Enhancing the Smart Readiness Indicator Scheme: Methodology Assessment through 20 Use Cases

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***Abstract*— The European Union developed the Smart Readiness Indicator (SRI) to enhance energy efficiency and encourage the adoption of smart technologies in buildings, tackling their high energy usage and carbon emissions. This study evaluates the SRI methodology through the assessment of 20 diverse use cases, including residential and non-residential buildings, using Methods A and B of the SRI assessment scheme. Key variables such as climate zone, building type, year of construction, and the integration of smart-ready services were considered to ensure a comprehensive evaluation.**

Five engineers assessed the buildings using the SRI EU Excel Tool and rated the methodology based on criteria including accuracy, usability, comprehensiveness, flexibility, and impact on decision-making. The results revealed high ratings for accuracy (45% rated as "Very Good" and 30% as "Excellent") and usability (50% rated as "Very Good"), while comprehensiveness was rated more moderately (40% "Good"). However, flexibility and adaptability emerged as areas requiring improvement, with 45% of assessments rated as "Fair." The SRI methodology demonstrated strong potential but requires further refinement to address the needs of diverse building types and more complex smart technologies. The study concludes that the SRI framework is a valuable tool for promoting energy efficiency and smart technology adoption across the EU building sector. However, additional research is recommended to integrate real-time data and automation technologies, and to enhance the framework's scalability and adaptability for future building systems.

Keywords: Smart Readiness Indicator (SRI), Decarbonization, Smart Buildings, Sustainability.

I. INTRODUCTION

The Smart Readiness Indicator (SRI) was developed in response to the urgent need to improve energy efficiency and reduce CO_2 emissions across the European Union [1]. In the EU, buildings play a major role in energy consumption, comprising about 40% of total usage and 36% of emissions linked to energy use. Notably, around 35% of the EU's buildings are over 50 years old and nearly 75% are considered energy inefficient.[2] With the expectation that 85-90% of these buildings will still be in use by 2050 [3], and a renovation rate of only about 1% per year, there is a clear necessity for action to enhance energy performance and sustainability in the building sector [4].

In alignment with the European Green Deal's objectives, by 2030, the EU seeks a 27% enhancement in buildings' energy performance, aiming for full decarbonization of building stock by 2050. Key milestones set for 2030, 2040, and 2050 include the requirement that all new buildings from 2021 be nearly zero-energy buildings (nZEB), and all new public buildings from 2019 also meet nZEB standards. The revised Energy Performance of Buildings Directive (EPBD)[5] mandates upgrading the lowest-performing 15% of EU buildings from Energy Performance Certificate (EPC) label G to at least label F by 2030, prioritizing public and non-residential buildings by 2027. Additionally, Member States must reduce public sector energy use by 1.7% annually and increase the use of renewable energy in buildings to 49% by 2030, with an annual increment of 1.1% in renewable energy use for heating and cooling.

To achieve these ambitious goals, the EU has launched the Renovation Wave[4], which includes regulations, financing, and strategies to promote building renovations, aiming to at least double the annual energy renovation rate of buildings by 2030. The revised EPBD, a key initiative of the Renovation Wave, requires Member States to establish long-term renovation strategies, set cost-optimal minimum energy performance requirements, and promote the installation of smart-ready technologies, including building automation and control systems (BACS).

Smart-ready technologies are essential for optimizing the energy-efficient control of technical building systems (TBS), enabling energy flexibility, creating healthier and more comfortable buildings, and enhancing the use of renewables. Smart buildings can adjust to the needs of both users and the energy grid, improving their energy and environmental footprint. [6]

In this context, the European Commission introduced the SRI as a voluntary scheme to rate buildings' smart readiness, thereby encouraging investments in smart-ready technologies and supporting innovation in the building sector. The evolution of the SRI began with its first mention in the Clean Energy for All Europeans package in 2016, highlighting the importance of ensuring that future buildings are smart and interconnected with the energy system, capable of demand flexibility and energy storage [7].

The revised EPBD of 2018 formally introduced the SRI, detailing a methodology to estimate buildings' capacity to adapt to occupant and grid needs while enhancing energy efficiency and overall performance. The SRI covers features such as smart meters, BACS, indoor air temperature regulation devices, home appliances, electric vehicle recharging points, and energy storage equipment. The methodology emphasizes simplicity, transparency, and accessibility for building owners, occupants, investors, and market participants, with the European Commission ensuring extensive consultations during its development.

To support the establishment of the SRI and its methodology, the European Commission conducted two technical studies, involving broad stakeholder engagement and consultations. These studies, completed in 2018 and 2020 [8], led to the publication of regulations in 2021 that established the SRI scheme and its implementation framework [9]. The SRI support team, established in 2021, continues to assist with the SRI's testing and implementation across Member States, providing technical assistance and promoting awareness.

The SRI has gained traction, with several smart buildings and SRI-related projects launched under the Horizon 2020 and LIFE Clean Energy Transition calls, focusing on enhancing the smart readiness and energy efficiency of buildings. As Member States progressively test the SRI scheme, the Directive (EU) 2024/1275 mandates its application to non-residential buildings with an effective rated output over 290 kW by 2027, reflecting the EU's commitment to advancing smart-ready buildings for a sustainable future.

While significant strides have been made in establishing the SRI framework [10], [11], [12], [13], there remains a need to test and refine the current methodology to ensure its effectiveness. This paper addresses this gap by presenting an in-depth assessment of the SRI scheme through the evaluation of 20 diverse use cases, utilizing both Method A and Method B of the SRI assessment scheme. The novelty of this work lies in its comprehensive approach to testing the existing SRI methodology across different building types, usage patterns, and technological integrations.

The primary objective of this study is to critically analyze the current SRI assessment procedures, identify potential areas for improvement, and provide practical recommendations for enhancing the scheme. By leveraging real-world data and scenarios from 20 different buildings, this research offers valuable insights into the practical application of the SRI, thereby supporting its broader adoption and effectiveness in driving energy efficiency and smart readiness in buildings across the EU. To achieve a thorough evaluation, specific criteria were developed to assess the SRI methodology, five qualified engineers have voluntarily performed the assessments and rated the methodology, and data were meticulously collected for each of the 20 use cases. This approach ensures that the results are grounded in empirical evidence and can provide a robust foundation for future refinements of the SRI scheme.

II. Methodology

In this section the approach used to assess the SRI scheme and develop criteria for its evaluation is presented. Initially, the SRI assessment methodology is outlined, detailing how it was applied to 20 different use cases using both Method A and Method B of the SRI assessment scheme. Subsequently, the development of criteria to evaluate the SRI methodology is described, introducing these criteria along with their respective rating systems, and explains how these criteria were implemented for each use case. This structured approach ensures a comprehensive evaluation of the SRI framework, providing empirical data to inform potential improvements.

A. SRI Assessment Methodology

As outlined by the Commission Delegated Regulation 2020/2155 [14], the smart readiness of a building or unit is evaluated by examining the existing or planned smart-ready services and their functionality levels. This readiness is quantified through a rating based on a total smart readiness score, expressed as a percentage representing the proportion of the building's current smart readiness compared to its maximum potential. Consequently, it evaluates the building's effective capabilities to adapt its operation to meet the occupants' and the grid's needs, thereby enhancing energy efficiency and overall performance.

The SRI methodology is structured around three key smart readiness functionalities *(f)*, as defined in Annex Ia of Directive 2010/31/EU [15], which encompass specific impact criteria *(ic)*:

1. **Energy Performance and Operation**
   - Energy efficiency
   - Maintenance and fault prediction
2. **Response to User Needs**
   - Comfort
   - Convenience
   - Health, well-being, and accessibility
   - Information to occupants
3. **Energy Flexibility**
   - Energy flexibility and storage

The SRI assesses nine technical domains *(d)*, each defined by Member States within a smart-ready service catalog that includes functionality levels $(FL(S_{i,d}))$ and corresponding individual scores for each impact criterion $(I_{ic}(FL(S_{i,d})))$. The smart-ready service catalog reflects the state-of-the-art smart-ready technologies, which may differ among building types. Member States also define the weighting factors $(W_{d,ic})$ characterizing the influence of each technical domain *(d)* on each impact criterion *(ic)*, expressed as a percentage summing to 100% for each criterion.

The second SRI technical study's final report outlined three potential assessment approaches: Method A, Method B, and Method C. Methods A and B focus on analyzing the functionality levels of smart-ready services currently implemented or planned for a building. Method A employs a streamlined service catalog, requiring minimal time, effort, and expertise, whereas Method B involves a comprehensive on-site inspection for a more detailed assessment. Method C, envisioned as a future advancement, would utilize measured data to assess the operational smartness of buildings in use.

A and B Methods are incorporated into the SRI assessment package created by the SRI support team, while C is planned for potential implementation. The assessment involves identifying general information about the assessed object and retrieving input data needed for calculations, similar to energy performance certificates.

An SRI assessment requires well-structured input data, including assessor details, property specifics, chosen evaluation approach, applicability of smart-ready features, primary operational levels, and the assessment timeline. The assessor information involves details about the individual or team conducting the assessment, while the general building information includes specifics about the building's location, type, and usage. Methodology selection refers to the choice between Method A or Method B, as discussed earlier. The definition of applicability determines which smart-ready services are relevant for the building, and the main functionality level identifies the extent to which these services are implemented.

The SRI calculation process involves several steps to determine the building's smart readiness score. First, the functionality level for each smart-ready service within a technical domain is defined. Then, scores for each impact criterion and technical domain are calculated. These scores are aggregated to obtain the smart readiness score per impact criterion (SR_{ic}) and technical domain (SR_d). Following this, the smart readiness score for each key functionality (SR_f) is calculated. Finally, the total smart readiness score (SR) is computed, and the corresponding smart readiness rating (SR_{class}) is determined based on a seven-class scale. The total smart readiness score, expressed as a percentage, corresponds to a rating class ranging from highest (90-100%) to lowest (<20%) smart readiness.

The findings of the SRI assessment are recorded in an official SRI report. This certificate includes the total smart readiness score (SR), the total smart readiness rating (SR_{class}), and the smart readiness scores per key functionality (SR_f). Additionally, it provides the smart readiness scores per impact criterion (SR_{ic}) and per technical domain (SR_d). This comprehensive documentation ensures that all relevant aspects of the building's smart readiness are transparently communicated. This methodology was applied to assess the smart readiness of 20 different buildings using both Method A and Method B of the SRI assessment scheme.

B. *Criteria to Assess the SRI Methodology*

To evaluate the effectiveness of the SRI methodology, specific criteria were developed, and data were collected for each of the 20 use cases. These criteria and their respective rating systems are presented in the table 1 below.

The criteria were designed to comprehensively evaluate the SRI methodology's accuracy, usability, comprehensiveness, flexibility, and impact on decision-making. These criteria were implemented for each use case to provide a robust evaluation framework. Each criterion was applied to the 20 use cases to evaluate the SRI methodology comprehensively. The results were recorded and analyzed to identify strengths, weaknesses, and potential areas for improvement in the SRI framework. This approach ensures that the evaluation is grounded in empirical evidence, providing a solid foundation for recommendations on enhancing the SRI scheme.

By systematically applying these criteria, this study aims to offer valuable insights into the practical application of the SRI methodology, supporting its broader adoption and effectiveness in driving energy efficiency and smart readiness in buildings across the EU.

TABLE I. ANALYTIC TABLE OF SRI METHODOLOGY ASSESSMENT CRITERIA

Criterion	Description	Rating System
Accuracy of Assessment	Measures how accurately the SRI methodology evaluates the smart readiness of a building based on its features and performance.	1 (Poor) to 5 (Excellent)
Usability and Simplicity	Evaluates the ease of understanding and applying the SRI methodology for users, including building owners, assessors, and occupants.	1 (Poor) to 5 (Excellent)
Comprehensiveness	Assesses whether the methodology covers all relevant aspects of smart readiness, including different building types, technologies, and use cases.	1 (Poor) to 5 (Excellent)
Flexibility and Adaptability	Evaluates the methodology's ability to adapt to various building types, sizes, and technological configurations.	1 (Poor) to 5 (Excellent)
Impact on Decision-Making	Measures the methodology's effectiveness in influencing decisions related to investments in smart-ready technologies and building improvements.	1 (Poor) to 5 (Excellent)

III. RESULTS AND DISCUSSION

The use cases were randomly generated to ensure a comprehensive evaluation of the SRI Scheme across various building scenarios. This approach was intentional to avoid any biases and to cover a wide range of variables that could affect the SRI calculations. The 20 use cases included a mix of residential and non-residential buildings. Specifically, 10 were residential and 10 were non-residential, representing a variety of building types. The variables considered in the use cases included the climate zone of the building (based on the five climate zones of the SRI methodology as presented in Figure 1), the useful floor area, the year of construction, and the functionality levels of smart-ready services integrated into the building.

The use cases were distributed equally among the five climate zones and five periods of year of construction, with 20% allocated to each zone and each period, ensuring comprehensive coverage and evaluation. The useful floor area varied widely, with most of the use cases (10) being less than 200 m², reflecting the typical size of residential buildings (Figure 2).

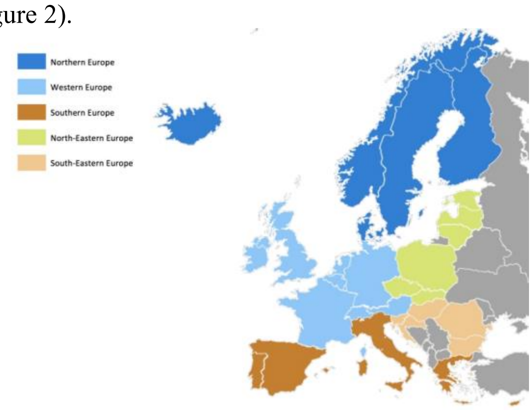

Fig. 1. Climate zones of the SRI methodology

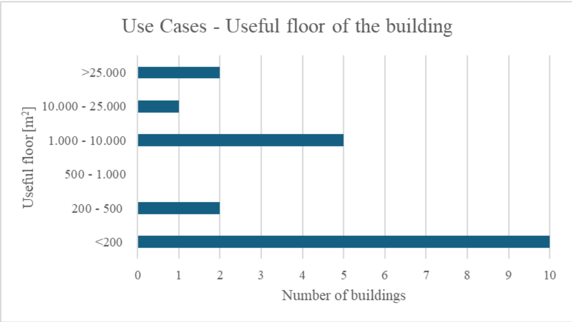

Fig. 2. Useful floor area of use cases' buildings

In addition to the application of the SRI methodology to the 20 use cases, five engineers utilized the SRI EU Excel Tool to assess the smart readiness of the buildings and, in parallel, rated the effectiveness of the SRI methodology itself. This assessment was conducted using a rating system based on the criteria described in the methodology section, allowing for an evaluation of the methodology's accuracy, usability and simplicity, comprehensiveness, flexibility and adaptability, and impact on decision-making.

The criteria were developed to comprehensively assess the strengths and weaknesses of the SRI methodology, ensuring a robust evaluation. Each criterion was applied systematically to all 20 use cases, providing empirical data that was analyzed to identify potential improvements in the SRI framework. By gathering feedback from the engineers during their assessments, the results were used to inform recommendations for enhancing the SRI methodology, further supporting its broader adoption and effectiveness in promoting energy-efficient and smart-ready buildings across the EU. The results of the rating using the criteria and their respective rating systems during the engineers' assessments are presented in Figure 3 below.

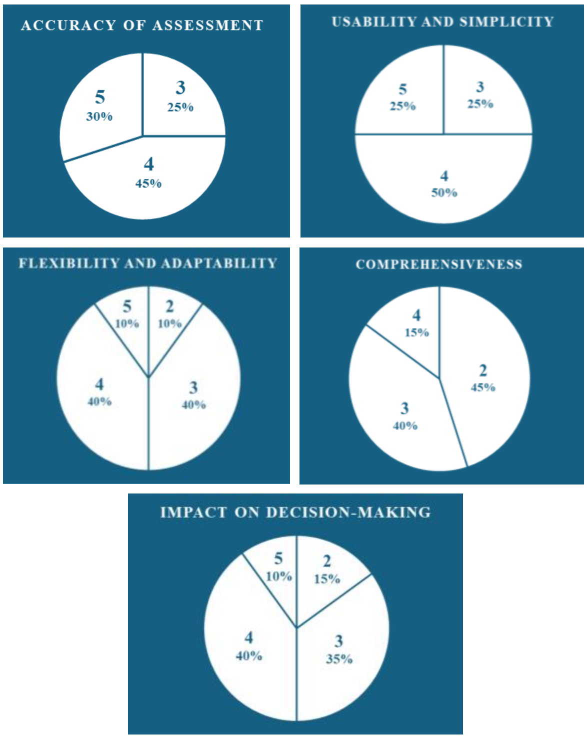

Fig. 3. Rating results of the of the SRI methodology

The results of the engineers' evaluations show how the SRI methodology was rated across the five key criteria. These ratings provide a detailed perspective on the areas where the methodology excels and where further refinements may be necessary.

The accuracy of the SRI methodology was highly rated, with 45% of the assessments receiving a score of 4 (Very Good) and 30% receiving a score of 5 (Excellent). A total of 25% of assessments were rated 3 (Good), indicating that while the methodology is generally effective, there may be room for further precision in specific scenarios. Usability and simplicity were also well-rated, with 50% of assessments receiving a score of 4 (Very Good) and 25% achieving a score of 5 (Excellent). This suggests that the SRI tool is user-friendly, although 25% of the evaluations were rated 3 (Good), indicating that in some cases the interface or processes could be streamlined.

The comprehensiveness of the methodology showed balanced results, with 40% of assessments rated as 3 (Good) and another 40% rated as 4 (Very Good). However, 10% of the evaluations were rated as 2 (Fair), highlighting that while the methodology generally covers a broad range of factors, there may be areas where additional detail or features could be beneficial. Flexibility and adaptability emerged as a notable area for improvement, with 45% of the assessments rated as 2 (Fair) and 40% rated as 3 (Good). Only 15% of the evaluations were rated as 4 (Very Good), and no assessments scored the highest rating of 5. This suggests that the methodology may face challenges when applied to highly diverse or unconventional building types and configurations, requiring further development to handle such variability more effectively.

The effectiveness of the methodology in influencing decision-making was generally well-rated, with 40% of assessments scoring 4 (Very Good) and 10% receiving a score of 5 (Excellent). However, 35% of the evaluations were rated 3 (Good), and 15% were rated 2 (Fair), indicating that while the methodology can guide investment and improvement decisions, further refinement may enhance its influence in more complex cases.

In summary, the analysis of these ratings reveals that the SRI methodology performs well in terms of accuracy, usability, and comprehensiveness. However, the flexibility and adaptability of the tool require further attention, particularly for buildings with unconventional configurations. The feedback from the engineers provides a clear pathway for enhancing the SRI methodology, ensuring its relevance and effectiveness for a broader range of building types and use cases.

IV. CONCLUSIONS

The assessment of the SRI methodology, applied across 20 diverse use cases, provides a comprehensive analysis of its current effectiveness and areas requiring further refinement. The results highlight the strengths of the SRI framework, particularly in terms of accuracy, usability, and comprehensiveness, which were rated highly by the engineers involved in the study. The methodology demonstrates a reliable capacity to evaluate smart readiness in both residential and non-residential buildings, supporting the European Union's broader goals of improving energy efficiency and decarbonizing the building sector.

However, the evaluation also revealed notable areas for improvement, especially in flexibility and adaptability. The lower scores in this criterion indicate that the current SRI methodology may face challenges when applied to buildings with highly varied or unconventional characteristics. This limitation suggests the need for further refinement to ensure the SRI can accommodate a broader range of building types, sizes, and technological configurations, enhancing its utility and relevance across diverse scenarios.

Additionally, while the methodology effectively informs decision-making in many cases, there is room to enhance its influence, particularly in more complex building environments where smart-ready technologies are integrated at different levels. The feedback from the engineers provides a solid foundation for future enhancements, ensuring that the SRI methodology continues to evolve in line with technological advancements and the evolving needs of the building sector.

Further research could explore the integration of real-time data and automation technologies to enhance the precision of assessments, potentially allowing for dynamic adjustments in building operations. Additionally, investigating the potential for scaling the SRI framework to accommodate evolving building technologies and advanced energy systems would support its applicability across diverse future scenarios, ensuring its long-term relevance.

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