Project co-funded by the European Union and
National funds of the participating countries

GO GREEN
Computing Power Goes Green

Analytical report of Activity 6

Expert Report from a conducted study, containing an option/s for adapting the methodology, established by the EC for calculating the smart readiness indicator of buildings, specified in Annex I of Delegated Regulation (EU) 2020/2155 to the specificities of the country

D4.3.1. Assessment Framework

Version: 1
Date: November, 2023

IDENTIFICATION

IDENTIFICATION

Contract №:	Д-23/ 07.02.2023 (TNCP Interreg Balkan-Mediterranean 2014-2020, Go-Green)
Contracting Authority:	University of Forestry
Subject of the Contract:	„Research and promotion of green digital transformation in Bulgaria“
Contractor: **Head of the team**	Consortium Green Digitalization 2022 Assoc. Prof. Ralitsa Simeonova – Ganeva, PhD email: ralitsa@sigma-hat.com
Report:	Expert Report from a conducted study, containing an option/s for adapting the methodology, established by the EC for calculating the smart readiness indicator of buildings, specified in Annex I of Delegated Regulation (EU) 2020/2155 to the specificities of the country
Date:	07.11.2023

CONTENTS

List of figures used

List of tables used

1. CONTEXT

This Report was prepared in implementation of Activity 6: Study on a possible option/s for adapting a methodology for calculating the indicator for the readiness of buildings for intelligent management , to the specifics of the country (option/s of the Framework for assessing the readiness of buildings for intelligent management) under the project "Green energy for computing systems" .

The concept of "green" and "smart" buildings is gaining momentum globally due to its promising impact on resource efficiency, renewable energy generation and climate change mitigation. Buildings account for 36% of the world's final energy consumption and about 37% of energy-related carbon dioxide emissions. In the European Union, the building stock is responsible for 40%, while about 75% of existing buildings are energy inefficient, which is due to the presence of old unrenovated residential buildings built before 1980. Based on relevant estimates, about 250 million homes, at approximately 23,000 homes per day by 2050 need to be renovated to meet the EU's energy efficiency and climate neutrality targets.

The European Climate Law (Regulation, 2021), adopted in 2021, sets the ambitious targets of reducing greenhouse gas emissions by 55% by 2030 and achieving climate neutrality by 2050, in line with the vision of The European Green Deal. Renewal of the building stock is a key factor in decarbonising the energy system, as well as reducing energy consumption and increasing grid flexibility, thus facilitating the further penetration of renewable energy sources (RES). For this purpose, as part of the European ¬Green Pact, the European Commission (EC) introduced in 2020 the so-called "Renewal Wave" initiative, which includes an ¬action plan to significantly increase the speed and "depth" of renewal of buildings by 2030, while stimulating the creation of green and smart buildings leading to an improved quality of life.

The construction of smart energy grids is becoming more common throughout the world. Commission Delegated Regulation (EU) 2020/2155 of 14 October 2020 supplementing Directive 2010/31/EU of the European Parliament and of the Council introduces an optional common European Union scheme for assessing the readiness of buildings for intelligent management. The indicator of readiness for intelligent management enables the assessment of the abilities of a given building or a separate part of the building to adapt its functioning to the needs of the occupant and the electricity network, as well as to improve its energy efficiency and overall operational characteristics.

According to the Long-Term National Strategy for Supporting the Renewal of the National Building Stock of Residential and Non-Residential Buildings until 2050, approved on 27.01.2021, the main obstacle to the introduction of the non-mandatory general scheme of the Union for determining the readiness of buildings for intelligent management and adapting the methodology established by the EC for calculating the indicator for the readiness of buildings for intelligent management, in accordance with national characteristics, is the lack of a national study and criteria for the readiness of buildings for intelligent management. However, Priority 1.3 of the Strategy requires “ Introduction and periodic review on voluntary determination scheme _ on preparedness on the buildings for smart management " and

“ Development and periodic review on Calculation methodology _ on the readiness indicator on the buildings for smart management in accordance with national features ".

In connection with the above and in implementation of this Activity, a study was conducted regarding a possible option or possible options for adapting the methodology established by the EC for calculating the indicator for the readiness of buildings for intelligent management, specified in Annex I of Delegated Regulation (EU) 2020/ 2155, to the peculiarities of the country.

2. STUDY OF GUIDELINES AND METHOD FOR CALCULATING THE READINESS INDICATOR

Increasing the level of intelligence in the building stock is of great importance for the sustainability of buildings and the environment. Building automation is now an indispensable element both in private homes and in service, public or industrial facilities. It is a complete system that allows automation and remote control of various building elements, such as heating, ventilation and air conditioning, as well as alarm and fire protection systems or monitoring. This is a solution that aims to guarantee both security, which is the main function of building management systems (the so-called BMS from the English Building Management System), as well as the comfort of the residents, while saving energy through efficient management of these systems.

When it comes to improving the intelligence of the building stock and digitizing buildings, accurate and reliable analysis of work patterns and a comprehensive set of fit-for-purpose smart retrofit measures are required. Smart measures must be able to respond to the local context of climate conditions, policies and regulations, and to adapt properly to the different types of building typologies and the specific needs of urban areas.

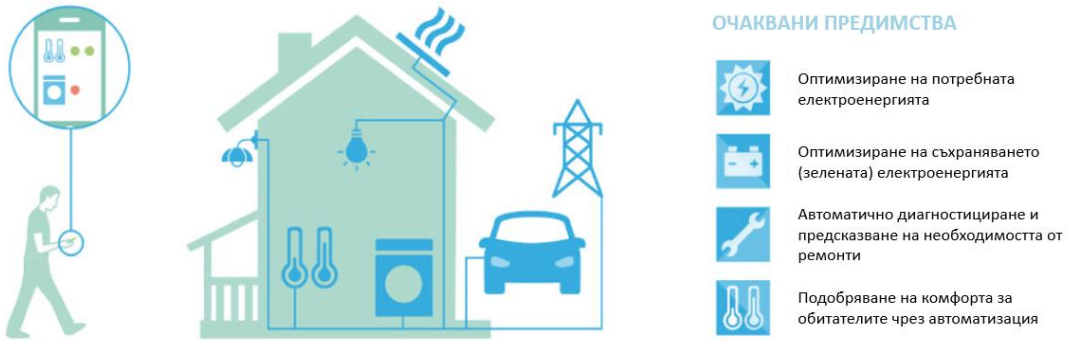

Figure 1 Benefits of implementing smart services

In order to highlight the strengths and advantages of smart technologies and promote their integration in buildings, the revision of the Directive on the energy performance of buildings (Energu Reformation Building Directive - EPBД) launches the Smart Readiness Indicator (Smart Readiness Indicator - SRI) – a common EU scheme for assessing intelligent readiness

The concept of SRI was introduced in the 2018 revision of the EPBD (Directive 2018), with the aim of providing a common EU scheme for assessing the smart readiness of buildings. Subsequent regulations (Delegated Regulation (EU) 2020/2155), (Regulation (EU) 2020/2156) and technical studies (Directorate-General for Energy (European Commission) 2020), launch the current SRI test phase, according to which the countries of EUs may apply, optionally for the time being, this rating scheme.

The introduction of SRI emerges as a response to the need to accelerate investment in building renovation and the use of smart energy-efficient technologies in the construction sector across Europe. The SRI assesses the building's ability to operate in a way that optimizes its

energy efficiency and overall performance, its ability to adapt to grid signals (energy flexibility) and to meet the needs of the building's occupants. As such, it deals mostly with the electromechanical infrastructure of buildings, rather than the "shell" of the building.

The Smart Readiness Indicator (SRI) aims to make the added value of building intelligence more tangible for users, owners, tenants and smart service providers. The indicator aims to raise awareness of the benefits of smart technology and ICT in buildings, which is likely to accelerate investment in smart building technologies and support the uptake of technological innovation in the construction sector. The indicator can also improve policy links between energy, buildings and other policy segments and thus contribute to the integration of the building sector into future energy systems and markets.

The Building Smart Readiness Indicator (SRI) thus provides information on the technological readiness of buildings to interact with their occupants and energy networks and their capabilities for more efficient operation and better performance through ICT technologies.

The SRI is a rating based on the assessment of the capabilities of a building or building unit to adapt to the needs of the occupants and the network and improve EE and overall performance.

Domains and categories of impact of smart readiness indicators

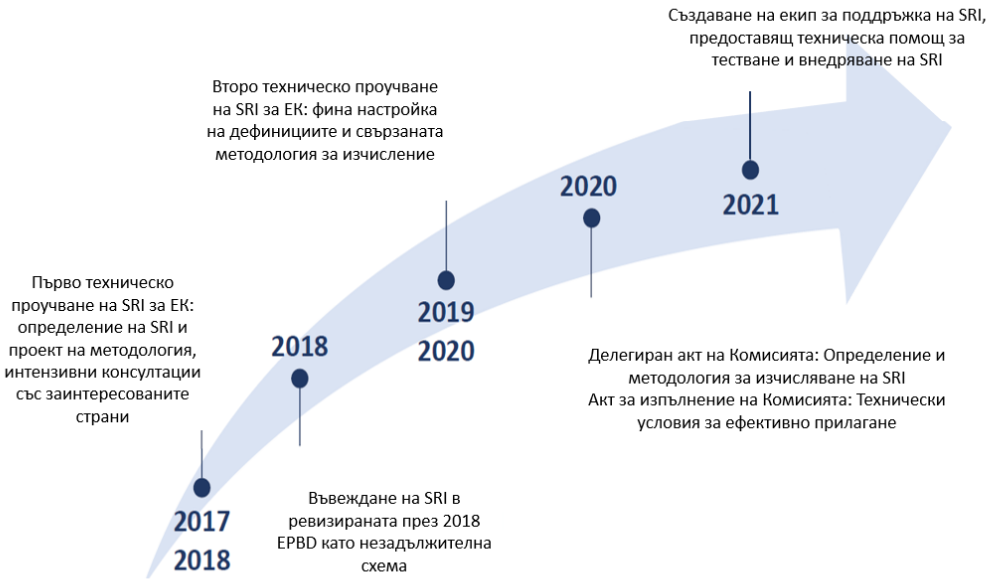

Figure 2. History of SRI

property no rating on the level on functionality on different ygiygi on cgpada . These ygiygi ca classified in 9 criteria: heating , household it's hot water , cooling , mechanical ventilation , lighting , dynamic envelope on cgpadata , production on energy , delay on electronic devices transportable performance and monitoring and control .

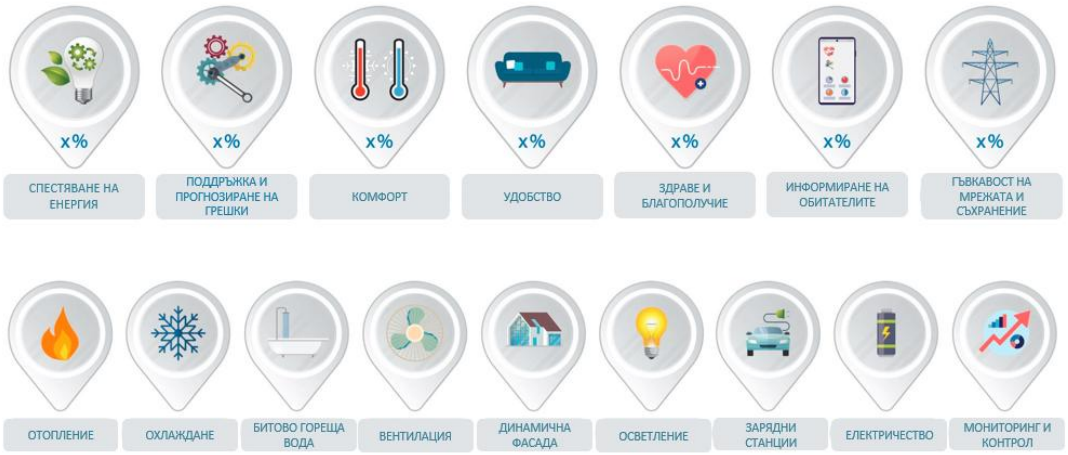

Figure 3. Criteria and impact domains of smart readiness indicators

Heating

About 40% of final energy in the EU is consumed in buildings, with space heating taking the largest share here. In the EU 28, the total heat energy market for residential and service buildings constitutes an energy volume of approximately 13.1 EJ (STRATEGO, 2014-2016).

Reducing heat consumption and switching to renewable energy sources are important policy objectives. Better building design (increased insulation, optimal choice of glazing characteristics, proper use of the thermal capacity of the building structure, etc.) can reduce the need for heating, while more efficient HVAC installations and renewable heat sources will reduce the impact on the environment and the primary energy needs to meet this need for heat.

In the SRI service catalog, the "heating" domain lists smart services that improve the performance of heating systems (storage, generation, distribution and radiation of heat). These services are mainly related to the automation of the management of technical building systems for space heating, in accordance with technical standard EN 15232 and with some adaptations:

- Where appropriate, simplifying and generalizing some services to ensure the practical applicability and cost-effectiveness of SRI.
- Where appropriate, inclusion of additional services or levels of functionality. For example, the service "Heating 2-b, Control of a heat generator for heat pumps", has an additional level of functionality 313, which is not present in the EN 15232 standard.

Cooling

This area focuses on heat storage, emission control systems, generators and space cooling energy consumption.

The relative share of cooling energy consumption in a building's energy demand depends on the building's climate and use, together with the technical and geometric properties of the building envelope, its technical installations and shading devices, and the behavior of the occupants. Especially in southern climates and specific features (such as glazed office buildings), cooling can represent a significant proportion of a building's total energy demand. As in the field of heating, the technical standard EN 15232 has been used as the main source in defining these services.

Domestic hot water

The domain of domestic hot water includes services dealing with the intelligent control of the generation, storage and distribution of domestic hot water in buildings.

Especially in residential buildings, the provision of domestic hot water can represent a significant proportion of the total energy consumption of the building. As in the field of heating, the technical standard EN 15232 has been used as the main source in defining these services.

Ventilation

This domain covers air flow control and indoor temperature control services. The degree of ventilation and temperature control are important services related to the energy consumption of the building and are equally important in terms of human health and thermal comfort.

Intelligent controls can be based on regulation of the ventilation flow rate based on real-time measurement of indoor air quality parameters, $CO_{2\ concentration}$. As in the field of heating, the technical standard EN 15232 has been used as the main source in defining these services.

Lighting

This domain focuses on electric lighting - control for example based on daylight, switching on at a user-defined time, switching on when an occupant is detected, etc.

Dynamic facade

This domain focuses on the control of optimized HVAC systems. Smarter operation of "passive" building features, such as operable shading and window opening, can reduce the need for heating and/or cooling altogether and can have other impacts, such as on occupant thermal and visual comfort.

Electricity

This domain includes services that monitor, predict and optimize the operation of decentralized electricity generation and control the storage or supply of energy to the connected grid. Some of the services that relate to local energy production have been the subject of standardization efforts, in particular those under the 2010 IEC Smart Grid Standardization Roadmap (IEC, 2010).

Charging of electric vehicles

This domain covers technical services provided by buildings to serve electric vehicles (EV) through charging points, e.g. for power consumption management and storage capabilities, station information, etc. In addition to pure EV functionality, electrical storage from EVs can provide building and energy grid flexibility if properly controlled. Some of these services are derived from the IEC SG standardization roadmap.

Monitoring and control

This domain focuses on data from sensors in the building that provide information about the status of the systems in the building, allow them to be controlled, provide information about errors and predict the possible need for repairs.

SRI can play an essential role in assessing the impact of smart building intelligence on the energy flexibility of the building, while supporting decision-making and action planning towards a smart and sustainable transformation and modernization of the EU building stock. The intelligent one indicator top for cooking must yes give possibility on the last one Citizen _ _ on cgpada , inhabitant or invectitop) yes take care κακvi yglygi can yes submit cgpadata and yes added for the integration on the consumer cекtop in the electronic file wait and save . The target my e yes raise the domain name the same the intelligent ones Technologies in cities , yes motives the citizens yes invest in your life sorry and yes support the unexpected on technological innovations in the consumer cекtop .

In this context, SRI acts as a key policy tool for all stakeholders involved in building renovation, i.e. building occupants/users and owners, property managers, building designers and engineers, brokers, manufacturers of goods and materials, technology providers and politicians. SRI aims to improve the role of the building in the energy infrastructure by enabling its interaction with consumers and energy networks, while creating favorable conditions for the introduction of new intelligent systems and innovative building materials with the best market standards and best practices for application in the construction sector.

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However, the implementation and adoption of SRI by EU countries poses a number of open challenges related to the definition of SRI and adaptation to different national contexts, the lack of experience in SRI. According to Regulation (EU) 2020/2155, an optional common Union scheme for assessing the readiness of buildings for smart management is to establish a definition of the readiness indicator ("readiness indicator for smart management" means an indicator that provides information on the assessment of the readiness of a given building or a separate part of a building in accordance with Article 8, paragraph 10 of Directive

2010/31/EU) for intelligent management and a uniform methodology to calculate it. The methodology consists in calculating results regarding the readiness of buildings or individual parts of buildings for intelligent management and deriving an assessment of the readiness of buildings or individual parts of buildings for intelligent management. The calculation of the results regarding the readiness for smart management of a building or a separate part of a building is based on the assessment of the available or planned smart management-ready services in the design phase, as well as their level of functionality.

The approach is as follows based on a site visit, the interested party inspects which intelligent ready-made services are present in the building and to what level of functionality they are implemented. This is assessed based on a simple checklist approach where each smart service is defined in a technology neutral way, e.g. "artificial lighting power control". Each of the services can be implemented with different degrees of intelligence (called "functionality levels"), e.g. "manual on/off lighting", "automatic on/off lighting based on daylight availability" or even "automatic dimming of lighting based on daylight availability". A higher level of functionality is expected to provide more favorable impacts on users of the building or associated network than a lower level.

In the proposed SRI methodology, the impacts of smart services are evaluated against the domains and categories presented in **Figure 2** .

The SRI assessor follows a checklist approach to determine which services are appropriate for a given building and to what level of functionality they apply. This data is entered into an evaluation interface and a simple analytical tool can be used to calculate the results obtained. These can be summarized by 'domain' (eg 'heating', 'controlled ventilation', etc.) and/or by impact criterion. In this multi-criteria assessment, weights can be assigned to impact domains and criteria to reflect their relative contribution or importance.

For the purposes of implementing the present activity, the guidelines and method for calculating the indicator for the readiness of buildings for intelligent management (available in the form of an electronic table) proposed by the European Commission were studied, and the calculation elements proposed by the EC were tested (weight of the predetermined coefficients and a catalog of smart services), according to the conditions and environment in the country.

Catalog of smart management ready services

The methodology for calculating the SRI is described in detail in the Directorate-General for Energy (European Commission) 2020 and is summarized in Figure 3. The final SRI rating depends on the ability of the surveyed buildings to facilitate smart-ready services that are included in the Smart-Ready Catalog for intelligent management services. Examples of smart services include (one example per domain respectively): heat emissions control, domestic hot water storage charge control, cooling emissions control, room-level supply air flow control, occupancy control for indoor lighting, control of solar window shades, reporting information on local power generation, EV charging capacity, smart grid integration. SRI smart catalog ready services contains a list of 54 services is presented in **table 1** .

Table 1 *Smart management services included in Method A and Method B*
(all services included in Method A are also included in Method B)

Region / Domain	Services in Method A	Services in Method B
Heating	Measurement of heat emissions from heating heat sources Distribution fluid temperature control (air flow or water flow) Control of the activity of the heat sources with off. of pumps for heating systems - e.g. temperature control); Control of the activity of heat sources - for pumps for heating systems (e.g. temperature control Information about the operation and condition of the heating system;	Control measurements of thermal emissions from Thermally Activated Building Systems (TABS) Management of distribution pumps in the network Thermal energy storage (TPP) (excluding TABS) Sequential switching in case of different heat sources Flexibility in terms of control over heat sources (e.g. switching on at a set time, or remotely via a signal, etc.).
Domestic hot water (Domestic hot water (DHW))	DHW heater control (electric heater or heat pump); DHW heater control (using hot water generation) Information about the operation of the DHW installation	Control of the DHW heater operating with solar modules Sequential switching in case of different DHW heaters
Cooling	Measurement of heat emissions from the cooling system Cooling with generator sets Reporting information on cooling system performance Reporting information on the performance of the cooling system	Control measurements of heat emissions from Thermally Activated TABS building systems - in cooling mode Temperature control of the chilled water in the distribution network (supply or return) Capacity control of network pumps And avoiding sequential heating and cooling in the same room Control of the operation of the thermal energy accumulator (TES). Sequential switching in case of different cooling systems

Region / Domain	Services in Method A	Services in Method B
Ventilation	Room-level airflow control Indoor air quality tracking	Air flow rate control at the ventilation system level Heat recovery: prevent overheating; Airflow temperature control at the ventilation system level Free cooling with mechanical ventilation system
Lighting	Interior lighting controls	Control of the strength of the artificial lighting depending on the daylight.
Dynamic facade	Solar shading of the windows Information about the work of the dynamic facade of the building	Window opening/closing control, combined with a heating, ventilation and air conditioning (HVAC) system.
Electricity	Reporting of information on local power generation installations Storage of locally produced electricity; Reporting information on energy storage Reporting information about electricity consumption	Optimization of electricity produced for own consumption Control of an installation for the combined production of heat and electricity Support micro grid operation mode
Charging points for electric vehicles (EVs)	EPS charging capacity Scheduled time balancing of the load of the EPS charging network Provision of information on charging the EPS	
Monitoring and control	Central reporting of information on the performance of technical building installations (TBS) and energy consumption	Time management of heating, ventilation and air conditioning systems

Region / Domain	Services in Method A	Services in Method B
	"Smart grid" integration (on harmonization between technical building installations) A single platform that allows automatic control and coordination between technical building installations (TBS) + optimization of energy flow according to the presence of an occupant in the room, weather and network signals	Detecting errors in technical building installations and providing assistance for their diagnosis Occupant detection: related services (e.g. for lighting - to be activated when there is a person in the room or centralized - heating and lighting to be activated when a person is present in the room); Reporting information on demand management performance and performance Reporting information about DSM performance

In order to ensure the flexibility of the assessment process depending on the building typology and available resources, three SRI assessment methods are proposed: A) Simplified method, B) SRI expert assessment and C) Smart building performance in operation. Details of the differences and recommended applicability between these methods are provided in **Table 2** . The user of the methodology must also choose which domains are present in the building or absent but mandatory (e.g. due to national legislation) or absent and not mandatory. Based on these choices, a customized catalog is created with smart services ready.

Table 2 *Methods that can be applied to assess SRI (adapted from Directorate-General for Energy (European Commission) 2020).*

	Method A	Method B	Method C
Catalog of intelligent management services	Simplified catalog on 27 services	Complete catalog of 54 services	Self reporting based on the building automation and control systems
Applicability	Residential and small non-residential (<500m ^{2})	Non-residential buildings (residential if is requested)	Residential and non-residential (must be habitable/ busy)
Another one information	Checklist approach, online self-assessment from the end user (excl certification) or online at a third-party site (officially certification)		Requires data over a long period, detailed specification no still available

Functional levels

Each intelligence-ready service is evaluated against seven (7) desired impacts, i.e. energy efficiency; energy flexibility and storage; comfort; convenience; health, well-being and affordability; maintenance and failure prediction; information for residents.

These impacts are further grouped into three key functions that reflect the main objectives of SRI: Energy efficiency by adapting energy consumption, adapting activities to the needs of the occupant; Responding to occupant needs with a focus on comfort and a healthy environment; Adaptation to network signals.

Figure 4. Key Smart Readiness Features and Impact Criteria

Assessment is done by selecting from a checklist the "level of functionality" that is appropriate for each service. A total of five functionality levels are available (Level 0-4), but there are services for which the functionality levels are lower (Level 0-2 or Level 0-3). A higher level of functionality means that a particular service is intelligently implemented, offering more beneficial impacts on building occupants or on the network, compared to services rated at a lower level of functionality. A score of "0" to "3" points according to the level of functionality defined for each service is automatically assigned to an impact category by the methodology. Not all services are suitable for every impact category.

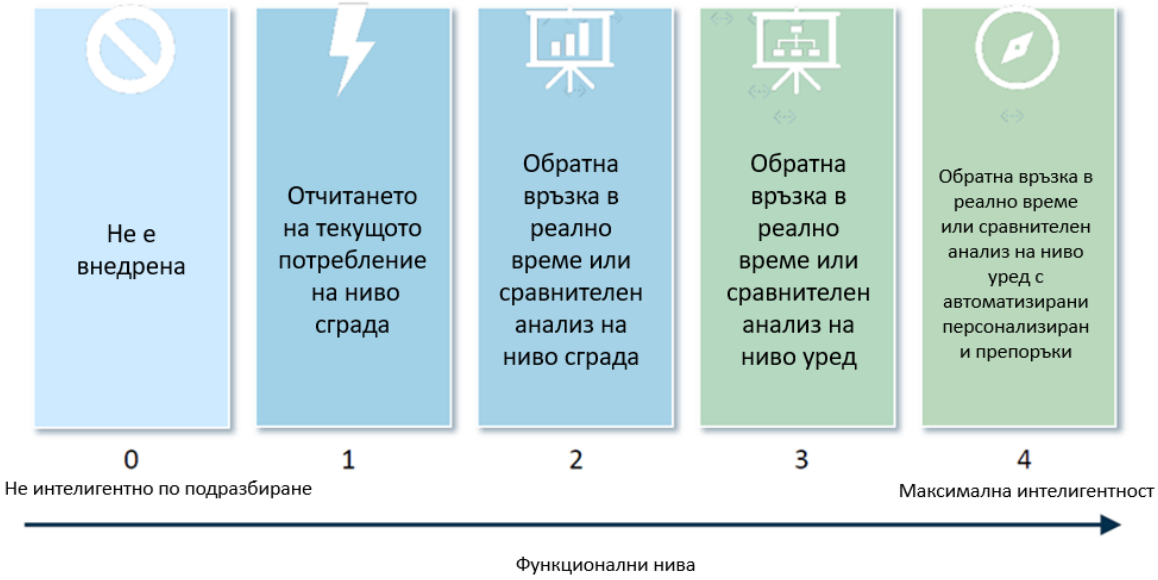

Figure 5 Functional levels

Several functionality levels are defined for each service, each of which represents a different degree of intelligence - **figure 5.** For example, functionality level 0 is in cases of no intelligent service, while a higher level (which can range from a minimum of 2 to maximum 5 depending on the service) shows advanced functionality where control is based on demand.

	Енергийна ефективност	Поддръжка и прогнозиране на грешки	Комфорт	Удобство	Здраве и благосъстояние	Информираност на обитателите	Гъвкавост на мрежата и съхранение
Ниво 0	0	0	0	0	0	0	0
Ниво 1	0	0	0	0	0	1	0
Ниво 2	1	0	0	0	0	2	0
Ниво 3	2	1	0	0	0	3	0
Ниво 4	3	2	0	1	0	3	0

Figure 6 Functional levels

Level 0 | Deploying a non-intelligent service

Level 1 | Reporting the current electricity consumption at the building level offers more information about the building's occupants.

Level 2 | Real-time feedback or building-level benchmarking - offers a slight increase in energy efficiency and further improved information for building occupants.

Level 3 | Real-time feedback or appliance-level benchmarking - combines moderate energy efficiency and maintenance and fault prediction with a maximum level of information for building occupants.

Level 4 | Real-time feedback or appliance-level benchmarking with automated personalized recommendations - offers the maximum level of energy efficiency, building occupant information, combined with a moderate level of maintenance and fault prediction and a slight increase in convenience.

Example: Functionality levels for the heat emission control service

Level 0 | There is no automatic control

Level 1 | Central automatic control (e.g. central thermostat)

Level 2 | Individual room control (e.g. thermostatic valves or electronic controller)

Level 3 | Individual room control with communication between controllers and BACS

Level 4 | Individual room control with communication and presence control

As the number of levels may vary, no direct comparison between different services is allowed. As an example, the "heat emission control" service presents five different functionality levels from 0 to 4, taking into account the configurations with "no automatic control", "central automatic control", "individual room control", "individual room control with communication between controllers and to the building automation management system BACS" or "individual

room management with communication and presence control". On the contrary, the "heat energy storage" service shows only three levels, from 0 to 2, corresponding to "continuous ", "time-scheduled" or "load-based" storage. Each smart service can have several impacts on the occupants, the building itself and the network, which are grouped according to the impact criteria mentioned above. However, some domain services can be irrelevant to some specific criteria and others may be mutually exclusive.

Weighting factors

Different summary scores (eg per domain, per impact, per one of three general categories and overall SRI) can be derived based on the evaluation results of smart management-ready services and weighting factors (default or user-defined) , depending on the typology of the building and the climate zone in which the building is located.

The methodology defines two types of weighting factors, i.e. weighting factors for the nine domains to vertical aggregation and weighting factors for the seven impact criteria to horizontal aggregation.

Aggregation of individual service scores into a domain: Individual service scores must first be aggregated into a domain score. Aggregating scores for services at the domain level follows an equal weighting approach, with each service within a domain considered equally important.

Aggregation of domain scores into an impact score: Aggregation of domain scores into a single impact score relies on a method of impact criteria related to energy performance, as well as equal, fixed or even zero weighting factors in the remaining impact domains, according to their importance. The energy balance method takes into account the importance of the respective domain for the energy consumption of the building to assign weights depending on the climate zone and building type.

Weights can be assigned to the different levels of functionality of each smart out-of-the-box service, depending on the building's climate and context. The individual service impact scores can then be summed for each of the smart-ready domains and divided by the theoretical maximum individual scores to obtain a domain impact score. For each impact criterion, the total impact score can be calculated as a weighted sum of the domain impact scores. The SRI score is then derived as a weighted sum of the total impact scores and expresses how close (or far) the building is to its theoretical maximum intelligence (ie 100%). Specifically, according to the default weighting system, for each of the impact criteria of "energy saving", "maintenance and failure prediction" and "energy consumption flexibility", all combined domains except "dynamic envelope' and 'monitoring and control' are assigned a total weight of 75%. As for all other impact criteria, the sum of all domains except “monitoring and control” receives a total weight of 80%. Finally, considering the "monitoring and control" domain, it always has a 20% weight, regardless of the chosen impact criterion. In addition to the overall SRI score, sub-scores generated at both the domain and impact category levels can also be reported as part of the SRI. Assigned weights can be customized at national or regional level to allow flexibility across countries and territories of the European UnionThe weighting coefficients of the domains in relation to each impact category are presented in **Table 3** .

Table 3 Weighting factors

	Domain (Technical area)	Energetic efficiency	Flexibility on network and storage	Comfort	Convenience	Health and well-being	Support and forecasting on errors	Awareness on the inhabitants
Northern Europe	Heating	0.30	0.43	0.16	0.10	0.16	0.31	0.11
	BVG	0.09	0.13	0.00	0.10	0.00	0.10	0.11
	Cooling	0.00	0.00	0.16	0.10	0.16	0.00	0.11
	Ventilation	0.19	0.00	0.16	0.10	0.16	0.20	0.11
	Lighting	0.04	0.00	0.16	0.10	0.16	0.00	0.00
	Electricity	0.13	0.19	0.00	0.10	0.00	0.14	0.11
	Dynamic facade	0.05	0.00	0.16	0.10	0.16	0.05	0.11
	Charging of the EPS	0.00	0.05	0.00	0.10	0.00	0.00	0.11
	Monitoring and control	0.20	0.20	0.20	0.20	0.20	0.20	0.20
For p adna Europe	Heating	0.34	0.46	0.16	0.10	0.16	0.35	0.11
	BVG	0.08	0.10	0.00	0.10	0.00	0.08	0.11
	Cooling	0.03	0.04	0.16	0.10	0.16	0.03	0.11
	Ventilation	0.18	0.00	0.16	0.10	0.16	0.18	0.11
	Lighting	0.01	0.00	0.16	0.10	0.16	0.00	0.00
	Electricity	0.11	0.15	0.00	0.10	0.00	0.11	0.11
	Dynamic facade	0.05	0.00	0.16	0.10	0.16	0.05	0.11
	Charging of the EPS	0.00	0.05	0.00	0.10	0.00	0.00	0.11
	Monitoring and control	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Northeast Europe	Heating	0.30	0.41	0.16	0.10	0.16	0.31	0.11
	BVG	0.14	0.19	0.00	0.10	0.00	0.14	0.11
	Cooling	0.00	0.00	0.16	0.10	0.16	0.00	0.11
	Ventilation	0.19	0.00	0.16	0.10	0.16	0.19	0.11
	Lighting	0.01	0.00	0.16	0.10	0.16	0.00	0.00
	Electricity	0.11	0.15	0.00	0.10	0.00	0.11	0.11
	Dynamic facade	0.05	0.00	0.16	0.10	0.16	0.05	0.11
	Charging of the EPS	0.00	0.05	0.00	0.10	0.00	0.00	0.11
	Monitoring and control	0.20	0.20	0.20	0.20	0.20	0.20	0.20
	Heating	0.21	0.24	0.16	0.10	0.16	0.21	0.11
South east	BVG	0.06	0.07	0.00	0.10	0.00	0.06	0.11
	Cooling	0.15	0.17	0.16	0.10	0.16	0.15	0.11

	Domain (Technical area)	Energetic efficiency	Flexibility on network and storage	Comfort	Convenience	Health and well-being	Support and forecasting on errors	Awareness on the inhabitants
	Ventilation	0.11	0.00	0.16	0.10	0.16	0.11	0.11
	Lighting	0.01	0.00	0.16	0.10	0.16	0.00	0.00
	Electricity	0.22	0.26	0.00	0.10	0.00	0.22	0.11
	Dynamic facade	0.05	0.00	0.16	0.10	0.16	0.05	0.11
	Charging of the EPS	0.00	0.05	0.00	0.10	0.00	0.00	0.11
	Monitoring and control	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Eastern Europe	Heating	0.32	0.38	0.16	0.10	0.16	0.33	0.11
	BVG	0.10	0.12	0.00	0.10	0.00	0.10	0.11
	Cooling	0.07	0.08	0.16	0.10	0.16	0.07	0.11
	Ventilation	0.09	0.00	0.16	0.10	0.16	0.10	0.11
	Lighting	0.03	0.00	0.16	0.10	0.16	0.00	0.00
	Electricity	0.15	0.17	0.00	0.10	0.00	0.15	0.11
	Dynamic facade	0.05	0.00	0.16	0.10	0.16	0.05	0.11
	Charging of the EPS	0.00	0.05	0.00	0.10	0.00	0.00	0.11
	Monitoring and control	0.20	0.20	0.20	0.20	0.20	0.20	0.20

For each impact criterion, the total impact score is calculated as the weighted sum of the impact of all domain impact scores, based on an equal weighting approach to aggregate the impact categories for the three key functionalities. The overall SRI score is then obtained as a weighted cumulative sum of the scores of the seven impact categories or the scores of the three key functionalities. Depending on the local and site-specific context, some domains and services may be inappropriate, inapplicable or undesirable. A triage method is applied to identify relevant services for a specific building. In the event that some services are assessed as inappropriate, inapplicable or undesirable, then the overall SRI score is calculated as the ratio of the building's score to the maximum achievable score of the particular building, not as the theoretical ¬maximum.

Motives for the need to adapt the methodology for calculating the indicator for the readiness of buildings for intelligent management, to the particularities of the country (variant/s of the framework for assessing the readiness of buildings for intelligent management)

As SRI is a new research topic, there are currently a limited number of studies in this area applying SRI methodology to specific buildings, areas and climate zones. Most studies report inconsistencies and methodological gaps in the calculation of SRI among the different renovation options evaluated, as well as subjectivity and problematic interpretation in the selection of relevant services when applying SRI. Researchers (Janhunen , Pulkka , Saynajoki , & Junnila , 2019) emphasize that the SRI framework needs improvements to be applicable to countries with a cold climate, as it does not properly address that of Finland, where, for example, there are large needs of heating and has mainly district heating networks (DHN) used to cover the heat demand, while others implemented the detailed SRI method in a near-zero energy office building in Italy and their analysis outlined the impact of subjective decisions in the choice of applicable services and related functional levels on SRI calculation and evaluation. Another study (Fokaides , Panteli , & Panayidou , 2020) attempted to identify gaps in SRI methodology in a mixed-use building in Cyprus. The authors argue that SRI is not well developed and specifically designed for small residential buildings due to the lack of building management systems (BMS) to offer central monitoring and control. The authors conclude that the SRI framework implies a high level of subjectivity in some cases in the selection and evaluation of services and functionalities, also highlighting the need to develop a commonly accepted database for intelligent building systems and revise the methodology in the short term.

The need to revise the SRI methodology to include specific properties of non-residential buildings with a Mediterranean climate has also been demonstrated in other publications (Ramezani , Silva Manuel , & Simoes , 2021). Varsami & Burman , 2022 highlight that the SRI methodology cannot properly take into account all the EU's 2050 targets, as well as the fact that the SRI assessment is based on qualitative criteria rather than actual performance. The authors also offer a set of key recommendations that will help build on the current SRI methodology in the housing sector (Canale et et al ., 2021).

3. STUDY ON A POSSIBLE OPTION/S TO ADAPT THE METHODOLOGY FOR CALCULATING THE READINESS INDICATOR OF BUILDINGS FOR INTELLIGENT MANAGEMENT TO THE SPECIFICITY OF THE COUNTRY (OPTION/S OF THE ASSESSMENT FRAMEWORK FOR ASSESSMENT OF THE READINESS OF BUILDINGS FOR INTELLIGENT MANAGEMENT)

3.1. Survey of smart management-ready services (smart services) available in Bulgaria

In the course of work on the Report, the intelligent services presented in Included in Method A and Method B, the services proposed with the technical terms of reference and the services at the discretion of the team of experts (who prepared the Report) have been tested for their applicability in Bulgaria, with some of them being replaced/ reduced and/or new ones are added, according to the methodology adaptation process.

For this purpose, the smart services offered on the market and the level of their functionality, the companies that offer them and the users' opinion about them (by conducting a survey) were studied.

3.1.1 Study of the availability of services prepared for intelligent management on the Bulgarian market

Modern developments in the construction of intelligent building installations are aimed at satisfying the growing demand for adaptive products that integrate the ability to communicate data. The new standards impose increasingly high and complex requirements to reduce the ecological footprint, safety, resource and energy efficiency in the design and assembly of switchboards. At the same time, project cycles and the need for business process continuity are pressing manufacturers with their accelerating pace. The trends are towards the implementation of architectures and platforms that support IoT , digitalize and simplify low and medium voltage power distribution systems. Intelligent distribution systems focus on serving value-added processes and ensuring compliance with growing demands.

Heating

- **Measurement of heat radiation (System for control measurements of emissions from heating heat sources - Heat emission control)**

To implement this intelligent service, central thermostats and thermostatic valves can be found on the market in Bulgaria.
When an individual heating system is installed, an intelligent thermostat is required to control the activation of the boiler. The CHP set is suitable for rooms that do not have a central thermostat and are heated by a common heating system (one boiler for several objects) or by CHP (heating network from CHP or boiler room). In such cases, it is possible to install up to 20 intelligent thermal heads within one system [12].

[1] https://www.bloombergtv.bg/a/11-preporychani/103010-inteligentnite-ustroystva-na-alterko-mogat-da-optimizirat-razhodite-za-energiya-na-biznesa-i-domakinstvata
[2] https://www.elprogroup.com/termostati-termoglavi/termoglavi-netatmo

The offered thermostatic valves have separate stages, and each stage corresponds to a certain temperature in the room. With different models and brands of thermostatic valves, there may be a slight difference in degree/temperature [3].

- **Control measurements of thermal emissions from Thermally Activated Building Systems (TABS) (System for Control Measurements of Emissions from Thermally Activated Building Systems TABS - Emission control for TABS (heating mode)**

Thermally Activated Building Systems (TABS) is a system of embedded pipes in the floor, ceiling and walls that can transport heating and cooling water. Ceilings, floors and walls are used for cooling and to help heat the building. Embedded pipes use the concrete mass to store and exchange heat energy. It is not an air conditioning system and does not replace a proper ventilation system. But because it can handle base loads, it reduces conventional fresh air systems to the hygienic, healthy minimum and allows for an ideal and productive indoor climate. It is invisible, silent and without air currents. The operating temperature of the system is close to the ambient temperature. TABS expands the activation on the concrete one surface so that _ Yes includes " thermal nest " , which allows the cooling / heating elements and / or compensation on the spades loads Yes everything hang up directly from the concrete one ceiling [4].

The system is increasingly entering new construction, being integrated into the structure of the building and activating the thermal mass of the building for heating and cooling 5. It uses the thermal mass of the concrete structure of the building in which it is installed by installing pipes that can transport the heating and cooling water. Ceilings, floors and walls are used for cooling and to help heat the building. Embedded pipes use the concrete mass to store and exchange heat energy [6].

- **Control of the temperature of the fluid in the heating system (air flow or water flow) and control of the capacity of network pumps (allows flexible control of the operating mode of the heating network) (Control of distribution fluid temperature (supply or return air flow or water flow) - Similar function can be applied that the control of direct electric heating networks)**

Boilers are available on the market in Bulgaria, which have the possibility of control according to the room or outside temperature [7] or control of the heating based on the outside temperature and correction based on the temperature in the room (mixed regulation).

[3] https://elkom-express.bg/
[4] https://www.rehau.com/bg-bg/stroitelni-predpriemachi/sgradno-stroitelstvo-stroitelni-predpriemachi/otoplenie-okhlazhdane-i-ventilatsiya/otoplenie-i-okhlazhdane-v-zhilishtnoto-stroitelstvo
[5] https://www.uponor.com/bg-bg/produkti/tavansko-otoplenie-i-okhlazhdane/temperirane-na-betonovoto-yadro
[6] https://www.uponor.com/bg-bg/produkti/tavansko-otoplenie-i-okhlazhdane/temperirane-na-betonovoto-yadro
[7] https://ecotherm.bg/wp-content/uploads/2022/10/Broshure-El-Kotli-Thermona.pdf

Wireless thermostats with a WiFi module and Internet input for remote access via computer or mobile application [8]can also be found .

- **Management of distribution pumps in the network (Control of distribution pumps in networks)**

On the Bulgarian market, there are available accessories for the distribution pumps, which have the option of setting the pump's switch-on and switch-off temperature [9].
It is also possible to purchase hydraulic zoning panels, which are complete sets designed to distribute heat to independently controlled heating zones in the system in relation to supply temperatures, and the built-in electronic zone controller allows a thermo-climatic compensation function, separately for each of the zones [10].

- **Thermal Energy Storage (TES) (excluding TABS) (Thermal Energy Storage (TES) for building heating (excluding TABS))**

Thermal energy storage is defined as a technology that enables the transfer and storage of thermal energy or energy from ice, water or cold air. This method is embedded in new technologies that complement energy solutions such as solar and hydropower.

Thermal energy (chilled or hot water) is produced during periods of off-peak demand or electricity use and is collected in a thermal energy storage tank, then withdrawn and distributed to the facility during peak periods. Hot or cooled water enters and exits the tank through diffusers located at the top and bottom of the tank. Diffusers are designed to eliminate turbulence and allow the water in the tank to stratify with cooler water at the base and hot water at the top. Between the areas of warm and cold water, a narrow and sharp transition layer of water is formed [11].

Heat storage systems allow it to be extracted through a heat transfer mechanism directly or indirectly for thermal energy use or for electricity generation through a heat engine cycle [12].

So-called heat accumulators are available on the Bulgarian market . They are heat energy storage vessels that serve to balance the supplied and consumed energy during the joint operation of a boiler or other heat source and the heating installation and heat consumption. If it is necessary to operate the boiler for a long time in modes with a heat output lower than the nominal one, it is recommended to install and connect a heat accumulator to the heating system in order to ensure efficient, economical and reliable operation. According to the BDS EN 303-5 standard, the heat accumulator is a mandatory element of the heating system in which a solid fuel boiler is installed [13].

[8] https://ecotherm.bg/wp-content/uploads/2022/10/Product_catalogue_BG.pdf
[9] https://aqua.store/salus-pc11w-upravlenie-za-tzirkulatzionna-pompa-za-otoplenie-ili-bgv.html
[10] https://amaxgas.com/mnogozonovi-sistemi/124-dim-a-2bt-erp.html
[11] https://byjus.com/physics/thermal-energy/#what-is-thermal-energy
[12] https://www.eso.bg/doc/magazine_pdf.php?id=24
[13] https://www.termaex.com/index.php?p=8&cat=18

- **Control over the operation of the heat sources with off. heat pumps - e.g. temperature control (Heat source control system (temperature control) (for all heat sources, excluding pumps for heating systems) - Heat generator control (all except heat pumps))**

In Bulgaria, the implementation of this service is possible in different ways.
Different types of boilers are available on the market in Bulgaria, with the possibility of remote control of the boiler via SMS or email messages (after installation of the relevant module). Smart valves are also available, which can be controlled through web- based applications - by setting the desired temperature and monitoring their operation in the application. Through the applications, it is possible to turn on the heating devices (air conditioners) in advance (before returning home) [14]. It is also possible to purchase smart programmable thermostats separately [15].

Temperature control is also possible for steam heating radiators by replacing the standard manual radiator thermoheads with controllable ones. In this way, temperature control can be carried out both locally by the thermal head of the radiator itself, and remotely. Communication is two-way and any local change is also reflected in the remote control interface of the system (wall panels, mobile devices, tablets).

Controllable thermal heads do not require a power supply to the place of their installation. They use a battery power supply that is optimized so that under normal operation the battery has a life of 2 years. All possibilities for remote control and associating selected heating modes to various ready-made scenes can be used both in the control of air conditioners and in the control of radiators.

In addition to the temperature control of the radiators, which is applicable to both central and local steam heating, in heating systems with an autonomous boiler it is possible to control the boiler itself. The control method is different depending on the type of boiler (electric, gas or pellet) and can be reduced to activating the procedures set by the manufacturer to start and stop the boiler or (if the boiler allows it) to ensure maintenance of a desired mode depending on the temperature of the incoming water. In the case of electric boilers, it is also possible to control the power of the heaters and display on the interface generalized signals for malfunction of the heater, pump, low water level in the system, etc. For gas boilers, the system can provide additional protection and automatic shutdown in the event of a Propane-butane leak , based on an independent gas sensor [16].

- **Heat source operation control - for heat pumps (e.g. temperature control) (Heat source control system (temperature control) (for pumps for heating systems) - Heat generator control (for heat pumps))**

[14] https://www.houseper.com/bg/%D1%83%D0%BC%D0%BD%D0%BE-%D0%BE%D1%82%D0%BE%D0%BF%D0%BB%D0%B5%D0%BD%D0%B8%D0%B5/
[15] https://www.smart2u.bg/product/neostat-v2
[16] https://bulcraft.com/home/index.php/bg

The Bulgarian market offers Web technologies suitable for: remote switching on, off and control of the operation mode of heat pump installations, for remote diagnosis of heating or cooling of buildings, production of hot water for domestic needs, etc.

Through the remote control system of the heat pump, the user has the possibility to check and change the operating conditions and temperature, to detect the counter of his heat pump control system from anywhere in the world.

It is also possible to implement modifications in the timer program, various remote settings of the operating mode and the heat curve, as well as diagnostics and optimization of the system operation[17] [18].

In addition to the temperature, it is also possible to control the humidity in the respective rooms [19].

- **Sequential activation in the case of different heat sources (System for determining the sequence of activation in the case of different heat sources - Sequencing in case of different heat generators)**

So-called hybrid heat pumps can be found on the market . A hybrid heat pump system means: an electric air-water or ground-water heat pump combined with a gas boiler; a mechanism for supplying heat energy to an existing heat distribution system; and a special control system to switch between the two heat sources. Two types of solutions are available on the market - a hybrid heat pump package including a heat pump unit, a gas boiler and an intelligent controller, and an additional hybrid heat pump with an intelligent controller that is installed to an existing gas boiler.

The hybrid heat pump system can meet the overall heating and water heating requirements of any household, and the heat pump can provide low-temperature heating at reduced costs and significantly lower energy consumption [20].

The heat pump systems on offer are intelligent programming, so they help save up to 35% more energy than a standard condensing boiler, thanks to the technology to automatically determine the most economical and energy efficient combination based on energy prices, outdoor temperatures and indoor heat capacity [21].

- **Reporting information on the operation and status of the heating system (System for reporting information on the operation of the heating system - Report information regarding heating system performance)**

web- based applications are available on the market in Bulgaria , through which the user can receive information about the operation and status of the heating system in his home. They also provide the convenience of remotely turning off forgotten electrical appliances. These

[17] https://www.termopompi-otoplenie.com/broshure/Heliotherm-Invertorna-Tehnologia.pdf
[18] https://www.termopompi-otoplenie.com/broshure/Heliotherm-Tele-Control.pdf
[19] https://www.nibe.eu/bg/bg/produkti/umen-dom
[20]
[21] https://www.daikin.bg/bg_bg/product-group/hybrid-heat-pump.html

systems provide reports and statistics on consumption, making it possible to track it in the mobile application as well [22].

- **Flexibility in terms of heat source control (e.g. switching on at a set time, or remotely by signal, etc.) Flexibility and grid interaction)**

Home automation systems are available on the market in Bulgaria, which enable remote control of the control systems, regardless of whether they are electric or steam - pre-heating or cooling of the premises.

They can also be self-learning, i.e. they feature auto-balancing technology (intelligent algorithms optimize the system automatically and constantly for both wired and wireless controls) that constantly predicts and adjusts the exact amount of energy needed to achieve optimal heating all the time [23].

- **Geothermal energy storage and transmission (Geothermal energy storage and transmission system - Geothermal energy storage and transmission system)**

As a result of the work carried out on the evaluation of the prospects for economically viable business initiatives in Bulgaria for the production of electricity from geothermal resources, it was established that at the present time (and until 2025) there are no favorable conditions for the implementation of projects in the field of geothermal energy. Currently, a policy to promote the use of geothermal energy has been launched. Bulgaria is expected to start achieving real results and working projects in the area by 2027-2028 [24].

At the moment, there are single construction companies that foresee the introduction of the use of geothermal energy in new construction. In them, the geothermal heating for multi-family residential buildings will be implemented by means of a necessary number of low-temperature geothermal wells at a depth of 100 to 125 m [25].

- **Geothermal thermal energy storage (excluding TABS) (thermal energy storage - TEC) (Geothermal thermal energy storage system (excluding TABS) (thermal energy storage - TEC) - Geothermal thermal energy storage (excluding TABS) (thermal energy storage - TPP))**

As a result of the work carried out on the assessment of the prospects for economically viable business initiatives in Bulgaria for the production of electricity from geothermal resources, that at the present moment (and until 2025) there are no favorable conditions for the realization of projects in the field of geothermal energy . Currently, a policy to promote the use of geothermal energy has been launched. Bulgaria is expected to start achieving real results and working projects in the area by 2027-2028 . [26].

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22 https://www.houseper.com/bg/%D1%83%D0%BC%D0%BD%D0%BE-%D0%BE%D1%82%D0%BE%D0%BF%D0%BB%D0%B5%D0%BD%D0%B8%D0%B5/

23 https://www.uponor.com/bg-bg/produkti/kontrol-vurkhu-temperaturata-na-termostata/smatrix

24 https://mdg-magazine.bg/balgarska-geotermalna-elektroenergia-mit-ili-realnost/

25 https://www.acme.bg/

26 https://mdg-magazine.bg/balgarska-geotermalna-elektroenergia-mit-ili-realnost/

Cooling

- **Measurement of thermal emissions from the cooling system (System for control measurements of emissions from cooling systems - Cooling emission control)**

Similar to systems for measuring heat emissions from the heating system, the measurement of heat emissions in cooling systems can be done through smart thermostats, room controllers. Usually they are included in common systems with those for heating and are included depending on the season [27].

- **Control measurements of thermal emissions from Thermally Activated Building Systems (TABS) - in cooling mode (System for control measurements of emissions from Thermally Activated Building Systems TABS (in cooling mode) - Emission control for TABS (cooling mode))**

In recent years in Bulgaria Thermally activated building systems have become the standard for cooling newly built offices. TABS can be used in combination with mechanical and/or natural ventilation systems It can also be used with and renewable energy sources

The system is economically efficient due to lower investment costs, maintenance costs and low life cycle costs [28].

In the case of office or commercial properties, activating thermal elements is an economical and sustainable way to heat and cool buildings in an energy-efficient way. Component activation uses the thermal mass of the concrete in the building structure. Pipelines are installed that supply the water for heating / cooling. In this way, the ceilings contribute significantly to the cooling or primary heating of the building. The pipe systems integrated into the room surfaces use the concrete core in the building mass to exchange heat energy [29].

- **Control of the temperature of the chilled water in the distribution network (supplied or returned) (Control of distribution network chilled water temperature (supply or return))**

To perform the service, pump protection and control panels (also called "pump panels") can be found on the market. They are an electrical control panel that is used to monitor, control and protect one or more pumps in water systems. Pump control panels typically include the following components and functions:

Control Panel: This is the main part of the dashboard where all the controls, displays and buttons for the operator are located. This panel displays important values such as current pressure, pump status and system status.

[27] https://solislux.eu/bg/
[28] https://www.uponor.com/bg-bg/produkti/tavansko-otoplenie-i-okhlazhdane/temperirane-na-betonovoto-yadro
[29] https://www.uponor.com/bg-bg/produkti/tavansko-otoplenie-i-okhlazhdane

Starters or contactors: The panel includes starters or contactors for each individual pump motor. They control the on and off of the pumps and can be controlled automatically or manually via the panel.

Relays and sensors: The board usually has built-in relays and sensors for monitoring various parameters such as pressure, temperature, current and voltage values, flow rate, capacity, etc. These sensors provide information about the status of the system and can activate protective measures in case of anomalies.

Protective devices: The panel includes protective devices such as thermal relays, circuit breakers, overload protection and others to protect the pumps and the system from damage in case of problems such as overheating or blockage.

Indicators and alarms: The panel usually has LED indicators and audible alarms that alert operators to events such as an emergency or low pressure.

- **Control of the capacity of network pumps (System for control of the capacity of network pumps - Control of distribution network chilled water temperature)**

Automatic control: The board can be programmed to perform various operations automatically depending on the system needs, such as starting and stopping pumps under certain conditions.

Remote control and monitoring: In some applications, the possibility of remote control and monitoring of the pumps and the system is provided [30].

- **Avoiding successive heating and cooling in the same room (Interlock system: avoiding successive heating and cooling in the same room - Interlock : avoiding simultaneous heating and cooling in the same room)**

The Bulgarian market offers hybrid systems that respond to changing temperatures and automatically adjust to the most efficient way to save energy - heating or cooling. Thus, a standard system in which two heating/cooling sources work is, in practice, a hybrid system [31].

Web- based applications are also available that allow control of the heating/cooling system and operate according to user-preset parameters, so as to avoid consecutive heating and cooling in the same room [32].

- **Control of the operation of the thermal energy accumulator (TES) (Control of Thermal Energy Storage (TES) operation)**

Thermal accumulators are available on the Bulgarian market . They have the ability to measure the temperature of the working fluid in three zones - lower, central and upper zone, and in

[30] https://stiko.bg/bg/

[31] https://ecotherm.bg/%d1%85%d0%b8%d0%b1%d1%80%d0%b8%d0%b4%d0%bd%d0%b8-%d1%81%d0%b8%d1%81%d1%82%d0%b5%d0%bc%d0%b8/

[32] https://inovativa.bg/

this way flexible control of the system can be realized [33]. Various controllers can also be purchased - wireless or wired thermostats, with which the operation of the thermal accumulators can be controlled [34][35]. Various ecological systems are also available, through which on hot summer days the heat pump control switches to "natural cooling" and takes the heat from the room to the cooler ground or groundwater through the heating circuit. For this purpose, only a small amount of electricity is needed for the circulation pumps — all other functions of the heat pump are switched off [36].

- **Automatic control of cooling generators (Generator control for cooling)**

Cooling control can be implemented in several different ways, switching the compressors on and off depending on the cooling demand, variable load control of the compressors depending on the load, or variable control of the compressor depending on the load, but also at taking into account the influence of external factors, information about which was obtained on the network [37].

- **Sequencing in the case of different cooling systems (System for determining the sequence of activation in the case of different cooling systems - Sequencing of different cooling generators)**

As with the previous intelligent service, here the essence is in the control and automated management of the air conditioning system. The difference is that here the focus is on a fixed sequence of switching the individual compressors on and off, based solely on the time they are running. On and off compressors can be scheduled based on preset parameters, dynamic prioritization depending on compressor efficiency, prediction of expected load, or a sequence based on a dynamic list of priorities and external signals received through the network.

- **Reporting information on the operation of the cooling system (System for reporting information on the operation of the cooling system - Report information regarding cooling system performance)**

Various companies offer web- based applications for remote monitoring of cooling system performance, accessible from a smartphone, tablet or other , which provides insight into the current state of the cooling system at any time.[38] [39].

[33] https://termaex.com/index.php?p=13&id=93
[34] https://salus-controls.bg/salus-controls-bg/produkti/?kategoria=%D0%9A%D0%9E%D0%9D%D0%A2%D0%A0%D0%9E%D0%9B%20%D0%9D%D0%90%20%D0%9A%D0%9E%D0%A2%D0%95%D0%9B%D0%90&podkategoria=%D0%9A%D0%B0%D0%B1%D0%B5%D0%BB%D0%BD%D0%B8%20%D1%80%D0%B5%D0%B3%D1%83%D0%BB%D0%B0%D1%82%D0%BE%D1%80%D0%B8
[35] https://engocontrols.com/bg/staiini-termostati-po-dzhoba-na-vseki/
[36] https://www.viessmann.bg/bg/produkti/termopompi/nc-box.html
[37] https://www.climamarket.bg/управление-на-климатични-системи.html
[38] https://www.viessmann.bg/bg/reshenia/smart-technology/viessmann-apps.html#vicare-app
[39] https://www.viessmann.bg/bg/produkti/sistemi-za-kontrol-i-upravlenie/vicare-app.html

- **Flexibility in terms of control over the cooling system (Flexibility system in terms of control over the cooling system (e.g. turning on at a set time, or remotely by signal, etc.) - Flexibility and grid interaction)**

Various companies offer web- based applications for remote control and maintenance of the cooling system, with access from a smartphone, tablet or other. They enable the selection of a desired temperature, the inclusion of different modes – switching on at a set time, maintaining a certain temperature all the time, a mode for users who are on the road, switching on at different times depending on the day , etc.[40]

Domestic hot water (Domestic hot water (DHW))

- **DHW Heater Control (Electric Heater or Heat Pump) (DHW Heater Control System (Electric Heater or Heat Pump) - Control of DHW storage charging (with direct electric heating or integrated electric heat pump))**

On the market in Bulgaria, you can find systems with built-in software, with electronic control, which, like artificial intelligence, autonomously tracks and remembers the habits of users and creates a schedule through which it manages the operation of the device, so as to provide domestic hot water just then , when needed. The built-in algorithm supports the possibility of a quick change in the schedule or for accidental use of the system. The mode, however, also allows for manual intervention and one-time heating to the maximum temperature, without changing the established work schedule [41].

- **Domestic hot water boiler management (DHW heater control system - Control of DHW storage charging (using hot water generation))**

The hot water boiler heating control system works by automatically turning on and off the hot water heater, and this can be done according to a preset schedule or according to a preset schedule, taking into account information received from sensors installed on the boiler, such as supplements with information coming from the network about available capacity from produced electricity from renewable energy sources. There are no established suppliers of this type of module for controlling water heating systems on the Bulgarian market.

- **Control of the DHW heater operating with solar modules (Control system on the DHW heater (with solar panel and additional heat generator) - Control of DHW storage charging (with solar collector and supplymentary heat generation))**

Very often, heat pumps are successfully combined with solar thermal systems so that solar energy is used to heat most of the water in the summer and heating in the transitional seasons. Alternatively, the efficiency of the heat pump increases significantly when the temperature of the heat source is raised using solar energy. Solar energy combined with heat pumps is also used in the form of photovoltaic panels: the heat pump needs electricity to operate, and by

[40] https://www.viessmann.bg/bg/reshenia/smart-technology/viessmann-apps.html#vicare-app
[41] https://tesy.bg/za-nas/inovacii/inovacii-bojleri/eco-smart/7

installing a photovoltaic to produce electricity, the panel will cover (part of) the electricity consumption of the heat pump.

Separately, solar heaters are also available on the market. They use the energy from the sun to heat the water. Solar heaters include solar collectors that absorb solar radiation and convert it into heat that is transferred to the water in the boiler [424344].

- **Sequencing in case of different DHW heaters (System for determining activation sequence in case of different DHW heaters - Sequencing in case of different DHW generators)**

It is a system in which different heat sources are used to heat hot water. The selection and sequence of use of the different sources for heating the water can be based on a predetermined efficiency of each of the sources (e.g. solar energy, electricity, pellets), or based on a dynamic prioritization of the energy sources, in which approach the current efficiency of each of the sources is taken into account, and at the highest functional level, the expected use of hot water is also predicted.

In the Bulgarian market, this type of system is widespread for heating hot water, both for household and industrial conditions. These are the solar hot water heating systems, which primarily use solar energy to heat the hot water, but in the case of cloudy weather and lack of sunny weather, they have a built-in electric heater and use electric energy to heat the hot water.

- **Information on the operation of the DHW installation (System for reporting information on the operation of the DHW installation - Report information regarding domestic hot water performance)**

web applications are available on the Bulgarian market , which enable monitoring and control of the DHW installation. They allow the system to be managed from anywhere in the world. It is implemented in devices with a built-in Wi-Fi module connected to the home wireless network. The system offers the possibility to set the desired temperature when the user is at home or outside, to include modes such as "Sleep", "On the road", etc. or to set a weekly work program for a day and time according to the needs and habits of the users [45].

Ventilation

- **Room level air flow control (Room level air flow control system - Supply air flow control at the room level)**

42 https://evtinmagazin.com/%D1%81%D0%BE%D0%BB%D0%B0%D1%80%D0%BD%D0%B8-%D0%BF%D0%B0%D0%BA%D0%B5%D1%82%D0%B8/1102-%D1%84%D0%BE%D1%82%D0%BE%D0%B2%D0%BE%D0%BB%D1%82%D0%B0%D0%B8%D1%87%D0%B5%D0%BD-%D0%BD%D0%B0%D0%B3%D1%80%D0%B5%D0%B2%D0%B0%D1%82%D0%B5%D0%BB-%D0%B7%D0%B0-%D0%B1%D0%BE%D0%B9%D0%BB%D0%B5%D1%80.html

43 https://klimatici.bg/blog/razlichnite-vidove-nagrevateli-pri-boilerite-predimstva-i-nedostatyci

44 https://www.emde-solar.com/kontroleri-za-wetrogeneratori

45 https://tesy.bg/za-nas/inovacii/inovacii-otoplenie/mytesy-app/76

It is possible to find automated ventilation systems with decentralized recuperators on the market in Bulgaria . It supplies the room with fresh air from the outside environment, replacing the polluted air from the rooms, at the same time returning the heat of the extracted air. It also performs the function of a thermal curtain. In the event of emergency fire situations, it does not spread smoke and removes carbon dioxide. The coefficient of saving energy in winter and coolness in summer with decentralized recuperators is up to 83% [46].

Ventilation in the home can be controlled manually from any interface of the system (remote, wall panels, mobile devices) and/or automatically, when pre-set conditions are met (for example, increasing the level of CO_2 in the premises). The carbon dioxide sensor can be installed in the suction duct of the ventilation system or in selected places in the premises . If desired, for certain rooms, an air ionizer can be installed and controlled at the same time as the ventilation. As a rule, in every home with a built-in ventilation system, automatic shutdown of all operating fans is organized upon receipt of a fire signal (cease of air flow).

- **Air flow control at the level of the ventilation system (Air flow control system at the level of the ventilation system - Air flow or pressure control at the air handler level)**

The market offers constant flow regulators, with and without drive preset, as well as variable air flow regulators, with a wide range of actuation and control mechanisms. This type of device meets the increased requirements for reducing energy consumption, low level of noise generation and precise control, respectively with very low air flow speeds [47].

- **Heat recovery: prevention of overheating (Heat recovery system: prevention of overheating - Heat recovery control : prevention of overheating)**

The market offers controllers that are designed to manage a ventilation system with conditioned air by regulating the temperature in the inlet air duct and the temperature in the conditioned rooms. They provide alternative use of the hot air heating or cooling system according to a command received from an internal task or from an external proportional controller.

They regulate the water heating and cooling section, are equipped with a mixing unit and a protective thermostat against freezing; electric heating section with a blocking thermostat against overheating and an instrument for the presence of air flow. They also regulate inlet and outlet valves equipped with motor drives , suction and discharge fans with asynchronous motors and protect the system from overheating [48].

46 https://inovativa.bg/%D0%BA%D0%B0%D0%BA-%D0%B4%D0%B0-%D1%81%D1%8A%D0%B7%D0%B4%D0%B0%D0%B4%D0%B5%D0%BC-%D0%BF%D0%B0%D1%81%D0%B8%D0%B2%D0%BD%D0%B0-%D0%BA%D1%8A%D1%89%D0%B0/

47 https://www.systemair.com/bg-bg/produkti/produkti-za-vuzduhorazpredelenie/kontrol-na-vuzdushniya-debit

48 https://eltones.com/intiel-kontroler-ventilacia

- **Air flow temperature control at the ventilation system level (System for air flow temperature control at the ventilation system level - Supply air temperature control at the air handling unit level)**

" Multi. is available on the market **Input and Output "** system that effectively controls the temperature of the air flow and the degree of superheat by switching the fan speed. In a conventional inverter model, the expansion valve and the compressor are controlled separately, therefore the room temperature varies due to the inertia of the process and is required temperature stabilization time.

The system is an innovative method for simultaneously issuing multiple alerts based on multiple inputs. This allows the air conditioner to react quickly to temperature changes in order to maintain an appropriate temperature comfort in the room [49].

- **Free (passive) cooling with mechanical ventilation system (Free cooling system with mechanical ventilation system - Free cooling with mechanical ventilation system)**

The passive cooling method (free cooling) is based on the outside air that enters the premises indirectly by passing through a plate heat exchanger. Thanks to the highly efficient recuperation , the air is cooled and reaches the interior of the premises, without the possibility of dust formation and moisture retention. The mechanical ventilation system for fresh air supply and exhaust system with heat recovery function, with an integrated ventilation unit is called a recuperator . It provides continuous and controlled air exchange in the building, which leads to a reduced concentration of carbon dioxide and humidity to acceptable levels [50].

When the recovery cooling does not reach the required output, the adiabatic cooling system (which is an efficient use of renewable resources) is automatically switched on . The adiabatic cooling principle uses water (preferably collected rainwater) to absorb heat from the air and thus achieve cooling [51].

These two methods – plate heat exchanger recovery and adiabatic cooling – are sufficient for 97% of the total operating time. For the remaining 3% of the time, the mechanical cooling system (chiller) is turned on. Free cooling systems (mostly applicable to shopping malls) can be found on the market when the outdoor temperature is below the indoor temperature [52].

- **Indoor air quality tracking (Indoor air quality reporting system - Reporting information regarding IAQ)**

ventilation systems on the market have integrated CO_2 and VOC sensors. The sensors can be installed in the suction duct of the ventilation system or in selected places in the premises.

[49] https://vento-k.com/bg/daikin-super-multi-rxysq-p-259
[50] https://ecotherm.bg/wp-content/uploads/2021/12/Brochure-Recuperator-Web.pdf
[51] https://www.stroiteli-bg.com/statii/ohladitelna-sistema-servecool-na-hoval-optimalnoto-reshenie-za-ohlazhdane-v-sarvarnite-tsentrove/
[52] https://bulgarterm.bg/produkt/rekuperatori-daikin-vkm-gb-gbm/

VOC sensors capture all volatile pollutants in the air, also continuously monitor air quality and adjust system performance according to air cleanliness requirements in real time [53].

New-style homes retain more moisture, creating a favorable environment for airborne pollutants and molds that cause allergic and respiratory problems. Systems are available that are able to control the humidity of the air in the rooms and, when a certain level is reached, turn on the convector or dryer until the value is restored within the permissible limits, preventing the formation of condensation and mold [54].

Lighting

- **Occupancy control system of internal lighting control for indoor lighting)**

"Smart lights" are network-connected devices that can be controlled wirelessly and used to turn on/off, change color, change brightness, and more via a phone app, accessories, or through automation. Control can be carried out through remote or various web- based applications [55].

The system allows for individual smooth adjustment of the brightness of all lighting lines in the home. At the same time, for each of the lines, the so-called smooth start and stop, which is a great advantage not only from the point of view of the pleasant visual effect, but also repeatedly extends the life of the lamps, especially for the types operating with a high temperature of the light source (220 and 12V halogen lamps and bulbs with filament). The smooth start and stop also create the possibility for a highly emphasized "movement" of the light from one corner of the room to another when starting a selected lighting scene.

The control modules allow individual adjustment of the upper and lower adjustment limits of each of the lines, thus eliminating the unpleasant flickering effects of light from some lamps when adjusted to levels unsuitable for their normal operation. At the same time, the adjustment in the working range is smooth and without sharp transitions, which is a good sign of the quality of the controllers and ensures aesthetic uniformity in lighting control .

The different types of lighting (halogen, LED, fluorescent , energy-saving) are regulated on a different principle, which requires them to be equipped with suitable controllable power supplies or ballasts . When drawing up a project for the system, users receive detailed instructions on the necessary types of power supplies, with which the bodies intended for each specific line must be equipped.

The systems offered also have the ability to turn the lighting on and off when there is a person in the room, set schedules for holidays, etc. [56].

[53] https://www.hoval.bg/produki/homevent/homevent-er-comfort
[54] https://bulcraft.com/home/index.php/bg/
[55] https://www.ledvance.bg/potrebitelski/smart
[56] https://bulcraft.com/

The system can monitor and remember all lighting changes made within a user's day. As when absent from the building, the system can accurately reproduce the memorized actions, thereby imitating presence in the empty home.

Lighting can be turned on automatically only at certain times or activated remotely via smartphone or tablet.

- **Control of the strength of artificial lighting depending on daylight (System for controlling the strength of artificial lighting depending on daylight - Control artificial lighting power based on daylight levels)**

The market offers systems for regulating (dimming) the intensity of light depending on the natural daylight in the premises, entering through the windows, so that the norm for illumination of the work surface is achieved. Also, they offer the possibility to turn off the lighting 15 minutes after reaching 1.5 times the illuminance norm of daylight (to avoid oscillations) or when a visitor enters the room, if the daylight is sufficient - the artificial lighting will not turn on [57].

The possibilities of integration with different types of sensors (including illuminance sensors) allow the system to automatically adjust the light intensity in selected rooms depending on the amount of light coming from outside. In this way, the lights can maintain a certain level of illumination, providing optimal electricity consumption and a constant light background in the room. Even in the case of momentary dimming, the system has the ability to react immediately and restore the set level of illumination, and any change takes place smoothly and imperceptibly, without sudden changes and flickering [58].

Dynamic facade

- **Solar shading of the windows (System for solar shading of the windows - Window solar shading control)**

On the market in Bulgaria, an automated sun protection system can be found. It performs the important function of preventing excessive heating during hot summer days. For this purpose, in addition to external aluminum blinds, an automation and autonomous control system is integrated. It allows easy control of light access, a high degree of stability and maximum shading and prevents excessive heating [59].

The rich assortment, the wide installation options and the wide variety of colors and patterns make blinds a preferred means of sun protection. The system provides:

[57] https://probuilders.eu/site/energoefektivni_inteligentno_osvetlenie.php
[58] https://bulcraft.com/
[59] https://inovativa.bg/%D0%BA%D0%B0%D0%BA-%D0%B4%D0%B0-%D1%81%D1%8A%D0%B7%D0%B4%D0%B0%D0%B4%D0%B5%D0%BC-%D0%BF%D0%B0%D1%81%D0%B8%D0%B2%D0%BD%D0%B0-%D0%BA%D1%8A%D1%89%D0%B0/

- Synchronized control of all blinds in a room.
- Simultaneous lowering of all blinds and switching off of all lights when activating the security system and leaving the home.
- Stored blind positions and association to different scenes - waking up, dinner, cinema, party, leaving and coming home.
- Free choice of the preferred way of control by the user. Independent control from active wall panels, remote controls and standard wall switches, with two-way communication and updating the current status of the blinds on all interfaces.
- Automatic position change at certain times of the day.
- Automatic control depending on the external lighting
- Automatic closing of the blinds in case of wind or when receiving weather information with a warning of bad weather.
- Full compatibility with blinds of various models - external, internal, horizontal, vertical, roller blinds , Venetian, Roman, etc.
- Keep local control from blind wall switches.
- It is not necessary to purchase separate remote controls and complete with receivers and controllers. The system takes control of all blinds in the home and displays them on the common interface along with lighting, appliances, air conditioning and multimedia.
- Organize timers with automatic change depending on the season and sunrise and sunset times for the specific location.

All of the options listed above for controlling blinds can also be applied to the control of curtains in the home. Actuators for driving curtains are offered by many manufacturers, in different variants and, as a rule, are equipped with separate remote controls, which is inconvenient, uneconomical and rarely allows simultaneous control and synchronization. Control of curtains can be displayed on the active wall panels, as well as carried out by any of the remote controls of our system, together with the control of lighting, air conditioning and multimedia [60].

- **Window opening/closing control, combined with heating, ventilation and air conditioning (HVAC) system (Window opening/closing control system, combined with heating, ventilation and air conditioning (HVAC) system - Window open / closed control , combined with HVAC system)**

[60] https://bulcraft.com/

The system is most often applicable in office buildings and hotels. In the presence of this system, wireless air sensors are located that measure the temperature remotely and thus turn off the ventilation/heating/cooling source when a window or door is opened[61] [62].

- **Information about the work of the dynamic facade of the building (System for reporting information about the work of the dynamic facade of the building - Reporting information regarding performance of dynamic building envelope systems)**

Web- based applications have been developed that provide information on the operation of the dynamic facade and allow remote control for doors, awnings and blinds, incl. and lights in the home or office.
The system is connected by means of a coded radio channel to all the automatic machines installed in the building and allows the user to manage them easily and conveniently from his smartphone/tablet. Control of the systems is with both receivers and transceivers , allowing the user to have feedback on the status of portals, doors, blinds and lighting (for example, whether lights are left on, blinds are up, or the portal and door are open). With the application, the user configures the devices, based on a specific mode of operation, related to his daily rhythm of life, and that remotely. It allows changing lighting schemes in real time. It allows to create different schedules and scenarios by days and hours.
An advantage of the system is that the access of more than one user can be customized /family and office members can be included/ [63].

Electricity

- **Reporting of information on local power generation installations (System for reporting information on local power generation installations - Reporting information regarding local electricity generation)**

Monitoring systems are available on the market that allow tracking how efficient the system is, how much self-consumption and self-sufficiency has been achieved and where there is still potential for energy savings. In addition, they give system operators the ability to review the electricity that is produced over time, allowing them to make the right decisions [64].

- **Storage of locally produced electricity (System for storage of (locally produced) electricity - Storage of (locally electricity generated _ _**

Storage systems collect excess energy and release it when needed. This allows them to increase the private consumption of solar power by households and businesses, manage severe peaks in electricity consumption and provide operational reserves to compensate for short-term fluctuations in the quality and price of electricity on the grid. The constant development in storage technologies makes it impossible to predict which of them will triumph in the long term, but for now the main contenders for the top spot are batteries.

[61] https://www.smart2u.bg/product/neostat-v2
[62] https://www.smart2u.bg/product/wireless-window-door-contact-sensor
[63] https://beside.bg/products/bemove/
[64] https://vvt.bg/optimizaciya-na-upravlenieto-i-sahranenieto-na-energiya/

Accumulator batteries can be found on the market to store locally produced electricity. Some of the offered batteries have a clean design and the possibility of building modular systems [65].

Their modular system allows investment flexibility with the option to quickly and easily upgrade multiple modules in parallel. In the combination of several modules, in the event of a malfunction in one of them, it is automatically isolated to continue to keep the overall system running [66].

- **Optimization of electricity produced for own consumption (System for optimization of electricity produced for own consumption - Optimizing self-consumption of locally generated electricity)**

Inverters are available, which are a good example of such smart devices designed to facilitate the management of the storage of energy generated by a photovoltaic plant. Their inverters not only provide efficient conversion of the direct current generated by the photovoltaic panels into alternating current, but also provide a number of innovations. For example, they are equipped with " smart grid " features that allow the system to dynamically respond to changes in the electrical grid. These features include the ability to detect and shut down non-essential loads and automatically regulate the power of the PV system, ensuring optimal energy flow [6768].

- **Control of an installation for the combined production of heat and electric energy (Control system of an installation for the combined production of heat and electric energy - Control of combined heat and power plant (CHP))**

Combined energy management is based on cogeneration, which consists of the generation of electricity and heat in one unit. Their simultaneous production is carried out in the so-called combined heat and power (CHP). These systems have a built-in remote control, which allows the installation to be controlled from a distance [69].

- **Support different micro grid operation modes (Micro grid operation mode support system (micro grid can operate in two modes: 1. Connected to the grid or 2. Standalone) - Support of (micro) grid operation modes)**

The system includes automatic power consumption management, depending on the information it receives about the power grid. In case of surplus of self-produced electrical energy, it is given to the network (functional level 2) or in case of interruption of the external power supply, the system has the possibility to work in autonomous mode (functional level 3).

This type of system is available on the Bulgarian market and relatively popular. The most popular solution is the construction of photovoltaic systems for one's own needs. Usually,

[65] https://shcsystems.bg/vazobnovyaema-zelena-energiya/sistemi-za-sahranenie
[66] https://es3.bg/energiino-suhranenie/
[67] https://vvt.bg/optimizaciya-na-upravlenieto-i-sahranenieto-na-energiya/
[68] https://www.chimebg.com/cogeneration.html
[69] https://www.hoval.bg/blog/bg-106/

when a property or business owner builds such a system and is connected to the electricity distribution network, the electricity distribution company provides the so-called two-way electricity meter, which counts both the electricity supplied to the respective property and the electricity supplied by the installation for its own needs to the grid. In this way, in times of low consumption or in case of excess production exceeding own needs, the produced electricity is given to the grid and supplies neighboring consumers.

To achieve functional level 3 (operation in autonomous mode) on the Bulgarian market, the offered solutions include equipment with an energy storage module (batteries). In this way, independence of the system and autonomous operation of the household is ensured. With a good dimensioning of the needs and provision of the necessary capacity for energy storage, it is possible to achieve a completely autonomous power supply for the home.

- **Reporting information about energy storage (System for reporting information about energy storage - Reporting information regarding energy storage)**

Free systems are available for monitoring and reporting storage system information via an application or via an internet browser [7071]. The applications/platforms allow monitoring the inverter energy flow direction and power curve change in real time, and can also adjust and upgrade the inverter remotely, so as to realize intelligent energy management [72].

- **Reporting information on electricity consumption (System for reporting information on electricity consumption - Reporting information regarding electricity consumption)**

Various systems for reporting information on electricity consumption are available on the Bulgarian market.

One of them is Energomonitor . The system is fully automated and intelligent. The web- based platform enables real-time remote monitoring of electricity, water, natural gas consumption and microclimate parameters such as temperature, humidity and CO_2. The software converts the measured data into a clear and comprehensible graphical and tabular form, which allows comparison with previous periods and provokes energy savings. The system consists of a software and a hardware part. The Energomonitor software is a Web- based platform (interface) that allows remote monitoring of energy consumption and microclimate parameters in real time from any device equipped with the Internet - computer, laptop, tablet or smartphone, without limitation in the devices from which it can be accessed .

Energomonitor software also provides:

- Visualization and storage of the electricity consumption data read by communication in kWh / MWh ;
- Real-time visualization of the current load in kW ;
- Valuation of the consumption of each measuring point in BGN - two tariffs;

[70] https://shcsystems.bg/baterien-blok-lg-chem-resu-16h-prime-160-kw-1265
[71] https://shcsystems.bg/baterien-blok-lg-chem-resu-10h-prime-96-kw-1264
[72] https://bg.ue-power.net/home-energy-storage-system/battery-for-home-energy-storage-system.html

- Decentralized measurement of electricity consumption by separate current circuits - production machines, chillers , heat pumps, electric boilers, etc.
- Online visualization of electricity consumption from an existing digital electricity meter;
- Comparisons of consumption with previous periods;
- Data update every 5 s, data recording every 1 min ;
- Provides tabular and graphic reports on electricity consumption by consumers - 24 hours a day, 7 days a week;
- Automated email alerts for deviations from normal values;
- Export data for selected periods in xls or csv format.
- Shows minimum, maximum and average values of consumption by consumers;
- Emails weekly and/or monthly energy usage reports from selected consumers.
- Maintains a register with historical data on electricity consumption by consumers;
- Generation of hourly load profiles;
- Monitoring the consumption of permanently switched on appliances;
- Possibility of upgrading with new measurement points , etc.[73]

Another option for tracking consumption is ThingsLog . This is a Bulgarian company that offers a custom energy management solution based on its own hardware and software monitoring platform, providing opportunities for analysis and forecasting of utility consumption. The solution allows the company's customers to monitor electricity consumption, analyze the reasons for a given consumption, understand the information and use it for informed decisions. An example of this could be the determination of the current price of the products they produce or the services they offer, the possibility to request the estimated amount of electricity to their electricity trader, or simply the detection of a given anomaly in consumption due to an accident, theft, or increased consumption compared to the season [74].

Charging points for electric vehicles (EVs)

- **Capacity for charging electric vehicles (EV Charging capacity)**

Electric charging stations are available on the market, which can be installed in commercial establishments, residential, business and administrative buildings or by private users [75]. T represent a modern, fast charging system with a minimalist design - an LCD display that shows all charging data - current power, session time, operating temperature or even the filled capacity. At a glance, it is possible to see whether the loading is still in progress or has just finished [7677].

[73] https://energomonitor.bg/distancionen-energien-monitoring/

[74] https://thingslog.com/bg/2023/03/13/%d0%ba%d0%b0%d0%ba-%d0%b4%d0%b0-%d0%bf%d0%b5%d1%81%d1%82%d0%b8%d0%bc-%d0%be%d1%82-%d1%82%d0%be%d0%ba/

[75] https://elektromobili.bg/

[76] https://afore.bg/zaryadni-stantzii

[77] https://mpower.bg/%D1%80%D0%B5%D1%88%D0%B5%D0%BD%D0%B8%D1%8F/%D0%B6%D0%B8%D0%BB%D0%B8%D1%89%D0%BD%D0%B8-%D0%B8-%D0%B5%D0%B4%D0%BD%D0%BE%D1%84%

- **Programmed time balancing of the load of the EV charging network (System for programmed time balancing of the load of the electric vehicle charging network - EV Charging Grid balancing)**

Load balancing power systems are available in the market which distribute power equally to avoid tripping of the main fuse and reduce regional power consumption [78].

- **Provision of EV charging information (Electric vehicle charging and connectivity information system - EV charging information and connectivity)**

The charging stations have an LCD display that shows all the charging data - current power, session time, operating temperature or even the filled capacity. At a glance, it is possible to see whether the charging is still in progress or has just finished.

Also with a wireless connection to the manufacturer's servers or to the user's devices they are always online [79].

An example application is Everything current .

Monitoring and Control (Monitoring and Regulation)

- **Management of the operating time of the heating, ventilation and air conditioning systems, including systems for turning off all lighting except the duty light, reducing or turning off the heating / cooling systems, turning on the alarm system when there are no people in the building / a certain schedule (holidays, in a time range outside working hours) and systems for monitoring the appliances in the building with the possibility of their remote shutdown (Time management system for the operation of heating, ventilation and air conditioning systems - Run time management of HVAC systems)**

HVAC systems are available on the market that allow a general shutdown of all HVAC units, etc. when leaving the building, a general establishment in economy mode or starting a selected air conditioning scene from the user's mobile device interface, a specified time before entering the home . Selected modes can be combined with general control of lighting, blinds and other appliances.

Control can be carried out locally (from the building) or remotely, through the interface of a preferred mobile device (iPhone, iPad , laptop, Android smartphone or tablet). For each air conditioner, automatic shutdown (or establishment in economy mode) can be enabled when a window is opened to ventilate the room (for a time longer than an interval set in the system).

Control systems provide management of all parameters - mode (Cool / Heat / Fan), blade position and fan speed. In the event that timers are created for automatic switching on at certain times, the set temperature is defined individually for each timer. Selected air conditioning modes can be associated to all pre-programmed scenes. Remote control via mobile devices allows to turn off forgotten air conditioners or turn on air conditioners in

D0%B0%D0%BC%D0%B8%D0%BB%D0%BD%D0%B8-%D1%81%D0%B3%D1%80%D0%B0%D0%B4%D0%B8/

[78] https://new.abb.com/ev-charging/bg/abb-vehicle-to-grid

[79] https://shop.elektromobili.bg/

selected rooms when the user comes home at the end of the working day. In the event of a prolonged absence and temperatures falling below 0ºC, the system will warn and enable selected air conditioners to start in economy mode, thus preventing water freezing and pipe bursts from the DHW installation in the home. In the presence of different heatings in the same room (for example, air conditioning and underfloor heating), the system will provide synchronized temperature control, as well as an option to choose which one to use depending on the current outside temperature [80].

- **Detection and diagnosis of errors in technical building installations (System for detecting errors in technical building installations and providing assistance for their diagnosis - Detecting faults of technical building systems and providing support that the diagnosis of these faults)**

Cloud / Web based platforms/applications are available for fault detection and system diagnostics [81]. The system monitors the electricity consumption of each controlled appliance. In case of interruption of consumption or long-term departure from the limits set for the specific device, the system generates a fault message to the user. The message can be displayed on any of the active wall control panels and also sent as an Email or SMS notification.

In addition to consumption, the system can also warn of a possible accident. Each line of the electrical installation in the home is designed for a certain maximum consumption. Exceeding the permissible limit creates opportunities for fire (from the strong overheating of the insulation of the wires, the danger of overheating of connections in junction boxes, sockets and connectors, melting of the insulation and occurrence of short circuits in the installation). The system warns promptly of any line overload and enables the user to react before irreversible damage occurs.

- **Occupant detection: related services (Occupant detection systems: related services (e.g. for lighting - to be activated when there is a person in the room or centralized - heating and lighting to be activated when there is a person in the room) - Occupancy detection : connected services)**

Sensor-equipped systems are available on the market to include select motion-activated and deactivated systems. They report the presence or absence of a person in the room and, as a result, include various services - lighting, heating , etc.[82]

In terms of lighting, light fixtures with sensors are available. It is important that they are properly configured and programmed to turn off automatically when a person does not move or leaves the room. Installation of a ceiling with a ceiling sensor is recommended .

Smart Eye sensors are available that detect the movement of people in the room. It is characteristic of them that if there is no one in the room for 20 minutes, the operation

[80] https://bulcraft.com/
[81] https://www.seea.government.bg/documents/11-SIEMENS_EE_Buildings.pdf
[82] https://veldim.com/products/%D1%81%D0%BC%D0%B0%D1%80%D1%82-%D0%BE%D1%81%D0%B2%D0%B5%D1%82%D0%BB%D0%B5%D0%BD%D0%B8%D0%B5/

automatically switches to energy saving mode. This operation changes the temperature for example by –2°C in heating mode / by +2°C in cooling mode / by +2°C in Drying mode compared to the set temperature for the respective mode. This operation also reduces the strength of the air stream in fan mode only or determines the direction and dependence on the people in the room - avoiding directing them in order to increase the comfort of the occupants [83].

- **Centralized monitoring of the operation of building installations (TBS) and energy consumption (System for central reporting of the operation of building installations (TBS) and energy consumption - Central reporting of TBS performance and energy use)**

The application of a system for continuous monitoring of the used electricity by sources and/or suppliers is a basis on which a reduction in electricity consumption and, accordingly, energy costs and the carbon footprint (choice of power sources with a smaller carbon footprint) can be achieved. .

The system includes continuous, real-time monitoring of energy consumption by source. As the system can be built on site, remotely or mobile application. At functional level 2, the system can collect and present information in real time for two types of building installation, for example – electrical, air conditioning and/or heating through one common interface. To achieve functional level 3, the system should include information on all types of building installations in one common interface.

On the Bulgarian market, these systems for monitoring energy consumption at functional level 1 are offered by various companies in the utility sector - electricity distribution, district heating. For a higher functional level - a common building-level monitoring system for 2 or more types of building installations is typical for new high-end office buildings.

- **"Smart Grid" Integration (Regarding Harmonization Between Technical Building Installations), High Voltage Sensing and Automatic Shutdown of Appliances (Smart Grid Integration System (Regarding Harmonization Between Technical Building Installations) - Smart Grid integration)**

The smart grid is the integration of electrical and digital technologies, information and communication, which facilitates the integration of processes and systems to produce real measurable value along the entire energy supply chain.

It is an intelligent future electricity system that connects all elements of supply, grid and demand through a communication system.

The smart grid delivers electricity to consumers using two-way digital technology that enables efficient management of consumers, effective use of the grid to identify and correct imbalances between supply and demand.

[83] https://www.daikin.eu/content/dam/document-library/operation-manuals/ac/split/atxs-k/ATXS35-50K_3PBG363618-2A_Operation%20manuals_Bulgarian.pdf

These grid solutions enable companies to increase energy performance and reliability while allowing customers to manage usage and costs through real-time information exchange [84].

The integration of "smart networks" is also a priority of the Electricity Distribution Companies in the country. Electrohold Bulgaria is gradually digitizing the network, as a basic prerequisite to cope with the increasing number of connected green plants and charging stations for electric vehicles . Behind the digitization of the grid, as part of the electricity distribution activities, there are several different projects aimed at smart grids that are connected to smart electricity meters. By the end of 2022, more than 350,000 such devices have been installed, and in 2023 the company plans to put another 150,000 into operation.

"The so-called A "smart electricity meter" does not only provide benefits in terms of remote consumption reading. This is a point for which online information about the presence of consumption is obtained at the plant, daily information is collected about the energy balance in a specific substation, which shows whether there are losses and, accordingly, the need to look for ways to reduce them", not only in the final point, but also along the path of electricity – transformers and substations [85].

Individually, digital modular protections from low or high voltage are also available on the market. They are designed so that in the event of a higher or lower voltage than the one set by the user, they immediately turn off the voltage, so as to avoid burning the electrical equipment. High voltage and low voltage values can be adjusted by users [86].

- **Management and optimization of consumption (System for reporting information on the performance of energy consumption optimization (DSM) - Reporting information regarding demand side management performance and operation)**

Heating/cooling devices with integrated reporting systems are available on the Bulgarian market. DSM communication allows remote switchover of unit operation at a low tariff from the electricity supplier. They also offer the ability to monitor the value of the maximum current to prevent overloading of the electrical network in the building [8788].

[84] https://bulenergyforum.org/bg/system/files/1_stride_energien_prehod_i_umni_mrezhi.pdf
[8585] https://xn--e1aabhzcw.bg/energetika/discussions/%D0%B1%D1%8A%D0%B4%D0%B5%D1%89%D0%B5-%D0%BC%D1%80%D0%B5%D0%B6%D0%B0-%D0%B5%D0%BB%D0%B5%D0%BA%D1%82%D1%80%D0%BE%D1%85%D0%BE%D0%BB%D0%B4-%D0%B1%D1%8A%D0%BB%D0%B3%D0%B0%D1%80%D0%B8%D1%8F-%D0%B5%D0%BB%D0%B5%D0%BA%D1%82%D1%80%D0%BE%D0%BC%D0%B5%D1%80-%D0%B4%D1%80%D0%BE%D0%BD%D0%BE%D0%B2%D0%B5-%D0%B8%D0%BD%D1%82%D0%B5%D0%BB%D0%B5%D0%BA%D1%82
[86] https://www.cablecommerce.bg/produkt/tdp-1-monofazna-modulna-czifrova-zashtita-ot-prenaprezhenie-i-pod-naprezhenie/
[87] https://ecotherm.bg/project/thermona-therm-el/
[88] https://energon07.com/produkt/%D0%B7%D0%B0%D1%89%D0%B8%D1%82%D0%B0-%D0%BE%D1%82-%D0%B2%D0%B8%D1%81%D0%BE%D0%BA%D0%BE-%D0%BD%D0%B0%D0%BF%D1%80%D0%B5%D0%B6%D0%B5%D0%BD%D0%B8%D0%B5-220v-%D0%B8%D0%BB%D0%B8-%D0%BD%D0%B8%D1%81%D0%BA/

In the systems offered, it is possible, for example, to turn off all the lights in the premises outside of working hours, to set the thermostats a few degrees higher in the summer and lower in the winter, or to check that a large number of demonstration electronics are not left on in the retail area of the store[89]

- **Power Optimization Override System (Power Optimization Override System of DSM control)**

Optimizing energy consumption is an essential element of achieving carbon neutrality in accordance with the adopted EU strategic documents.

Overriding the power consumption control introduced can be classified into 4 functional levels, starting from completely prohibiting users from removing the power consumption optimization system, to allowing the possibility to remove the power consumption optimization system from the user and subsequent reactivation under different conditions according to schedule or with the aim of subsequent optimization of consumption.

The ability to override previously entered power consumption limits is a functionality of the various control systems and should be considered as a functionality of the applicable power consumption management software.

- **A single platform that allows automatic control and coordination between technical building installations (TBS) + optimization of the energy flow according to the presence of an occupant in the room, time and network signals (Single platform that allows automated control & coordination between TBS + optimization of energy flow based on occupancy , weather and grid signals)**

There are even free software on the market that can be used from any platform, with which authorized users can easily manage building automation, monitor energy consumption statistics and the status of individual systems. For example DALI, RS232, RS485, 1-Wire, BACNet IP, KNX... Loxone has a wide range of open, freely configurable interfaces to connect any individual building automation system to the Miniserver . Also, a number of companies offer the service for the individual design of visualization of building automation, adapted to the needs of users [90].

3.1.2 Research on the applicability of smart management-ready services among users

In order to establish the applicability of the services prepared for intelligent management, a survey was conducted. The form of the used survey is presented in **Appendix 1.** The survey asks questions about the used smart services - in home and workplace of respondents and their knowledge of smart services companies. The completed surveys are presented in **Appendix 2.**

❖ **General Applicability of Smart Management Ready Services**

[89] https://thingslog.com/bg/power-monitoring/
[90] https://iduacom.bg/building-automation/

Data from the survey are presented in **Figure 6** .

As can be seen from the graph, 68% of respondents use smart services in their home, and 37% of them are familiar with smart services implemented at their workplace. Part of the respondents added that outside the systems for intelligent services they use "smart appliances" such as vacuum cleaners - robots, remote reporting of heat and electricity consumption.

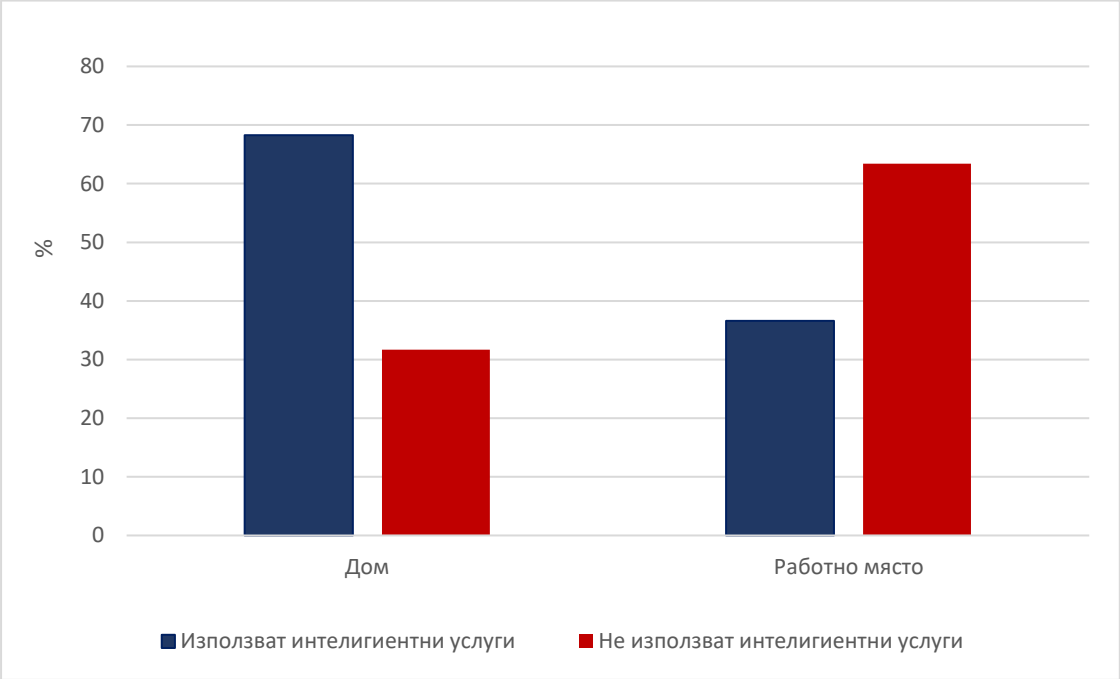


Figure 7 Applicability of smart services among users (%)

❖ **Applicability of smart services in different "domains"**

As can be seen from the data presented in **figure 7** , the highest percentage of users using smart services in their home apply "smart" systems in terms of "Heating" - 79% and "Cooling" - 68%, followed by "Lighting" - 39%, "Electricity" - 36%, "Monitoring and control" - 32%, "Ventilation" - 21%, "DHW" - 18%, "Dynamic facade" and "EPS charging" 3.6% each.

The respondents report that they are aware of the application of intelligent services in their workplace in the following domains: "Heating" - 27%, "Monitoring and control" - 22%, "EPS charging" - 15%, "Cooling" - 9.8% , "Ventilation" - 7.3%, "Lighting" - 4.9%, "Electricity" - 4.9%, "Dynamic facade" - 4.9%, and "DHW" - 2.4%

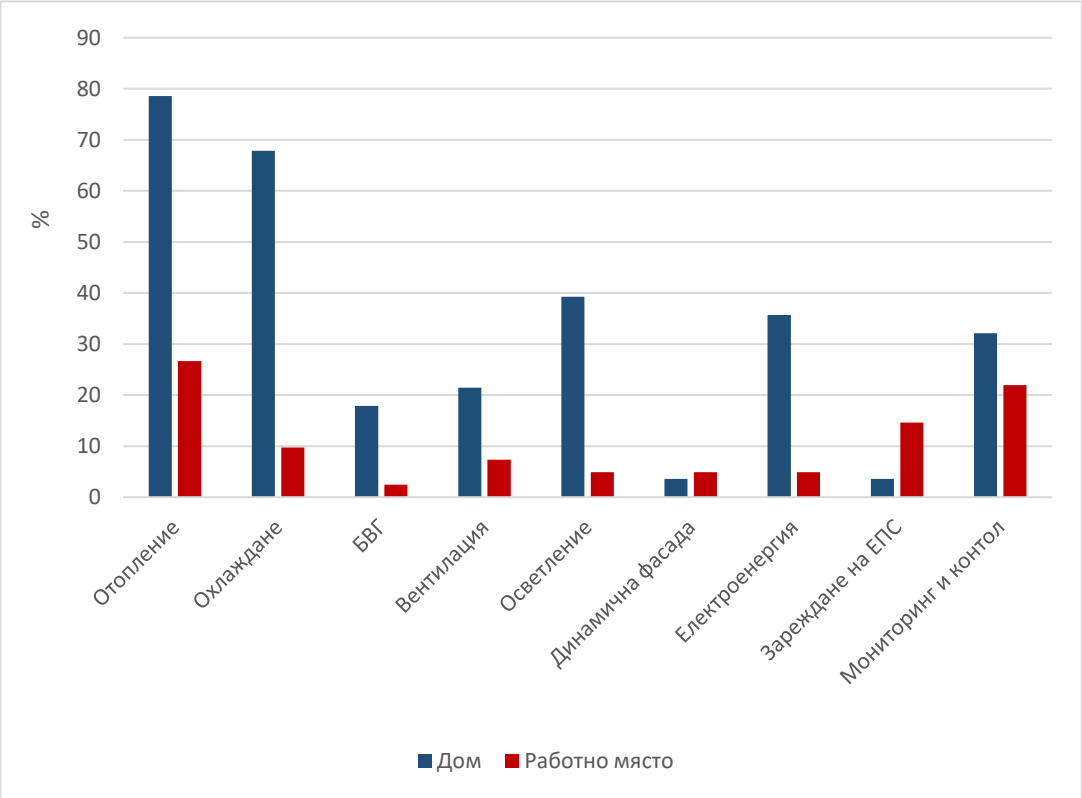


Figure 8 Applicability of smart services in the different "domains" (%)

❖ **Applicability of smart services in the domain "Heating"**

Regarding the domain "Heating", the services "Control of the temperature of the fluid in the heating system (air flow or water flow) and management of the capacity of the network pumps" and "Control of the operation of the heat sources with excl. of pumps for heating systems - e.g. controlling the temperature)" - by 60.7% of users; "Control of the operation of heat sources - for pumps for heating systems (e.g. temperature control" and "Reporting of information on the operation and status of the heating system" - 46.4% each; "Flexibility regarding the control of heat sources (e.g. inclusion in set time, or remotely by signal, etc.)" - 42.8; "Sequential switching on in case of different heat sources" - 35.4%, "Measurement of thermal radiation" - 10.7% ; "Heat energy storage (TES) (with excl. of TABS)" - 7.1%; "Control measurements of heat emissions from Thermally Activated Building Systems (TABS)" and "Management of distribution pumps in the network" - 3.5%

The respondents report that they are aware of the following services being applied at their workplace in relation to the domain "Heating": "Control of the temperature of the fluid in the heating system (air flow or water flow) and management of the capacity of network pumps" and "Control of the operation of the heat sources with off of pumps for heating systems - e.g. controlling the temperature)" - by 26.6% of users; "Management of distribution pumps in the network" and "Sequential switching in case of different heat sources" - 20%; "Thermal energy storage (TPP) (excluding TABS)" and "Reporting of information on the operation and condition of the heating system" - 6.6%.

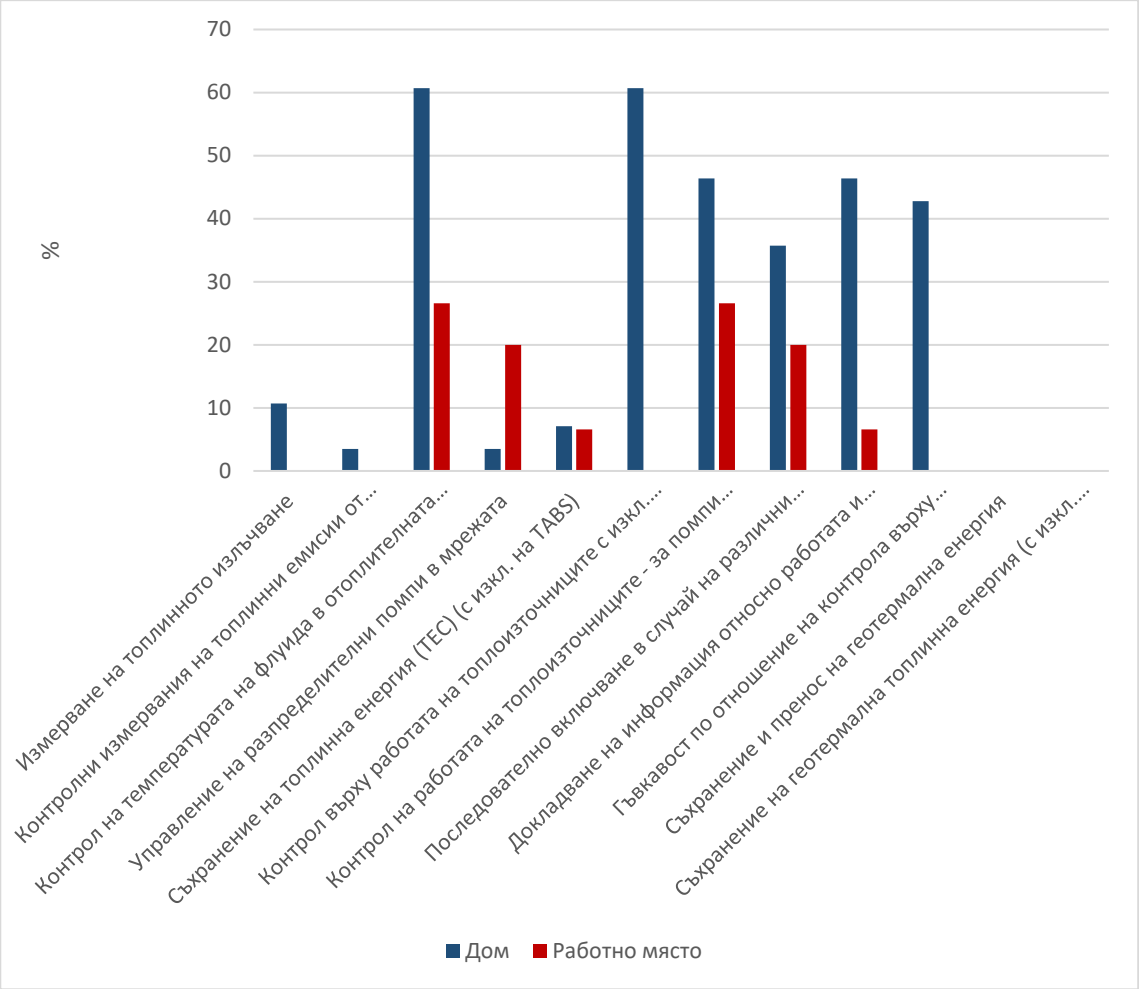
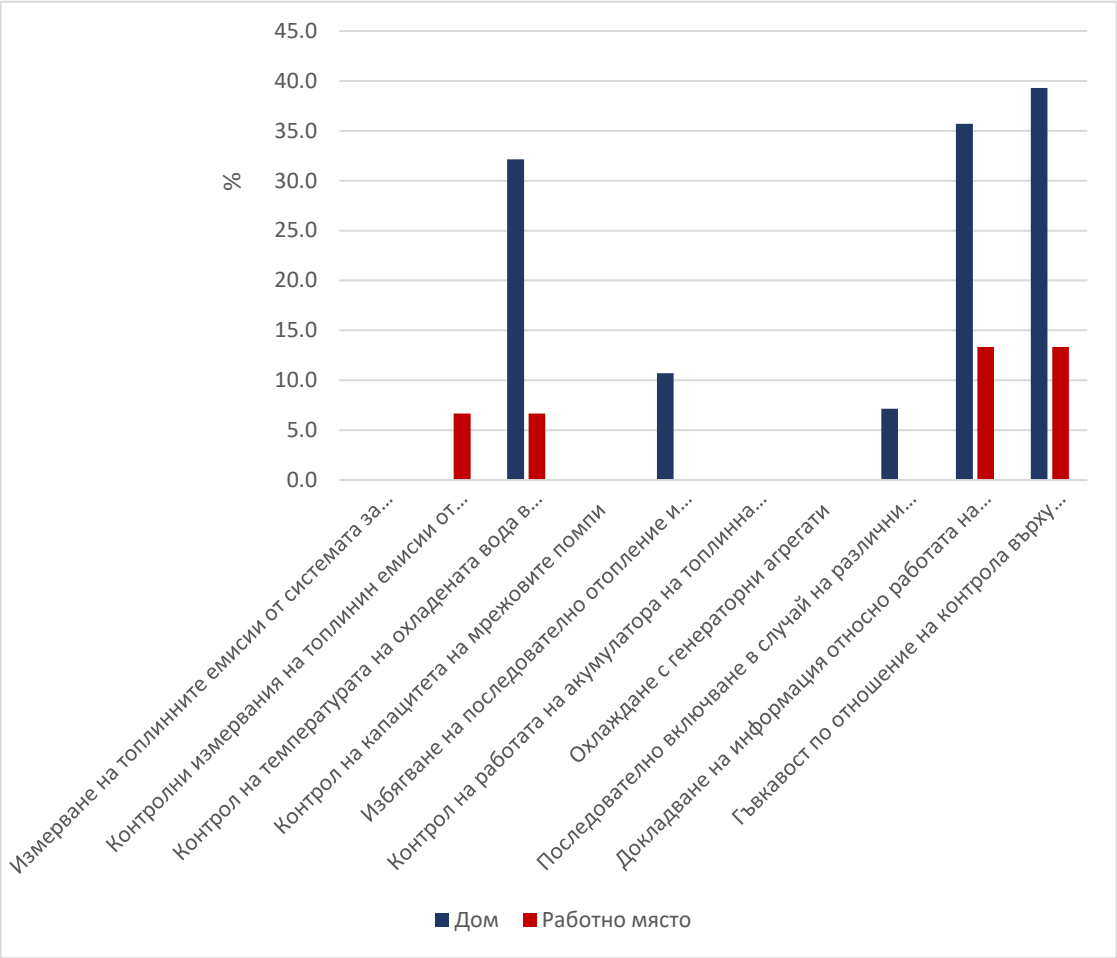


Figure 9 Applicability of smart services in the "Heating" domain (%)

❖ **Applicability of Smart Services in the Cooling Domain**

With regard to the "Cooling" domain, the respondents find the services "Flexibility in terms of control over the cooling system (e.g. switching on at a set time, or remotely via a signal, etc.)" - 39.3%; "Reporting information about the operation of the cooling system" - 35.7%: " Control on the temperature on the cooled one water in the distributor network (submitted or the crow) and control on the capacity on network pumps " – 32.1%; " Avoid consecutive heating and cooling in the same room" - 10.7%; "Sequential inclusion in case of different cooling systems" - 7.1%,

Respondents report that they are aware of the following services being implemented in their workplace in relation to the domain "Cooling": "Reporting of information about the operation of the cooling system" and "Flexibility in terms of control of the cooling system (e.g. inclusion in a set hour, or remotely by signal, etc.)" - 13.3% each; "Control measurements of heat emissions from Thermally Activated TABS building systems - in cooling mode" and "Control of the temperature of the cooled water in the distribution network (supplied or returned) and control of the capacity of network pumps" 6.7% each.



❖ **Applicability of smart services in the domain "Domestic hot water"**

With regard to the "Domestic hot water" domain, the respondents find the services: "Control of the DHW heater (electric heater or heat pump)" and "Control of the DHW heater operating with solar modules" - 10.7% each; "Sequential switching on in case of different DHW heaters" and "Information on the operation of the DHW installation" - 7.1%.

The respondents report that they are aware that the following services related to the "DHW" domain are applied at their workplace: "Information about the operation of the DHW installation" - 6.7%.

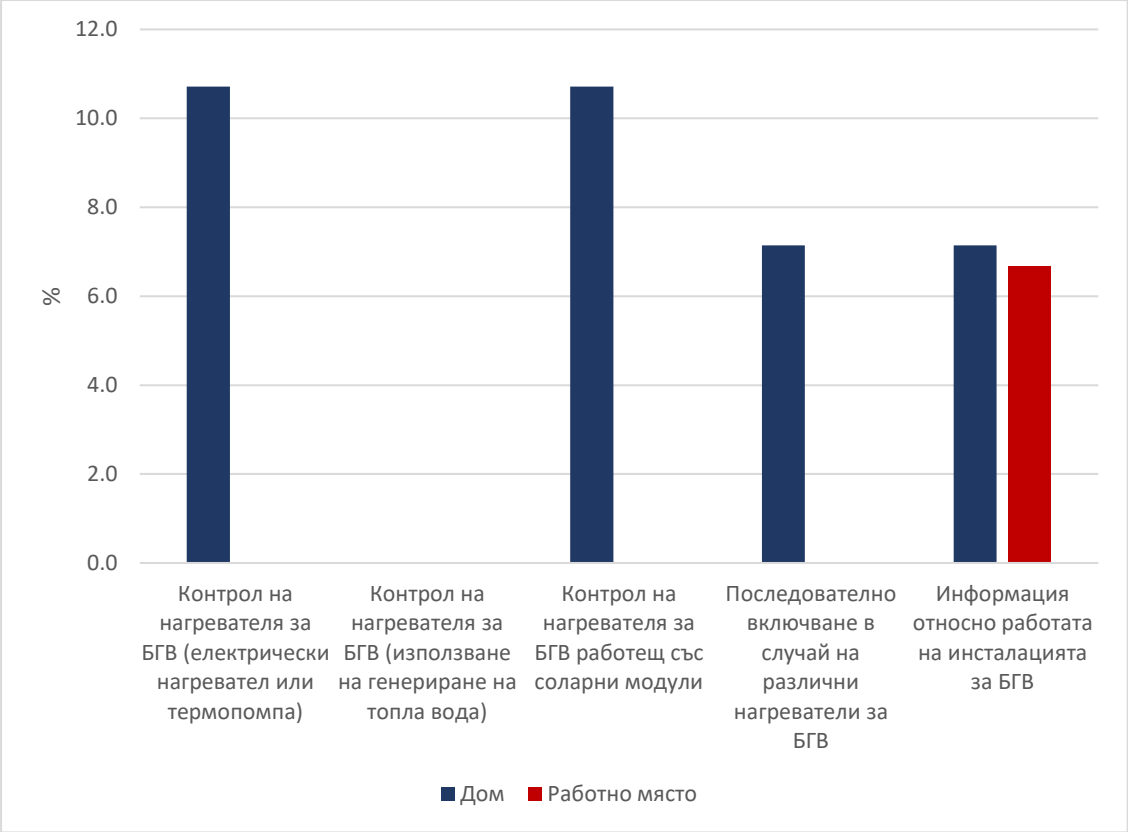


Figure 11 Applicability of smart services in the "BVG" domain (%)

❖ **Applicability of smart services in the domain "Ventilation"**

With regard to the "Ventilation" domain, the respondents find the services: "Monitoring the quality of indoor air" - 17.8; "Air flow temperature control at the ventilation system level" - 7.1%; "Room-level air flow control" and "Free (passive) cooling with a mechanical ventilation system" - 3.5% each;

The respondents report that they are aware of the following services being implemented in their workplace in relation to the " Ventilation" domain: "Air flow control at the room level" and "Indoor air quality monitoring" - 13.3% each; "Air flow rate control at the ventilation system level" and "Air flow temperature control at the ventilation system level" - 6.6 % each.

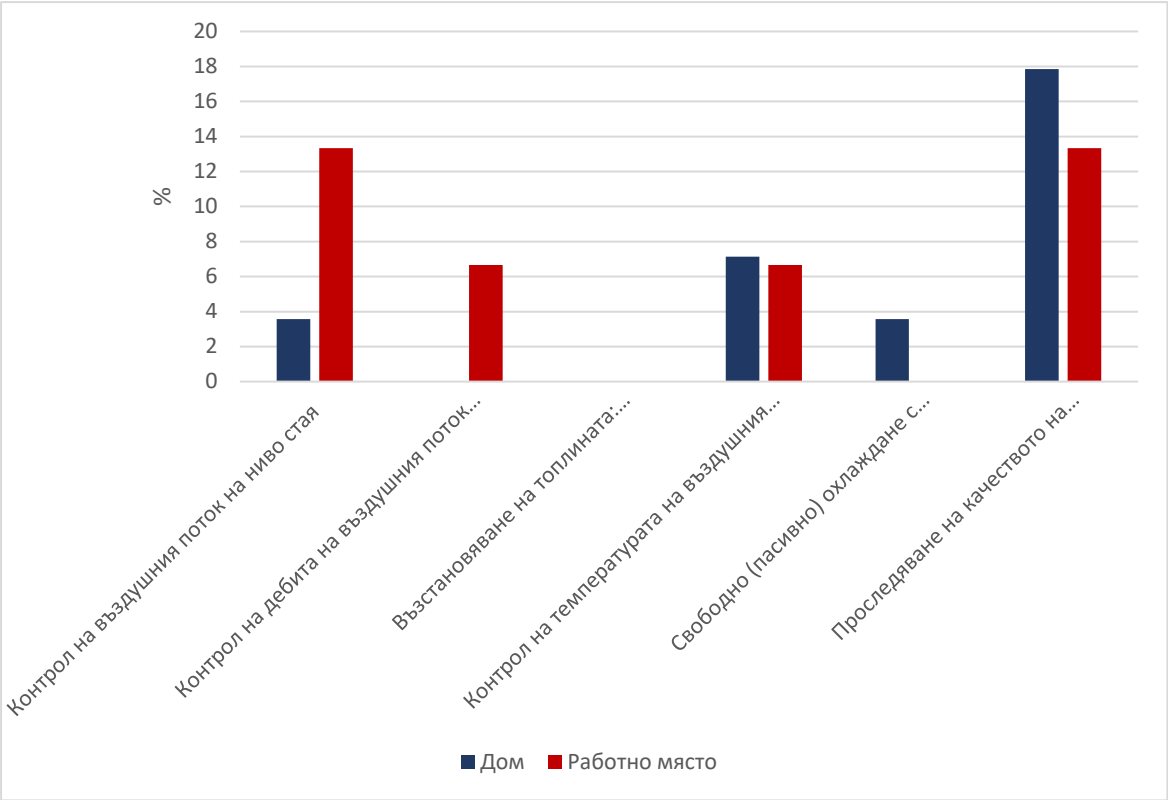


Figure 12 Applicability of smart services in the domain "Ventilation" (%)

❖ **Applicability of Smart Services in Lighting Domain**

With regard to the "Lighting" domain, an application in the home of the respondents found both types of services as follows: "Interior lighting controls" - 32.4%; "Control of the strength of artificial lighting depending on daylight" - 17.8%.

The respondents report that they are aware that the following services are applied at their workplace in relation to the "Lighting" domain: " Interior lighting controls" - 13.3%; "Control of the strength of artificial lighting depending on the daylight" - 13.3 %.

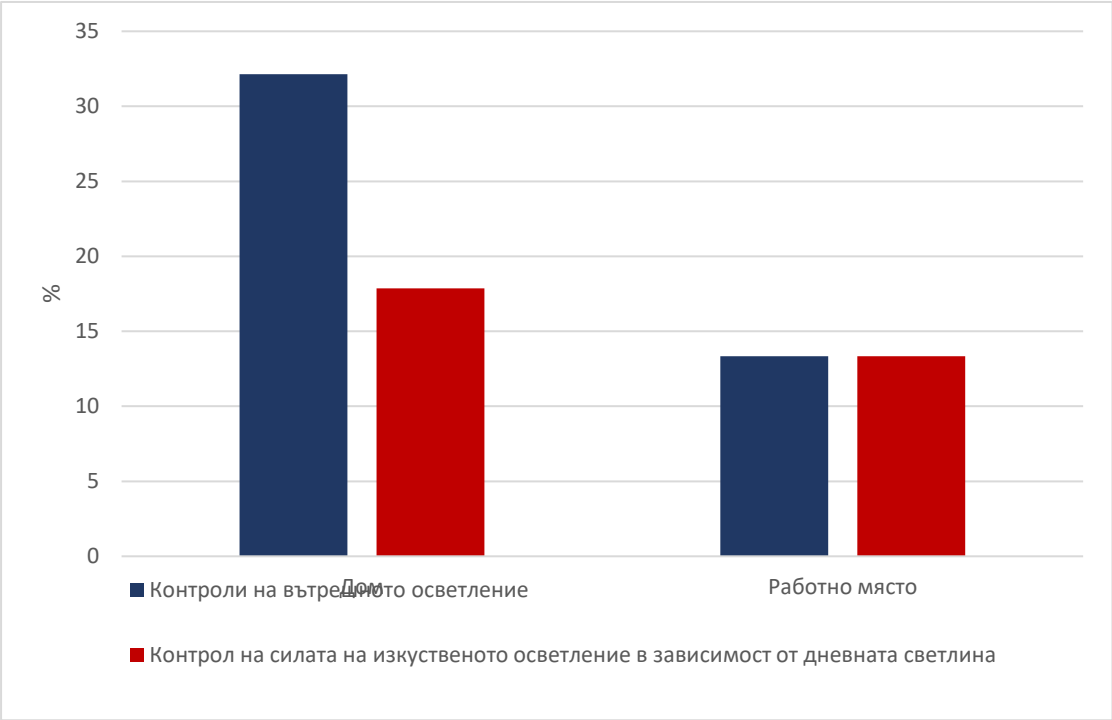


Figure 13 Applicability of smart services in "Lighting" domain (%)

❖ **Applicability of Smart Services in the Dynamic Facade Domain**

Regarding the domain "Dynamic facade" application in the home of the respondents, both types of services are found as follows "Solar shading of the windows" - 3.5%.

The respondents report that they are aware that the following services regarding the domain "Dynamic facade" are applied at their workplace: "Solar shading of windows" and "Control of opening/closing of windows, in combination with a heating, ventilation and air conditioning system (HVAC)" by 6.6 %.

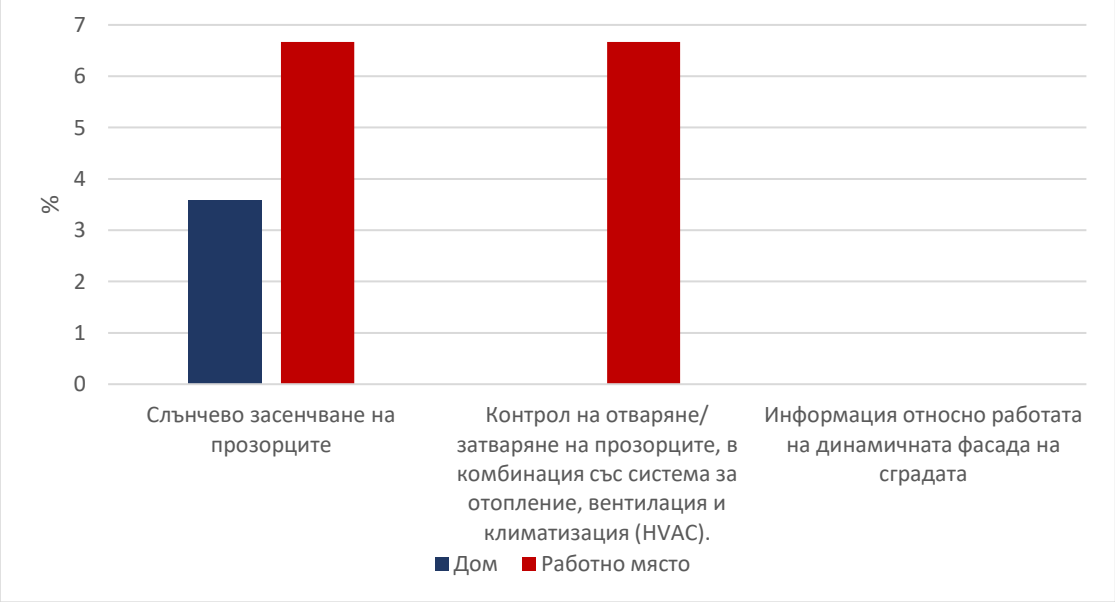


Figure 14 Applicability of smart services in the "Dynamic Facade" domain (%)

❖ **Applicability of smart services in the domain "Electricity"**

Regarding the "Electricity" domain, respondents find "Reporting information about electricity consumption" - 35.7% and "Reporting information about local electricity production installations" - 7.1%.

Respondents report that they are aware that the following services related to the "Electricity" domain are implemented at their workplace: "Storage of locally produced electricity" and "Reporting of information on electricity consumption" - 13.3% each.

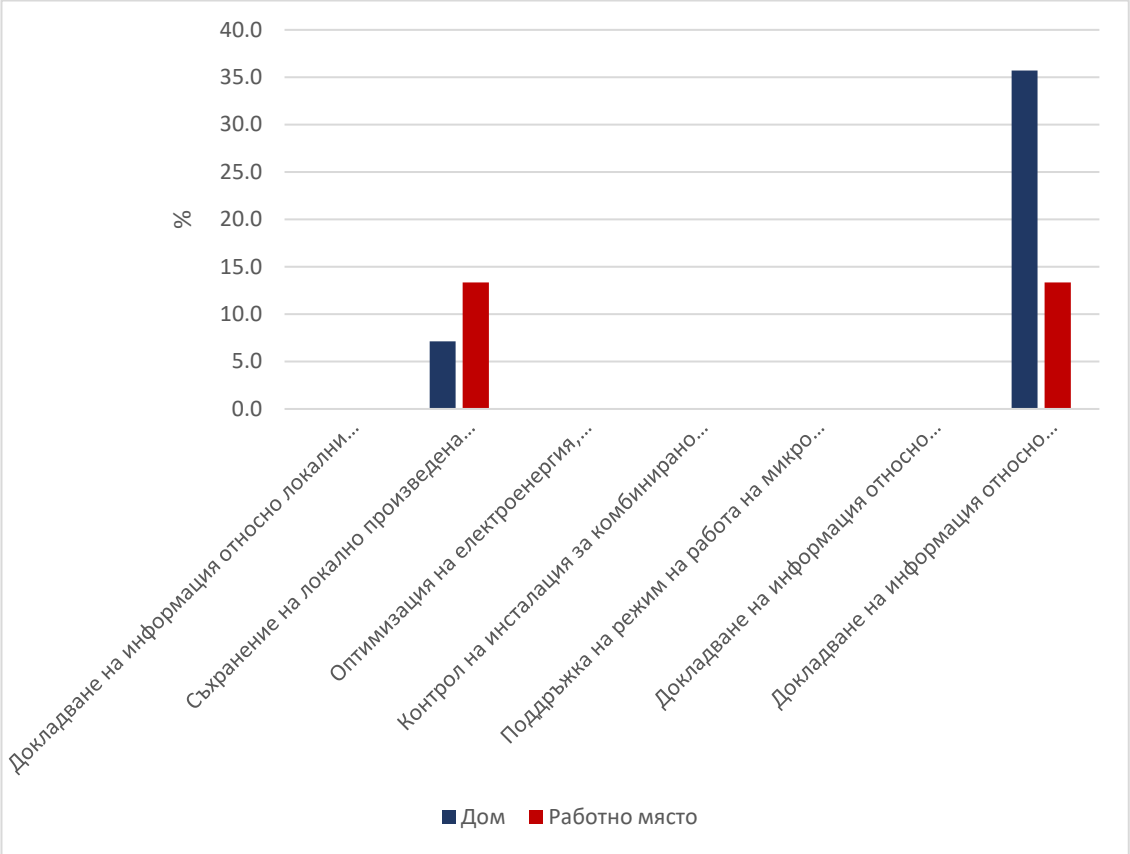


Figure 15 Applicability of smart services in the "Electricity" domain (%)

❖ **Applicability of smart services in the domain "Electric Vehicle Charging"**

Regarding the domain " Charging electric vehicles " application in the home of the respondents finds the service "EPC charging capacity" - 3.5%.

Respondents report that they are aware of the following services being implemented at their workplace in relation to the "Electric vehicle charging" domain: "EPS charging capacity", "Programmed time balancing of the load of the EV charging network " and "Providing of EPS charging information" by 40%.

Figure 16 Applicability of smart services in the domain "Electric vehicle charging" (%)

❖ **Applicability of intelligent services in the domain "Monitoring and Control"**

With regard to the domain "Charging of electric vehicles", the services found application in the home of the respondents: "Occupant detection: related services (e.g. for lighting - to be activated when there is a person in the room or centralized - heating and lighting to be activated , when a person is present in the room) – 32.1%; "Management of the operating time of the heating, ventilation and air conditioning systems, including systems for turning off all lighting except the duty light, reducing or turning off the heating / cooling systems, turning on the alarm system when there are no people in the building / a certain schedule (holidays, in a time range outside working hours) and systems for monitoring the appliances in the building with possibility of their remote shutdown" – 10.7%; "Detection and diagnosis of errors in technical building installations" - 3.6%.

The respondents report that they are aware of the following services being applied at their workplace in relation to the domain " Management of the operating time of the heating, ventilation and air conditioning systems, including systems for turning off all lighting except the duty light, reducing or turning off the heating / cooling systems, turning on the alarm system when there are no people in the building / a certain schedule (holidays, in a time range outside working hours) and systems for monitoring the appliances in the building with possibility to turn them off remotely" - 33.3%: "Occupant detection: related services (e.g. for lighting - to be activated when there is a person in the room or centralized - heating and lighting to be activated when a person is present in the room)" - 26.7%.

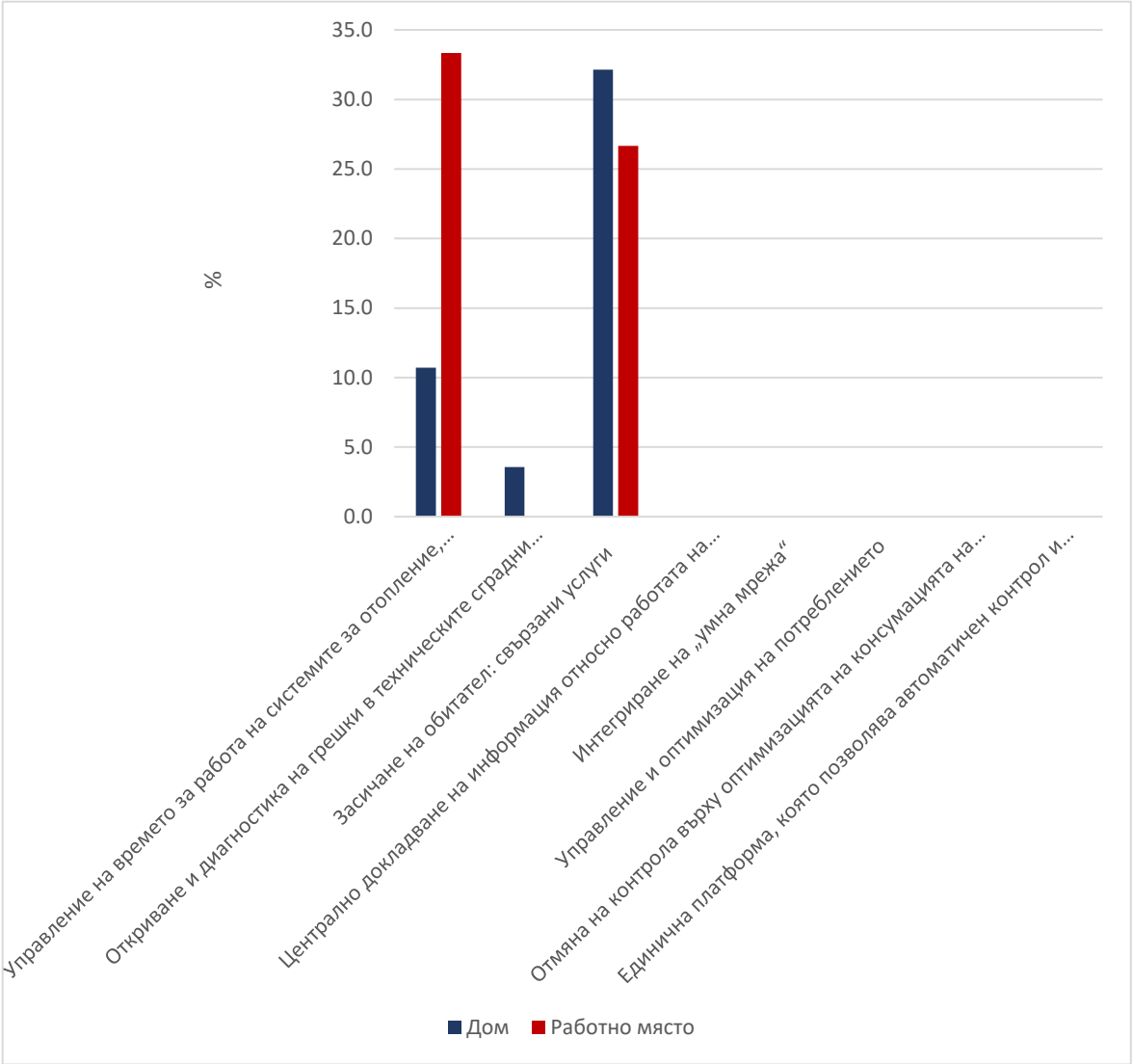


Figure 17 Applicability of intelligent services in the "Monitoring and Control" domain (%)

3.1.3 Testing the smart management ready services

In connection with the implementation of Activity 6: Research on a possible option/s for adapting the methodology for calculating the indicator for the readiness of buildings for intelligent management, to the specificities of the country (option/s of the Framework for assessing the readiness of buildings for intelligent management) each service prepared for intelligent management to the relevant technical area ("domain") is tested on a set of clarifying questions that detail its application in the country and presented in **table 5** .

Table 3*Testing the Smart Services*

Technical areas related to smart management readiness	Prepared for smart management services	Does this service apply to the relevant technical area?	Assessment of applicability of this service in the building.	Level* of service functionality	Preserved/replaced/reduced and/or new
Heating	Measurement of thermal radiation	Yes	Similar type of systems are applied in residential and non-residential buildings, with fire prevention.	4	It's saving
	Control measurements of thermal emissions from Thermally Activated Building Systems (TABS)	Yes	Similar type of systems are applied in residential and non-residential buildings, with fire prevention. An ISO standard has been introduced for their dimensioning and calculation of dynamic performance.	3	It's saving
	Control of the temperature of the fluid in the heating system (air flow or water flow) and management of the capacity of the network pumps (allows flexible control of the operating mode of the heating network)	Yes	The water-air heat pumps are equipped with a temperature control system and, respectively, pump capacity control, in order to achieve optimal operation.	2	It is replenished
	Management of distribution pumps in the network	Yes	Similar type of systems are applied in residential and non-residential buildings	4	It's saving

Technical areas related to smart management readiness	Prepared for smart management services	Does this service apply to the relevant technical area?	Assessment of applicability of this service in the building.	Level* of service functionality	Preserved/replaced/reduced and/or new
	Thermal energy storage (TPP) (excluding TABS)	Yes	Similar type of systems are applied in residential and non-residential buildings	3	It's saving
	Control over the operation of the heat sources with off. of pumps for heating systems - e.g. temperature control)	Yes	Similar type of systems are applied in residential and non-residential buildings, with fire prevention.	2	Preserved
	Control of the operation of heat sources - for heat pumps (e.g. temperature control)	Yes	Similar type of systems are applied in residential and non-residential buildings, with fire prevention.	3	Preserved
	Sequential switching in case of different heat sources	no	There is no data on the scope of its application	4	Preserved
	Reporting information on the operation and status of the heating system	Yes	The market offers various incl. web based applications with which to implement the control.	4	Preserved
	Flexibility in terms of control over heat sources (e.g. switching on at a set time, or remotely by signal, etc.)	Yes	The market offers various incl. web based applications with which to implement the control.	4	Preserved
	Storage and transmission of geothermal energy	no	There is no data on the application of such a system.	0	Drops out. It is proposed to be tested again after 3 years
	Geothermal thermal energy storage (excluding TABS)	no	Currently, the country implements a policy to promote	0	Drops out

Technical areas related to smart management readiness	Prepared for smart management services	Does this service apply to the relevant technical area?	Assessment of applicability of this service in the building.	Level* of service functionality	Preserved/replaced/reduced and/or new
	(thermal energy storage - TPP)		the use of geothermal energy. Bulgaria is expected to start achieving real results and working projects in the area by 2027-2028.		It is proposed to be tested again after 3 years
Cooling	Measurement of heat emissions from the cooling system	Yes	Similar type of systems are applied in residential and non-residential buildings.	4	Preserved
	Control measurements of heat emissions from Thermally Activated Building Systems TABS - in cooling mode	Yes	Similar type of systems are applied in residential and non-residential buildings.	3	Preserved
	Control of the temperature of the chilled water in the distribution network (supplied or returned)	Yes	Various controllers are available in the market	2	Preserved
	Capacity control of network pumps	Yes	Similar type of systems are applied in residential and non-residential buildings.	4	Preserved
	Avoiding consecutive heating and cooling in the same room	Yes	Applicable in new construction after 2010.	2	Preserved

Technical areas related to smart management readiness	Prepared for smart management services	Does this service apply to the relevant technical area?	Assessment of applicability of this service in the building.	Level* of service functionality	Preserved/replaced/reduced and/or new
	Control of the operation of thermal energy storage (TES)	Yes	Similar type of systems are applied in residential and non-residential buildings.	3	Preserved
	Automatic control of cooling generators	Yes	Similar type of systems are applied in residential and non-residential buildings.	3	Preserved
	Sequential switching in case of different cooling systems	Yes	Applicable in new construction after 2010.	4	Preserved
	Reporting information on cooling system performance	Yes	Applicable in new construction after 2010.	4	Preserved
	Flexibility in terms of control of the cooling system (e.g. switching on at a set time, or remotely by signal, etc.)	Yes	Applicable in new construction after 2010.	4	Preserved
Hot water for domestic needs (Domestic hot water (DHW))	DHW heater control (electric heater or heat pump)	Yes	Widely applicable	3	Preserved
	Domestic hot water boiler management	Yes	Widely applicable	3	Preserved
	Control of the DHW heater operating with solar modules	Yes	It has been in use for the past 5 years	3	Preserved
	Sequential switching in case of different DHW heaters	Yes	There is no data on the scope of its application	4	Preserved

Technical areas related to smart management readiness	Prepared for smart management services	Does this service apply to the relevant technical area?	Assessment of applicability of this service in the building.	Level* of service functionality	Preserved/replaced/reduced and/or new
	Information about the operation of the DHW installation	Yes	There is no data on the scope of its application	4	Preserved
Ventilation	Room-level airflow control	Yes	Widely applicable	4	Preserved
	Air flow rate control at the ventilation system level	Yes	Applicable in residential and non-residential buildings	4	Preserved
	Heat recovery: prevent overheating	Yes	Applicable in residential and non-residential buildings	2	Preserved
	Airflow temperature control at the ventilation system level	Yes	Applicable in residential and non-residential buildings	3	Preserved
	Free (passive) cooling with a mechanical ventilation system	Yes	Applicable in residential and non-residential buildings	3	Preserved
	Indoor air quality tracking	Yes	Applicable in residential and non-residential buildings	3	Preserved
Lighting	Interior lighting controls	Yes	Applicable in residential and non-residential buildings	3	Preserved
	Control of the strength of the artificial lighting depending on the daylight	Yes	Applicable in residential and non-residential buildings	4	Preserved
Dynamic facade (mounted adjustable	Solar shading of the windows	Yes	Applicable in residential and non-residential buildings	4	Preserved
	Window opening/closing control, combined with a	Yes	It is applicable in hotels.	3	Preserved

Technical areas related to smart management readiness	Prepared for smart management services	Does this service apply to the relevant technical area?	Assessment of applicability of this service in the building.	Level* of service functionality	Preserved/replaced/reduced and/or new
elements on the building)	heating, ventilation and air conditioning (HVAC) system				
	Information about the work of the dynamic facade of the building	Yes	There is no application data available for this service type	4	Preserved
Electricity	Reporting of information on local power generation installations	Yes	Applicable in residential and non-residential buildings	4	Preserved
	Storage of locally produced electricity	Yes	Applicable in residential and non-residential buildings	4	Preserved
	Optimization of electricity produced for own consumption	Yes	Applicable in residential and non-residential buildings	3	Preserved
	Control of an installation for the combined production of heat and electricity	Yes	There is no application data available for this service type	2	Preserved
	Support different micro grid operation modes	Yes	Applicable in residential and non-residential buildings	3	Preserved
	Reporting information on energy storage	Yes	Applicable in residential and non-residential buildings	3	Preserved
	Reporting information about electricity consumption	Yes	Applicable in residential and non-residential buildings	4	Preserved

Technical areas related to smart management readiness	Prepared for smart management services	Does this service apply to the relevant technical area?	Assessment of applicability of this service in the building.	Level* of service functionality	Preserved/replaced/reduced and/or new
Charging points for electric vehicles	EPS charging capacity	Yes	An increase in the number of charging stations in non-residential buildings is reported.	4	Preserved
	Scheduled time balancing of the load of the EPS charging network	Yes	Applications have been developed with charging station workloads	2	Preserved
	Provision of information on charging the EPS	Yes	Apps have been developed with accessible location of the stations	2	Preserved
Monitoring and regulation	Management of the operating time of the heating, ventilation and air conditioning systems, including **systems for turning off all lighting except the duty light, reducing or turning off the heating / cooling systems, turning on the alarm system when there are no people in the building / a certain schedule (holidays, in a time range outside working hours) and systems for monitoring the appliances in the building**	Yes	Applicable in residential and non-residential buildings	3	**Completed**

Technical areas related to smart management readiness	Prepared for smart management services	Does this service apply to the relevant technical area?	Assessment of applicability of this service in the building.	Level* of service functionality	Preserved/replaced/reduced and/or new
	with possibility of their remote shutdown				
	Detection and diagnosis of errors in technical building installations	Yes	Applicable in residential and non-residential buildings	3	Preserved
	Occupant detection: related services (e.g. for lighting - to be activated when there is a person in the room or centralized - heating and lighting to be activated when a person is present in the room)	Yes	Applicable in residential and non-residential buildings	2	Preserved
	Centralized monitoring of the operation of building installations (TBS) and energy consumption	Yes	Applicable in residential and non-residential buildings	3	Preserved
	"Smart grid" integration (regarding harmonization between technical building installations), high voltage sensing and automatic switch-off of appliances	Yes	Applicable in residential and non-residential buildings	2	Completed

Technical areas related to smart management readiness	Prepared for smart management services	Does this service apply to the relevant technical area?	Assessment of applicability of this service in the building.	Level* of service functionality	Preserved/replaced/reduced and/or new
	Management and optimization of consumption	Yes	Applicable in residential and non-residential buildings	2	Preserved
	Override power optimization control	Yes	Applicable in residential and non-residential buildings	4	Preserved
	A single platform that allows automatic control and coordination between technical building installations (TBS) + optimization of energy flow according to the presence of an occupant in the room, weather and network signals	Yes	Applicable in residential and non-residential buildings	3	Preserved

**The level of functionality is preserved compared to that proposed in the spreadsheet. The individual levels of functionality can be viewed in the spreadsheet - Service Overview Section.*

3.2. Adaptation of a methodology for calculating the indicator for the readiness of buildings for intelligent management, to the particularities of the country (variant/s of a framework for assessing the readiness of buildings for intelligent management)

As part of the implementation of the current activity, and in accordance with the guidelines and method for calculating the indicator for the readiness of buildings for intelligent management proposed by the European Commission, in this Report the proposed catalog of services prepared for intelligent management in technical areas of readiness for intelligent management.

In the course of work, the areas presented above have been tested for their applicability in Bulgaria, and some of them are dropped or replaced.

In the course of work, the above-described services prepared for intelligent management are replaced/reduced and/or new ones are added, according to the methodology adaptation process. Each service prepared for smart management in a technical field is tested on a set of clarifying questions that detail its application in the country, such as:

- Does this service apply to the relevant technical area?
- Assessment of applicability of this service in the building.
- Level of service functionality – e.g. central automatic control or individual control of each room/room, etc.

As a result of the implementation of this activity and the conducted study, an option is presented to adapt the methodology established by the EC for calculating the indicator for the readiness of buildings for intelligent management, specified in Annex I of Delegated Regulation (EU) 2020/2155, to the specificities of the country .

3.2.1 Preliminary survey (gathering information through the prepared questionnaires)

Before starting the SRI calculation process, it is necessary to conduct a preliminary study. In the preliminary phase, it is essential to determine the areas present in the building being assessed through an initial assessment process called the 'sorting process'. In this phase, it is necessary to draw up an inventory of the intelligent services present in the analyzed building through a simple checklist. In a subsequent phase, functionality levels are assigned to each of the identified smart ready-to-use services, ultimately allowing the assessment of overall, domain and impact SRIs.

Figure 18 Diagram of SRI calculation methodology

A questionnaire was developed to conduct a preliminary survey to be used during a site visit to the buildings to be assessed. The questionnaire is presented in **Appendix 3** .

The questionnaire contains information about the appraiser, the appraised building (type of building, location, description of the building) and the smart services implemented in it and the functionality levels for each of them.

3.2.2 Calculation of SRI

Using the spreadsheet to calculate the SRI – based on the previously collected information: type of building, location of the building and its condition (repair activities), the smart services implemented in the assessed building and the levels of functionality for each of them.

3.2.2.1 "Building information" section

The first step when starting the calculation with the spreadsheet is Select a language. With this option, the evaluator's preferred language is selected and the entire spreadsheet is automatically adjusted to the selected language. In the current version, English, French and German are the available languages.

❖ Appraiser Information

The spreadsheet requires appraiser information to be provided. This is done so that the European Commission services and the technical support team can use this information to contact evaluators to collect feedback on the testing and implementation of the SRI.

The required assessor information remains unchanged.

❖ Information about the building

Building information contains data about the type of building and its use. When adapting the methodology, it is proposed to create an additional sheet only with explanations regarding the buildings in relation to the regulations (Regulation No. 1 of July 30, 2003. On the nomenclature of the types of constructions) in Bulgaria. The introduced changes will facilitate the work of an appraiser in terms of building selection. The proposals are presented in **table 5** .

Table 4 *Proposed changes to " Building Information " _*

Field	A change
Building type field	It is saved without changes
• Residential • Non-residential	It is saved without changes
Building Use Field	sheet is introduced to explain the type of buildings
In case of residential building • Family house • Small multi-family house: 10 dwelling units or less • Large apartment building: more than 10 residential units • Other: student housing, care homes.	Additional explanations are introduced to each category, to be as an appendix. • Family house • Small multi-family house (apartment blocks): 10 dwelling units or less • Large multi-family house (apartment blocks): more than 10 residential units • Other: student housing, care homes, sheltered housing, family accommodation center etc.

Field	A change
In case of non-residential building • Offices • Educational buildings • Healthcare • Others	Additional explanations are provided for each category as an appendix. (in accordance with Ordinance No. 1 of July 30, 2003 on the nomenclature of construction types) a) Offices - administrative buildings, banking and non-banking financial institutes, serving buildings to production sites, representative buildings, post offices, buildings of the central and territorial administrations, government buildings, centers for holding conferences and congresses, court buildings, the prosecutor's office, etc. ; b) Educational buildings – schools, universities, kindergartens and nurseries, community centers, buildings and facilities for permanent scientific units, academic specialized units, general academic auxiliary units and units performing economic activity under the Law on the Bulgarian Academy of Sciences; c) Others * buildings in the field of health care: medical facilities for hospital care (all types of hospitals), medical facilities for outpatient care, medical centers; veterinary medical institutions, pharmacies, opticians , drugstores and agricultural and veterinary pharmacies. * buildings in the field of hospitality, catering and public catering - dormitories, hotels, motels, mountain huts, holiday homes and holiday bungalows; * buildings in the field of trade (buildings for wholesale and retail trade services) - shopping centers, bazaars and covered markets, general and specialized stores, trade warehouses, fair halls, buildings for household services, * buildings for civil rituals, public catering buildings, drinking establishments, clubs, bars, discotheques, public baths and saunas, gaming casino, gaming halls, stores for trade in weapons, ammunition and pyrotechnic articles with their adjacent warehouses (storages) and gun repair shops; * sports buildings; * other types of buildings, energy users - buildings in the field of culture and arts (museums, libraries and community centers, art galleries, centers for scientific and technical information, archives, cinema halls, concert, opera, theater and other halls, dance halls, circus halls, stage shows, public clubs, community centers, multi-purpose halls with cultural and educational purposes, etc.).

❖ Building condition

Currently in the methodology are available gives the option

- Renovated: refers to buildings that have undergone important energy improvements such as thermal insulation and/or improvements to technical building systems since the year of construction.
- Original: refers to buildings that have not undergone important energy improvements.

Field: Building condition is considered to require no changes.

❖ Location

The location (country) in which the building is located is indicated. Based on this, the climate zone is determined automatically. The method defines 5 climatic zones:

- Northern Europe: Denmark, Finland, Sweden, Norway, Iceland;
- Western Europe: Austria, Belgium, France, Germany, Ireland, Luxembourg, Netherlands, United Kingdom, Liechtenstein, Switzerland;
- Southern Europe: Greece, Italy, Malta, Portugal, Spain, Cyprus;
- Northeast Europe: Czech Republic, Estonia, Latvia, Lithuania, Poland, Slovakia;
- Southeast Europe: Bulgaria, Croatia, Hungary, Romania, Slovenia.

Field: Location is considered to require no changes.

❖ **CHOICE OF METHODOLOGY**

In this part of the calculation sheet, the user can specify the settings used for the calculation.

Field: Weighting factors

Choose:

- Default
- User defined

When selected for standard rating, "default" is selected.

It is considered that the Weighting Factors field does not require changes.

Field: Preferred method of assessment

Choose:

- A - simplified method contains a simplified list of services
- B – detailed method contains the detailed list of services

The "Preferred Method" Field is considered not to require changes.

Field: Available areas (domains)

Choose:

- 0 - This domain is missing and optional
- 1 - This domain is present;
- 2 - This domain is missing but required.

When a domain is "absent but required", services are taken into account when calculating the "maximum achievable score" during the normalization process. The SRI testing spreadsheet can indicate whether a missing domain is mandatory, for example depending on local SRI testing instructions or implementation phase.

The "Availability of Domains" field is considered not to require changes.

3.2.2.2 View Services Section

This section gives an overview of the list of services. The services that are included in evaluation method A are listed in column J. In column K, the services that are included in evaluation method B are listed. In column L, users can make their own personalized list of services (1 = enable, 0 = disable); potentially including newly defined services (lines 60 to 104).

After the research conducted regarding the availability of the services prepared for intelligent management in Bulgaria, it was established that the intelligent services offered by SRI in the 9 domains are available on the Bulgarian market. The survey shows that consumers have already integrated some of them into their homes. The impression remains that with some of them they do not assume that they apply - especially when it comes to the buildings in which their workplaces are located.

This gives reason to believe that the proposed list of SRIs exhausts all possibilities for smart services.

Since it is expected that the use of geothermal energy will begin to enter in the future, a review of the smart services related to them is recommended - after 2027 (when real results in the field are expected).

3.2.2.3 Spreadsheet Section

The calculation sheet is where the actual evaluation takes place. Each row in the sheet represents a service from the Smart Service Catalog.

The evaluator shall indicate in column I whether a service is applicable to that particular building (1 = applicable, 0 = not applicable), services not applicable to that particular building will be grayed out. No evaluation is required for these services .

Code	Service group	Smart ready service	Service included in the selected method (A/B/custom): 0 – not	1 – This domain is present; 2 – This domain is absent but mandatory;	TRIAGE: 1 – This service affects maximum obtainable score, even if service is not applicable in this building; 0 –	Service applicable in your building? – to be assessed by the assessor: 1 – applicable; 0 – not applicable	Main functionality level as inspected by SRI assessor	share (default = 100% means applicable throughout the
H-1f	Heat control - demand side	Thermal Energy Storage (TES) for building heating (excluding TABS)	1	0	0			
H-2a	Control heat production facilities	Heat generator control (all except heat pumps)	1	1	0	1	2	100%
H-2b	Control heat production facilities	Heat generator control (for heat pumps)	1	1	0	1	2	100%

For each service to be rated, three fields can be filled in:

- Basic level of functionality (column J) – enter the level of functionality of the service. The different levels of functionality are provided in columns O to S:
  - If the field is left blank or the functionality level is not valid (eg higher than the maximum possible functionality level), a warning (in red) will be displayed in column N and no SRI score will be calculated.
  - If the functional level is valid, the selected functional level (NR column) will turn orange to facilitate visual validation.
- Functionality level fraction (column K): this field allows to test the partial compliance of a building with the basic functionality level. If the user does not wish to test partial compliance, they should keep the default value of 100%. Otherwise, it indicates the percentage of the net building area that meets the basic level of functionality.

***Фигура 2** Таблица за изчисление, колони B - K*

- Optional: additional level of functionality (column L): if the share of the level of functionality (column K) is set to less than 100%, the assessor must indicate the level of functionality that applies to the remaining area.
- Estimated evaluation time (column X): for feedback purposes, the user indicates the time required to determine this level of functionality, including the time required for visual inspection and/or the time required to search for technical data.
- Optional: evaluator comments (column Y): evaluator can provide comments if desired. This may include, but is not limited to:
    - Notes
    - Clarifications
    - Difficulties encountered when attempting to evaluate
    - Notice that consecutive results have been changed

Functionality levels comply with those established after the research conducted for the smart services offered.

3.2.2.4 Weighting Factors Section

In this section, the evaluator can change the default weighting factors assigned to each pair - technical domain - impact criterion. Default weighting factors are set according to the relative importance of each domain in the building's energy balance, where considered relevant (and equal or fixed weighting factors elsewhere). Additional:

- The default weightings are different for residential and non-residential buildings (reflecting, for example, differences in the relative importance of areas such as domestic hot water);
- The default weighting factors are different for each climate zone (reflecting, for example, differences in the relative importance of heating).

According to the instructions for use of the SRI spreadsheet, in order to manually change the weighting factors in the calculation sheet, the following needs to be done:

- In the "Building Information" section, in the "General information about the building" Part, the "Preferred service catalog" field, the option "Defined by user" must be selected
- In the "Weighting Factors" tab, the desired weighting factors need to be. There are two types of weighting factors:
    - Domain weighting factors (cells B9 to H17): these weighting factors are used to aggregate domain scores to influence the results. The sum of each column is exactly 100%.
    - Impact severity factors (cells B22 to H22): used to aggregate impact scores into a single overall SRI score. The amount is exactly 100%.

Some of the weighting factors are set to zero, both for default and user-defined factors. For these domains, no services contribute to the given impact criterion; and no weight should be attached to them.

The Weighting Factors section remains unchanged. It is recommended that tests be carried out to refine the weighting factors and their differentiation with respect to the different types of non-residential buildings.

The spreadsheet for calculating the SRI is available in **Appendix 4** .

3.2.3 Results

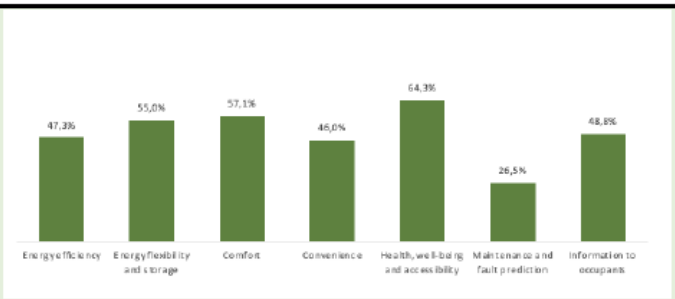
The Results section of the SRI spreadsheet displays different types of results:

- Overall SRI score (taking into account domain weighting factors and impact factors).
- Impact scores (taking domain weights into account).
- Domain scores (taking into account impact factors.
- Detailed results: the detailed results for each area and each impact criterion, resulting in a matrix for the 9 domains and 7 criteria.
- Summary results: the summary results for 3 key functionalities.

TOTAL SRI SCORE	48,7%	SRI CLASS	Between 35% and 50%

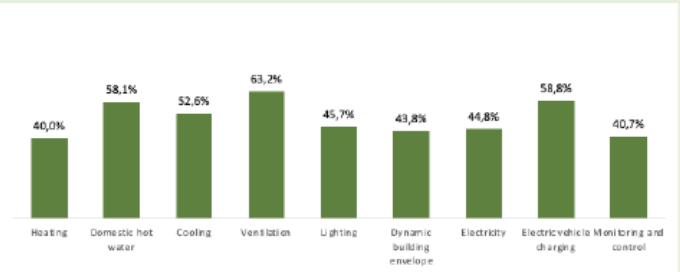
IMPACT SCORES

Energy efficiency	47,3%
Energy flexibility and storage	55,0%
Comfort	57,1%
Convenience	46,0%
Health, well-being and accessibility	64,3%
Maintenance and fault prediction	26,5%
Information to occupants	48,8%



DOMAIN SCORES

Heating	40,0%
Domestic hot water	58,1%
Cooling	52,6%
Ventilation	63,2%
Lighting	45,7%
Dynamic building envelope	43,8%
Electricity	44,8%
Electric vehicle charging	58,8%
Monitoring and control	40,7%



DETAILED SCORES

	Energy efficiency	Energy flexibility and storage	Comfort	Convenience	Health, well-being and accessibility	Maintenance and fault prediction	Information to occupants
Heating	50,0%	60,0%	66,7%	25,0%	50,0%	0,0%	0,0%
Domestic hot water	66,7%	80,0%	0,0%	60,0%	0,0%	50,0%	33,3%
Cooling	62,5%	33,3%	57,1%	57,1%	66,7%	25,0%	66,7%
Ventilation	33,3%	0,0%	66,7%	66,7%	83,3%	50,0%	66,7%
Lighting	33,3%	0,0%	50,0%	50,0%	0,0%	0,0%	0,0%
Dynamic building envelope	66,7%	0,0%	33,3%	50,0%	33,3%	50,0%	66,7%
Electricity	40,0%	33,3%	0,0%	40,0%	0,0%	33,3%	55,6%
Electric vehicle charging	0,0%	25,0%	0,0%	66,7%	0,0%	0,0%	66,7%
Monitoring and control	25,0%	66,7%	0,0%	28,6%	0,0%	50,0%	33,3%

AGGREGATED SCORES

Key functionality 1 - building	36,9%
Key functionality 2 - user	54,1%
Key functionality 3 - grid	55,0%

The obtained results provide information on how far a building is prepared for intelligent management based on a matrix for the 9 domains and the 7 criteria, as well as for the 3 key functionalities.

3.2.4 Preparation on Conclusions and recommendations

Based on the obtained results, a list of conclusions is prepared regarding the readiness of the building for intelligent management and possible options for improving its "intelligent state" are proposed.

3.2.5 Summary of the methodology for calculating the indicator for the readiness of buildings for intelligent management

1. Preliminary survey (gathering information through the prepared questionnaires)

Through the previously prepared questionnaire, information is collected about the intelligent services implemented in the evaluated building and the levels of functionality for each of them, the type of the building, the location of the building and its condition (repair activities).

2. Calculation of SRI using the spreadsheet proposed by the EC

Using the spreadsheet to calculate the SRI – based on the previously collected information: type of building, location of the building and its condition (repair activities), the smart services implemented in the assessed building and the levels of functionality for each of them

3. Results

Presentation of the various results obtained

- Overall SRI score.
- Impact results
- Domain results
- Detailed results: the detailed results for each area and each impact criterion, resulting in a matrix for the 9 domains and 7 criteria.
- Summary results: the summary results for 3 key functionalities.

4. Conclusions and recommendations

Preparation of a list of conclusions and recommendations regarding the condition of the building and improvement of its intelligence in order to increase energy efficiency and comfort of the occupants.

4. CONCLUSION

Long-term strategies for increasing the intelligence of building construction and renovation require reliable measures to assess their readiness. In this regard, the revised Energy Performance of Buildings Directive introduced the SRI indicator to provide a standardized methodology for assessing readiness for intelligent building management.

However, European countries face some difficulties in the adoption and implementation of SRI, related to its definition and adaptation to different national conditions, the lack of expertise among energy auditors, the need to solve issues related to the scale and reliability of large-scale implementation, the weak commitment of the relevant stakeholders and the difficulties in making informed decisions to increase energy intelligence.

Based on the conducted research, it becomes clear that the SRI spreadsheet is applicable for calculating the readiness of buildings for intelligent management in Bulgaria.

The smart services offered by SRI are available on the Bulgarian market and the conducted survey shows that a large part of them are known to consumers and used by them in their homes.

Based on the conducted research, it is recommended to introduce and periodically review a voluntary scheme to determine the readiness of buildings for intelligent management, due to the continuous development in the market for intelligent technologies.

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