Concept of the "Smart House" System for the Green Campus Project

Teslenko Pavlo
Ph.D., Associated professor
Odesa National Polytechnic University, Ukraine, Odesa
p_a_t@ukr.net

Lobachev Mikhail,
Ph.D., Professor
Odesa National Polytechnic University, Ukraine, Odesa
lobachevmv@gmail.com

Kondratiev Serhii,
Senior Lecturer
Odesa National Polytechnic University, Ukraine, Odesa
kondratiev@opu.ua

Terentiev Kyrylo, Student,
Odesa National Polytechnic University, Ukraine, Odesa
kirillterentyev1999@gmail.com

Kuznichenko Andrii, Student,
Odesa National Polytechnic University, Ukraine, Odesa
andrewkuznichenko2@gmail.com

The abstracts present the results of many years of work by teachers and students of the Institute of Computer Systems of Odessa National Polytechnic University on the task of reconstructing the building of the institute. A retrospective of project management processes from the generation of an idea to obtaining theoretical developments and practical results in creating Green Campus based on smart building technologies is presented.

Keywords: *project management, Green Campu, smart building technologie, Institute of Computer Systems, Department of Project-Based learning in IT*

,

Introductory part. The strategic development plan of the Institute of Computer Systems of Odessa National Polytechnic University provides for the modernization of the building, bringing it closer to the "green". For this, the Green Campus project is being developed - a project of a phased evolutionary transition to a new type of building, which involves the development of a complex of various systems. The project has been repeatedly discussed and presented at many international conferences since 2017 [1, 2].

However, the introduction of such an innovative project at the university in the conditions of economic and financial instability in Ukraine will require consistent risk management during its implementation, by applying the principles of a risk-based approach [3].

For the first time, the Green Campus concept was tested back in the 70s of the last century. Its history began with the global oil crisis, when OPEC countries refused to supply oil products to the allies of Israel. Accordingly, the largest companies in the USA and Western Europe found themselves without the necessary fuel. Representatives of the hippie movement around the world supported enforced corporate economy measures. They became the main carriers of the idea of a "green office" [4].

According to the report of the Dodge Data & Analytics company about the development of green buildings, their number doubles every three years around the world, and today both buyers and tenants increasingly prefer energy-efficient and environmentally friendly premises. The main differences of the green building is its intellectualization, energy efficiency, increased comfort and safety. The benefits of green construction can be felt right now, while the main customers of green projects are administrative institutions (schools, universities, hospitals, public buildings) [5].

In 1987, Norwegian Prime Minister Gro Harlem Bruntland proposed the following definition of a green office: Green Campus is an organization management philosophy that reduces the negative impact of companies by maximizing the conservation of resources and energy and optimizing the amount of waste in the environment [6].

The concept of conservation of resources has received state support in many countries of the world. It is based on the principle of reducing waste and conserving resources. Thanks to this, a competent leader optimizes the expenses of his company and significantly raises its image. Today Green Campus allows you to solve a whole range of problems. As a rule, they are divided into three areas: economic - saves company resources; environmental - reduces emissions of harmful substances into the atmosphere and improves waste management; social - enhances the reputation of the company, its image.

All the advantages of sound environmental management have already been appreciated by such organizations as Intel, Schneider Electric, Johnson Controls, Google, Black Stone, UPECO, etc. [7].

Every day an increasing number of Ukrainian companies join the Green Campus environmental concept. The transition to "green" standards is considered the rule of good taste, which improves the image of the company in the eyes of customers and partners.

The economic and environmental benefits of Green Campus are the reduction of excess costs and respect for resources. The most popular component is reducing the use of paper - from printing on “transactions” to electronic document management and waste paper collection [8].

In this regard, there was an urgent need to spread the Green Campus initiative to universities, within the walls of which the formation of environmental awareness and lifestyle of future specialists is taking place.

Main part. Odessa National Polytechnic University, like most modern universities, has a developed infrastructure and a certain territory. In this regard, the concept of a “green office” for educational institutions is expanding significantly and goes beyond the scope of individual administrative buildings, classrooms and classrooms, teachers and laboratories, practice bases, sports complexes and halls, energy supply management systems and other structural units. The "green office" of the university should be considered in a complex, taking into account all the objects of its infrastructure [9].

At this stage, a project team of students from ONPU and the University of Applied Sciences of Augsburg is working on the Green Campus project in order to modernize the buildings of their universities by equipping the premises with IoT systems, to improve the environmental and economic situation, and reduce excessive energy consumption.

For the Institute of Computer Systems, the Green Campus Project provides for the reconstruction of the building in order to provide comfortable learning and working conditions for students and its employees and safety [1, 2]. Green Campus is essentially a multiproject, one of the components of which is the Smart Home project.

The Smart Home project for Green Campus IKS ONPU provides for several stages of implementation, including market analysis, search for suppliers, installation and commissioning. The scale of the project depends on the area of the object, the timing of execution and the level of complexity of the system itself.

The area of IKS ONPU is more than 2800 square meters. m. The system will contain the necessary set of sensors for temperature, light, door openings, fire, humidity, twilight sensors and others, elements of connection, power, communications for the respective systems, provide comfortable and environmental conditions in the rooms with significant savings in energy resources.

We can say that work on the project began with the creation of a “stratap school” at the ICS, which became the center for innovative student learning [10, 11, 12]. The school was created in 2016, since then a base has been created that formed the basis for the development of elements, and systems of the Internet of things for the Green Campus project [13-19]. In 2018, the positive experience of the new concept of teaching students in the work of the Start-up School was developed in the creation of the department “Project Goal and IT” [20-22].

Currently, students of the PNIT department and the Strat-up school have developed two large blocks for the Smart Home project, as part of the Green Campus international project. The first block is the project to create a battery monitoring system for solar energy. Currently, the relevance of the use of solar energy is growing due to its environmental friendliness and low resource intensity [23]. Solar panels are used in different areas of life: to provide electricity to buildings, to recharge batteries of household appliances, to charge electric vehicles, etc. The batteries generated by solar panels during the day are stored in batteries. The efficiency of using solar energy is largely determined by the requirements for rechargeable batteries (limited charge voltage, the number of possible recharge cycles, etc.).

To monitor these requirements, a battery controller is required. Currently, there are many different charge controllers, but, as a rule, their manufacturers do not provide for the simultaneous monitoring of the state of the battery (в оригинале АКБ). Such monitoring would make it possible to obtain in a convenient form charge data and other auxiliary information about the battery so that the consumer can get acquainted with the results of research and testing of innovative technologies being introduced, as well as for energy management [24].

As mentioned above, this development is part of the large Green Campus project, according to which it is planned to provide the ICS building with an independent energy supply system based on photovoltaic solar panels. The aim of the project is to create a battery charge controller that allows you to collect data on the parameters of the solar energy system to track its status when used to provide buildings with electricity using the “smart house” technology [25]. The developed structure of an environmentally friendly power supply system using solar panels suggests the presence of 5 components (Fig. 1): a consumer of clean electricity, solar panels, batteries, a charge controller and a web server.

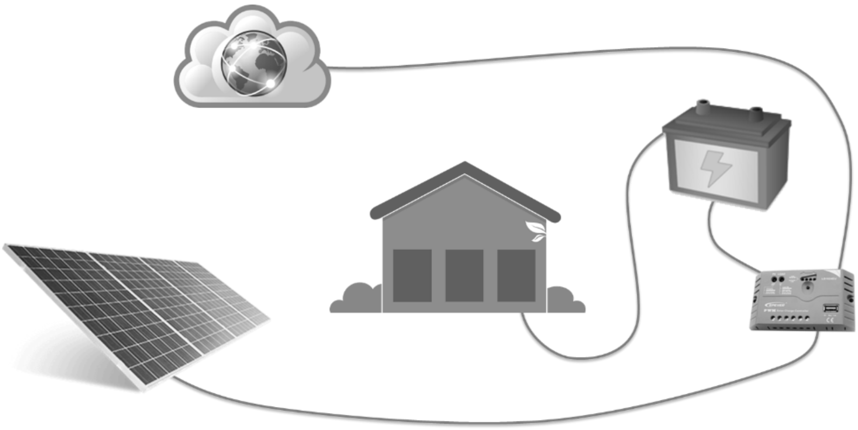

Fig. 1. System structure

The basis for creating a battery charge controller is the BeagleBone microcontroller, in view of its availability and the availability of all the necessary peripherals. Various variations of charge controllers were analyzed, as a result of which, for implementation, a PWM controller was chosen. It has several advantages, the main one of which is that the battery maintains optimal voltage [26], thereby extending the battery life.

This controller collects statistical data on the system parameters for sending to the web server, their further processing and display on the corresponding web page (Fig. 2), which displays the following data: voltage, current strength of the batteries and solar panels, level charge, time to the end of battery charging. Analyzing the collected data, we can draw conclusions about the state of the batteries or the efficiency of the location of the solar panels. Also, system parameters are displayed in real time on the LCD display.

Fig. 2. Web interface

Features of the developed controller:

– work in high voltage systems in the field of "green" technologies.

– collection and display of statistics on the battery charge and the efficiency of solar panels, which allows you to most efficiently position the solar panels on the roof of the building, monitor the condition of the batteries and determine the optimal number of solar panels (reduces the cost of the consumer of clean electricity);

– the ability to use in IoT and "smart home" systems;

– providing an API for tracking and managing the controller.

For this project, a WBS structure, a Gantt chart, and a resource matrix were developed for which further implementation of the project is planned.

The project was developed on the basis of the International R&D and StartUP School [27].

The developed charge controller has a number of advantages over existing analogues, based on the price-quality ratio. In addition, it allows you to get all the necessary information about the battery charge and other system parameters on a special web page, which can be used not only by the end user, but also by various platforms for researching innovative technologies. As a result of using this “smart” controller, it is possible to efficiently position the solar panels on the roof of the building and calculate their optimal number, monitor the condition of the batteries and receive notification if they need to be replaced [27].

The second block is the project to create a climate monitoring and control system. It allows you to control the temperature and air quality (CO2 content) and maintain a comfortable level of microclimate parameters by ventilation and changing the humidity level.

The situation, when the level of air quality in classrooms is below acceptable, is quite common in universities. The problem of CO2 level appeared due to the tightness of modern windows. Prolonged stay of a person in a room with low air quality worsens his health his well-being - it can cause weakness, drowsiness, headaches, problems with concentration, or even an increase in blood acidity, leading to acidosis (Table 1). The aim of the work is to develop a system consisting of a microcontroller and a set of sensors for measuring microclimate parameters, able to ventilate the room and also interact with the air humidification mechanism. In addition, the system should have Internet access for conducting measurement statistics and also to notify staff about abnormal changes in microclimate parameters (dangerously low air quality due to smoke or an excessively high temperature).

During market research, a lack of competitive systems was found that could simultaneously control the microclimate and automatically maintain it at a comfortable level. In addition, existing systems, such as room humidifiers, are expensive. Therefore, it was decided to develop this system.

Our innovation is the automatic ventilation of the room when CO2 is exceeded and the automatic switching on and off of humidifiers or dehumidifiers, since this method is less expensive than turning on the air conditioner or other temperature control systems indoors (fireplace, central heating, fan, etc.). Automatic ventilation can be opening a pressurized window or starting a ventilation system of a room (recuperator, for example), if such a system is present.

Table 1. Discrepancy between building codes and hygiene recommendations [1]

CO_2 Concentration (ppm)	Building codes (GOST 30494-2011)	Effect on the human body (according to sanitary research)
<800	High quality air	Perfect well-being and vitality
800-1000	Medium quality air	Stuffiness, lethargy, decreased concentration
1000-1400	Min. allowable air quality	Lethargy, problems with attentiveness and information processing, panting
>1400	Low quality air	Extreme fatigue, lack of initiative, inability to concentrate, dry mucous membranes, sleep problems

When choosing components, we first of all paid attention to cheap devices with low energy consumption, since for a full implementation in the university building it will be necessary to install such a system in each audience. Based on this, ESP32-based module with WiFi would be an ideal option for us: power supply 2.2 … 3.6V, maximum power consumption 500mA. To read data from two sensors, display information on the display, control the relay and send data with HTTP to the remote server, its performance was neither small nor redundant.

We selected DHT22 sensor to measure temperature and relative humidity (relative humidity within 0-100%, temperature from -40 - 125°C [2]), MH-Z19 to measure CO2 concentration (within 0-5000ppm [3]). We also need one or several relay modules and small LCD display.

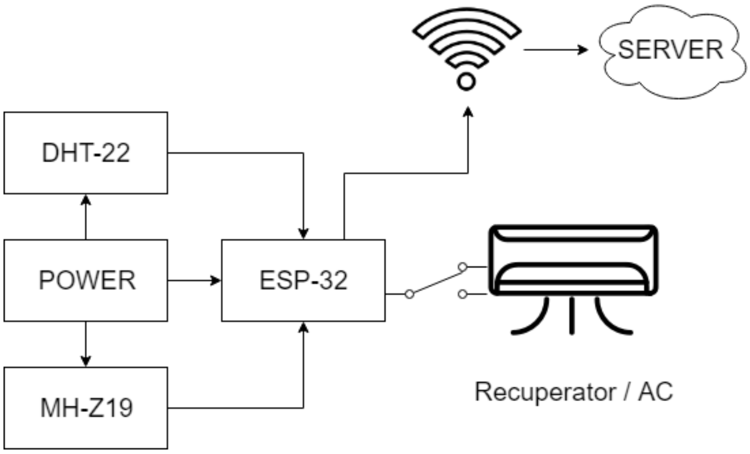

Fig. 3. Scheme of microclimate module

Measurements are displayed on the display and sent to the server using the built-in Wi-Fi module. The server processes, records and analyzes data, and if certain indicators go beyond the normal range, the system signals this and automatically performs actions aimed at normalizing the relevant indicators - it ventilates the room, changes the humidity to maintain the comfort temperature. The interaction of the controller and the ventilation or humidification mechanisms occurs through a relay module with a control voltage of 5V. In a simplified version, the user is notified of deviations from the norm and an appropriate recommendation is issued for their normalization.

The DHT22 sensor was chosen for measuring temperature and relative humidity (relative humidity in the range 0-100%, temperature from -40 to 125 ° C [29]), MH-Z19 for measuring CO2 concentration (in the range 0-5000ppm [30]) . We also need one or more relay modules and a small LCD.

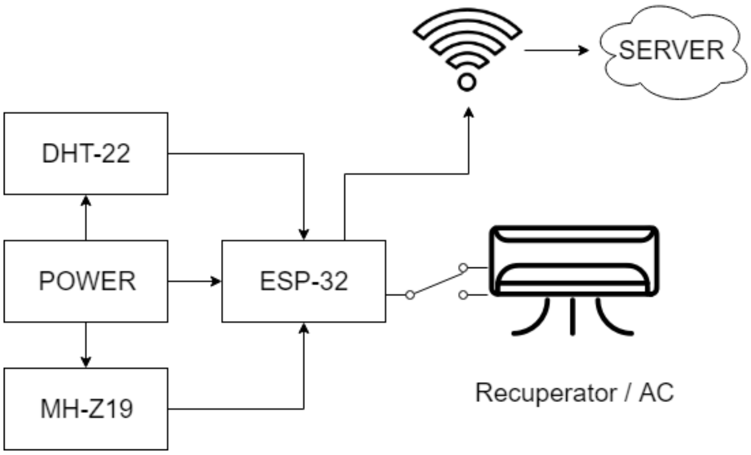

Fig. 4. Scheme of the microclimatic module

Measurements are displayed and sent to the server using the built-in Wi-Fi module. The server processes, records and analyzes the data, and if certain indicators are outside the permissible range, the system signals this and automatically performs actions aimed at normalizing the corresponding indicators - it ventilates the room, changes the humidity to maintain a comfortable temperature. The interaction of the controller and the ventilation or humidification mechanisms occurs through a relay module with a control voltage of 5V. In a simplified version, the user is notified of deviations from the norm and an appropriate recommendation is issued on their normalization.

At the moment, the development of the system has already been completed - there is a ready-made prototype. Work is underway to optimize and expand the functionality of the server side. Thus, the system can, with a sufficient degree of accuracy, determine the temperature, humidity and CO2 concentration in the room, display the data on the display, send it to the server for accounting and statistics, and interested users can see the microclimate parameters for each room on the web page where it is installed system. if some indicators deviate from the norm, a notification is displayed on the system screen.

Registered users are notified by email [31].

Conclusions. The paper presents the concept of the Greencampus project, which is being developed by students of the Department of Project Training in IT as part of the reconstruction and modernization of the building of the Institute of Computer Systems of Odessa National Polytechnic University. Staying an hour or two positively recommending yourself to be better at international teams of Ukrainian and international students, you can fully evaluate the project once and for all with the IT company. At the time, the synergetic effect of such changes is especially peculiar to the project and the public will be fully extended to the Department of Project-Based learning in IT.

References

1. Bodnarash S.I. Risk-Oriented Green Campus Project Management / Bodnarash S.I., Teslenko P.A. / / Project, ProgramPortfolio Management. P3M: Abstracts of the reports of the Second International Scientific Conference: [in 2 vols.]. // Responsible for the release of P.O. Teslenko - Volume 2. Part 2 - Odessa: Balan VA, 2017 - P.106 - 109]

2. Rukavishnikov ME Managing Risks of Creating a Smart Home System for Green Campus / Rukavishnikova ME, Rianicheva MA, Mileiko TM / / Project, Program, Portfolio Management. P3M: Abstracts of the reports of the Second International Scientific Conference: [in 2 vols.]. // Responsible for the release of P.O. Teslenko - Volume 2. Part 2 - Odessa: Balan VA, 2017. - P. 37 - 70.

3. Anatolyev AA Determination of risks and their consequences in reconstruction projects / A.A. Anatolyev, P.A Teslenko // Proceedings of the X International Scientific and Practical Internet Conference “Sustainable Development of Cities. Management of urban and regional development projects and programs "; Hark. nat. Univ. the city. the owner in it. OHM. Becketova. - X .: KhNUMG, 2014. - P. 5 - 7.

4. A National Report Card on Sustainability in Higher Education // Trends and New Developments in College and University Leadership, Academics and Operations - 2nd edition. Released on August 21, 2008. http://www.nwf.org/campus- ecology / resources / reports / campus-report-card.aspx

5. Tazhibaeva T.L. Green office - the basis of sustainable development of a modern university / Tazhibaeva T.L. , Salnikov VG, Polyakova S. E // Electronic scientific publication "Sustainable innovative development: design and management." - Volume 12 No. 4 (33), 2016. - S. 85-122. - www.rypravlenie.ru6. USGBC Research Committee Revised. Febuary 2008.

7. The Princeton Review. 2011. Guide to 311 Green Colleges. http://www.princetonreview.com/uploadedfiles/sitemap/home_page/green_guide/princetonr eview_greenguide_2011.pdf

8. The University of British Columbia. Sustainability. http://www.sustain.ubc.ca/

9. Zhadan M.S. Project management of creating localized business formations. Classification / M.S. Zhadan, P.A. Teslenko, T.M. Didur, // East European Journal of Advanced Technologies. - Kharkov: "Technology Center", 2012. - No. 1/11 (55). - S. 28 - 30.

10. Lobachev M. University and industry cooperation - Win-Win strategy / M. Lobachev, S. Antoshchuk // Carte Blanche No. 1-2, 2016. - P. 24-27

11. Lobachev M. Synthetic models of university industry cooperation case studies on R&D and Start-Up school / M Lobachev, S Antoshchuk, V Kharchenko, T Schöler, V Brovkov // V Ukrainian-German conference „Informatics. Culture. Technology “, 2017. - pp. 10-13

12. Lobachev M.V. Strategy 3win of sustainable industry-university IT-cooperation: R&D Start-Up schools / M.V. Lobachev, S.G. Antoshchuk, V.S. Kharchenko // Radioelectronic and computer systems, 2018 .-- pp. 71-76

13. Lobachev M.V. The monitoring system of the condition of buildings in the Green Campus project / MV Lobachev, SG Antoshchuk, IM Lobachev // Modern Information and Electronic Technologies 1 (17), 2016. - P. 36-37

14. Antoshchuk S.G. Face recognition task in a smart "Green" room / S.G. Antoshchuk, A.D. Ischenko, D.G. Filyagin // Modern Information Technology – Suchain Information Technologies, 2, 2017. - P. 113-115

15. Antoshchuk S.G. Mobile application for Green Smart Room / S.G. Antoshchuk, M.V. Lobachev, D.G. Filyagin, A.D. Ishchenko // Modern Information Technology – Scientific Information Technology 2, 2017 - S. 116-117

16. Antoshchuk S.G. Automated system for monitoring and controlling battery charge for solar systems / S.G. Antoshchuk, M.V. Lobachev, R.P. Malerik, K.V. Solovyova, O.V. Tsygankov // Modern Information Technology – Such as Information Technology 2, 2017. - P.197-198

17. Malerik R.P. Instrumental means for increasing the efficiency of use of solar systems / R.P. Malerik, S.G. Antoshchuk, I.M. Lobachev, M.V. Lobachev // Odessa Politehperiodika, 2017

18. Ishchenko A.D. “Green” smart room management information system / A.D. Ishchenko, D.G. Filiahin, S.G. Antoshchuk // V Ukrainian-German conference „Informatics. Culture. Technology “, 2017. - pp. 123-125

19. Lobachev I.M. Development of a method for constructing dynamic systems for off-server data processing / I.M. Lobachev, R.P. Malerik, D.G. Filyagin, S.G. Antoshchuk // Modern Information Technology – Сучасні Інформаційні Техії, 2018

20. Brovkov V.G. International cooperation projects as a means of enhancing students' competencies / V.G. Brovkov, M.V. Lobachev, S.G. Antoshchuk // Project, Program, Portfolio Management. P3M-2016, 1, 2016 - S. 17-19

21. Oborskiy G.A. The experience of implementing models of project-oriented training for IT specialties in ONPU / G.A. Oborsky, M.V. Lobachev, S.G. Antoshchuk // Project, Program, Portfolio Management. P3M 2, 2017. - S.122-125

22. Antoshchuk S. Summer schools for students of IT specialties - a guarantee of the successful implementation of international IT projects. Antoshchuk Svetlana, Teslenko Pavel, Brovkov Vladimir // These are the first International Science-Practical Conference "Realization of the largest international projects and reform of the business: science, viro business and market." Vidpovidalny for VIP P.O. Teslenko - Odessa. : Balan V.O., 2018. No. 1 - S. 99-106.

23. Solar power supply [Electronic resource]. - Access mode: URL: http://robocraft.ru/blog/3161.html

24. The choice of charge controller for solar panels [Electronic resource]. - Access mode: URL: http://www.solnechnye.ru/controllery-zaryada/vybor-controllera-zaryada.htm.

25. Malerik R.P. Development of a battery charge controller for use with solar panels / Malerik R.P. // MIT - Odessa: ONPU, 2016 .-- S. 61.

26. PWM charge controller on Attiny13 [Electronic resource]. - Access mode: URL: http://arduino.ru/forum/proekty/pwm-kontreller-zaryada-na-attiny13.

27. Malerik R.P. Project for monitoring battery charge for a solar energy system / Malerik RP // Management of projects, programs, portfolios: These are the first I International Scientific and Practical Conference: [2t.]. // Vidovdalny for VIP P.O. Teslenko - Volume 1. - Odessa Bondarenko M.O., 2016 .-- S. 92 - 95.28. CO2 Standarts. [Blog]. – URL: https://tion.ru/blog/normy-co2/

29. Temperature sensor [Website]. – URL: https://arduino.ua/prod301-datchik-vlajnosti-i-temperatyri-dht22 – DHT22.

30. CO2 sensor [Website]. – URL: https://arduino.ua/prod1532-datchik-co2-mh-z19 – MH-Z19 CO2

31. Terentiev Kyrylo. Development of indoor microclimate monitoring and control module for “Green Campus” system / Kyrylo Terentiev, Eugene Molchanuk, Nazariy Yatsuk, Serhii Kondratiev, Mykhaylo Lobachev // VII International scientific & technical conference "Informatics. Culture. Technology" ICT–2019. Odesa, 23.09.2019 – 25.09.2019. — С. 119 – 120.