Implementation of smart building management systems for residential complex “PANORAMA”

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Abstract. The European Union (EU) and Ukraine, which is following a precise European integration course, have a priority to improve energy efficiency in order to prevent negative environmental impact and achieve climate neutrality. It is known that more than 40% of the energy produced is accounted for by energy consumption in existing buildings. Analysis of energy consumption reveals a high percentage of energy losses due to poor management, which necessitates the development and implementation of systems and tools for improved energy management. Therefore, the development of energy efficient building management systems using modern engineering and technical solutions to control and optimise energy consumption is a relevant and promising way to solve the issue of energy resources saving, increase energy efficiency and enhance energy independence. Within the framework of the international research grant “A novel decentralized edge-enabled PREsCriptiVe and ProacTive framework for increased energy efficiency and well-being in residential buildings” — PRECEPT under the Horizon 2020 programme, smart building management system was developed and implemented at the residential complex “PANORAMA” in Dnipro city, Ukraine.

1 Introduction

The European Energy Performance of Buildings Directive [1] states that all new buildings starting from 31 December 2020 must comply with the zero-energy building standard or be “positive”, and all existing buildings need to be thermally modernised in accordance with relevant requirements. It should be noted that the revised directive [1] provides more stringent requirements for energy efficiency, as well as a significant reduction in the timeframe for achieving the declared energy consumption indicators. Private Construction and Assembly Enterprise “STROITEL-P” received funding to improve the energy efficiency of the

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residential complex “PANORAMA” within the framework of the international research grant “A novel decentralised edge-enabled PREsCriptivE and ProacTive framework for increased energy efficiency and well-being in residential buildings” – PRECEPT – [2] under the European Union's Horizon 2020 research and innovation programme.

A large number of scientific publications are devoted to the development and implementation of energy management systems for buildings [3-5], including the so-called proactive energy management schemes [6]. The most recent developments include the development of self-adaptive algorithms [7] and the introduction of machine learning tools [8] for automated control and supervision of building systems.

The purpose of the work is the development and implementation of smart building management systems, increasing the energy efficiency of the building and improving the quality of the internal environment for residential complex “PANORAMA” in Dnipro city (Ukraine).

2 Results

Under the Grant Agreement, 10 volunteer apartments from three buildings of the residential complex “PANORAMA” in Dnipro city will be equipped with wireless equipment for monitoring and individual control of energy consumption and indoor comfort at the expense of the EU.

All 10 participating apartments will be equipped with mini-computers that act as a wireless switching hub. Each mini-computer enables the collection of information based on the results of monitoring energy consumption in the building's apartments and the total energy consumption of each apartment and the transfer of data to a common server for analysing the information and issuing recommendations on energy consumption and management.

In addition to the mini-computers, all 10 project participants will receive wireless smart sensors to be installed in each apartment.

<table>
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<tr>
<th>Integration controller WebHMI (SCADA system)</th>
<th>Powerful web interface, which includes all the necessary ready-made tools for collecting, processing, storing, and visualizing data, as well as control capabilities</th>
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<tbody>
<tr>
<td>Transcend Flash Card Transcend industrial 1GB</td>
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<td>Meanwell Power Supply 24Vdc</td>
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<td>7bit AirGate AirGate Wireless Data Gateway, Lora 868MHz, Ethernet, PoE</td>
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<td>7bit AirPoint Wireless telemetry module Lora 868 MHz ((temperature / humidity, air quality (CO2)), ~220B</td>
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<td>7bit AirPoint Wireless telemetry module Lora 868 MHz ((temperature / humidity), self-contained (3xAAA)</td>
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<td>Eastron Smart Meter (three-phase energy monitoring), Modbus</td>
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<td>Current transformer (for electric meters) 50/5A</td>
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<td>SHARKY 774 Thermal energy meter, Mbus, ДУ-15, 0.6 м³</td>
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<td>7bit USB-Mbus Interface converter Mbus</td>
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<td>E.Next Enclosure (plastic) 250×330×130mm, IP65 with transparent door, (or equivalent in size)</td>
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<td>Smart sockets with the ability to control the load, WiFi, 16A</td>
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</table>

The consumption of all types of energy will be monitored for 18 months. The equipment that will be installed in the apartments will remain for further use by the residents of these apartments. This equipment can be used as an “Smart Apartment” system or connected to the
common “Smart Control Room” of the residential complex. Figures 1 and 2 show an example of the equipment location in the premises of a participating apartment and a photo of the installed equipment. Figures 3-5 show the general architecture of the proposed energy management system of the residential complex “PANORAMA” and some results of the current monitoring of the participating apartment heating system as an example of the data that is received for further processing to manage energy consumption.

Fig. 1. Example of installing energy consumption monitoring equipment in an apartment

Fig. 2. Photo of the installed equipment
Fig. 3. Architecture of the energy management system of the residential complex “PANORAMA”

Fig. 4. Monitoring data of the heating power of a participating apartment heating system
A very important result is that after the installation of PRECEPT modernisation solutions, the Ukrainian pilot project's Smart Readiness Indicator (SRI) increased from 31% to 38%, and the Smart Proactive Indicator (SPI) from 24% to 28%. In other words, the modernisation and implementation of the energy management system developed under the PRECEPT project have a positive impact on the smart readiness indicator and smart proactive indicator.

3 Conclusions

The implementation of intelligent building management systems necessarily depends on:

1. Conducting trainings with end users. Collecting and systematising feedback from stakeholders on how to improve PRECEPT solutions.
2. Scientific and technical support for the installation and configuration of smart equipment in pilot buildings.
3. Conducting real-time testing of smart equipment in pilot buildings.
4. Development of detailed plans and recommendations for the installation of smart device equipment in pilot buildings.
5. Communication (correspondence, participation in online working meetings) between the international PRECEPT team and the team of the “STROITEL-P”;
6. Communication with the management of “PANORAMA” condominiums regarding the installation of equipment provided by the project on the territory of the complex “PANORAMA” DNIPRO.
7. Communication with the ICT contractor (DDS LLC), responsible for the installation of equipment in the participating apartments, collection and transfer of data to the PRECEPT portal.
8. Coordination between DDS LLC and the international PRECEPT team.
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