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Active Consumers in Smart Grid Systems - Applications of the Building Automation Technologies

Streszczenie. *Systemy automatyki budynkowej (BAS) spełniają coraz bardziej znaczącą rolę w budynkach, zwłaszcza komercyjnych i użyteczności publicznej. Są podstawowym elementem organizacji systemów zarządzania budynkami – BMS, integrując na poziomie obiektowym wszystkie podsystemy infrastruktury budynkowej. W artykule przedstawiono koncepcję wykorzystania systemów BAS w organizacji lokalnych sieci pomiarów zużycia energii elektrycznej i mediów, w perspektywie wdrożenia systemów zdalnego opomiarowania Smart Metering, inteligentnych sieci elektroenergetycznych Smart Grid oraz pojawienia się tzw. prosumentów. (**Aktywni odbiorcy w systemach Smart Grid – aplikacje technologii automatyki budynkowej**).*

Abstract. *The Building Automation Systems (BAS) fulfil an increasingly important role in buildings, especially commercial and public buildings. They are an essential element of the building management systems (BMS) organization, integrating all building infrastructure subsystems on the field level. This paper presents the concept of using BAS systems in organization of local energy and the media consumption measurement network, in view of the remote metering Smart Metering and Smart Grid implementation as well as emergence of so-called prosumers.*

Słowa kluczowe: automatyka budynkowa, LonWorks, integracja, SmartGrid.
Keywords: building automation, LonWorks, interoperability, SmartGrid.

Introduction

The electrical power systems need modernization and adaptation to new conditions of their functioning. First of all it is connected with growing energy demand, reducing system reserves and more and more popular using of renewable sources of energy. They are going to be connected to the power systems in different, random points, additionally with different power level. It brings changes into power distribution system and its load. Since it is important to implement more dynamic energy management in the power system as well as monitoring and improvement of power quality parameters. Information about the power level in the electric power system regions and changing energy demands is needed. These questions are base for the Smart Grid idea – the traditional power grid with some main power plants will be transformed into interactive, distributed power network. Power distribution in this kind of network will be depend on active consumers demand (demand data, energy consumption monitoring, different tariffs) as well as energy distributors and local generating points (wind turbines and PV panels farms etc.) The Smart Grid it is not only buzzword, but the first of all huge chance to improve energy efficiency, energy consumption minimization, appropriate energy management and power grid improvement. To put it simply, Smart Grid it would be hybrid of the energy distribution system and IT networks to provide bidirectional communication between all modern electrical power system subjects. The first element of this conception should be intelligent, remote measurement system of energy and other media consumption – Smart Metering. This kind of system contains: electronic, intelligent meters, data transmission infrastructure, database and management system with bidirectional, real-time communication [26]. Information from main and local power plants are transmitted to the individual and commercial consumers (supply parameters, energy quality parameters) and from consumers to the providers (power demand, failures, problems) [10,26,27]. This way classic consumer could be prosumer with possibility to active manage energy consumption (switch loads out of peak load/maximum demand; different tariffs) and produce and sale energy to the grid. Consumers are usually connected with different kinds of the buildings (houses, offices, industrial buildings, supermarkets, entertainment centers etc.). Very often they are equipped with IT infrastructure and more often building automation and BMS systems as well. It concerns especially public, office and commercial buildings [2,14].

Since it is very important and current question: to select tools and standards for Energy Service Interface (ESI) – software and hardware platform of communication and activity between prosumers, providers and producers in the buildings ESI could work as a part of the BMS or BAS (Building Automation System) system and in the houses as a part of the EMS (Energy Management System) or HAN (Home Area Network) networks [11,29].

Development of the Smart Grid is directly connected with implementation of new electric, electronic, automation and IT technologies as well as working out suitable directives, laws and standards. Progress in both fields should be systematic and simultaneous, especially taking into consideration current and binding directives and strategic programs accepted by the European Union.

Legal regulations

The question of the Smart Metering systems implementation was first time brought up in the European Parliament and of the Council Directives. First of them No. 2006/32/WE concern on energy end-use efficiency and energy services. it is state there that Smart Metering systems, with individual meters for each consumer, are one of the means to achieve energy efficiency in European countries. There are general regulations for measurements and energy savings verification there as well. The second one is Directive No. 2009/72/WE concerning common rules for the internal market in electricity. In this document the Smart Metering systems are mentioned as a tool to achieve main directive goals: creating competitive and safe electrical energy market with consumer protection [6]. The directive states that consumers should have access to their energy consumption data (consumer is owner of the data) and data should be available for energy providers (other regulations). This statement resulted in necessity to work out new regulations in the personal data protection field and data security in the IT and transmission systems as well as on the filed level (direct connection between devices and meters in the automation systems) [29]. In the Directive there is on very important thread – in Annex I it is stated that each country implementation of the Smart Metering systems for the electrical power supply may be subject to an economic assessment of all the long-term costs and benefits to the market and the individual consumer or which form of intelligent metering is economically reasonable and cost-effective and which timeframe is feasible for their distribution. Such assessment shall take place by 3 September 2012. Where roll-out of smart meters is assessed positively, at least 80 % of consumers shall be equipped with intelligent meter-ing systems by 2020 [2,7].

To carry out mentioned assessment in Poland special team for the Smart Grid implementation questions have been appointed by the Minister of Economy at 6th of December 2010.

At the December 2011 this team have announced positive recommendation to implement intelligent measurement systems – Smart Metering in Poland. It resulted in preparing special new regulations to amended energy law (pol. Prawo Energetyczne) and obligate distribution network operator (pol. OSD – Operator Sieci Dystrybucyjnej) to install intelligent meters for all consumer to 31st December 2020 [25,28,33]. It is worth to emphasize that the team have proposed the Minister of Economy to withdraw from detailed analysis of cost-effectiveness of the Smart Metering implementation. The Member of Parliament and the chairman of a parliamentary committee for power and energy industry – Mr. Andrzej Czerwinski explains that preliminary assumptions to the Smart Grid law and implementing regulations had been prepared earlier and some pilotage installations had been implemented in Poland by different energy providers, so positive recommendation have been natural step in that situation [5,7,34]. The faster way to implement the Smart Metering idea have been opened. In April 2011 a law on energy efficiency was passed – it obligate entities operating in the energy industry to take action to improve the energy efficiency factor and obtain the so-called "white certificates". However, from the point of view of the Smart Grids and Smart Metering concept development more important are legislative work of the Ministry of Economy, associated with the development of so-called Smart Grid Law within the amendment of the Energy Law. Main objectives of the mentioned amendment are [5]:

- Reducing peak demand for the power and ensure balance in the National Power System
- Development of a competitive electricity market through introduction of billing based on the actual consumption profile with facilitation of change the provider
- Provide information about the current energy and other media consumption
- Limiting in electricity prices increases for end-user through the implementation of new competitive forces in the electricity market.

These objectives have been the subject of extensive sectorial and social discussion, undertaken in the relevant documents, among others by the President of the ERO (Energy Regulatory Office). In one of them the concept of the Smart Metering market in Poland is outlined, with indication of the different actors role and requirements for the Independent Measurement Operator. This name in the latest documents proposed by the Energy Regulatory Office has evolved to the following: Measurement Information Operator [35]. As already mentioned, particular concern is dedicated the customers who in the new concept of operation of the power system, will become the active players, with an appropriate level of independence and the right to dispose of the data on energy consumption and demand. The aware consumer should be able to choose their electricity supplier/provider and to sale energy produced from renewable sources – acting as a prosumer. Additionally, attention is drawn to the fact that modern Smart Grid systems should increase the safety and reliability of the whole power system and energy supply to the customers. It is assumed to introduce monthly billing for electricity, based on actual measurements of the short-term consumption [25,36]. Many of these aspects were also discussed in a study on the implementation of the Smart Metering in Poland [13], with detailed analysis of the objectives, costs and benefits of this process. According to the authors, the main objective of implementation is to meet the requirements of the European Parliament and of the Council directives and to ensure energy security, with the least social cost. Reference is made to the fact that intelligent energy system should be stable and better balanced, ensuring the full support of renewable energy sources (RES) connected to the power grid and improving power quality. It was also established several key functional requirements that should provide the smart grid system. Each is now considered as a separate issue: the availability of data in relation to privacy and protection of personal data; the choice of tariffs and energy suppliers in the light of competition in the energy market and the already mentioned issue of the energy sale to the system, in the perspective of a bi-directional meters implementation. There is emerging conflict of interests of different social groups, industry and market. It turns out that energy consumers are primarily interested in reducing bills and simultaneously suppliers and manufacturers – profit and market share maximization. From the industry point of view even more considerable conflict is the pursuit to stabilize and better balancing the power system form the producers side and the possibility to easy connect the renewable sources to the system from independent producers – prosumers side. These issues should be explicitly addressed in the new law and related regulations [13,28]. In current sectorial debate associated with the inevitable necessity of Smart Metering systems implementation, the two main trends are outlining. One, created around the position of the President of the ERO and the Distribution Network Operators (DNO). Second, generated on the basis of the advisory team of the Ministry of Economy findings and propositions for the New Energy Law. Experts point out the need to synchronize the activities and positions of these two trends. It would be prerequisite for the future development of a uniform system of the intelligent power grid, both in the field of instrumentation, control and information sharing [32].

Active consumers – prosumers

In all discussions about a legal for the development of Smart Metering, the questions of the need to activate consumers and carry out extensive public information campaigns are raised. Active consumers are key to the Smart Metering and the Smart Grid idea success. To activate them good information campaign is needed about benefits, possibilities, functionalities and requirements connected with smart meters installing. But even the best organized information actions will not bring desired results if they will not follow a specific (not necessarily large) the benefit for the consumers, which motivate them to engage in the idea of energy saving and improve efficiency. The Smart Grid and intelligent power grid will retain and use its enormous potential, only with the approval of the customers. While significant progress has been made in the efficiency and reliability of the energy system, largely due to the modernization of transport infrastructure network, changing customer behaviours and their demands, remains a very difficult, particularly if they are not convinced of the benefits awaiting them. There are different kinds of benefits [17,25]:

- Simplification of settlements with customers
- Energy bills based on actual energy consumption

- Ability to change and adjust power tariffs to the "profile" of the energy consumer
- Increasing the efficiency of the power supply and distribution systems
- Simplify the process of energy supplier changing
- Increased protection of the so-called vulnerable customers (network performance monitoring)
- Increase public awareness on energy consumption, effectiveness and savings.

But installation of smart meters it is not everything – it is the only necessary tool. It should be implemented market mechanisms in the energy sector as well – not only in sale for large industrial consumers and institutions, but also for the smaller, individual consumers. Only such action, including mentioned previously awareness-raising actions, should result in the involvement of them, encourage to rationalization of the energy consumption and invest in renewable sources. Otherwise, it may be that Poland will be in the same situation as some of European countries, such as Italy, where in recent years a large-scale smart meters installations have been introduced (about 40 million customers) and the social awareness of their possibilities and functionalities increased only about 5% to 10%. In this situation the smart meters capabilities are used mainly by energy suppliers to detect and eliminate energy theft and power system balancing [27].

Another question connected with consumer involvement is personal data protection. It is often emphasized by energy sector experts and the Inspector General for Personal Data Protection [5,13,38]. As it was mentioned before the energy consumption data of the consumer are his own. This issue does not seem to be discussed, but energy consumption data should be collected remotely by the provider or Measurement Information Operator. Therefore, it should be properly take into account in the energy supply contracts [11,36]. From the other side data from meters should be available for the consumers to browse them both directly and processed – reports, analysis, profiles of the energy consumption etc. The different concepts of that supplier-operator-consumer interaction are verified in the pilot projects and the existing smart metering systems in Europe. One idea is to provide customer specific portable modules with wireless communication to track current consumption and effects of different types of devices activation at different hours of the day (peaks, tariffs). Another idea is based on the use of modern mobile phones, tablets and television sets with corresponding applications, dedicated to communication in a local network HAN (Home Area Network called) by different standards such as Bluetooth, Wi-Fi or TCP-IP – Internet [12,16]. However, it seems that one of the best solutions, to simplify service and allow remote access to measured data is setting up of virtual consumer accounts on websites provided by the Measurement Information Operator. Many attempts are made in this field in Western Europe and the USA. This kind of websites offer wide range of possibilities to browse reports, analyses, current meter readings, tariff selection and energy charges in on-line mode. From the average consumer point of view these features allow self-control and verification of actions taken to improve energy efficiency. Good example in this field is website Google Power Meter provided by Google for one of the pilotage projects [1,9]. But the convenience of the use of such services is governed need to ensure a high standard of data security, control access and protect against unauthorized access attempts.

The active support of energy systems - key elements

Previously mentioned the active energy consumers are only one part of the planned active, dynamic power system - Smart Grid. The implementation of this idea requires a number of elements: support and data transmission organization between all elements of the system as well as modernization and installation of modern system that will be control power in the supply system, according to changing demands. This also applies to technologies, systems and infrastructure in buildings, which are among the most intensive consumers of electricity and heat. Around the world, the steps are taken to enable commercial and other buildings interact with smart electricity grids. These actions will allow the users to directly participate in the energy market, with increased emphasis on energy savings and improve power management. This concept is called the Building-to-Grid or B2G [11].

One of the emerging Smart Grid standards allowing buildings connection to the network is OpenADR (Open Automated Demand Response). OpenADR is an open and standardized method of communication signals about energy demand (called DR - Demand Response) [2,22]. This data is for the electricity providers, system operators and their customers and should be communicated by means of a common language with the use of existing network based on IP protocol, such as the Internet. It is worth noting that the number of buildings equipped with an Energy Management System (EMS) is increasing, so they are ideal platforms for the implementation of demand response energy consumption (OpenADR). Such objects can use or modify existing intelligent network control to accept signals from the OpenADR systems. With pre-programmed set of events, building automation system can reduce the load according to the messages received in real time and provide information about its use of energy back to the energy supplier and operator. To allow the EMS systems receive signals from the OpenADR will likely require software update or installation of additional equipment, the purpose of which will provide relevant information to the building management system [11]. One of the most critical issues is appropriate programing of energy control strategy in the EMS. This system must react accordingly depending on the message coming from the OpenADR, which can include information about the incident or the current and projected energy prices. For example, if the message contains information about the growth rate for electricity, building automation system can dim the lights or change the temperature settings to reduce the energy consumption – heating or HVAC system [10]. Leading organizations caring for distributed smart grid standards are actively involved in the development of Smart Grid system through several industry initiatives, including:

- The standards of building automation should be considered as a tool for the Smart Grid system realisation. The main objective of this process is to ensure that products comply with the standard can be used in many cases recommended for use in the smart power grid projects
- Adaptation of the standard to the B2G idea and the appropriate type of communication with the OpenADR. This process is designed to make the most effective use of the systems properties and ensure their mutual cooperation
- Mobilization of the operators, distributors, integrators and consumers, primarily to increase their awareness about the capabilities of the Smart Grid.

Building automation systems as part of the active customers infrastructure

So far, the building automation system integrators have been concentrated primarily on providing users with the appropriate comfort and safety in buildings. Thus, common functionalities and features in automated buildings include: lighting and lighting scenes and scenarios control, service of blinds and shutters in windows, HVAC control - thermal comfort, access control, monitoring of devices and subsystems operating parameters, monitoring and acquisition of events, cooperation with anti-theft and fire systems, etc. In larger buildings these functionalities are more and more integrated and implemented into a single building management systems - BMS. In this kind of the applications, building automation systems have been used for many years, and their functionality in this field is still improving. They are becoming more reliable, and users derive benefit from them more and more confidence. The purpose of installers and integrators of the automation and monitoring systems is to achieve such a state that users use them involuntarily and the building infrastructure devices perform their functions reliably and quickly. According to the AGH researchers building automation systems can be used at field level as a tool for monitoring and optimizing the electrical energy and other media (heat, gas, water) consumption. It could be achieved by introduction of integrated remote metering modules and control procedures as well as mutual interaction between the different subsystems installed in the modern buildings [20].

Pilotage and research installations – examples and case studies

Taking into considerations presented information and directions of building automation systems development, to implement them in the Smart Metering and Smart Grid applications, AGH scientists and research workers undertaken research in the field of the building automation systems used to perform tasks connected with implementation of the Smart Grids. At AGH in Krakow is conducted project: "Optimising energy consumption in buildings", funded by the National Research and Development Centre (NCBiR). In this project have been implemented comprehensive systems of the electricity consumption metering in three buildings - one in the AGH Krakow campus and two in the office and commercial complex. One of the buildings is built as so-called energy-efficient, using the latest building and telecommunications technologies [10].

Define the parameters of the energy consumption of buildings analysed in the project, with different groups of receiving energy, have required proper metering. To achieve this, three systems of energy consumption monitoring have been developed, for all three mentioned types of buildings. The first one is educational and office pavilion B1 AGH from the 50's of last century. Another one is a No. 6 building with traditional technologies located in Science and Technology Park Euro-Centrum (PNT) and the last one is energy-efficient building No. 7, also located within the PNT [20]. The most detailed metering installation is in the building No. 7 PNT. The monitoring energy consumption system has been developed and implemented using the existing supply network topology, including among others meters for: individual lighting circuits, computer and power sockets both for groups of rooms (some rooms for one tenant) as well as power circuits of technical infrastructure in the building, such as a heat pump, heat exchanger, chiller, central HVAC, elevators. Monitoring system has a tree structure, including the main meter, the meters in the floor cabinets and ultimately individual meters for groups of rooms. An important element of the monitoring was to develop a system of data acquisition, reading all the meters in a 5-minute periods, and designating the difference in readings (5-minute power/load). Additionally, if the meter allows the measurement of other parameters such as voltage, current, reactive power, they are also recorded in the system. The data acquisition system is carried out on computers and servers at AGH Krakow with the building No. 7 PNT remote data communication via the Internet network. To present the collected data, visualization has been developed, allows to display 5-minute and hourly measurements from each meter of any moment of time. The visualization includes meters installed in both the main switchboard as well as floor cabinets on the ground, first and second floors. The window of visualisation display meters for the main switchboard is shown in Figure No. 1. [1)] It shows the structure of the monitoring system with 5-minute power indicators for each meter for preset time/moment. The visualization allows to observe and analyse the data form any time, with the possibility of moving about five minutes or one hour [3,23].

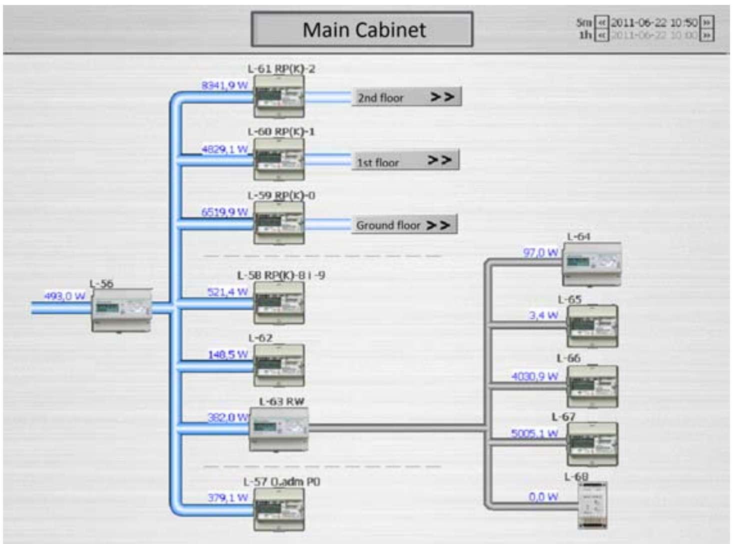

Fig. 1 - View of the monitoring visualization with energy meters in main switchboard

The metering system have been built using energy meters of different companies. Some types of the meters, such as U1389, allow direct data collection through a bus with international standard of building automation system – ISO / IEC 14908 (LonWorks®) [4]. Others, having only a pulse outputs, are connected to the LonWorks building automation system by appropriate modules, used to convert pulses to LON standard network variables (SNVTs). With the developed visualization system is also possible preview of all recorded parameters for each meters [3] [1)]. In Figures No 2a and No 2b two views of parameters form different kind of meters are presented.

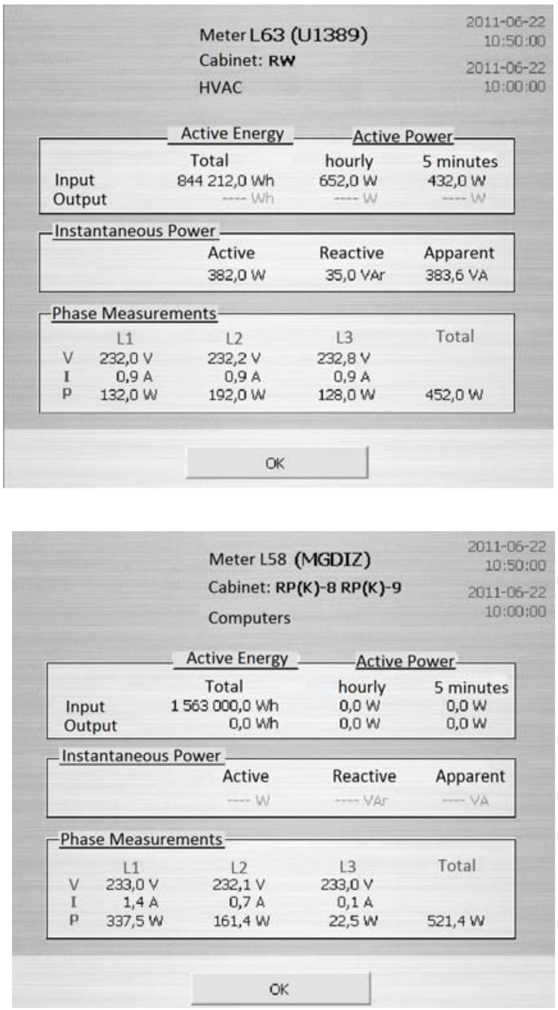

Fig. 2a i 2b - An example views of the details form energy meters

Experience with implementation of the remote metering system in these buildings point to that the network building automation systems could be successfully used as a tool for organization and implementation of the Smart Metering systems, particularly in perspective of integration them with the BAS or EMS systems on the field-level. Therefore, if in buildings is infrastructure of the building automation systems, always should be considered use it to carry out mentioned tasks and functions. A very important features of the bus, international building automation systems (LonWorks, KNX, BACnet) are openness and distribution, simplify integration of the measurement and control-monitoring infrastructures in one building management system BMS [24,37]. By this system it is possible to check on information from different meters and correlate it with optimal control scenarios and algorithms. It could be use also to identify areas with the greatest potential of energy save and improve energy efficiency of whole building.

It is worth noting that the mentioned Smart Metering systems have not been implemented with data collection protocol in accordance with IEC 62056 (successor to IEC 61107), dedicated to smart metering applications [30]. The measuring system have been performed using a network-compliant ISO/IEC 14908, mainly used for building automation systems and in industrial automation, with option of standardized data transfer over the Internet. Use of the ISO/IEC 14908 standard infrastructure instead the IEC 62056, contributed to an easier and faster implementation and avoid the additional costs of metering and control systems installation. Recording and reporting of data was carried out using the public, free software tools, with development of own methods for processing the data. As a result, the installation allows for implementation of the Smart Metering functions:

- Identification of the distribution of energy consumption per day for all the buildings and the selected areas (floors, rooms)
- Presentation of the energy consumption in different forms: graphs, trends and reports
- Identify the areas with the greatest energy consumption of electricity, etc.

The system allows use of its architecture and structure to almost directly implement for monitoring and reporting of other, new buildings.

Another example of use the building automation systems as a tool to support the active energy consumers – mainly buildings' users, is organizing of an energy management system in the buildings - EMS. This kind pilot system is implemented and researched in Certified Laboratories Network for Energy Efficiency and Building Automation - AutBudNet in AGH Krakow, equipped with infrastructure of the building automation system and BMS, based on the European and international standard ISO / IEC 14908 (LonWorks) for distributed control system [4,18,21,29,31]. With this infrastructure, it is possible to implement classical building automation functions such as lighting and heating control, access control, and more. Additionally, the automation system can operate on the field level and the remote monitoring and management of different sub-systems: fire extinguishing system, CCTV, remote meter reading of electricity consumption and heat, monitor the operating parameters of the solar collectors and PV panels. It allows use laboratory rooms as real object for research of functionalities and features of building automation systems and their influence on operation of the buildings [21,37].

In the current design practice for the building automation systems commonly used solution is implementation of different building infrastructure subsystems as autonomic installations and their integration is not possible at field level, but only at higher levels of the building management systems organization. In addition, most energy and media monitoring systems are carried out completely independent of the building automation (the intelligent control of building resources), commonly only for accounting purposes, for the suppliers of energy and media as well as costumers. It generates limitations in functionality and possibilities to devices, sub-systems cooperation. The open building automation system implemented in the AutBudNet laboratories allows integrating devices on the lowest, field level and data exchange is faster, more effective, without higher levels of monitoring and management systems. Research conducted in the AutBudNet laboratories confirm the thesis that implementation of new, distributed control systems, based on international standards, provide reduction of energy consumption in buildings by integration all automation features and functionalities and cooperation different devices and sub-systems [10][1)]. In the latest research several scenarios have been prepared for optimization of energy costs, depend different energy prices at different periods of days [8]. Monitoring of the control system in these scenarios as well as observation and analysis of the effects of optimization, required to organize the installation and integration of the existing energy consumption monitoring system (Smart Metering) and the energy management system (EMS). The last one cooperate with touch panels LVis by Loytec with graphical interface for user and TCP/IP and LonWorks standard interfaces for communication. Thanks this LVis panels could be connect to the BAS network directly on the field level (for example direct data exchange with meters) and remote controlled – TCP/IP communication with PCs, tablets or smartphones. For LVis panels suitable control screens have been prepared to present data from different devices and subsystems. They are presented on the 3 and 4 figures.

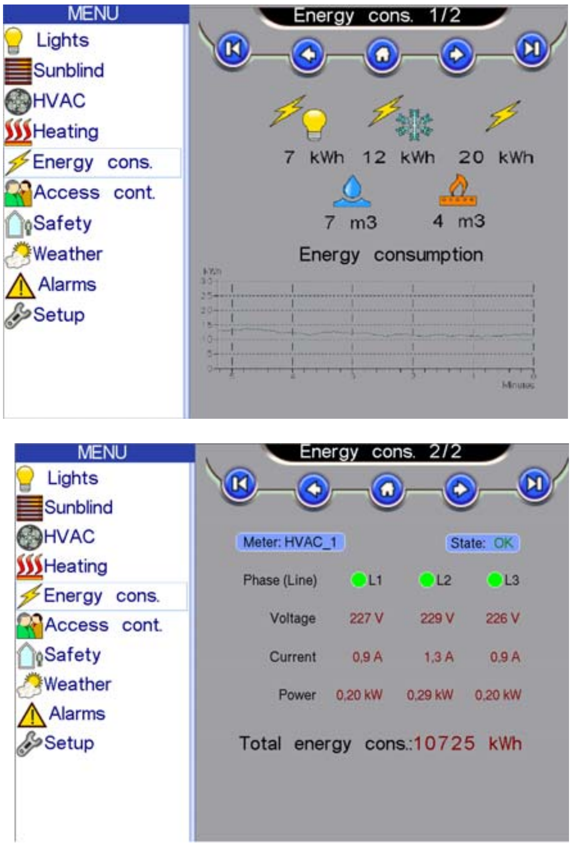

Fig. 3 – The LVis panel screens with selected functions and parameters from EMS.

Based on the presented system for monitoring electricity consumption with integrated subsystems of the building infrastructure, currently are conducted research aimed at long-term measuring the level of consumption in particular electrical equipment groups in the building laboratory infrastructure and their analysis[1)]. Research workers try different new settings and correct earlier applied settings to obtain optimal work conditions - maintain comfort in rooms with a maximum reduction of energy consumption. In addition, there are verified opportunities for EMS system cooperation with different elements of HAN network - remote PCs and mobile devices, designed to support user (presentation of data, access to interim analyses, reports, energy consumption, etc.) [3,12,15,16,18]. An integral part of these networks is object-oriented communication standard LonWorks - dedicated to the building automation and increasingly used in public and commercial buildings (offices, sports and entertainment centres, etc.).

Conclusions

From the first experience, building automation systems could become an integral part of communication infrastructure organization for the Smart Metering systems in buildings. Particularly noteworthy is the ability to integrate measurement systems with building automation components in the field level. This is very important especially in larger buildings, commercial and public, where usually network infrastructure for automation and monitoring have been installed. With the mentioned integration, this infrastructure could be used for organization of the local Smart Metering systems. The user has ability to monitor energy and media consumption in building, with possibility to dynamic impact on the building infrastructure facilities integrated in the single system EMS, allowing to optimize the energy and media consumption. In addition, advanced routers and servers, dedicated to building automation, also allow remote operation with monitoring and control systems, providing user with free access to measurement data and to make the necessary changes, settings, etc.

Therefore, it is worth remembering the building automation standards in determining guidelines and standards for communication protocols, dedicated to the Smart Metering systems, especially for commercial and public buildings as well as dwellings. They allow for much easier integration of measurement systems with the overall power management system (EMS) and the whole building management systems (BMS). In perspective introduction of dynamic and interactive energy management systems (Demand Response), integration with the building automation infrastructure will enable to realize automated response procedures for all subsystems and equipment in buildings. Impulses that trigger these reactions would be outside signals - from the Measurement Information Operator , supplier of energy/media or the settings made by the user directly in the system by HAN or BMS. Importantly, part of these activities will be done automatically, without user involvement, but only with signalling events and changes in the visualization panels or dedicated websites [12,16].

In the coming years in the AutBudNet laboratories and other AGH-UST buildings, will be conducted further research on implementation of the building automation systems in the area of optimizing energy and other media consumption in the buildings and testing of various components of the Smart Metering for different types of the buildings. The results of these research and case studies, carried out on real objects with the modern infrastructure and devices integrated on the field level with international building automation standards, are quite significant. This is confirmed by strenuous activities of the U.S. and European organizations responsible for development and protection of these standards. They are engaging in any initiative on development of the Smart Metering and Smart Grid systems. Firms associated with these organizations the dominant product group are solutions and technologies to support implementation of the Smart Metering and Smart Grid, and allowing them to integrate with building automation systems. It seems, that in the coming years, this kind of application of the international standards for distributed and building automation will dominate in the field of the building automation and functionality of the EMS, BMS systems development.

[1)] *Prace prowadzone w ramach zadania badawczego nr 5 Narodowego Centrum Badań i Rozwoju: „Zoptymalizowanie zużycia energii elektrycznej w budynkach", w strategicznym projekcie badawczym: pt. „Zintegrowany system zmniejszenia eksploatacyjnej energochłonności budynków".*

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