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Energy auditing, certification and thermo-modernization of NUWEE buildings

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Abstract: The National University of Water and Environmental Engineering (NUWEE) from Rivne (Ukraine) is implementing a program of energy efficiency on its own educational, residential and auxiliary buildings. The measures were implemented according to the following program: installation of 15 automated heat energy metering units; construction of a solid fuel boiler house; partial thermo-modernization of buildings; introduction of decentralized ventilation systems with recuperation; use of renewable energy sources; training and certification of specialists in energy efficiency of buildings and inspection of engineering systems; and provision of an energy audit. All this requires significant financial and material resources. Therefore, NUWEE participates in a number of grant and credit projects, and attempts to raise funds based on energy service contracts. The largest of these projects is the Ukraine Higher Education Project, which involves 21 universities in Ukraine. The main goals and preliminary results of the project are given in this paper as an example of the NUWEE subproject.

Keywords: energy auditing, energy certification, thermo-modernization, energy efficiency

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Introduction

The National University of Water and Environmental Engineering (NUWEE) in Rivne is a regional institution of higher education, where more than 7,000 students,

including more than 4,200 full-time students, receive higher education. Education takes place in 8 educational buildings of the university. The 8 dormitories were built between the 60-80s to provide housing for students and staff of NUWEE. Both the educational and dormitory buildings do not meet modern requirements for energy efficiency.

NUWEE is interested in the implementation of energy efficient measures for comprehensive thermal modernization of the buildings and creating an energy management system taking into account the increasing cost of energy resources. NUWEE has a long way to go to implement energy-efficient measures as part of the buildings' modernization and energy management systems, but some important steps have already been taken by the university.

1. Experience of implementing energy efficiency measures in NUWEE

One of the first energy efficiency measures in NUWEE was the installation of heat energy meters during 2000-2001 at necessary control points. The automatic control unit of heat consumption (ACUHC) was put into operation in 2006 in educational building # 8.

Three automatic control units for heat consumption were installed in 2006-2008 for dormitory # 8, which was reconstructed into a residential building for NUWEE employees, educational building # 1 and for the building of the Institute of Postgraduate Education.

The thermal modernization of the external walls, and the replacement of the windows and roof of one of the three biggest lecture halls was carried out in autumn 2010. Part of the external walls of educational building # 4 was thermo-rehabilitated in summer 2012, and the old windows were replaced by new metal-plastic windows. The work began with the design and installation of ACUHC in 15 buildings of the campus in 2012. Some of these were put into operation in spring 2013, first in the educational buildings, and then in the dormitories. The payback period of the installed ACUHC was during the heating season in 2013-2014. Currently, NUWEE has 18 ACUHC, which saves a significant amount of thermal energy, especially in autumn and spring, when there are significant fluctuations in ambient temperature during the day.

The design project to reconstruct the internal boiler house to use alternative fuel started in 2012 and it was an urgent task due to thermal energy tariff increases.

The boiler house reconstruction project was given the go-a-head by state construction experts in 2014, but there were no funds for its implementation at the university. After a long search for various options to finance the reconstruction, one company specializing in the producing and installation of equipment for boiler houses, offered to rent a boiler house. An agreement was concluded with the company, according to which the reconstruction of the boiler house should be carried out at its own expense. The company provides heating to all NUWEE buildings of the campus for 4 years at a rate much lower than the previous supplier had. This

cooperation is economically beneficial for both the university (reduction of heating costs) and for the company, which has a large and regular consumer of services for several years. At the time, it was an energy service company (ESCO) contract, the legal framework of which came into force later (Law of Ukraine, 2015).

In 2012, during the reconstruction of the computer center in the scientific library, new energy-efficient windows were installed, which was significantly detrimental to the natural ventilation of the room. The design of the decentralized system of supply and exhaust ventilation for the computer center with the heat recovery of exhaust air was developed in order to provide standard microclimatic conditions. The specialized company installed the equipment under the technical supervision of the author and specialists from the Department of Heat, Gas Supply, Ventilation and Sanitary Engineering of NUWEE.

One effective payback measure is the replacement of incandescent lamps in indoor and outdoor electric lighting systems to LEDs. Therefore, all classroom renovations involve the mandatory replacement of existing electric lighting systems to energy-efficient ones.

The express energy audit of educational buildings # 1-8 was conducted because of the initiative and the efforts of specialists from the Educational and Scientific Institute of Construction and Architecture NUWEE in spring 2017. The results of this energy audit became the basis for filling electronic forms posted on the website of NUWEE and State Agency on Energy Efficiency and Energy Saving of Ukraine in order to unify data on existing facilities of budgetary institutions that require thermal modernization and the conclusion of ESCO contracts for its implementation.

Despite the significant amount of energy efficiency measures implemented in NUWEE and the implementation of the energy management system, there are a number of difficulties, which require significant investment and skilled personnel (energy auditors, designers, builders, installers of modern energy efficient engineering systems and energy managers) to overcome.

2. Training of energy certification specialists in NUWEE

The appropriate attestation commission (AC) was established in 2018 to prepare and certify persons who intend to conduct energy certification and inspection of building engineering systems at NUWEE.

Training of specialists on energy efficiency and inspection of building engineering systems is provided by the Law of Ukraine “On energy efficiency of buildings” (Law of Ukraine, 2017) and is carried out according to the approved resolution of the Cabinet of Ministers of Ukraine from 26 of July 2018 # 605 “The procedure for conducting professional certification of persons who intend to carry out activities for certification of energy efficiency and inspection of engineering systems” (Resolution of Cabinet of Ministers, 2018). Such central executive bodies as the Ministry for Communities and Territories Development of Ukraine and State Agency on

Energy Efficiency and Energy Saving of Ukraine provide activities for energy certification and inspection of building engineering systems.

NUWEE became a participant in the program for the training of qualified energy auditors to work with the Ukrainian Energy Efficiency Fund (EEF) in spring 2019. This program started under the program of cooperation with GIZ in June 2019 by conducting regional trainings for teachers, and conducted at 34 institutions of higher education. Three members of NUWEE passed a training course for teachers of energy auditors in Lviv under the program "Preparation of energy auditors to work with EEF". In August 2019, two members of the NUWEE attestation commission were trained as representatives of the Free Economic Zone program "Energy Efficient Management of Buildings" under the program GIZ GmbH. One of the members participated in a two-week training program in Poland within the project "E-ETAP – Training Project on Energy Efficiency and Energy Audit in Ukraine", which was supported by the Krajowa Agencja Poszanowania Energii S.A. – KAPE (www.kape.gov.pl) and Fundacja Poszanowania Energii – FPE (www.fpe.org.pl) of the Republic of Poland.

The work of the NUWEE attestation commission on the training and certification of specialists of energy efficiency and inspection of building engineering systems is described in (Kizyeyev et al., 2020).

3. NUWEE participation in the Ukraine Higher Education Project

3.1. UHE Project Summary Information

The UHE Project aims to refurbish teaching, research and supporting facilities at selected Universities in Ukraine with a view to improve:

- energy efficiency of buildings and reduce the running costs of participating state higher education institutions;
- quality of teaching, learning, academic, research and residential facilities.

It is anticipated that the Project will bring operational conditions of these facilities (inside temperature, air exchange, etc.) to the minimum required standards. In addition, the project will result in a significant greenhouse gases emission reduction. The specific facilities and corresponding investments at each University (Final Beneficiary) comprise of a sub-project and all sub-projects comprise of a UHE Project.

The Project is financed by 160 million EUR from the European Investment Bank (EIB), Nordic Environment Finance Corporation (NEFCO) and Eastern Europe Energy Efficiency and Environment Partnership Fund (E5P).

On December 19, 2016, the Ministry of Finance and EIB concluded a finance contract. According to the finance contract the EIB agreed to provide a loan in the amount of 120 million EUR.

The finance contract between Ukraine and EIB was ratified by the Law of Ukraine of November 8, 2017. On December 19, 2017 Ukraine, represented by the Ministry of Finance and NEFCO concluded a finance contract. According to the

finance contract, NEFCO agreed to provide a loan in the amount of 30 million EUR. The finance contract between Ukraine and NEFCO was ratified by the Law of Ukraine of June 20, 2018.

On December 18, 2018, the Ministry of Education and Science (MoES, the Promoter) and EIB concluded a grant agreement for an investment grant of 10 million EUR. VAT and other taxes and duties are not eligible for financing by EIB and E5P.

The Project Coordination Group (PCG) is the main overseeing and coordinating body of the project. The PCG is composed of representatives of the main stakeholders in the project, such as EIB, NEFCO, MoES and Ministry of Finance (MoF).

UHE Project implementation is supported by consultants engaged by EIB (PMSU consultant providing assistance to PMSU and EIB funded Universities) and NEFCO (NEFCO consultant assisting NEFCO funded Universities) with utilization of donor grant funding.

The MoES has the general supervision of and responsibility for the implementation of the project. The promoter established the Project Management and Support Unit (PMSU) to support the UHE Project implementation, coordination, oversight and administration. The PMSU members are MoES officials who perform their PMSU-related duties. The MoF is the central governmental body that acts on behalf of the borrower (Ukraine), conducts UHE Project monitoring and also supervises, coordinates and approves all finance related transactions under UHE.

Each participating University as a final beneficiary of the project has responsibility for the implementation of its sub-project. For this purpose, the final beneficiary has to set-up a Project Implementation Unit (PIU).

At the operational level, project implementation is guided by the Project Procedures Manual based on provisions of the EIB and NEFCO finance contracts and other guiding documents pertaining to procurement and other areas.

The UHE Project includes two phases: Phase I – pre-selected Universities identified in the finance contract and Phase II – Universities selected through a competitive process. NUWEE is one of 8 universities selected by the MoES competition committee to participate in Phase II and whose subprojects are financed by an EIB loan.

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3.2. Information about the NUWEE subproject

From 2019 to 2021 the PMSU and EIB funded Universities are supported by a consortium of companies led by Ramboll (Denmark).

One of the first key stages of the consortium of companies led by Ramboll regarding the UHE Project was to conduct comprehensive energy audits of buildings (EAB) in all subprojects. The main volume of work at this stage in support of the UHE Project was performed by ESCO Ukraine.

EAB NUWEE was held in November 2019-March 2020. EAB was conducted according to European norms, directives and standards, as well as Ukrainian standards, norms and rules in force at the time of preparation of the report. EAB determined the program (plan) of priority investments for the implementation of energy efficiency measures in NUWEE.

The result of the EAB was the final audit reports, which contain, in particular, information on the condition of buildings, a description of measures, energy consumption, energy savings and other parameters. The EAB also became the main source of information for the preparation of the subproject description. The preliminary amount of financing allocated by EIB for the implementation of the NUWEE subproject, which includes energy efficiency measures and non-energy efficiency measures, according to EAB, is 5,271 thousand EUR (excl. VAT).

The measures for increased energy efficiency under the subproject should provide a significant reduction in energy consumption of heating, ventilation, as well as electric lighting and auxiliary equipment.

Thermal insulation (repair) of building envelopes will reduce energy consumption and increase the service of buildings. At the same time, thermal insulation will significantly reduce the external airflow into the building. This usually creates problems related to comfort and potentially impacts the productivity and health of visitors to the buildings. To solve this problem, it is proposed that each educational building has a decentralized mechanical ventilation system, which combines the system with heat recovery units (recuperators).

The possibility to modernize the heating systems for all the buildings was considered because of their poor functionality. Reconstruction of the heating system and modernization of individual heating stations (existing ACUHC) was proposed to be carried out in each building.

It was planned to replace the existing luminaires/lamps with LEDs. This measure would significantly reduce energy consumption and at the same time increase the visual comfort for people in the buildings.

It was recommended that all buildings have an energy management system to provide energy monitoring, energy efficiency, various types of analyzes and corrective actions.

Energy efficiency measures were designed to reduce energy consumption and related costs, while increasing functionality and comfort inside buildings (updating the indoor conditions to standard levels).

At the same time, measures were considered, not directly related to energy efficiency, but which affected the building's functionality, comfort, as well as providing a sustainable effect of the implemented energy efficiency measures. It was indicated that such measures required implementing within the subproject.

The list and investment costs of measures, not directly related to energy efficiency, should be determined during the preparation of the design documents for the thermal modernization of the buildings included in the subproject. These included the following: roof repair; modernization of the sewerage system; modernization or installation of fire safety systems.

3.3. Results of NUWEE energy audits of the buildings

All investment costs developed by EAB (Ramboll, 2020) were divided into 2 types: investments aimed at energy efficiency increase and investments not related to energy efficiency. General information on NUWEE subproject based on the results of the energy audits of 7 buildings is given in Table 1.

Table 1. General information about the NUWEE subproject (*own study*)

Indicator	Description / value
Number of educational buildings	7
Heated area [m^2]	47,238
Basic energy consumption [kWh/year]	10,286,336
Measurement of energy consumption	Heat energy consumption using meters in most cases is much lower than the basic calculated value. In most cases, energy metering is common for a group of buildings
Reduction of energy consumption [kWh/year]	6,232,230, incl. district heating – 6,188,247, electric energy – 43,983
Estimation of energy consumption after thermal modernization [kWh/year]	4,054,106
Investment valuation (excl. VAT) [EUR]	5,270,981
Estimated breakdown of investments (excluding VAT) [EUR] • Thermal insulation of building shells • HVAC systems • Lighting systems	 2,767,788 (52.5% of the total) 2,362,446 (44.8%) 124,846 (2.4%)
Estimated cost of non-EE measures (excl. VAT) [EUR]	15,901
Estimation of annual savings (excluding VAT)	338,572
Easy payback period for subproject [years]	16
GHG emission reductions (CO_2) [t/year]	1,649 (compared to baseline)

Conclusions

The proposed subproject was analyzed to determine the simple payback period of the investment provided for each building. As mentioned in the section above,

the total investment in the proposed packages is 5,270,981 EUR. This includes energy efficiency measures valued at 5,255,080 EUR and non-energy efficiency measures valued at 15,901 EUR (all amounts excluding VAT). The total amount of savings of the subproject is 338,572 EUR per year. The simple payback period of the subproject is 16 years. This period is varies from 10 to 24 years for different buildings on the campus.

Buildings selected for the energy efficiency projects usually demonstrate a combination of high energy efficiency potential as well as accumulated maintenance and repair needs (facades, basements, roofs, heating and ventilation systems, etc.). This leads to the need to include in the project a considerable amount of total investment, as it is technically impossible or impractical to implement only measures to improve energy efficiency, ignoring other important issues. Although the overall investment components effectively extend the service of the buildings and reduce future maintenance costs, these benefits are not fully monetized and worsen the economic efficiency of the project.

The concept adopted by EAB takes into account several benefits beyond the cost of energy saved when evaluating the energy efficiency of projects (including, for example, the cost increase of the object and maintenance costs' decrease).

Thus, the NUWEE UHE Project, according to EAB, conducted by an international consortium led by Ramboll, has a strong economic basis and provides a long-term solution compared to the alternative scenario (not taking measures to modernize or construct new buildings). The subproject showed a positive net present value (NPV) and the internal rate of return (IRR) above the social discount rate.

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