RISING PUBLIC AWARENESS OF ENERGY EFFICIENCY OF BUILDINGS ENHANCED BY "SMART" CONTROLS OF THE IN-DOOR ENVIRONMENT

by

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Buildings consume a significant amount of energy today and are expected to consume even more in the future. This consumption necessitates the use of fossil fuels such as coal and natural gas, both of which have significant environmental impacts. While renewable energy sources remain promising, the most of the energy supply will still use conventional fuels in the near term. Therefore, improving the energy efficiency in buildings is critical, and one of the central visions of "smart buildings" is to reduce their energy use while maintaining the same level of service and comfort. However, to make the buildings meaningfully "smart", their envelopes must first be made compliant with the current energy efficiency standards. In this paper, we first examine how the public awareness of energy efficiency was risen in Serbia through different demonstration projects, funded by the state budget and through implementation of the energy efficiency measures in public buildings, funded by municipal funds and soft loans from the banks. Then, we describe how the energy efficiency in buildings might further be increased by the use of new technologies and smart networks for control of the energy consumption. We finally, argue that these controls should take into account the personal variables (activity, clothing) along with environmental variables (air temperature, velocity, and humidity) for an optimum thermal comfort to be achieved in public and residential buildings.

Key words: *public awareness, education, energy efficiency, intelligent buildings*

Introduction

The buildings (residential and commercial) are among the largest consumers of energy. They use about 40% of final energy consumption, of which about 60% is spent for heating and cooling. In particular, residential and commercial buildings consume a major part of electricity, and their share of energy consumption is projected to increase even further as compared to industry and transportation. With fossil fuels the primary energy source, the building sector currently produces 22% of total CO_2 emissions in the EU, more than that produced by the industrial sector [1]. A modern building typically has four major energy-consuming subsystems: heating, ventilation and air conditioning (HVAC), refrigeration, lighting, and miscellaneous plug-load devices. They include a growing share of information technology (IT) equipment and other consumer electronics, which is expected to account for 45% of

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domestic electricity usage by 2020 [2]. Therefore, building owners and operators are being challenged to increase the efficiency of their facilities to reduce cost, minimize their carbon footprint through green sustainable building design, and drive business best practices. With a converged building approach, higher asset utilization can be achieved with an improved cost structure over the building life cycle, and use of energy resources managed more efficiently.

In today's increasingly automated world, the ability to tie multiple systems together for greater efficiencies and to lower the operating costs is a reality. By consolidating network cabling infrastructure it is possible to reach all building systems and devices and enable enhanced commissioning to help meet energy performance requirements, and add flexibility to accommodate ever-changing user needs. Intelligent hardware and software can monitor power and cooling systems to optimize power consumption. Such design principles allow to gain total control over the entire infrastructure, thus reducing capital and operational expenses to ensure a sustainable building infrastructure that is physically available where and when needed.

Buildings are inherently linked to their usage and surroundings. Hence, their indoor environment is the result of a range of interactions affected by seasonal and daily changes in climate and by the requirements of occupants varying in time and space. The design of buildings in the mid-late twentieth century has sought to eliminate the effect of outdoor daily and seasonal changes through the use of extensive heating, cooling, lighting and ventilation equipment, resulting in spiraling energy consumption, and environmental impact. Intelligently designed buildings are those that involve environmentally responsive design taking into account the surroundings and building usage. The modern designs involve the selection of appropriate building services and control systems to further enhance building operation with a view to the reduction of energy consumption and environmental impact over its lifetime.

The new concern over energy and environment is changing both legislation and consumer behavior. The public awareness of the energy efficiency measures is of utmost importance for the energy savings. The same applies to the environmental pollution and climate change issues. However, to make the consumers fully aware of these issues, considerable efforts are still required both by the educational institutions and the scientific community. The national energy policy should include legislation and governmental incentives for increasing energy efficiency and mitigation of environmental pollution and climate change.

Energy efficiency in Serbia is rather low. One of many reasons is that public awareness of that fact is generally poor. This is particularly so when an outdated building stock without energy efficient envelopes is in question. Figure 1 shows the current structure (in percentages) of residential building stock in capital city of Belgrade, built during the 20th century, before the new standards of energy efficiency came into force [3]. Evidently, the majority of building stock is from the period 1960-1970, when massive construction was needed to accept the people moving to the urban settlements and when the care of energy efficiency was not a priority neither for the governments nor for individuals. In buildings constructed before 1945 installed capacities of heating systems were on average 200 W/m^2, in those constructed after 1960 about 145 W/m^2, which means that average heat energy consumption in an average cold year, and with an ideal maintenance of buildings and heating systems is 200-300 kWh/m^2, sometimes even higher [4].

In the European countries with similar climate conditions, buildings are today constructed with annual consumption of energy for heating, hot water, air conditioning, and lighting lower than 100 kWh/m^2. It is evident that specific energy consumption in buildings in Serbia is 3-4 times higher, and that a large potential for increase of energy efficiency [5]. Herewith, we present first of the efforts made in Serbia to promote energy efficiency as a national policy challenge and to demonstrate how it can be improved in the existing public buildings.

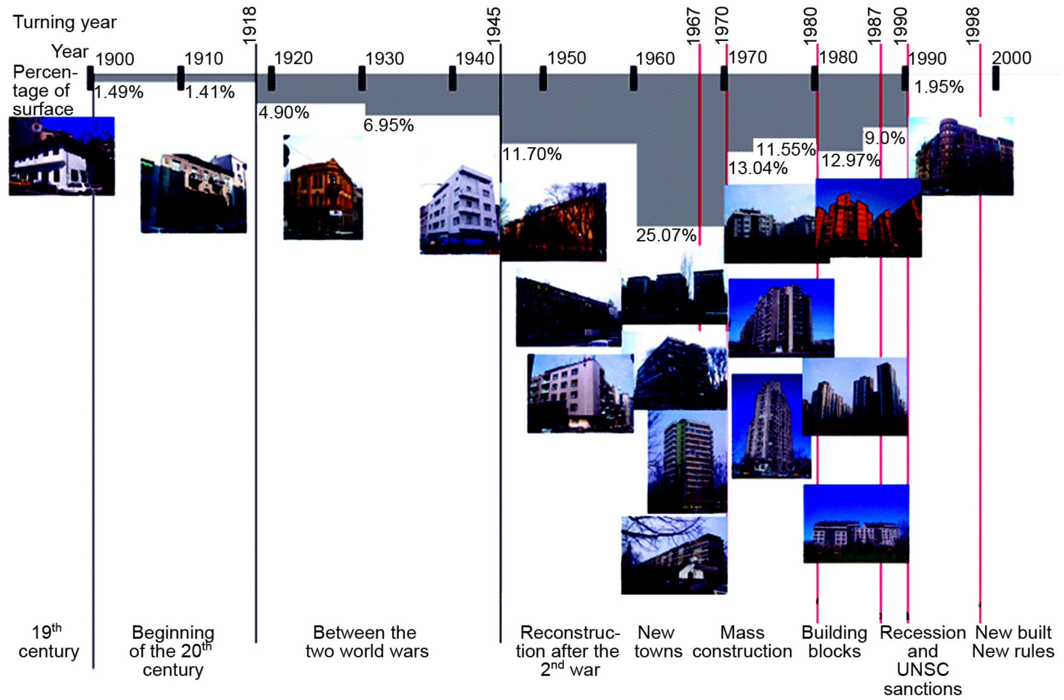


Figure 1. Structure of the existing residential building stocks in Belgrade built during the last century

Then, we describe in certain details how energy efficiency of buildings can be enhanced by involving information technologies to further reduce energy consumption while providing a better quality of life for the residents. Such high-performance (intelligent) buildings integrate disparate building systems so they can be controlled by a centralized common user interface. The design, construction, and operation of intelligent buildings require a new approach, innovative strategy, and a team with different players involved. Such a widespread adoption of intelligent technologies can mean transformation for the real estate industry to a large extent.

Rising public awareness of energy efficiency in Serbia

Inefficient use of energy represents a major concern worldwide. Consumption of primary energy per unit of GDP in Serbia is significantly higher than that in the EU (13 times higher than in Germany, 10 times higher than in France, five times that in Slovenia, and almost twice that of Romania) [6]. In line with global attempts, Serbia has recently adopted a series of regulations that are intended to contribute to national energy efficiency increase. The National Energy Efficiency Action Plan was adopted in 2010, and Decree on Energy Efficiency in Buildings Decree on Modalities of Issuing, and Content of Building Energy Performance Certificates came into force in late 2012. In addition, the new Law on Efficient Use of Energy was adopted in early 2013. As specified in the National Energy Efficiency Action Plan, building sector in Serbia is expected to contribute largely to national energy efficiency increase, with 9% reduction in the final energy consumption planned to be achieved until 2018 [7]. However, for these legislative measures to be implemented effectively, awareness of the consumers of the energy efficiency issues at the individual and national levels should be risen as well. Many actions have been undertaken in that direction by governmental, educational, professional, and other players on the energy scene.

National Energy Efficiency Program

To support the governmental policy on energy efficiency be implemented and make Serbian public aware of the importance of saving the energy, Government launched a research, development and demonstration program to increase energy efficiency and implement the renewable energy sources. The National Energy Efficiency Program (NEEP) was founded in 2001, and was funded (about 2 million € per year) by the Ministry of Science and Technological Development [4, 5, 8]. The main objective of NEEP was to unite research, engineering and legislative activities in order to study, develop and implement new technologies and methods, and also to transfer already proven technologies and methods to the specific conditions in Serbia. Also, the aim of NEEP was to financially support the application of already proven energy efficient technologies, software tools, methods and equipment in order to promote their wide dissemination in industry, transportation, commercial and public services and households of Serbia [8].

The strategy of NEEP was based not only on the principle that an increase in energy efficiency must result in energy savings, but also on an increase in security of supply, as well as on higher quality of energy supplied to the end users. The NEEP had to cover all sectors and subsectors of the Serbian energy system, and to include efficiency in energy transformations, transmission, and distribution to the end users in industry, traffic, buildings, municipal systems, and households, taking care of specific characteristics of each subsector and formulating specific development programs for each of them.

The NEEP was composed of nine sub-programs, devoted to the respective subsectors of energy system in Serbia [4, 5]:

1. Energy efficiency in electric power generation,
2. Energy efficiency in electric power transmission and distribution,
3. Energy efficiency in industry,
4. Energy efficiency in municipal systems,
5. Energy efficiency in households,
6. Development of domestic ovens and boilers burning solid fuels,
7. Use of alternative and renewable energy resources,
8. Energy efficiency in buildings, and
9. Energy efficiency in transportation.

In each of the NPEE subprograms specific priorities have been formulated for the subsector in question, according to the main objective to obtain maximum possible increase of energy efficiency and satisfaction of the total energy needs. Priorities were formulated based on the results of previously done strategic and feasibility studies of the available potential of energy efficiency or of the potentials of domestic energy sources, fossil and renewable [8]. These studies gave also basis for formulation of the measures for support and stimulation of the energy efficient behavior of the consumers. The researchers (mainly from universities and scientific institutes) had to apply for governmental funding jointly with potential users of their results, that usually took part in the realization and/or co-financing NEEP projects. By this approach the researchers improved their practical experience and got additional measuring devices and software tools, while the targeted users, either producers or consumers of energy, gained from an increased efficiency of their processes leading to a shorter returns of (their own and governmental) funds, as well as to a reduced carbon footprint.

A Board of directors consisting of directors and deputy directors of the subprograms was appointed by the Ministry to take care on the achievement of the objectives of NEEP. Board of directors was responsible for management and directing all activities of NEEP including formulation of the strategy, choice of priorities, announcement of the open invitations for financing R&D and demonstration projects, selection of the proposed projects for financing, control and follow-up of their realization, and evaluation of the results achieved by the projects. The results achieved by the demonstration projects were of importance not only for the users and researchers, but also for a nation-wide promotion of particular successful solutions in rising energy efficiency.

The energy efficiency of buildings was specifically addressed by the sub-programs 8 (Energy efficiency in buildings) and 5 (Energy efficiency in households). Of particular interest were the software packages developed or applied for the design of energy efficient envelopes of the buildings as well as a series of demonstration projects which showed that the energy for heating can be halved. This was confirmed by measurement of energy for heating in residential buildings. Promotion of energy efficiency in households was done through an informative campaign on energy efficiency in households carried out through targeted lectures given at all levels of the national educational system, and promoted through different media, including web site and other suitable means (leaflets attached to monthly bills, phone books, *etc.*).

Serbian Energy Efficiency Project

Public sector has been identified as one that needs to set an exemplary role in the implementation of energy efficiency measures [9, 10]. In line with such intention, Serbia has implemented a series of projects aimed at energy-efficient refurbishment of public buildings, particularly schools, health-care, and social-care institutions. The largest energy efficiency project was the Serbian Energy Efficiency Project (SEEP), funded through IDA credit and IBRD loan with total investment value of 49 million USD [6]. The project has been implemented in two phases (SEEP 1 and SEEP 2), carried out from 2004 through 2013, fig. 2 [11]. The project objective was to improve energy efficiency in public buildings in municipalities across Serbia including 2 large clinical centers and 90 public buildings (school, health-care and social-care institutions). The project was managed by one of the authors of this paper [11, 12]. It included selection, design and implementation of the measures aimed to provide more efficient space heating services, as well as more functional and healthy environment for the end-users, with additional environmental benefits achieved through CO_2 emission reduction. Some of the buildings were also provided with lighting system upgrade or reconstruction.

Measures implemented in the public buildings within the scope of SEEP project have been selected so as to provide the best cost-effective building refurbishment *i. e.* to result in the largest energy savings in the shortest span of time. Individual measures included intervention on building envelope, as well as modernization of boiler rooms with fuel switches from coal and oil to natural gas, installation of thermostatic radiators, balancing valves, variable flow pumps and automatic control systems. Each building was audited with respect to its physical conditions and energy consumption Then, all feasible refurbishment measures that could increase efficiency of heating system operation have been analyzed. Proposed refurbishment measures have been grouped into energy efficiency packages, so as to identify and propose to the key stakeholders the implementation of the cost-optimal solution for the improvement of buildings' energy performance.

The selection of public buildings for refurbishment was intentionally made so as to demonstrate to all the stakeholders what energy saving potential is available in the buildings.

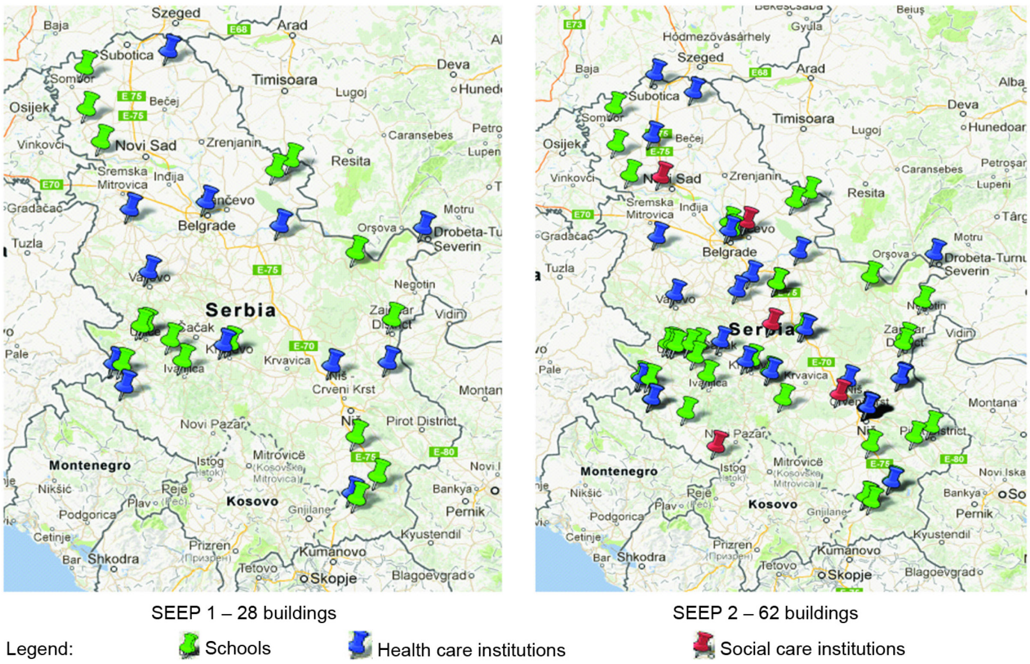


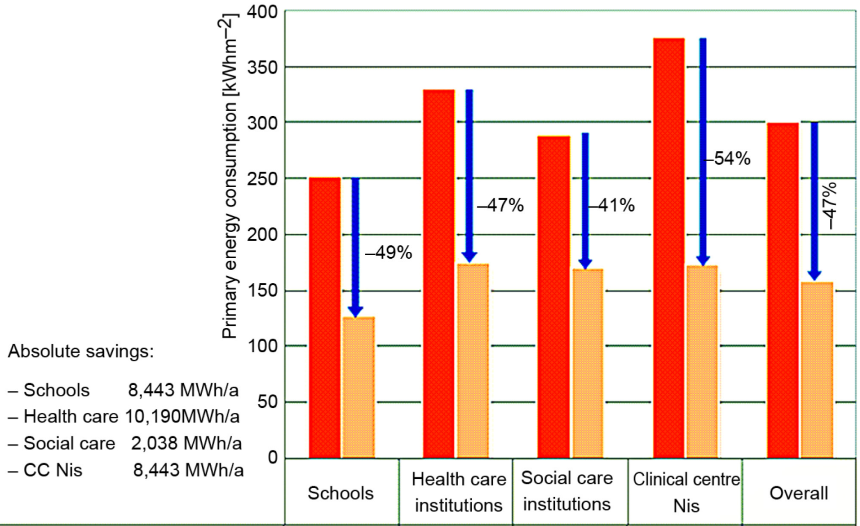
Figure 2. Locations of public buildings included in the scope of SEEP

It is worth mentioning that measurements conducted in some schools prior to improvements have indicated that indoor temperatures in the classrooms were only 15-16 °C [12]. Therefore, the indoor temperatures achieved by the refurbishments show that a portion of potentially *saved* energy needed to be used to provide required in-door conditions and necessary end-user comfort.

As seen in fig. 3, about 47% energy consumption reduction has been achieved in 62 refurbished public buildings [11, 12]. Clinical centre of the city of Nis is here presented as an individual building group since it represents a complex comprising 19 buildings included in the project scope. An unacceptably large specific energy consumption recorded prior to refurbishments, 252-376 kWh/m^2 annually [12] was reduced down to much lower levels, but still above those achievable in modern building automation and information technology.

Although, the consumption values presented surely leave room for additional improvements, it is important to mention that only a small handful of buildings have been fitted with full set of energy efficiency measures, while majority were only fitted with a couple of improvements selected as the cost-effective refurbishment solution. This was mainly due to budgetary constraints as well as situations when end-users failed to conduct prerequisite repair works that were deemed necessary in order to implement certain energy efficiency improvement. In addition, facilities needed to remain operational during the entire work execution, which was particularly challenging in case of health care and social care institutions.

Energy savings achieved in health-care facilities are particularly important when considering the overall annual energy consumption, since hospital heating systems are designed to operate continuously *i. e.* 24/7 and achieve relatively higher indoor temperatures when compared to social care institutions. It was particularly so when compared to schools whose heating systems are usually completely shut-down (or operate at reduced capacity) during



	Schools	Health care institutions	Social care institutions	Clinical centre Nis	Overall
Energy consumpt. before [kWhm−2]	251.9	331.1	290.0	376.4	301.5
Energy consumpt. after [kWhm−2]	128.3	175.8	170.6	173.3	159.3

Figure 3. Annual energy savings in public buildings included in the scope of SEEP 2

overnight/weekend and holiday periods. This is more evident from the fact that total annual energy consumption of 62 considered buildings has been reduced by 29,114 MWh. Of this annual value 64% is attributed to the energy savings achieved in 29 health care institutions, while 29% comes from the savings achieved in 28 schools [11, 12].

Environmental benefits achieved through implementation of the SEEP2 project have also been considered with respect to reduction in CO_2 emissions achieved on the account of reduced energy use. Annual carbon footprint of the facilities considered has been reduced by more than five thousand tons of CO_2, with 60% of indicated emission reduction achieved by energy efficient refurbishments of health care institutions, 34% by school improvements, and 6% by refurbishments of social care institutions [11, 12]. Light fuel oil represents the dominant fuel used in the refurbished schools and social care institutions, while majority of the health care institutions uses natural gas. The reduction in CO_2 emissions is closely related to heat-supply operation regime and required indoor conditions in the facilities considered, as well as to fuel used in their heating system.

The implementation of energy efficiency improvements in the public sector in Serbia has proven to be beneficial with respect to associated financial and social aspects as well. As an added value to social benefits related to the SEEP project promotion is spreading the word about the effects achieved by implemented energy efficient refurbishments. Public awareness about the benefits achieved shall further increase when financial effects reflect in reduced energy bills and when information on positive financial effects reach broader population in the municipalities where building refurbishment works have been performed.

Enhancement of energy efficiency by smart networks

The consumers are even much less aware that, when building envelopes are adjusted to the energy efficiency standards as demonstrated in the previous paragraph, the next step to further increase the energy efficiency in buildings is to implement *smart* electronic devices that enable the energy consumption to be fully controlled [13, 14]. Energy management and control system technology has evolved over the past three decades from pneumatic and mechanical devices to direct digital controls or computer based control systems, thus narrowing the gap between building and information technologies, fig. 4 [14].

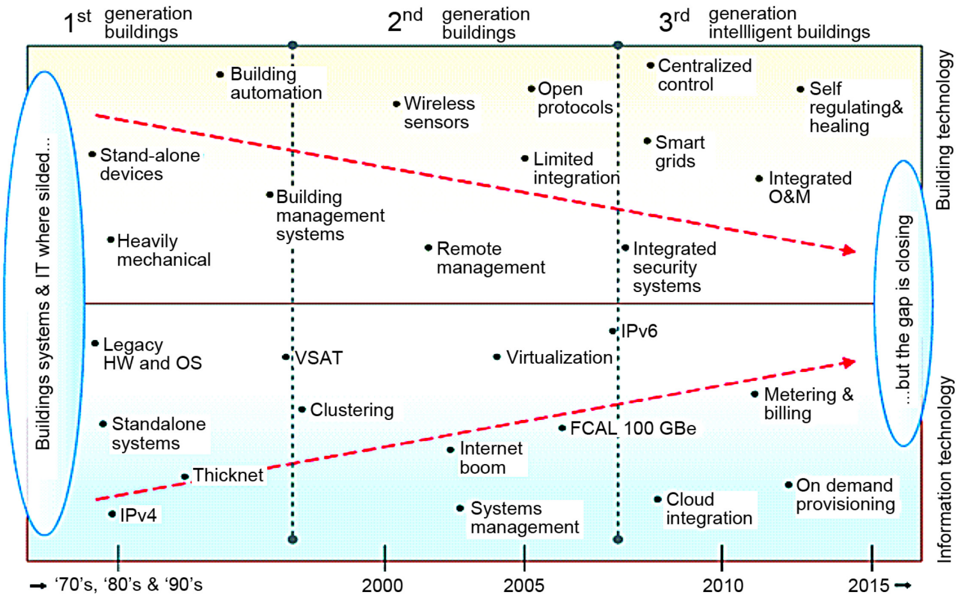


Figure 4. Closing the gap between building and information technologies; *FCAL – Fibre Channel Arbitrated Loop, HW – HardWare, IPv4 – Internet Protocol version 4, IPv6 – Internet Protocol version 6, O&M – Operations & Maintenance, OS – Operating System, VSAT – Very Small Aperture Terminal*

Intelligent buildings successfully merge building management and IT systems to optimize system performance and simplify facility operations. Being able to actuate different building subsystems, both for energy efficiency and demand response reasons, is therefore of critical importance in the design of a smart building. In traditional buildings, disparate systems (such as HVAC and lighting) each have their own controls and, in many cases, use a different method of cabling. The days of using four or five different computer systems to support security, HVAC, and other building systems are long gone. Anything that need to be done in a building now, can all be done from one interface only.

Obviously, not every building system has to be integrated to make an intelligent building. However, the more systems that are connected, the greater the benefits [14]. Today, a single redundant backbone offers ability to check lighting and climate controls via the Internet, and more. While no one can foresee where the future of technology is going, experts predict that a building with an Internet protocol (IP) backbone will be ready to support almost anything that comes onto the market. It is, therefore, important to have a building flexible enough to adapt quickly. In several decades from now, the majority of the world's population will live in large cities and urban areas. Megacities and the demographic shift (such as constantly increasing life expectancy) are having a profound effect on the way people live and do business. It is therefore of prime importance to ensure flexibility in selecting the level of building automation in accordance to the expected changes of user context.

When the energy consumption is considered, it appears that lighting, HVAC systems and plug-load devices are the dominant consumers in buildings. A modern centrally managed HVAC system in commercial buildings includes a central air handler that produces chilled air, which gets circulated through the ducts that span the entire building. The standard way of controlling HVAC in commercial buildings causes significant energy waste during the periods of vacancy, when also many other devices are left powered on, regardless of actual occupancy or needs. Even in stand-by regime, many such devices cause energy losses [15]. Because the air conditioning system exhausts most energy in the building, it is necessary to adopt a control method to get the optimum energy efficient by making the best of the resources in the intelligent buildings. The air system is a complex system with too many factors involved, non-linear in nature, long delaying, with strong inertia, *etc.*, so that an accurate mathematics model is hard to make out. Also, the performance of classical control theory can hardly be satisfying based on the software tools alone. However, thanks to measuring, recording and analyzing the data, some advanced methods can be used to achieve both good control effect and ideal efficiency. We consider them both a challenging subject for further research and experimental testing.

Sensing modalities and techniques

Sensing is a key function of intelligent buildings, and therefore a significant amount of research world-wide has examined various sensing modalities and techniques. Occupancy and user context, environmental conditions, and energy usage should be sensed in order to know the building status in real-time [16]. To design effective actuation policies, it is necessary to detect occupancy within a building. For that purpose, of particular importance is the actual sensing infrastructure. Wireless sensor networks have emerged today as enablers for delivering very valuable and precise sensor data.

The occupancy sensors usually detect movement and are very useful in optimizing building operations. Having occupancy as an input allows user to dynamically control the HVAC settings per zone. The HVAC control scheme saves about 12%, in thermal cooling loads and 10% in thermal heating loads, and total savings are in excess of 30% across the entire building [17]. Going forward, more advanced control policies should be developed on top of the HVAC control mechanisms in order to minimize energy consumption while maintaining occupant comfort.

Environmental sensing is another important area of sensing the temperatures and other variables for the zones in a building. Most modern buildings come installed with building management systems (BMS) that monitor (and control) these conditions. A smart building server can interface with existing BMS and retrieve these values through standardized protocols. Through interfacing with the existing BMS, one can obtain the temperature, damper position, fan speed, cooling set points, and user override settings. This information is important for optimized control over HVAC settings in Serbia. This is worth studying because a fast growing number of HVAC systems in buildings is being implemented.

Two broad classes of plug-load energy detection exist: direct sensing, which connects a meter directly in line with the device, and indirect methods, which attempt to measure energy usage without having to deploy a meter for every device. Indirect sensing techniques utilize sensors to detect the magnetic field variations and magnetic state transitions that occur near plug-load devices [18]. However, the most accurate way in Serbia is still through the use of industrial mains meters to measure the energy consumption, with a possibility to show energy consumption by each sub-system.

Actuation technique

The ability to control the building operations is essential in improving energy efficiency. The key challenges that must be addressed relate to exercising control over building subsystems and determining when to control them. Modern buildings with BMS systems not only sense the environmental conditions, but also control the per-zone environmental settings. A smart building must be able to access these controls in order to actuate the HVAC system on a fine-grained basis. Such controls include setting the thermal set points for each zone (the temperature that HVAC system should meet) and the command state for each zone in the building.

Actuating HVAC and other plug-load devices is therefore very important towards improving building energy efficiency. The significant energy consumers in a building (HVAC equipment, IT equipment, lighting, and miscellaneous plug-loads) may be approached differently in terms of mechanisms for actuation. A natural way to remotely actuate devices is to apply a mechanical relay that allows to turn on or off the electrical load plugged into the meter, while the software allows remote management over the wireless network, fig. 5 [19].

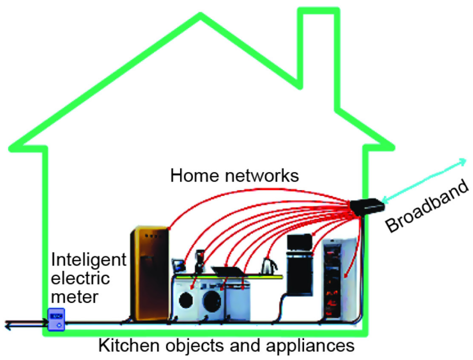


Figure 5. Home networks for actuation

With continuous monitoring and management of lights coupled with an access control system and motion detectors can cut electricity use by up to 45% [19]. Cooling systems, combined with an access control system and detectors of motion can reduce consumption by up to 15%, while maintaining perfect space conditions for the physical wellbeing of users [20]. When compared to buildings operating with traditional automation technology, intelligent buildings save between 22% and 30% of energy [14].

Thermal comfort

Building automation provides solutions and services for the control and management of HVAC and lighting. The principle behind all these solutions, however, is that buildings should only be working when the people inside them are working. Saving energy involves connecting, controlling, monitoring and optimizing building systems by tying them with time and attendance systems to create a completely integrated intelligent building solution. Integrating a wide range of technologies towards one common goal takes a wide range of experience, skilled and well trained experts and a vision for the future [21, 22]. The users must also be educated and trained to be able to profit from their building automation.

The intelligent building serves the user and efficiently implements the desired energy-saving measures including his/her thermal comfort. Comfort is defined as the sensation of complete physical and mental wellbeing. The perceived need for both heating and cooling is to achieve accepted standards of thermal comfort, usually defined (directly or indirectly) by temperature limits. Controversy exists as to what these standards of thermal comfort are. It has been observed that there has been an apparent discrepancy between comfort predictions using models derived from laboratory experiments, such as those by Fanger [23], and subjective assessments of comfort found in field studies by Humphreys [24]. Humphreys found from field studies in predominantly warm and hot climates that the preferred comfort temperature T_c in buildings was a function of the average monthly outdoor temperature T_0 in the form:

$$T_c = 0.534\ T_0 + 11.9 \tag{1}$$

Thermal neutrality, where an individual desires neither a warmer nor a colder environment, is a necessary condition for thermal comfort. The factors affecting comfort are divided into personal variables (activity, clothing) and environmental variables (air temperature, mean radiant temperature, air velocity, air humidity). These environmental variables vary spatially in a room, and the actual values experienced by an occupant may not be those described by a *room-average value*. Thermal comfort parameters vary with time, whereas the existing models predict a steady condition. Neither the clothing level assumed in the models is the same as is actually worn in the real situation, nor the activity may be the same as the actual one [25]. These facts deserve further very detailed research.

Regardless of whether a building serves as an office or a home, the technology it houses should always create the best possible conditions for users and inhabitants, be it working or simply living. The desired thermal comfort is in close connection with the energy balance dependent on the activity a person does and cloths he/she wears. The metabolic rate (the amount of energy produced per unit of time by the conversion of food) is influenced by activity level and is expressed in Mets (1 Met = seated relaxing person [26]). Table 1 presents energy dissipation from the body surface expressed in metabolic units Met. Clothing describes the occupant's thermal insulation against the environment. This thermal insulation performance of different garments is expressed in Clo units, tab. 2. Tables 1 and 2 present quantitative values for Met and Clo as given in [26].

Table 1. Metabolic Met rates

Activity	[Wm^{-2}]	[Met]
Seated, relaxing	58	1.0
Standing, relaxing	70	1.2
Teaching, Presentation	95	1.4
Walking slow, 2 km/h	110	1.9
Standing, medium activity	116	2.0
Walking fast, 5 km/h	200	3.4

Table 2. Garment insulation Clo values

Garment type		[Clo]	[Wm^{-2}K]
Underwear	Sleeveless	0.06	111.1
	Long sleeves	0.12	52.6
Shirt	Short sleeves	0.09	71.4
	Long sleeves	0.25	25.6
Trousers	Normal	0.25	25.6
Jacket	Normal	0.35	18.5

Totally networked systems within a technical infrastructure should ensure that the building delivers the highest possible levels of comfort and energy efficiency. For that purpose, the building services infrastructure should gather not only signals from temperature and air sensor equipment, cameras, motion detectors and other systems, but also the information on the activity occupants do (Met) and cloth they wear (Clo) to achieve an optimal energy efficiency. These should also be taken into consideration whenever attempting to determine the optimum thermal comfort.

Conclusions

Thanks to an intelligently networked building automation, energy consumption and operating costs, as well as the impacts on the environment, can be minimized. Intelligent buildings thus make an important contribution to the energy savings, which ensure that any modernization of the building equipment is virtually self-financing, and capable of controlling all of the building processes. Optimizing the building systems can provide a high level of energy efficiency that has been unknown until today. Developing control algorithms that can optimally control all of the building processes is therefore an ongoing technical challenge. The result of these technologies is a building that not only significantly reduces energy consumption, but also improves the quality of service for every occupant.

The design, construction, and operation of intelligent buildings require a new, innovative strategy, as well as a team work, with different players involved. The thermal conditions of each room could be set automatically according to each individual's preferences. By integrating the existing systems into a single user interface will make the public aware or even train individuals and teams on how to maximize the use of new system to achieve the preferred thermal comfort while minimizing the energy consumption. An adoption of *smart* technologies can also mean widespread transformation of the real estate industry.

Internet and social media are expected not only to be a part of the building management system, but also to play the major role in transferring the knowledge on the energy efficiency to all stakeholders. Education of the users of building automation through the Internet and social media will be of enormous help to them in learning how to optimize their own thermal comfort.

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