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Testing of Pilot Buildings by the SRI Method

Testování pilotních budov metodou SRI

The paper deals with the issues of the Smart Readiness Indicator (SRI), which describes buildings in terms of their intelligent systems. In first part, the principles of SRI and the processes of a building's assessment are explained. The second part contains a case study of four buildings in the Czech Republic with different technical systems and the Smart Readiness Indicator is calculated for them.
Keywords: *Smart Readiness Indicator, Intelligent Buildings*

Článek se zabývá tzv. Indikátorem připravenosti budov na chytrá řešení (Smart Readiness Indicator, SRI), který popisuje úroveň inteligence budov a jejich systémů. V úvodní části článku jsou popsány principy SRI a procesy, jak budovy hodnotit. Druhou částí článku je případová studie 4 budov v České republice s různými technickými systémy, pro které je proveden výpočet indikátoru.
Klíčová slova: *Smart Readiness Indicator, inteligentní budovy*

INTRODUCTION

The revised European Energy Performance of Buildings Directive (EPBD) supports smart building technologies, but the question, how to describe the "smartness", has arisen. The European Commission has assembled a consortium of experts accordingly. This consortium put together a so-called Smart Readiness Indicator (SRI) which describes how the building is prepared for smart systems, which can ensure the indoor environmental quality, energy performance, convenience and other parameters of a building's operation.

The SRI is a percentage of the real level of smart systems according to the maximal achievable conditions in an assessed building. The total SRI score is calculated from the impact scores and domain scores by weighting each impact/domain. The term impact score means how the fields of a building's use are equipped by smart ready technologies, the domain scores are focused on a building's technical systems and their "smartness".

THE PROCESS OF A BUILDING'S ASSESSMENT

At first, the general information of an assessed building is defined:
- Building type (residential, non-residential),
- Building usage (for residential building, e.g. Single-family house, large multi-family house etc., for another type, e.g. Educational, office building, etc.)
- Location in climate zone (European Union is divided into five zones)
- Net-floor area
- Year of construction
- Building state (original, renovated)
- Building domains (technical systems) present (heating, domestic hot water, cooling system, controlled ventilation, lighting, dynamic envelope, electricity: renewables and storage, electric vehicle charging, Monitoring & Control)

Then, for each building domain, the type of technical system is defined. For example, each heating service has its own emission type (TABS, hydronic or non-hydronic system), production type (district, central, decentral heating, heat pump), presence of energy storage and number of heat generators. Thereafter, each domain has its services. The maximum number of services is 52, but the real number depends on presence of the domains and their type.

Each service has its own impact and domain weighting according to the functionality level, climate zone and building usage. The functionality level is a description of the service and marked by a number. The number 0 means a simple system with nothing smart and a higher number means a smarter service. Some services have their maximum at functionality level 2 (for example detecting faults of the technical systems and their diagnostics), or the maximal functionality level is 4 (for example heat control on the demand side).

The final SRI score is calculated from these parameters and their impacts. The score for a single impact parameter is a percentage of the real score versus the maximum which can be achieved. The total SRI score is a percentage of the sums of the scores for each impact to the maximal achievable score.

The impact scores which make up the total SRI score together, are:
- Energy savings on site
- Flexibility for the grid and storage
- Comfort
- Convenience
- Wellbeing and health
- Maintenance and fault prediction
- Information to occupants

The domain scores are calculated for each domain (technical system) which is installed in the assessed building.

CASE STUDY

The case study contains the SRI assessment of four different buildings in the Czech Republic. Each building has a different level of smart services.

Building 1 – A family house in Všenory
The first case is a small renovated family house located in the Central Bohemian region. It is a stone-structure, combined with a newer extension of aerated concrete. It is a traditional non-smart family house built in the early 19^{th} century and only equipped by electrical heating (accumulation stoves) and electrical hot water preparation in a water tank. The lighting is a classic system as well (on/off switches). The charging of the stoves has a timetable connected to the switching to a cheaper tariff (8 hours per day). The renovation took place in the 2000s and 2010s.

Fig. 1 Building 1 – the family house in Všenory (source: www.mapy.cz)

Building 2 – An apartment block in Praha-Suchdol

Another residential building is an apartment block located in the outskirts of Prague. It is a large multi-family house of a prefab concrete structure built in the 1980s and renovated in the 2000s. As in the previous case, the building has heating, domestic hot water preparation and lighting. The heat source is a gas boiler, which prepares the domestic hot water as well. The heating system is a hydronic system with radiators and is controlled by the outside temperature (equithermal regulation). The DHW (domestic hot water) has its own schedule of charging the water tank. The lighting is similar, the HVAC (heating, ventilation and air conditioning) system is simple with the indication of detected faults and alarms.

Fig. 2 Building 2 – the apartment block in Praha-Suchdol (source: www.mapy.cz)

Fig. 3 Building 3 – Building A of the Faculty of Civil Engineering (source: cs.wikipedia.org)

Building 3 – The Faculty of Civil Engineering, CTU in Prague, Block A

It is the only non-residential building in this case study. The building is a 15-storey building located in Prague-Dejvice, built in the 1970s and renovated in the 2010s. This building is supplied by district heating as the only heat source for both the heating and DHW preparation. Part of the building is equipped by controlled ventilation (air-handling units). The exposed south/west facade has movable motorised shades reacting to the solar irradiation. Each room has its own heat control, the distribution of the heat is in accordance with the outside temperature. The heating system is hydronic. Some parts (corridors) have the occupancy control for lighting.

Tab. 1 The description of the buildings and their technical systems

	Building	**Building 1**	**Building 2**	**Building 3**	**Building 4**
GENERAL INFORMATION	**Building type**	Residential	Residential	Non-Residential	Residential
	Building usage	Single-family house	Large multi-family house	Educational	Single-family house
	Net-floor area (m²)	<200	1.000-10.000	>25.000	<200
	Year of construction	<1960	1960-1990	1960-1990	>2010
HEATING	**Emission type**	Non-hydronic	Hydronic (radiators)	Hydronic (radiators)	Hydronic (radiators)
	Production type	Decentral	Central	District	Decentral
	Thermal Energy Storage	Yes	No	No	No
	Multiple heat generators	No	No	No	Yes
DOMESTIC HOT WATER	**Production type**	Electric	Non-electric	Non-electric	Combination
	Storage present	Yes	Yes	Yes	Yes
	Solar Collector	No	No	No	Yes
CONTROLLED VENTILATION	**System type**	No	No	Controlled natural ventilation (10% of the building)	No
DYNAMIC ENVELOPE	**Movable shades**	No	No	Yes	No

Fig. 4 Building 4 – The family house in Rýmařov (source: Kabele, Urban: Grant no: te02000077 Smart Regions – buildings and settlements information modelling, technology and infrastructure for sustainable development)

Building 4 – A family house in Rýmařov

The fourth case is a family house located in the Moravian-Silesian region in the Jeseníky mountains. It is a newly built wooden one-storey structure with a currently non-occupied attic. The main heat source is a stove where pieces of wood are burnt. The stove is connected to the hydronic heating system. There is also an electrical boiler as a backup source, which is connected to the heating system as well. The DHW is prepared in a water tank, whose main heat source is the above-mentioned heating system, heat is tranfered by heat exchanger inside the tank. There is another heat exchanger connected to a circuit with solar collectors. Third back-up source is an electric heat cartridge. The heat emission is controlled room by room, the DHW is controlled in accordance with the solar energy supply. All energy flows are measured and the data are collected for the indication of any changes. So, the HVAC system has a central reporting of the technical building system performance and the energy use.

Tab. 1 above describes all the different input parameters of the buildings. All the buildings are in the Czech Republic, so the climate zone for the SRI assessment is North-East Europe.

In the field of technical systems, no assessed building is equipped by cooling, renewable electricity source or electric vehicle charging.

SRI CALCULATION

This chapter includes the results of the SRI calculation for all four buildings. The total SRI score and the single impact scores are shown in Tab. 2. Tab. 3 describes the domain SRI score.

Tab. 2 The total SRI score and the impact SRI score assessment

Building	Building 1	Building 2	Building 3	Building 4
Total SRI score	**14%**	**28%**	**35%**	**37%**
Energy savings on site	17%	31%	43%	52%
Flexibility for the grid and storage	31%	35%	36%	12%
Comfort	9%	34%	39%	51%
Convenience	5%	29%	30%	39%
Wellbeing and health	0%	100%	31%	100%
Maintenance & fault prediction	0%	12%	25%	32%
Information to occupants	0%	13%	18%	31%

The results shown in Tab. 2 say that Building 4 has the best total SRI score. Building 1 has the worst score, which is as expected, as it is equipped by a classic technical system only. The number is increased partly thanks to the flexibility of the heating system to the grid. Building 2 is a common apartment block type. In can be estimated that many apartment blocks in the Czech Republic can reach a similar SRI score. Building 3 is strong in the energy savings because of the shading control. The shading increases the comfort of the building. Building 4 is designed as a low-energy house, so the energy savings on site have the highest score, but there is low flexibility to the grid.

In Table 2, one peculiarity can be observed: The 100% impact score of the Wellbeing and health. The reason is that only the two HVAC services have influence on the Wellbeing and health assessment. The maximal score is reached in the case of the presence of any functionality, not in the case of the functionality level.

Tab. 3 The domain SRI score

Building	Building 1	Building 2	Building 3	Building 4
Heating system	26%	36%	55%	39%
Domestic hot water	29%	12%	34%	57%
Cooling system	-	-	-	-
Controlled ventilation	-	-	4%	-
Lighting	0%	0%	10%	0%
Dynamic envelope	-	-	38%	-
Electricity: renewables & storage	-	-	-	-
Electric Vehicle Charging	-	-	-	-
Monitoring & Control	0%	25%	27%	32%

The most interesting, in terms of the domain score, is Building 3, which is equipped by more technical systems than the other buildings. As only a part of the building has controlled ventilation, only a 4% score of the Controlled Ventilation domain was reached. The dynamic envelope only contains an automatic shading system, not the control of a window's opening or performance information reporting, so the score is "window opening" 36%. Building 4 has the highest DHW score because of the renewable energy source present.

CONCLUSION

The Smart Readiness Indicator provides simplified, but good information about the technical building systems in terms of their smartness. The calculation has some shortcomings. For example, it is impossible to define two different heat sources (e.g. hydronic heat systems combined with a fireplace). Some impact score calculations are insufficient, so the Wellbeing score can easily reach 100 % because there are a small number of services which have an impact on this score.

It is difficult to reach 100 % of the total SRI score because such buildings would have very sophisticated intelligent systems, which can be expensive and sometimes be non-user friendly. On the other side, the assessed buildings have a big potential to improve their parameters in terms of smart readiness.

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