WP3-D1: Review of the SRI and other appropriate systems for measuring the 'smartness' of a building and requirements for data monitoring and DIY toolkits as a result.

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SMART LAB

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List of Acronyms

AI	Artificial intelligence
AuI	Augmented intelligence
DEC	Display Energy Certificate
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Certificate
KPI	Key Performance Indictors
LEED	Leadership in Energy and Environmental Design
MFH	Multi-Family Homes
PV	Photovoltaic
SBC	Smart Building Certification
SRI	Smart readiness indicator
USGBC	United States Green Building Council

Executive Summary

The SMARTLAB project, piloted in Limerick city's Decarbonisation Zone, will promote smart technologies that improve building system efficiency focusing on local engagement via Living Lab approach. The SMARTLAB project aims to educate and empower local building owners with the tools they need to embrace the new European Commission's Energy Performance of Buildings Directive (EPBD) certificate scheme known as Smart Readiness Indicator (SRI). Smart building technologies are both a combination of smart devices and digital solutions that support a building's ability to improve system efficiency and internal conditions for the building occupants that dwell within them. The SRI is a certificate of compliance regarding crucial smart technologies needed to improve these systems. Moreover, it will assess a building's smart technological solutions on its ability to improve the overall building energy performance as well as occupant health and wellbeing. In the future, the SRI will be assessed and certified by accredited assessors which will survey buildings using an index of key performance indicators (KPI) related to the overall smartness of the buildings under review. By educating and supporting building owners in the SMARTLAB pilot site on how they can improve the SRI of their building, the SMARTLAB project aims to tackle financial and technical barriers related to the development of building smartness within the Irish context.

Deliverable 3.1, A review of the SRI and other appropriate systems for measuring the 'smartness' of a building and requirements for data monitoring and DIY toolkits as a result. This deliverable explores the various kinds of smart building Display Energy Certificates (DEC) smart services, which are currently available on the market, and how the SMARTLAB project will align with current data monitoring KPIs related to the certification criteria of these smart services.

This report includes a deliverable and is connected to tasks **T3.1** ": Explore the various levels of systems and programmes for enabling smart buildings such as the Smart Readiness Indicator (SRI) and other initiatives such as WiredScore", **T3.2** "The SRI has the most potential due to its drive from the EU and will be the core focus, however a watch function on other initiatives identified will be enabled to ensure future proofing of any recommendations. Based on this review, the data monitoring requirements will be determined and fed to the specification of the DIY toolkits in WP2" and **T2.2** "Investigate the available off the shelf infrastructure for buildings to improve their smart readiness and enable them to avail of such smart services including affordable DIY toolkits that non-experts can deploy".

1 Introduction

Deliverable 3.1 sets out to review the various Display Energy Certificate (DEC) services available in the market today which certify the level of building "smartness". Currently, building smartness is often defined by a building's ability to respond to exterior signals such as climate, grid, and building occupants which are programmed to improve the efficiency of building systems. However, DECs were originally introduced in the 2010/31/EU directive on building energy performance and have been a tool leveraged by the European Commission towards improving the energy performance of European building stock (Commission, 2010). Since this legislation was introduced, there have been several updates to the directive taking the focus from building thermophysical characteristics towards more advanced system improvements using both innovative technologies and digital solutions to achieve ambitious building decarbonisation goals which are linked in with the European Commission's Green Deal.

Key to the Green Deal is its 'renovation wave' initiative which boosts the energy performance of buildings in the EU by tackling energy poverty and the worst performing buildings stock, public building renovations, and decarbonations of building heating and cooling systems. It seeks to improve the energy performance of residential and non-residential buildings within the EU, taking into account the outdoor climate, the indoor climate requirements and effectiveness of the building systems that maintain this indoor climate. Currently, EPC evaluation is now broadening its scope beyond the confines of building thermophysical and system properties to consider the buildings abilities to adapt occupants in the most energy efficient way. To do this, DEC services need to evaluate smart solutions for building systems which, to date, have broad range of options on the market, not all of which are suitable for energy performance needs. Moreover, smart solutions require a plethora of technologically advanced devices and services that enable the monitoring and control of various building systems to suit the needs of the occupants (Apostolopoulos, et al., 2022 ; Dakheel et al., 2020). These systems can respond to commands from digital solutions such as artificial intelligence (AI) or augmented intelligence (AuI) to automate building controls and aid occupant decision making processes respectively. In order to properly discern which technological solution enhances building smartness and thus improves a building DEC, specific KPIs related building smartness have been identified to serve as certification criterium. These KPIs identify building type, location, systems specs, occupant profiles, system functionalities, amongst a plethora of other KPIs which must be addressed with appropriate technological solutions to improve smartness and ultimately, improve the buildings energy efficiency (Dakheel, et al., 2020).

As stated above, this review considered the DEC services available in the market today towards building energy efficiency using smart solutions. These various DECs services are generally provided by private institutions which leverage their services for capital gain. To fully appreciate the scope of DEC certification criteria, this review focuses on the EUs SRI certificate as it is free to use and comprehensive in its evaluation of building smart services. Moreover, the SRI certificate will focus on building system smart solutions that monitors and controls building systems by optimizing energy perforamnce that meet the occupants needs. This literature review is broken into two components, the first focuses on the SRI and how the SRIs KPI criterium defines smartness, then the second component reviews the roles private DEC organisation could have in the SMARTLAB project. The results of the review will be summarised in the Findings section of this deliverable, followed by conclusion.

2 Literature Review

2.1 Smart Readiness Indicator

The Smart Readiness Indicator (SRI) is a high-level key performance indicator of a building's, both residential and non-residential, ability to respond to external signals. The SRI Directive 2018 was initiated as part of the EPBD towards better energy-efficient buildings. Although EPBD introduced the energy performance certificate (EPC, 2010/31/EU) directive as a mandatory DEC for all European building stock to be implemented, the SRI is currently a voluntary scheme and is intended to support the EPC directive, not replace it (Commission, 2010; Verbeke, et al., 2020). Fundamentally, the SRI is a common scheme for rating the smart readiness of buildings, but in practice, the SRI serves as a tool to close the performance gap between estimated energy use based on the building thermophysical and system properties (EPC) and actual energy use based on occupants needs. The SRI serves a means of assessing a building's ability to adjust to exterior stimuli from the grid, climate, and its occupants by recording the actual energy flux of buildings towards better energy management leveraging novel technologies (Volkov & Batov, 2015; Verbeke, et al., 2020). Although the SRI key aspect is primarily focuses on energy performance in buildings, the overall far-reaching aspects of the technological and digital solutions overlap with other disciplines related to connectivity, cybersecurity as well as data protection. Considering the broad scope of these disciplines and the plethora of certification and management series associated with them, the author has opted to omit detailed discussion on the aforementioned themes as they fall outside the scope of building energy performance[1].

The SRI is an important tool for transitioning current and future building stock towards a smart and more efficient future. More so, the SRI is designed to influence stakeholders such as "building occupants and owners, property managers, building designers and engineers, product manufacturers, technology providers, and policy-makers" towards smart and sustainable systems during the design and operational phase of existing and future buildings (Apostolopoulos, et al., 2022, pg. 2). More directly, the SRI supports the role in which building users, owners, tenants, and smart service providers play in improving building energy efficiency and liveability (Verbeke, et al., 2020). Fundamentally, in today's market, any system operation related to a building, whether space heating & domestic hot water to electricity supply and communications connectivity, will have a wide range of smart services with technological solutions that must be organized into relevant domains.

[1]https://smartreadinessindicator.eu/sites/smartreadinessindicator.eu/files/sri2-_second_interim_report.pdf

The SRI is broken down into three themes: energy optimization, occupant health and wellbeing, and grid response. As the SRI is fundamentally a tool towards energy efficiency, priority and weight is put behind technical solutions that optimize buildings systems that burden energy consumption the most. These often take the form of smart controls for heating ventilation and air conditioning systems (HVAC), domestic hot water (DHW), dynamic envelopes, and lighting. These kinds of smart systems can be adjusted and controlled for optimal efficiency with the occupant's needs being met with minimal energy input. Following energy systems, health and wellbeing are considered in the indexing criterium towards the better health of the building occupant. These usually take the form of KPIs related to optimal indoor environmental conditions such temperature, CO_2, and Humidity levels. Lastly, the ability of a building to respond to signals from the grid is a key functionality of smart buildings, and thus, an important theme related to energy efficiency in the SRI. Grid response enables a standalone building to communicate with a network of neighboring buildings to respond to fluctuations in grid demand. For example, a building or group of buildings can reduce energy consumption during peak times, or enable energy assets such as PV and energy storage devices (batteries, V2G Cars) that could provide backup during high grid demand. This grid response can negate the need for auxiliary energy generation during peak times which is often inefficient and dependent on fossil fuel sources. In summary, the SRI is a means to direct existing and future building stock towards smart and sustainable energy solutions for the built environment.

2.2 SRI Calculation Key Performance Indicators

To address data requirements for DIY toolkits, SRI KPIs need to be reviewed in detail to ensure that the appropriate sensors can be identified in the findings section of this deliverable. The SRI KPIs can be broken into two key sections. The first section determines the building archetype (location, age, thermophysical properties, use, and size). The second section evaluates the smartness of the building, weighting the scores related to the geographical context of the building (from the first section inputs). For example, a house situated in northern Europe in a heating-dominated climate will weigh the SRI scores in favor of heating energy efficiency; whereas, a building situated in a southern European country, with a cooling climate, will favor cooling efficiency. The first section of the SRI serves only to provide the direction in which weighting should be applied to the overall assessment of energy efficiency and smartness.

The aforementioned three SRI themes are broken into KPIs that cover 9 domains and 7 impact criteria; of the Seven impact criteria, four are for occupant health and wellbeing, two for energy optimization, and one related to grid flexibility (Figure 1[2]).

[2] https://smartreadinessindicator.eu/sites/smartreadinessindicator.eu/files/sri_summary_2nd_interim_report.pdf

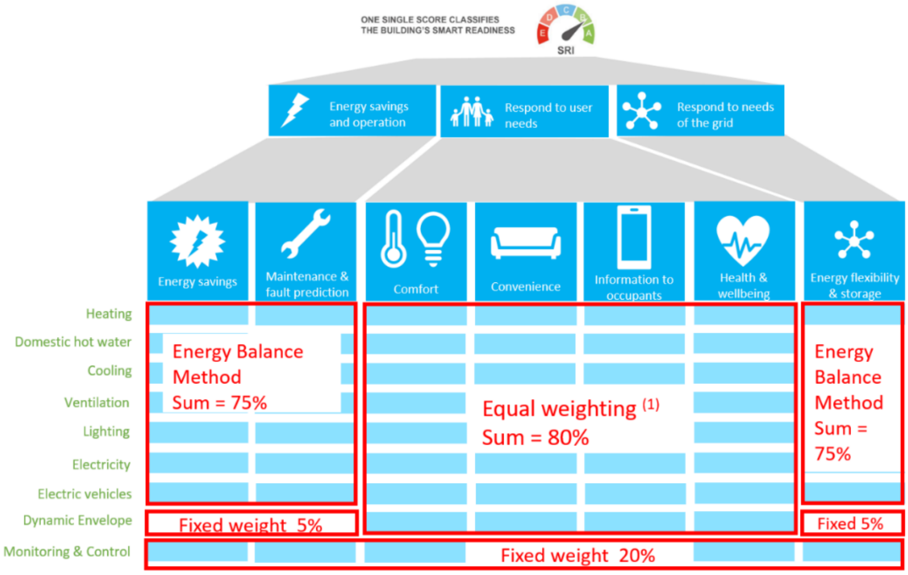

Figure 1 SRI KPI Calculation Structure[3].

These seven criteria are assessed across nine technical domains, such as heating, cooling, and lighting. Each technical domain is assessed on its level of functionality in response to external stimuli. The least functional domain is referred to as manual, where a building occupant must manually control and monitor the technical domain i.e., switch on heating when it's cold. The most functional, or smarter domain, is where the technical and digital solutions (devices and software) regulate the domain with little or no conscious input from the occupant i.e., the heating switches on automatically based on a machine learning algorithm that learns from occupant behavior. The more functional a domain is, the higher the score SRI score will be for building smartness, with optimal scores in domains that contribute to energy efficiency (Figure 2). Finally, the SRI considers the percentage of floor area influenced by smart devices. This floor area can be considered lived space, which removes semi-exposed spaces such as garage and attic storage floor area as these spaces have little influence on energy use; however, this is up to the assessor's discretion who may choose functionally levels pending building type or use. In summary, the SRI KPIs focus on the functionality of smart solutions within the 9 domains of a building occupant's needs with an overall focus on energy efficiency.

[3] https://x-tendo.eu/wp-content/uploads/2020/01/SRI_F1_guidance-document_X-tendoV_Reviewed_Beta_v_final.pdf

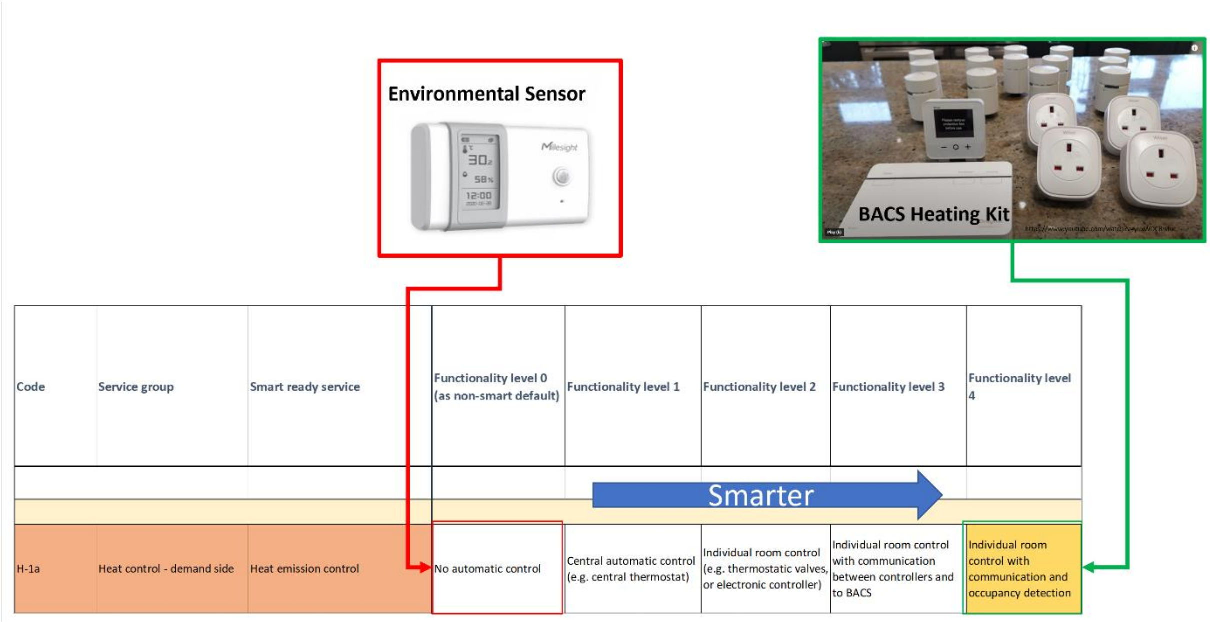

Figure 2 Example of functionality score with associated smart solutions.

2.3 The SRI Assessment

Much like the original EPC certificate, the SRI will need to be assessed by an accredited assessor to evaluate the level of smartness for current and future building stock. As the primary goal of the SRI systems to improve energy efficiency, EU guidelines suggest using current EPC assessors to adapt the SRI DEC assessment. However, as the SRI is still in development across the EU, each member state will have to explore the most appropriate strategy towards SRI implementation and adoption, a decision best assessed at member state level (no one size fits all)[4].

However, even at member state scale, assessors may differ in opinion and expertise depending on their background. For example, a case study of a near-zero energy building (nZEB) in Bolzano, Italy found that assessors can interpret SRI technical solutions differently (Vigna, et al, 2020). These experts trialed the SRI on this new nZEB building generally agreeing across sections of the SRI devoted to building archetype, use, size, and location; however, the expert assessors differ on areas of the SRI related to the main functionality and structure of the building systems. The assessors found issues with defining the presence of the system (hot water storage, heat recovery) difficult to qualify based on assessor's experience. Although in this example, the assessors were ultimately able to reconcile their divergent findings into a final score, any difference in interpretation can have real financial impacts on buildings owners in a real-world context.

[4] https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/smart-readiness-indicator_en

Fundamentally, the assessment process in the SMARTLAB project should be agreed by project partners to help prevent any misunderstanding or misinterpretation by the designated assessors. Furthermore, a notable finding from this study illustrated the marginal score a modern building attained with an average score of C (61%) despite the modernity of the systems (Vigna et al, 2020).

2.4 SRI Costs

The cost of smart technologies can vary depending on the device spec, functionality, and complexity of implementation (DIY or Expert installation). For example, the cost of an environmental sensor that records indoor conditions such as temperature, CO2, and humidity, can be in the region of €100 - €300 euro with no additional installation costs. However, if a building owner wishes to address its heating systems toward smarter more efficient systems, the prices can vary between €5,000 - €15,000, potentially costing more depending on material and labor costs (Apostolopoulos, et al, 2022).

Apostolopoulos, et al (2020) examines the cost associated with improving SRI scores in buildings built after 2010 in five climate zones across Europe. The methodology applied two smart retrofit scenarios, light and deep retrofits concerning the improved smartness of each building. On average, the cost of increasing single family homes SRI score by 4% was €5,000 across these building type in this case study (Apostolopoulos, et al, 2022). Although less expensive smart solutions can improve a building's SRI, deep solutions (solutions that overhaul entire systems and sometimes fabric of the building) were the only solutions that had meaningful improvements to the SRI scores.

2.5 SRI for Ireland

As Ireland is situated in western Europe with a heating dominated climate, the weighting factors for SRI scoring primarily focus on space heating efficiency. Moreover, with roughly 40% of Irish building stock built before the introduction of building energy standards (pre-1980), a substantial amount of Irish building stock will need energy refurbishment to hit EU Green Deal 2030 and 2050 targets[5][6]. Thus, building owners of old energy inefficient building stock will need consideration when adapting the new SRI framework so that SRI technical solutions can be appropriately applied. Furthermore, as these older building systems and fabrics will need modernization, the SMARTLAB project may provide support by educating such building owners on the value of improving their EPC and SRI in tandem.

[5] https://episcope.eu/building-typology/country/ie/

[6] European Green Deal - Consilium (europa.eu)

SRI is designed for European building stock, both residential and non-residential. Building stock is classified into geographic region, use, size, age, and condition. This is standardized and common across EU nation states. However, some member states vary in definition with regards to categorizing building stock with Ireland being one of these exceptions. Ireland various in its description of multifamily homes (MFH) and how these buildings are surveyed from a local and European point of view. A majority of European countries survey multi-family buildings (apartment blocks) as a single building, whereas Ireland surveys individual apartments as single buildings (or dwellings). For this SMARTLAB Project, this will require some consideration when describing the smartness of MFHs for the SRI indexing tool to appropriately describe individual apartments rather the buildings themselves[7][8].

2.6 Private Display Energy Certificate Organizations

Building DEC organisations have played important roles across both, UK, Europe, US, and multiple markets across the developed and developing world, in establishing best practice in building energy performance. Once established in a dominate market space (USA, Europe), private building DEC firms often serve a role of standardising best practice and prestige across diverse markets which incentivise building owners to invest in these DECs, and by extension encourage better energy design and operational energy practices. For example, the Leadership in Energy and Environmental Design (LEED) brought to the market by the United States Green Building Council (USGBC) is a prime example of a private DEC institution leveraging best practice via a dominant market toward global standardisation[9]. LEED buildings are now considered the commercial standard for sale and rental of commercial office buildings in both the US and European real estate markets as their global recognition opens up their intrinsic value to global entities[10][11]. Given the role private DEC firms play in the building energy sector, this review identified three private DEC organisations developing and promoting Smart Buildings Certificates (SBC)[12] which are available on today's market.

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[7] https://ndber.seai.ie/BERResearchTool/ber/search.aspx

[8] https://episcope.eu/building-typology/

[9] https://www.usgbc.org/

[10]https://www.gbci.org/europe#:~:text=LEED%20is%20the%20most%20widely,ACPs%2C%20and%20Regional%20Priority%20Credits.

[11] https://www.bsria.com/uk/news/article/breeam-or-leed-strengths-and-weaknesses-of-the-two-main-environmental-assessment-methods/

[12] https://smartbuildingcollective.com/why

Currently, there are multiple SBC services for building developers and owners towards the design and operation phases of their buildings. Most of these organisations focus their services on non-residential entities promoting a combination of building system operational optimisation and prestige. Furthermore, these services do not describe in great detail the format and structure of SBC KPI functions. For the SMARTLAB project, the three private SBC services were chosen due to their scope in specific SBC types which covered a wide range of potential buildings within the SMARTLAB demonstration area. These services are WiredScore, Smart Building Collective, and the Irish Manufacturing Research (IMR) company[13][14]. All Three organisations promote the principles of efficiency and improved occupant experience, with a specific focus on operational optimisation toward cost saving, energy efficiency, and improved occupant well-being. The following paragraphs will review each SBC individually culminating in a final summary covering their relevance to the SMARTLAB Project.

WiredScore is a US-based company specialising in SBC across broad range of buildings, including residential (focus on the building owner/ landlord). The WiredScore promotes a wide range of assessment criteria for building services specific to buildings owners such as mobile and wireless connectivity, points of infrastructural entry, electricity resilience, standardised access agreements…etc. For WiredScore buildings, much like the SRI KPIs, there are 7 sections covering 105 specific criteria that can be accredited. Furthermore, WiredScore promotes a SmartScore for building occupants and technical related services ranging from user functionality (health and wellbeing, safety and security) to technological foundations (cyber security, data sharing, building systems) of which WiredScore KPIs covered 13 sections consisting of 105 specific criterium, altogether covering a considerable number of smart services. Although WiredScore covers a large range of smart services, the overall approach is catered towards commercial building owners both residential and non-residential. To purchase a WiredScore, the overall cost (depending on building and client type) can vary between $1,000 - $10,626.

Smart Building Collective is a Dutch organisation which sits within the same space as WiredScore. Much like the WiredScore, the Smart Building Collectives SBCs focus on building operational efficiencies and prestige; however, there is an added aspect of educating and enhancing clients SBC score via collaboration. Moreover, Smart Building Collective advertise both design and operational phase support to ensure buildings are constructed and operated in line with smart operational criterium. Ultimately, Smart Building Collective are the European equivalent of WiredScore, focusing their attention on non-residential building owners towards operational efficiencies and prestige. The cost of the service varies by building type but are not clearly advertised.

[13] https://wiredscore.com/

[14] https://imr.ie/

The IMR company has a Smart Industry Readiness Index (SIRI) which is pivoted towards industrial operational optimisation and excellence, a similar modus operandi as the prior SBC services. However, the SIRI certificate is a process-based certification designed to improve the smartness of primary and secondary service industries (materials and manufacturing), with the former SBCs marketed toward tertiary services (office space). Although the SIRI is less established and often less relevant to urban environments than the aforementioned SBCs services, it still supports the scope of the SMARTLAB project considering the diverse range of building types and uses found within the demonstration area. Ultimately, SIRI could serve as a useful tool towards any building owners which provide material or manufacturing activities (breweries, coffee rotisseries, textile producers). The cost of the service varies by type of industry and are not clearly advertised.

In conclusion, private SBC services supply a wide range of services for accrediting commercial stakeholders for both operational efficiencies and recognition of operational excellence. Although the SBC comes with an upfront cost, depending on building type, location, and size, the accreditation has far reached commercial benefits when marketing buildings for commercial leases. This is a proven and standard practice in the building energy DEC practice.

3 Findings

The following findings are based on the requirements for data monitoring which have the most substantial impact the Irish SRI KPIs. Considering SMARTLAB duration and scope, the optimal solution for influencing SRI scores is ranked as follows:

1) Smart heating solutions (space, storage, and DHW) - Optimal impact on energy efficiency
2) Smart Energy Meter (consumption, storage, generation, and grid flexibility) - Cost beneficial and optimal impact on energy efficiency and grid decarbonization
3) Environmental sensor, first supporting heating energy systems (thermostats) and secondly improving occupant wellbeing (indoor air quality and thermal comfort) - Cost beneficial and optimal impact on thermal comfort and occupant wellbeing

All sensors' services should be linked to a monitor and control network.

3.1 Smart Heating

Smart heating services are costly and depend on the ability of the owners building to adapt to new systems i.e., whether the building has a heating system that is ready for adaptation of smart services, or the ability of the owner to invest in a new system. Furthermore, these smart systems are not DIY friendly, and will often require installation from an accredited professional. However, if there are SMARTLAB participants with appropriate systems as well as a willingness to adapt or invest, then it will be possible to apply heating related smart solutions.

3.2 Smart Meter

Smart meters specifications must be capable of real-time energy readings to avoid costly energy behavior and inform the building owners when to reduce consumption, particularly during peak times (demand side management). Smart meters are generally affordable and provide a service that supports cost saving energy behavior; however, smart meter costs can vary depending on more advanced functions that record energy generation and storage as well as export toward the following scenarios:

1) Record energy in storage for use or export
2) Record energy generated for use or export
3) Record energy exported for financial reimbursement

Furthermore, smart meter solutions can couple with smart plugs which are budget friendly devices that can provide high resolution electricity usage data as well as control across electrical building equipment. However, a watch-function (automated notification of updates) will be used to evaluate whether these smart plugs can be classified as part of the building or external equipment independent of the building.

3.3 Environmental Sensors

Environmental sensors are relatively cheap when compared with other smart solutions designed for use in buildings; furthermore, these sensors enhance the user's ability to monitor environmental conditions towards optimal health and comfort, in turn achieving a majority of occupant health and wellbeing criteria toward the monitoring functionality of the SRI calculation. However, without appropriate environmental control systems i.e., automated window control when CO_2 levels exceed indoor thresholds, these sensors have limited ability to influence the overall SRI scores. Moreover, considering the limitations of environmental sensors to cover entire floor areas of multi-zoned buildings, most building owners will need to invest in multiple sensors to cover the total floor area of their buildings.

3.4 Remaining categories

Building ventilation, cooling, dynamic envelope, and lighting will be promoted as part of the SMARTLAB roll out but will not be prioritized as part of the sensor kit due to duration and cost- benefit associated with these categories. For examples, consider the cost benefit of dynamic building envelopes which influences the passive behavior of buildings utilizing sensors, automated mechanisms, and smart services to regulate the indoor thermal comfort leveraging outdoor passive energy. During cold winter days, daylight sensors connected to automated window shading will automatically open all shading to let in passive solar rays which help keep building temperature up using passive solar gains. The smart solutions, although fitting for the needs of Irish buildings stock, would be a costly solution for such dynamic measures compounded with the need for expert installation which is ultimately a prohibiting factor for its use in the SMARTLAB project and therefore not included in the sensor kits supplied to project participants[15].

Finally, a watch-function will be placed on lighting, although the costs of retrofitting a building's wiring towards smart solutions can be expensive, new smart-lightbulbs are available on the market which are relatively cheap and easy to install. However, much like the aforementioned smart plugs, it is unclear if these bulbs can be considered part of the building or external solutions.

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15 https://www.skylight-blinds.ie/skylight-blinds/roto?gclid=Cj0KCQiAyracBhDoARIsACGFcS76S0G2onS2jcItTdf4Yq1AJ7gCtERwYcdLlvMBvn-GCkHJ-tQbAuwaAhAKEALw_wcB

4 Conclusion

Deliverable 3.1 set out to review SRI and other similar DEC services available on the market as well as the data monitoring needed to fulfil SRI KPIs. The review demonstrates how the SRI surveys building attributes related to smartens which is outside of the usual thermophysical and system properties associated with energy performance certificates. Furthermore, the review highlighted the role the SRI plays in supporting current building energy performance certificates, rather than replacing them. Although the building smartness covers a broad range of criteria, particularly occupant health and well-being, the overall goal of the SRI is to improve building energy performance which ultimately biases results towards energy efficient solutions. As such, the data monitoring solutions suggested in the findings section describe heating monitoring and control as the most impactful solution towards energy efficiency in the Irish context which is where the SMARTLAB pilot site is based. However, heating monitoring and control tend to be more expensive and complex when applying smart solutions to older building stock; moreover, these complex costs are compounded by need for expert installation driving up cost and removing the DIY element of the solution. Finally, two more technical solutions are suggested, the first is energy meter which is relatively cost friendly; however, depending on model, will need expert installation. The second is an environmental sensor, which is the converse of the former being more expensive but requires non-expert to installation. Finally, alternative DEC services in the private sector were reviewed with three organisations ear marked to cover the diverse range of building stock in the pilot site.

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