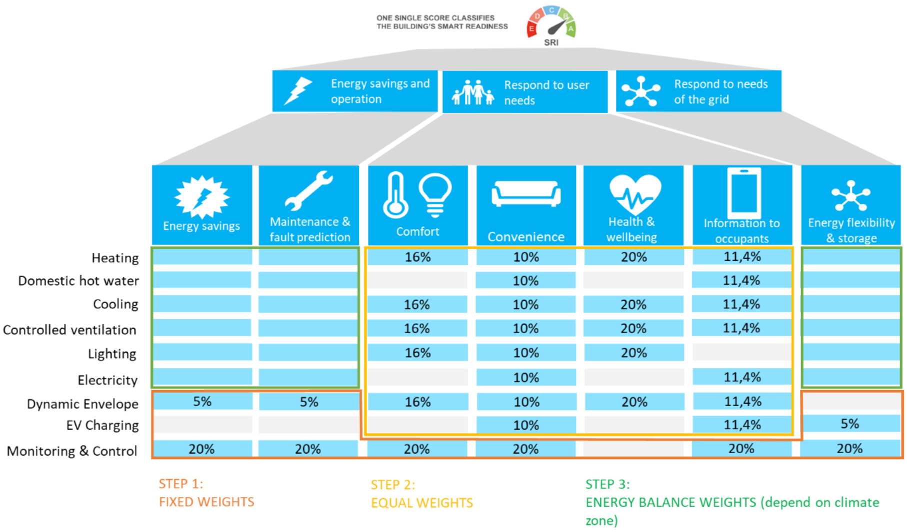


Figure 12 – Overview of the weighting scheme

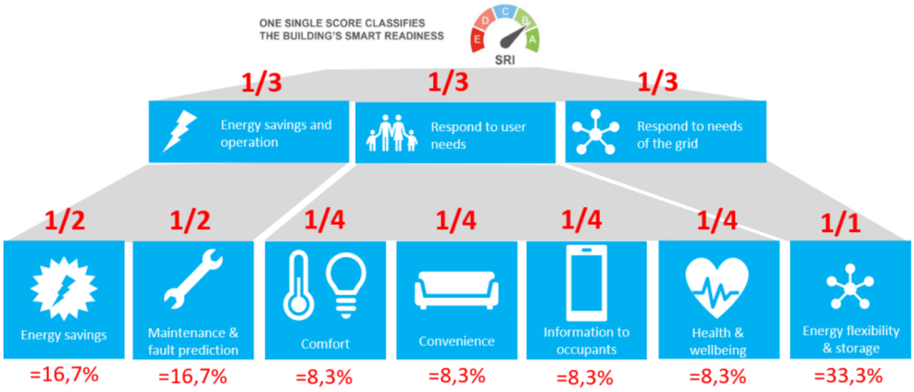


Figure 13 – Aggregation of impact scores to three key functionalities or to a single score

CONSOLIDATED PROPOSAL ON WEIGHTING FACTORS FOR SERVICES AND DOMAINS

- *Based on the input from stakeholders, the study team has developed a hybrid approach for the derivation of the weighting factors. The methodology defines a weighting scheme with three types of weighting factors: fixed weights, equal weights, and energy balance weights. The methodology includes the option to use building-specific energy balance data whenever available (for instance from an EPC calculation).*

- *The proposal allows flexibility regarding the communication of results at the two aggregation levels. The study team has investigated ways to efficiently communicate these impact criteria, aiming to balance clarity and conciseness. Information on cybersecurity and interoperability can be communicated together with the SRI and its accompanying documents. Some elements of interoperability are also implicitly integrated in the SRI calculation methodology, thus attributing to the overall score.*

5.4 NORMALISATION OF SRI SCORE AND TRIAGE PROCESS TO SELECT THE APPLICABLE SERVICES

The proposed SRI methodology provides a **flexible and modular framework**. The applicability of the SRI methodology is likely to vary depending on specific circumstances (building type, climate, site specific conditions, etc.). Local and site-specific context will mean that some domains , services and service levels are either not relevant, not applicable, or not desirable and thus the SRI needs to be flexible enough to accommodate this. The maximum nominal impact score is not simply the sum of the impacts of the services listed in the streamlined SRI catalogue. It is highly likely that due to local and site-specific context some domains and services are either not relevant, not applicable, or not desirable. The SRI methodology accommodates this by performing a **triage process** to identify the **relevant services for a specific building**.

It may be that some domains are not relevant, e.g. some buildings might not be able to provide parking (and hence electric vehicle charging facilities) and some residential buildings might not need cooling. Furthermore, some of the services are only applicable if certain technical building systems are present, e.g. a storage vessel for domestic hot water or a heat recovery ventilation unit. Also, some services may be mutually exclusive, since it is unlikely that a building has both district heating and combustive heating and heat pumps. If such services are not present, they obviously do not need to be assessed during on-site inspections. Due to these different factors, in any real building, the number of services to be inspected as part of an SRI assessment will be lower than the 54 (or 27 in case of method A) smart ready services listed in the SRI catalogue.

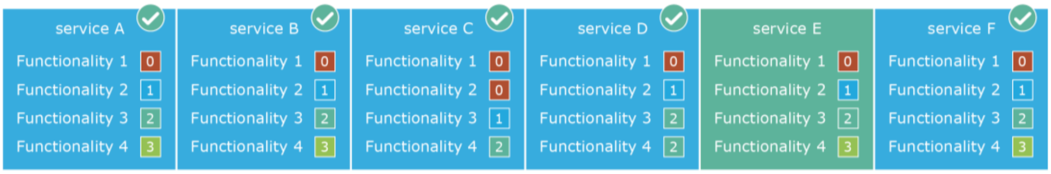


Figure 14 – Visualisation of triage process: for this specific example service E is not considered relevant for the building and thus is not inspected

The triage process does not only affect the inspection time and efforts, but also the 'maximum obtainable score', as it would be unfair to penalise a building for not providing services that are not relevant. The SRI should not promote complexity in buildings and will therefore only take into account services which are either present or desirable. For some services, this can be context specific. For instance, a passive house with solar shades, ventilation and / or window opening control, would not need mechanical cooling and should not be penalised for not having such services.

In essence, two approaches to deal with absent domains or services are combined:

- Some services only have to be evaluated in cases where the relevant technical building systems are present (hence: "smart ready"). This approach is appropriate when assessors cannot unambiguously determine the relevance of the domain. For instance, the relevance of automated shading devices strongly depends on the building’s design (orientation, window-to-wall ratio, etc.). Such an assessment cannot be made objectively within the scope of the SRI. When moveable shading is present, the SRI can however assess how smartly the shading devices are controlled.

- Some services might be absent but nonetheless desirable from a policy perspective (hence: “smart possible”). This approach may provide stimuli for upgrading existing buildings with additional (smart) services. For instance, penalising the absence of a controlled ventilation system could create an incentive to install such a system to improve the SRI score.

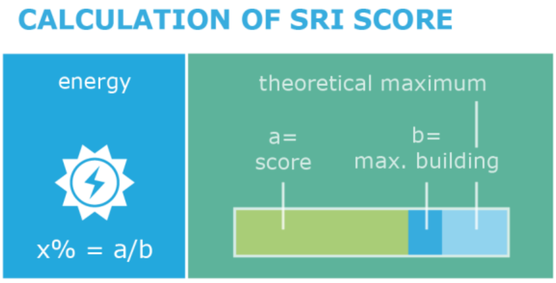


Figure 15 – Normalisation of the domain score. As a result of the triage process, certain services are not included in the maximum score of a building (b), which can therefore be lower than the theoretical maximum score (c). The SRI score is calculated by dividing the building score (a) by the maximum score of the building (b).

CONSOLIDATED APPROACH ON DEALING WITH ABSENT SERVICES

The study team recommends the following approach to deal with absent services

- *For some services, an evaluation is only relevant in cases where the technical building systems it relates to are present. This approach is appropriate when one cannot a priori conclude that a domain or service should be present in a particular building (e.g. a building could be comfortable without cooling systems). If such a service is not present, the service is excluded from the assessment and does not affect the maximum attainable score.*

- *Some services may be mutually exclusive; if such services are not present, they can be excluded from the assessment*

- *Some services might be absent but nonetheless desirable from a policy perspective. This approach may provide stimuli for upgrading existing buildings with additional (smart) services. A suggested solution is to allow implementing bodies to define guidelines depending on contextual factors such as the relevance of specific services and domains to particular building types and climatic zones and requirements in local building codes. These services are included in the assessment.*

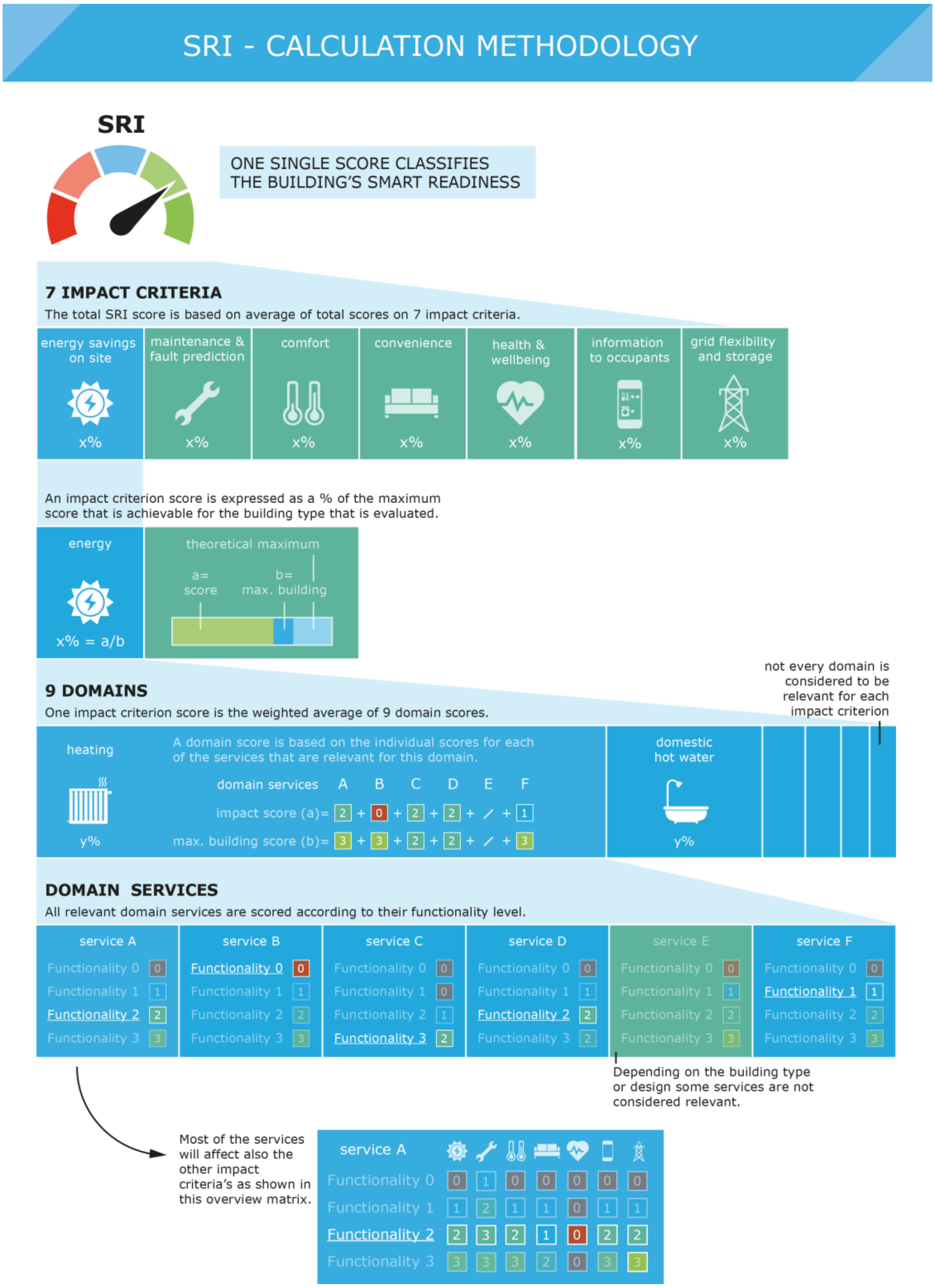


Figure 16 - summary of the calculation method

6 BENEFITS AND COSTS OF THE SRI'S IMPLEMENTATION

As part of the technical study, an **impact analysis** was performed to analyse the benefits and costs of implementing an SRI to support an increased uptake of smart ready technologies in buildings across the EU. It is also intended to help understand the impact of implementing the SRI in conjunction with other accompanying policies to enhance the impact of the SRI. The methodology used to assess the potential impacts of the SRI is split into two steps:

- The first focuses on the modelling of the evolution of the **EU building stock** within the framework of the revised EPBD. The building sector pathways used in this analysis describe the general development of the building sector calculated in five geographic zones across the EU. They consider new buildings, the demolition of buildings and retrofits with regard to energy efficiency measures applied to the building envelope and the heating, ventilation, and air-conditioning (HVAC) systems. These models are in line with the impact assessment carried out in the first technical support study for the SRI.
- In the second part of the impact assessment, the effects of an **uptake of smart ready technologies** (SRTs) is modelled. Various scenarios of how the SRI and accompanying policy measures spur the uptake of SRTs are modelled. For this impact assessment, the level of smart readiness of buildings is clustered into different levels (from I to IV) in the models. If a building undergoes improvements, it will be allocated to a higher smart readiness level (e.g. moving from I to II or from II to IV). This translates into final energy savings, monetary savings, and CO_2-savings due to the improved energy efficiency of the buildings and enhanced demand side flexibility. Additional benefits (increased work force, health and well-being…) will be described in a qualitative way but not explicitly quantified.

Various implementation scenarios are investigated in the study, including a potential mandatory linkage to Energy Performance Certification (referred to as 'pathway A1') and a market-based voluntary scheme where self-assessment is supported by on-line tools and 3rd party certified assessment is offered to those willing to pay for it (referred to as 'pathway C').

The business-as-usual (BAU) scenario for the SRI already includes the impacts of all the other policy measures within the Energy Performance of Buildings Directive and thus has already locked-in very significant final energy savings in EU the building sector. These measures pertain to the construction of new energy-efficient buildings, and energy-efficient retrofits of existing buildings with regard to the building envelope and the heating, ventilation, and air-conditioning (HVAC) systems. Nonetheless, the impact analysis indicates that the SRI can unlock up to 5% additional final energy savings by 2050. Under the BAU scenario an investment of 75 billion euro would be made in smart ready technologies over the next 30 years, yet under the SRI A1 implementation pathway this would increase by an additional 126 billion euro, resulting in final energy savings up to 198 TWh by 2050 and 32 million tonnes of avoided greenhouse gas emissions per year. The annual projected cost of conducting the SRI assessments and annual energy savings also depend on the preferred implementation pathways. Across the EU-28, SRI assessment costs are projected to range from €560m in 2050 (under pathway A1) to just €2m (under pathway C), yet the value of annual avoided energy bills in 2050 is projected to range from €16.8 billion (under pathway A1) to €5.3 billion (under pathway C). The annual net cost savings from implementing the SRI in 2050 are projected to range between 12.9 billion (for pathway A1) and

3.9 billion (for pathway C) – note these costs are the sum of the investments in smart ready technologies, the SRI assessment costs and the value of the energy bill savings. Co-benefits of the SRI roll-out are also assessed in the study. For example, the projected value of health & wellbeing benefits as a result of the SRI-induced investments are estimated to be up to €3.8 billion in 2030 higher compared to BAU (for pathway A1), while the incremental net employment created is up to 72 thousand jobs (for pathway A1). Details on the material circularity impacts and the findings of a detailed sensitivity analysis are presented in the main report.

7 GENERAL CONCLUSION

The Energy Performance of Buildings Directive (EPBD) introduced the concept of a Smart Readiness Indicator (SRI) which is expected to become a cost-effective measure that can effectively assist in creating healthier and more comfortable buildings with a lower energy use and carbon impact, and can also facilitate the integration of renewable energy sources. Within the scope of the first and second technical study on the SRI, the following definition has been adopted:

"Smartness of a building refers to the ability of a building or its systems to sense, interpret, communicate and actively respond in an efficient manner to changing conditions in relation the operation of technical building systems or the external environment (including energy grids) and to demands from building occupants,"

The SRI aims to raise awareness of the benefits of smarter building technologies and functionalities and their added value for building users, energy consumers and energy grids. Thereby it can support technology innovation in the building sector and become an incentive for the integration of cutting-edge smart technologies into buildings.

A first technical study developed a definition and draft methodology for the SRI. The second technical support study has built further on the available knowledge of the first technical study to deliver the technical inputs needed to refine and finalise the definition of the SRI and the associated calculation methodology. Furthermore it explored possible options for the implementation of the SRI and evaluated their impact at the EU level in order for the Commission Services and Member States to be informed on the possible modalities for an effective implementation of the SRI scheme and related potential impacts.

Throughout this work the consortium partners of both technical studies have consulted with relevant stakeholders and used the findings to inform the analysis while helping to build awareness and consensus with regard to the project's aims and the most viable approach to achieve them.

In the final report the technical study team propose a consolidated methodology to calculate the SRI of a building. The methodology is a flexible and modular multi-criteria assessment method which builds on assessing the smart ready services present in a building. Services are enabled by (a combination of) smart ready technologies but are defined in a technology neutral way. The proposed calculation methodology is structured amongst 9 technical domains and 7 impact criteria. For each of the services several functionality levels are defined. A higher functionality level reflects a "smarter" implementation of the service, which generally provides more beneficial impacts to building users or to the grid compared to services implemented at a lower functionality level.

In the proposed method, the smart readiness score of a building or building unit is expressed as a percentage which represents the ratio between the smart readiness of the building or building unit compared to the maximum smart readiness that it could reach.

The disaggregated scores can express smart readiness for one or more of the following:

- Three key smart readiness capabilities as highlighted in Annex Ia, point 2 of the EPBD:
    1. Energy performance and operation
    2. Response to the needs of the occupants; and
    3. Energy flexibility.

- The seven smart readiness impact criteria:
    1. Energy efficiency
    2. Maintenance and fault prediction
    3. Comfort
    4. Convenience
    5. Health and wellbeing
    6. Information to occupants
    7. Energy flexibility and storage.

- The nine smart readiness technical domains:
    1. Heating
    2. Cooling
    3. Domestic hot water
    4. Controlled ventilation
    5. Lighting
    6. Dynamic building envelope
    7. Electricity
    8. Electric vehicle charging
    9. Monitoring and control.

A smart service catalogue for both a detailed and a simplified assessment method was elaborated in extensive consultation with stakeholders. The simplified Method A would be mainly oriented towards small buildings with low complexity (single family homes, small multi-family homes, small non-residential buildings, etc.), whereas the more detailed Method B is mainly oriented towards buildings with a higher complexity (typically large non-residential buildings, potentially large multi-family homes). For either method an informative self-assessment could be made available as an alternative to a formal certificate. The final report of the study also includes a proposal for weighting factors, a methodology for normalisation of the scores and a suggested triage process which details how to deal with absent services.

The SRI calculation methodology was successfully tested in a public beta test comprising 112 cases across Europe, which proved the viability of the approach. The feedback from the stakeholders participating in this test led to further finetuning and harmonisation of the SRI calculation methodology and the delivery of two consolidated service catalogues which are distributed as annex C and annex D of the full report. The proposed SRI calculation methodology is flexible to allow for adaptations to specific local contexts and allows for future updates in order to keep pace with new innovations in smart products and technologies available on the market.

The study also investigated the potential pathways for the effective implementation of the SRI in the EU. The review of various schemes and initiatives on which the SRI could build or connect to has led to the development of a set of six primary potential implementation pathways and the identification of various trigger points in the building lifecycle that the SRI deployment could link to. The SRI is expected to exert an influence on the market adoption of smart services and technologies by both a "market pull" and a "market push" effect. The market *pull* effect is driven by the impact that SRI assessments on properties have on the deployment of smart services and technologies, through raising awareness among stakeholders in the value chain at the property level. The market *push* effect is a result from the common framework that the SRI provides for service providers to self-organise and promote their service offers on a common basis in line with the SRI criteria across the EU. Research was initiated to determine potential designs for the format of the SRI. This recognises that for the scheme to be effective it will need to have an attractive and recognisable format that gives visibility to the SRI and effectively conveys information to users of the scheme.

Building on the outcomes of this work, the study provides technical guidelines and recommendations addressing (1) the operational, organisational and legal design of the SRI scheme, (2) the efficient and cost-effective assessment of the SRI and (3) the management of the SRI after adoption. These were informed by considerations of costs, data needs, training for assessors, etc. which helped to shape the development of the methodology and implementation pathways in an iterative manner.

Finally, the study quantified the costs and benefits of implementing an SRI in the EU building sector for the horizons of 2030, 2040, 2050. The impact analysis reveals that rolling out the SRI across the EU would be strongly beneficial, with the greatest net benefits arising from linking the SRI assessments to the Energy Performance Certification (EPC) assessments of buildings, or the article 8 requirements under the EPBD. The SRI could lead to 5% higher final energy savings by 2050, unlocking an increase in investment of 181 billion euro over 30 years compared to a business-as-usual case and up to 32 million tonnes of avoided greenhouse gas emissions per year.

The study team concludes that the roll-out of the SRI would result in a strongly beneficial impact and observes a broad consensus among stakeholders on most of the key principles and methodological choices of the proposed SRI developments.

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