

Application of SRI Advanced Evaluation on Auto-DAN Case Study

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Abstract

Building Automation represents one of the key leverage points for speeding up the decarbonization of the building sector. In this framework, two schemes exist: the BACS (Building Automation and Control Systems) classification, regulated by the EN ISO 52120-1:2022 standard, and the SRI (Smart Readiness Indicator), introduced by the European Commission. Although these two methodologies for assessing building automation levels are similar, they still remain disconnected so far. This paper presents an innovative tool that combines these two approaches, allowing the user to automatically assess the BACS class of a building starting from a completed SRI assessment. This tool was initially developed in MS Excel and then converted into a MATLAB app. It also allows the user to highlight possible automation bottlenecks and to estimate the potential energy savings linked to the suggested renovation actions, based on the BACS factor method. The tool has been validated within the Auto-DAN project (GA number 101000169), using a historically protected building (Palazzo Terragni in Lissone) as a case study. The analysis has shown how, although the planned renovation actions will lead to a substantial increase in the SRI score, the presence of automation bottlenecks in some services is limiting the improvement of the BACS classes, highlighting the need for an integrated vision for automation. This tool is intended as operational support for both building and energy managers to use the SRI framework as the basis for techno-economic assessment and regulatory compliance checks through a user-friendly interface, enabling even a non-technical user to compare the results of both assessment frameworks.

Keywords

Auto-DAN, Building Automation, Energy Saving, SRI, Tool

1. Introduction

Building automation is considered one of the key sectors for improving the sustainability of the building industry, along with a substantial increase in user comfort. Building Automation and Control Systems (BACS) allow the automatic regulation of all the major services of buildings (heating, cooling, ventilation, lighting) depending on external conditions and occupancy patterns, enabling more efficient use of energy and maximising the user's well-being [1] [2]. The introduction of BACS also increases the building's value, and it is also a key component in sustainability certification schemes like LEED [3].

A key standard for the building automation sector is the EN ISO 52120-1:2022 [4] standard that provides a globally harmonized methodology to evaluate the impact that the BACS have on the energy efficiency of the building, defining four levels of efficiency (from A to D) and facilitating the design of this type of system. This standard is also used to set minimum requirements for new buildings in terms of automation (for example, in Italy, a minimum Class B is required for new non-residential buildings, D.M. 26/06/2015, [5]).

In parallel to this advancement, the European Commission (EC) has introduced in the Energy Performance of Building 2018/844 (EPBD) [6] a new indicator called SRI (Smart Readiness Indicator) with the aim of assessing the capability of buildings to integrate smart technologies to improve energy efficiency, comfort and energy flexibility with respect to the needs of both the users and the national grid. This indicator is calculated using an articulated methodology divided into nine technical domains (e.g., heating, ventilation, dynamic building envelope...), and it is considered by the EU a key tool to plan the energy transition towards more sustainable and smart buildings by 2050.

Despite this increasing interest of the EC, the SRI has not reached a high level of popularity among European building experts, and the reasons can be found in: 1) low level of knowledge and awareness; 2) technical and methodological complexity; 3) an ageing building stock, which often results in low SRI scores and significant challenges in the implementation of BACS; 4) slow bureaucracy in making SRI an official certification scheme at national level and 5) an energy-centred approach, that considers energy consumption certificate as the only possible indicator for the performance of building, also because is the one that directly affects energy bills. For these reasons, research centres, universities, and R&D branches all over Europe are investing money in SRI-related projects [7]. Several European Commission initiatives are actively developing tools and methodologies related to the SRI [8]. Significant progress has been achieved in the policy domain [9] in the development of SRI calculation tools [10] [11] and in extending SRI applicability to historical buildings [12]. The tool presented here, however, is unprecedented in its approach: it uniquely integrates the SRI methodology with the UNI EN 52120 certification framework, creating a standardized bridge between two complementary but traditionally separate evaluation schemes. A further push to the spread of SRI assessment will come in 2027, when the SRI assessment will become

mandatory for non-residential buildings with thermal plants > 290 kW (the same type of building that is subjected to the ISO 52120 requirements) [13].

2. Background and Related Work

During the last 4 years (2021-2025), RINA has collaborated in the Auto-DAN project [14] (GA number 101000169), a Horizon 2020 project which aims to make EU buildings smarter using augmented intelligence and an advanced monitoring system. RINA focused on the development of an extended framework for the SRI assessment, facing the problems that affect the SRI methodology, especially point e). For this reason, a new tool that combines the SRI methodology [15] with the EN ISO 52120:1 prescription has been developed. This tool, initially developed as an MS Excel spreadsheet and then converted into a MATLAB app, allows to use of the SRI assessment as a basis for: 1) evaluating the BACS class of the different domains of the building; 2) individuating the most critical service that acts as bottleneck; 3) have an estimation of the energy saving that will occur if these improvements would be implemented. Although designed for energy managers, the tool is easy to use and does not require expert knowledge. It can support non-technical users through a simplified, one-step process or help real estate funds manage multiple buildings by leveraging SRI assessments to gain actionable insights into building performance.

The Auto-DAN project is being tested in six demonstrators spread across Spain, Italy, and Ireland. These demos vary a lot in size, building use, and type of users, offering a wide range of different scenarios. The implementation of the Auto-DAN solution consists of the development and installation of an interactive dashboard to show live energy consumption to the user, together with suggestions towards a smart use of appliances and other electric loads to optimize energy consumption, developed using Augmented Intelligence and predictive models. Therefore, comparing the pre- and post-Auto-DAN scenarios, the major smart improvements are related to the sub-metering of energy consumption and reporting and information to the occupants.

All the demos underwent SRI assessment of both scenarios, and generally, an improvement from class G to class E or F has been seen. Among all the demos, the most interesting case study has been represented by Palazzo Terragni in Lissone, Italy, a heritage-protected building dating back to the 1930s, which is now an auditorium and theatre. An external view of the building is presented in **Figure 1**. This demo will implement more smart-ready services compared to the others, while also developing Demand Side Management (DSM) strategies. For this reason, this demo will be used as a case study for the testing of the tool.

3. Body of Text

3.1. The EN ISO 52120-1 Standard

The SRI assessment methodology has been developed starting from the service list of the EN ISO 15232 standard, introduced in 2012 and substituted in 2022 by the

EN ISO 52120 standard, keeping the same structure and the same smart services. This standard defines four levels of automation (A, B, C, D) for a large catalogue of services, and depending on the result of the different services, identifies a BACS class for the domains (heating, cooling, ...) and for the whole building. Furthermore, the same standard provides coefficients to quickly estimate the impact that the BACS have on the energy performance of the building. These coefficients, called BACS factors, are based on statistical estimation and are related to the type of domain and to all four classes (class C is used as reference with a factor equal to 1, classes A and B have factors smaller than 1, and class D has a factor greater than 1). These factors represent a key element in assessing how building automation affects energy efficiency. BACS factors also vary by building type and technical domain, enabling more detailed energy performance estimates. UNI EN 52120 provides specific tables for categories such as residential and non-residential, with significant differences across automation classes.



Figure 1. External view of Palazzo Terragni in Lissone (image from *Viaggiare in Brianza*, accessed May 2025) [16].

3.2. The SRI Assessment Framework

Compared to the 52120-1 standard, the SRI assessment framework presents some pros and cons, despite the fact that the topic is the same and, as said in the previous paragraph, a high number of services overlap with the two frameworks. Below is an overview of the main advantages and disadvantages.

Pros:

1) The SRI assessment is not limited to the traditional automation system of electrical and thermal plants but also includes innovative aspects like dynamic building envelope, Electric Vehicles (EV) charging, and wider monitoring and control functionalities, especially related to energy flexibility, demand side management, and energy exchange with the national grid.

2) The SRI assessment is a multi-dimensional assessment that evaluates the effect that every service has on seven impact criteria:

- a) Energy efficiency: reducing energy consumption and optimize resources.
- b) Energy flexibility: adapt and respond dynamically to the needs of the national grid.
- c) Comfort: optimize internal conditions by regulating temperature, indoor air quality (IAQ), lighting, ...
- d) Predictive maintenance: facilitate maintenance to reduce faults and operating costs.
- e) Convenience: user-friendliness of the building.
- f) Health and well-being: optimize user experience in terms of both physical and psychological aspects.
- g) Information to occupants: inform the user about the real-time operation of the building services; this allows for more detailed reporting of the result, with information on the score for each impact score and for each domain.

Cons:

- 1) The SRI assessment does not provide any information on energy consumption related to the smartness level.
- 2) It does not represent a mandatory law provision, but it is, by now, an optional assessment, still in the testing phase (it will become mandatory in 2027 [13]).
- 3) It is limited in diffusion, often perceived as complex, and totally unknown to non-technical people.

Besides this, there is a huge difference between the two assessments: the SRI methodology assesses each Smart Ready Service (SRS) by itself, providing the result of the whole assessment based on each domain and each impact area; the EN ISO 52120-1 assessment on the other way prescribe that to fall in a specified BACS class, all the services related to that domain must be at least in that class (e.g., to be in class B related to the heating domain, all the applicable services of the heating domain must be at least in class B).

Table 1 provides a schematic overview of the pros and cons of the two methodologies.

Table 1. Overview of the comparison between SRI and EN ISO 52120 methodologies.

Comparison of the Methodologies	SRI (Smart Readiness Indicator)	EN ISO 52120-1
Objective	Assess smart features	Classify automation level
Method	Service-by-service, multi-criteria	Domain-level, all services must align
Innovation	Covers EVs, grid flexibility	Focused on HVAC and lighting
Output	Detailed scores per impact and domain	Simple A-D class per domain
Limitations (cons)	Complex, not mandatory yet	Less flexible, less detailed

For all these reasons, a future is taking shape in which SRI assessment will become increasingly widespread. However, there is still a lack of common understanding of this scheme, which is increasingly perceived as complex, and the as-

assessment fails to provide practical guidance to users, whether ordinary consumers or energy managers, on the actual savings they might achieve on their energy bills.

3.3. Tool Creation

The SRI-52120 automatic tool has been developed by coupling the analogous services of the two schemes. In **Table 2**, all these services for the heating, domestic hot water (DHW), cooling, ventilation, and lighting domains are listed. The table reports the number of analogous services present in each domain and the names of these services.

Table 2. List of common services across the two schemes (EN ISO 52120:1 and SRI).

List of Common Services per Domain	# of SRS Services	# of BACS Functions	Common Services
Heating	10	6	Emission control Emission control for TABS Control of distribution pumps in networks Control of thermal energy storage operation Heat generator control Heat generation control (heat pumps) Sequencing of different heat generators
DHW	5	3	Control of DHW storage charging with direct heating or electric HP Control of DHW storage charging using hot water generation Control of DHW storage charging with solar collectors
Cooling	10	7	Emission control Emission control for TABS Control of the distribution network chilled water temperature Control of distribution pumps in networks Interlock Control of thermal energy storage operation Generator control for cooling Sequencing of different heat generators
Ventilation	6	5	Supply air flow control at the room level Air flow or pressure control at the AHU level Heat recovery control Supply air temperature control at the AHU Free cooling
Lighting	2	2	Occupancy control Daylight control

For each one of these services, the work of coupling the functionality level from the SRI assessment and the BACS class from the 52120 standard has been done, so that once the SRI assessment is conducted, it is possible to automatically have the corresponding value of the BACS class for that service. An example of the coupling is provided below in **Table 3**.

Table 3. Comparison between the BACS classes and the SRI functionality levels for the Heat emission control service.

Comparison of the Functionality Levels	
Smart Ready Service	EN ISO 52120-1 Function
<u>Heat emission control</u>	<u>Emission control</u>
0. No automatic control	D
1. Central automatic control (e.g., central thermostat)	D
2. Individual room control	C
3. Individual room control with communication between controllers and to BACS	A
4. Individual room control with communication and occupancy detection	A

Once this process is carried out for all the SRS, it is possible to evaluate which is the BACS class of each domain by looking at which is the worst-performing service of that domain (among the applicable ones).

After having collected the BACS class for each domain, it is possible to use the BACS factors to evaluate the possible energy saving in passing from the actual class to the next one. In **Figure 2**, the flowchart (created by the authors) of the whole process is presented, while in **Table 4**, an example of BACS factors concerning the heating domain is reported. It is important to note that the tool automatically reads from the SRI assessment the building typology, and it uses the appropriate BACS factor, since they strongly depend on building typology.

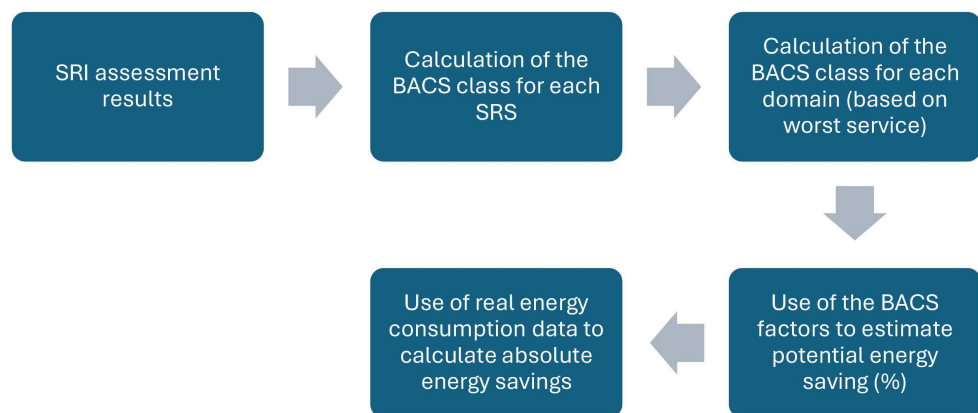


Figure 2. SRI tool flowchart (created by the authors).

Table 4. BACS factor for the heating domain in non-residential buildings [4].

BACS Factor—Heating (non-residential—other)			
D	C	B	A
1.56	1	0.71	0.46

Therefore, supposing that, once having assessed that the building is in class C, it is possible to estimate that it will reduce its consumption for heating by 29% by passing to class B. Once the user has the value of yearly energy consumption for heating (in kWh or sm3 of natural gas), he/she can pass from percentage terms to absolute terms and then perform the financial analysis of possible investments in automation.

In conclusion, the user has the possibility of having insight into:

- BACS classes are in his building for each domain
- Which are the worst-performing services for each domain
- What can be the energy saving linked to the implementation of this improvement (in percentage and absolute terms)

All this information can be received by only updating the SRI assessment spreadsheet in the tool, without the need to manually open or interact with the spreadsheets. The tool is designed to automatically read the right cell of the assessment as input data.

The tool was originally developed in MS Excel, and in the initial version, users were required to manually transfer data into the tool. Then, it was developed, creating a MATLAB App, further increasing the level of detail. In this last version, the user only has to upload the SRI Excel file, without having to find the value in the right cells, extensively increasing the user-friendliness of the tool. Once the calculation is completed, this is the result that will appear to the user (Figure 3).

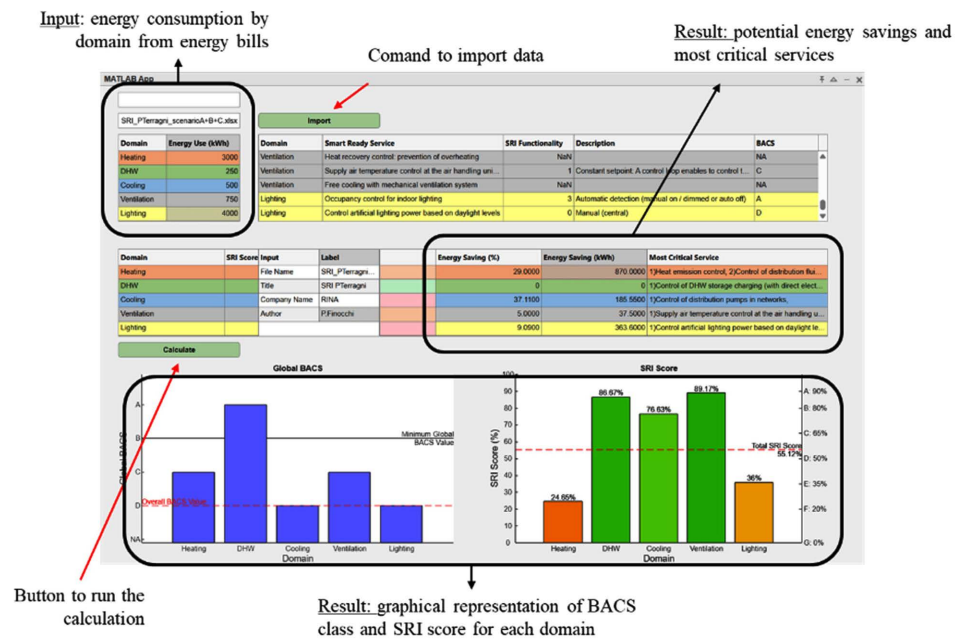


Figure 3. Result dashboard of the MATLAB app (screenshotted from the tool).

Furthermore, the tool can be used in the design phase of a new building, to link future SRI levels to the law requirements imposed by the 52120-1 standard (minimum class B for new non-residential buildings).

3.4. Possible Tool Limitations

The tool has some limitations, mainly due to the structure of the UNI EN 52120 standard. The first limitation concerns how BACS factors are defined: they are based on a statistical and probabilistic approach. Although this method is supported by a large amount of data, it is still less accurate than a dynamic energy simulation of the building.

The second limitation is that several aspects included in the Smart Readiness Indicator (SRI) are not considered by this tool, because they are not part of UNI EN 52120 (for example, EV charging).

However, these limitations are directly related to how the standard was designed. In addition, the fact that UNI EN 52120 is widely adopted shows its practical relevance and usefulness.

3.5. Application to a Case Study—Palazzo Terragni (Lissone)

As written in the chapter “Background and related work”, Palazzo Terragni in Lissone represented the most interesting case study in the Auto-DAN project concerning SRI. Palazzo Terragni is one of the most emblematic examples of rationalist architecture in northern Italy, and it is now used as a municipal auditorium and theatre for local plays. In the context of Auto-DAN, the following renovation activities are planned [17]:

- Installation of a user dashboard for live monitoring of energy consumption
- Installation of IAQ sensors and occupancy detection
- Implementation of a strategy of demand response in the control system of the cold thermal energy storage (TES)
- Implementation of a strategy of demand response in the control system of DHW production inside restrooms

This allowed us to have a substantial impact on the SRI score, which passed from 11% (class G) to 55% (class D). For this reason (*i.e.*, it is a building with a medium-high level of automation), it has been interesting to apply the tool to understand if the increased level of SRI leads to a corresponding increase in the BACS class.

Below, the result of the application of the tool to the post-AutoDAN scenario of Palazzo Terragni is presented (Figure 4, Figure 5).

Energy Saving (%)	Energy Saving (kWh)	Most Critical Service
29.0000	870.0000	1)Heat emission control, 2)Control of distribution flui...
0	0	1)Control of DHW storage charging (with direct elect...
37.1100	185.5500	1)Control of distribution pumps in networks,
5.0000	37.5000	1)Supply air temperature control at the air handling u...
9.0900	363.6000	1)Control artificial lighting power based on daylight le...

Figure 4. Details of the result dashboard—energy saving and critical services (screenshotted from the tool).

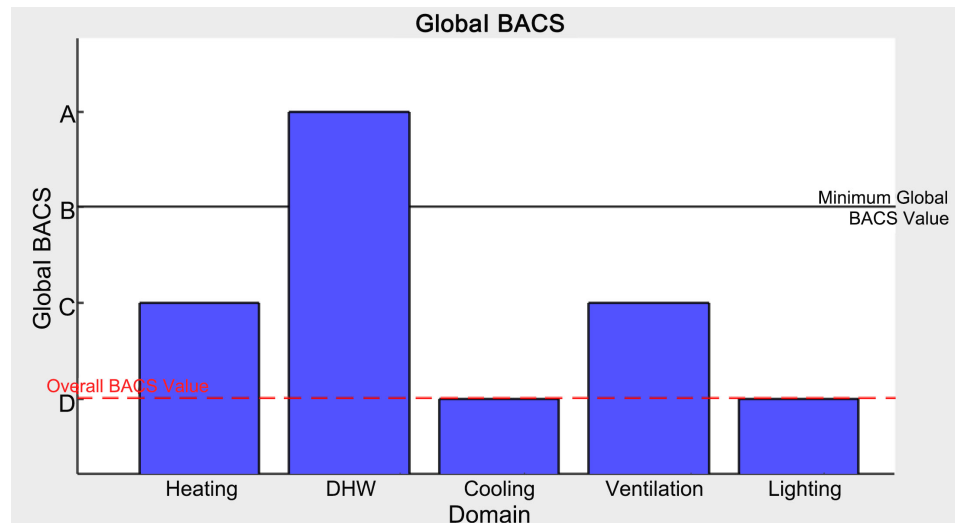


Figure 5. Details of the result dashboard—BACS classes (screenshotted from the tool).

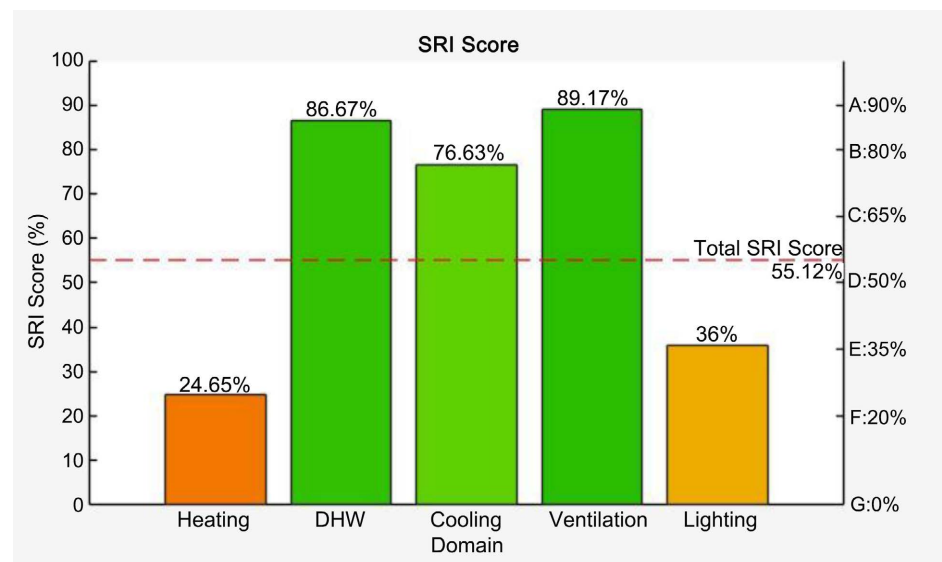


Figure 6. Details of the result dashboard—SRI.

3.6. Results Discussion

In relation to the results presented in the charts above (Figures 4-6), different interesting aspects could be extrapolated.

The cooling domain, with the interventions planned in the renovation, has a very high SRI score (77%). On the other hand, due to the absence of an upgrade in the control of distribution pumps, the obtained BACS class is D (BACS class is driven by the worst service in the domain).

Therefore, this represents a critical automation bottleneck that must be addressed to improve overall system performance and guarantee proper compliance with regulatory requirements. Indeed, if this assessment had been conducted during a major renovation or new construction, this building would not comply with the legal minimum requirements established by the UNI 52120-1 standard (class B for all

the domains).

When considering the DHW domain, it obtained a similar SRI score, but reached the maximum BACS class (A), ensuring optimal performance. The heating domain shows the poorest score in terms of SRI, but having all services at least class C, it has a domain BACS class of C (higher than the cooling domain).

This pragmatic example shows how sensitive the evaluation of these aspects is, and how much the tool developed by RINA is needed in order to have a comprehensive evaluation of automation.

4. Conclusions

This paper presented the tool developed by RINA in order to properly align the BACS classes with the SRI score, ensuring a holistic comprehension of the building smartness and assessing also the compliance with the requirements set by standards and norms. The application of the tool to a real case study has highlighted how the SRI assessment does not always reflect the impact that the building automation services have on energy consumption, even though it provides a huge amount of information to the user in terms of the level of automation, by impact scores and building domain. BACS systems need to be integrated organically in the same domain, avoiding the creation of an automation bottleneck that can negatively affect energy performance. The tool described in this paper offers an instrument to use SRI assessments as a guide for investments in building automation.

The proposed tool enables building managers to practically use the SRI assessment—currently complex and difficult to interpret—to prioritize modernization interventions or benchmark the performance of BACS systems against regulatory requirements. While UNI EN 52120 is widely recognized among industry experts, installers, and component manufacturers, the SRI methodology is expected to gain prominence in the coming years. This tool acts as a bridge between a well-established standard and an emerging approach.

Furthermore, in the same research framework, RINA is actively working on an extensive mapping of the costs of the different smart solutions. This work, when integrated with the SRI tool, will allow the user to have an estimation of both energy saving (through BACS factors) and capital expenses of the suggested installation, enabling a simple payback analysis.

Summarizing, the tool described in this paper allows:

- Link the SRI assessment to energy consumption
- Highlight suggested BACS improvements to avoid automation bottlenecks
- Link the SRI assessment with the minimum law requirements
- Use a simple tool, even without advanced technical knowledge

In conclusion, in a future where SRI assessments will become increasingly common due to both growing knowledge and regulatory requirements, an application like the one described in this could serve as a key tool for end users and energy managers, providing a clear quantification of the benefits that building automation offers.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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