

1.3. METHODOLOGY FOR THE FORMATION OF ENERGY EFFICIENCY COMPETENCE OF FUTURE SKILLED WORKERS IN THE CONSTRUCTION INDUSTRY

Tetiana Piatnychuk

Candidate of Pedagogical Sciences,
Senior Researcher of the Department of
content and technologies of vocational
education of the Institute of Vocational
Education of the NAES of Ukraine,
<https://orcid.org/0000-0002-5607-2949>
ptv2613@ukr.net

*In connection with the need for
post-war restoration of facilities as a
result of full-scale military operations,
reducing the energy dependence
of enterprises and organizations,
and implementing targeted state
energy efficiency programs in Ukraine,
the problem of training qualified
specialists with developed energy
efficiency competence is acute.
Improving the professional training
of future construction workers
in energy conservation and energy
efficiency involves the study of
modern construction technologies,
materials, types of energy from
renewable sources, resource reuse, etc.*

*An optional course «Formation
of energy efficient competence of
future skilled workers of the construction
industry» has been developed, which
includes the content, pedagogical
technologies, methods and forms of
conducting classes.*

Keywords: energy efficiency,
energy saving, competence,
pedagogical technologies,
methods and forms.

1.3. МЕТОДИКА ФОРМУВАННЯ ЕНЕРГОЕФЕКТИВНОЇ КОМПЕТЕНТНОСТІ МАЙБУТНІХ КВАЛІФІКОВАНИХ РОБІТНИКІВ БУДІВЕЛЬНОЇ ГАЛУЗІ

Тетяна Пятничук

кандидат педагогічних наук,
старший науковий співробітник відділу
змісту і технологій професійної освіти
Інституту професійної освіти
НАПН України,
<https://orcid.org/0000-0002-5607-2949>
ptv2613@ukr.net

*У зв'язку з необхідністю повоєнного
відновлення об'єктів внаслідок
повномасштабних військових дій,
зменшення енергозалежності
підприємств і організацій, виконання
цільових державних програм з
енергоефективності в Україні гостро
постає проблема підготовки
кваліфікованих фахівців зі сформованою
енергоефективною компетентністю.
Удосконалення професійної підготовки
майбутніх робітників-будівельників з
питань енергозбереження та
енергетичної ефективності передбачає
дослідження сучасних будівельних
технологій, матеріалів, видів енергії з
відновлюваних джерел, повторного
використання ресурсів тощо. Розроблено
факультативний курс «Формування
енергоефективної компетентності
майбутніх кваліфікованих робітників
будівельної галузі», який включає зміст,
педагогічні технології, методи та форми
проведення занять.*

Ключові слова: енергоефективність,
енергозбереження, компетентність,
педагогічні технології, методи
та форми.

The need to form energy-efficient competence of future skilled workers is largely related to the complexity of extraction and shortage of basic energy resources, their constantly growing cost, and global environmental problems. Energy-efficient competence should ensure people's conviction that the introduction of energy-efficient and energy-saving materials and technologies into the economic activities of enterprises and individuals at the household level will make it possible to solve many environmental problems: climate change, environmental pollution, depletion of natural resources, etc.

The purpose of the article is to substantiate the necessity and feasibility of forming energy-efficient competence of future qualified workers in the construction industry in vocational education institutions using modern pedagogical technologies.

Research methods: theoretical – analysis of scientific works, regulatory documents, educational and methodological literature; comparison, systematization and generalization of data; empirical – observation, modeling of educational situations, conversation, survey.

In their works, scientists, in particular V. Barannik, M. Zemlyanyi, U. Marushchak, M. Sanytskyi, O. Sukhodolya, O. Poznyak, A. Shevtsov, O. Shevchuk and others, investigated theoretical and practical aspects of energy efficiency and energy saving.

The results of this work determine the directions of energy saving and strategic objectives: the use of modern building materials, technologies, energy consumption accounting devices at the stages of design, construction and operation of facilities, modernization and insulation of residential buildings, the use of alternative renewable energy sources, waste recycling and others.

According to the «Association Agreement between Ukraine and the EU...» our state has undertaken to implement directives in the field of energy efficiency, in particular Directives 2012/27/EU «On Energy Efficiency» (European Parliament and Council of the European Union, 2012) and 2010/31/EU «On the Energy Performance of Buildings» (European Parliament and Council of the European Union, 2010).

Today, Ukraine has a significant need to restore destroyed residential, industrial, and educational facilities as result of full-scale military operations, implement energy efficiency and energy saving measures at enterprises, and implement state programs to reduce energy dependence. At

the same time, the problem of training qualified specialists with formed energy efficiency competence is acute.

It should be noted that the formation of professional (and energy efficiency as part of it) competence of future qualified workers in vocational educational institutions of the construction industry takes place in accordance with educational standards. However, most of them do not include (or partially include) requirements for energy efficiency competence of future workers, in particular:

- the standard of professional (vocational and technical) education of SP(PT)O in the profession of tiler in the content of general professional competencies ZPK-2 «Mastering the basics of market economy, ecology, energy saving» provides for the acquisition by applicants of knowledge of «the basics of preserving and protecting the environment in professional activities and the skills to rationally use electricity; use energy-saving technologies». At the same time, the qualification characteristics of tilers of the 3rd-7th categories do not provide for the presence of knowledge and skills of qualified workers on the issues of energy efficiency of buildings (Ministerstvo osvity i nauky Ukrainy, 2017);

- the state standard of professional (vocational and technical) education of SP(PT)O in the profession of manual electric welder includes as a professional basic competence «understanding the basics of industry economics and entrepreneurship, energy management requirements»: knowledge of «the basics of energy management and the skills to rationally use electricity». The qualification characteristics of manual electric welders of 2nd-6th categories do not provide for any requirements for knowledge and skills on energy efficiency in the construction industry in the sections «Tasks and Responsibilities», «Must Know», and «Examples of Work» (Ministerstvo osvity i nauky Ukrainy, 2016).

Individual topics from certain areas of energy efficiency and energy saving are studied according to the profession, in particular the topic of «facade insulation systems» for the profession of «plasterer, facing tiler», the topic of «energy saving» for «manual electric welders». In general, there is no system, a unified plan and program for studying the problems of energy efficiency and energy saving in construction, world experience and the potential of Ukraine. Considering the above, in institutions of vocational (vocational and technical) education in the construction industry there is a need to improve the professional training of future construction workers on energy saving and energy efficiency, which involves studying the areas of

using modern construction technologies, materials, increasing the share of energy from renewable sources, reusing resources, etc., i.e. - the formation of energy-efficient competence.

Scientists identify the following main areas of increasing the efficiency of fuel and energy resources in the construction industry:

- introduction of new and improvement of applied technologies in the production of energy-intensive building materials, products and structures;
- development and implementation of energy-efficient technologies for performing construction and installation works;
- automation of technological processes, implementation of regulated electric drives;
- increase in thermal resistance of housing building envelopes;
- implementation of energy-efficient lighting systems for residential and public buildings;
- increase in the efficiency of boiler rooms;
- installation of low-power turbogenerators in boiler rooms;
- equipping with metering devices and regulating the consumption of main energy carriers;
- use of woodworking waste and local fuels, utilization of secondary energy resources (Sanytskyi et al., 2013).

Energy-efficient competence of future construction workers should include not only knowledge, but also the ability to solve complex technical problems, interact in a team, and quickly adapt to modern technologies. The optional course, as part of the teaching methodology, enables the development of technical, analytical, and creative abilities of students, preparing them for real professional activity.

Therefore, the need to develop a methodology for forming energy-efficient competence in the process of studying the optional course is due to the need to train construction industry specialists with a conscious attitude to the problems of energy efficiency, energy conservation, and the environment, as well as the desire and ability to solve them.

Important methodological approaches that contribute to the development of students' practical and theoretical skills in the formation of energy-efficient competence are as follows:

- interactive – involves the use of interactive methods and technologies of learning, in particular discussions, seminars, case studies (Piatnychuk, 2023), presentations, information and communication, design technologies (Piatnychuk, 2022b), etc., work with real life and production

situations and allows you to clearly see the result. For future builders, interactive learning technologies are especially important, as a set of methods, means and forms of organizing the educational process, which ensure the active nature of interaction between students and teachers, cooperation and creativity;

- the formation of critical thinking and the ability to evaluate existing problems of energy conservation, environmental protection related to the construction industry, which provides not only practical skills, but also an understanding of modern problems;

- a communicative approach is important for the development of teamwork skills, which is necessary for modern specialists and involves the following methods: joint work on projects, tasks; presentation of topic materials and their discussion, because the construction industry involves constant teamwork, which contributes to the development of social and professional skills;

- individualization of learning ensures the selection of effective learning methods: tasks according to the student's level of training; use of additional online resources and platforms to support individual learning;

- a problem-oriented approach involves students completing problem tasks and finding answers to problematic questions focused on real problems of the modern construction industry: analyze the situation, suggest options, etc. This contributes to the development of creative and practical skills, understanding the importance of solving these problems (Piatnychuk, 2022a).

Energy-efficient competence of future construction workers depends on correctly selected methodological approaches that form theoretical knowledge, practical skills and the ability to creatively solve problems, provide for the use of interactive, problem-oriented approaches by teachers and their integration with established teaching methods.

Taking into account the above-mentioned problems of forming energy-efficient competence of future qualified construction workers in vocational education institutions, we consider it appropriate and necessary to introduce into the educational process an optional course «Formation of energy-efficient competence of future qualified construction workers».

The purpose of the optional course is to develop in students the ability to choose optimal solutions when performing production tasks on energy-efficient and energy-saving technologies; analysis of production situations;

desire for professional improvement, the ability to think and act as a professional.

The conceptual idea of forming energy-efficient competence of future qualified workers in the construction industry in the process of elective classes is the provision that today it is necessary to develop their cognitive interests, professional inquiries, and advanced training in solving problems of energy efficiency and energy saving in construction.

The elective program includes the following topics: «The problem of energy efficiency in the construction industry of Ukraine»; «Characteristics of “passive houses”»; «Architectural and planning solutions»; «Use of renewable energy sources»; «Application of modern building materials and technologies»; «Energy-saving windows and doors»; «Types of thermal insulation of enclosing structures»; «Energy-efficient heating and hot water supply systems»; «Energy-saving lighting»; «Recycling of construction waste», etc.

Optional classes can be conducted by teaching staff at the expense of hours for extracurricular work, subject weeks, completion of general school projects (Artyushyna et al., 2018), etc.

The presentation of theoretical material is combined with trainings, role-playing and intellectual games, excursions, presentations of projects, etc.

The content of each topic includes technical information on the specified problem and options for using pedagogical technologies, methods, forms for use in the educational process.

It should be noted that the effectiveness of students' educational activities on energy-efficient and energy-saving technologies in construction largely depends on the content of the topics, pedagogical technologies and forms of organizing the process.

Optional classes are proposed to be conducted using problem-based learning technology, information and communication, project technologies, modern methods: discussion, round table, interactive presentations, brainstorming, role-playing games, analysis of stories and situations, case method, etc.

It is envisaged that teachers will use innovative forms of organizing the educational process, organizing non-standard lessons, in particular:

- oral journals, dialogues, reflections, debates with students highlighting environmental problems in the construction industry using computer, multimedia and technical equipment;

- travel lessons with presentations on «ecological use of building materials» in different countries; «green» construction;
- organizing and conducting excursions to enterprises producing building materials and products with a summary of the results in the direction of «compliance with environmental requirements»;
- conducting interdisciplinary lessons on «industrial training», «technology», «materials science», etc.

The content of the optional course complements the curricula and programs of subjects of professional-theoretical and professional-practical training.

Here are several possible options for conducting classes on various topics of the optional course.

Topic «Characteristics of «passive houses».

The purpose of the lesson is to form the ability of students to analyze the advantages and disadvantages of existing «old houses» and modern energy-saving ones, to distinguish between ways of building houses with a zero and positive energy balance; to activate cognitive activity.

Methods of conducting: «brainstorming» method, heuristic (Socratic) conversation, verbal, visual.

Tasks for students based on the results of the lesson:

- identify the signs of energy-inefficient buildings, give examples;
- identify incentives for building houses with a zero and positive energy balance;
- from your own experience, give examples of energy-efficient houses at the place of residence, study, etc.

Content.

Teacher's information: After December 31, 2020, it is recommended in EU countries to build only «houses with zero energy consumption», that is, with heat losses of about 0 kWh/m² per year. This requirement is declared by the EU directive on the energy performance of buildings 2010/31/EU. Zero energy consumption in houses can be achieved by using renewable energy resources (solar, wind, river energy, etc.).

Even more effective is the construction of houses not with a zero, but with a positive energy balance. Such «active houses» or buildings built according to the «energy plus» standard, not only do not consume energy on an average annual basis, but also produce it using heat pumps, solar collectors, solar panels, wind generators, biogas combustion plants, etc. Such

structures use excess energy to power surrounding structures or feed it into the country's general power grid.

The incentive for such tightening of norms in the European Union is largely explained by considerations of economy, but also by the need to reduce carbon dioxide emissions into the atmosphere (up to 40% of greenhouse gases are produced by residential buildings). Europeans have seriously thought about how to protect the planet from dangerous climate change and global warming.

Construction of energy-saving passive houses is a comprehensive concept. Its implementation involves the performance of work in the following areas: reliable insulation of all building envelopes; thermal insulation of the house according to the principle of a closed thermal circuit, without cold bridges; use of energy-efficient warm windows; use of ventilation systems with heat recovery; high tightness of the building.

Speeches by students expressing opinions, substantiating ideas, and proposals on the problem of building energy-efficient houses in Ukraine.

Summing up.

Topic «Use of renewable energy sources»

The purpose of the lesson is to form the ability to analyze the advantages and disadvantages of energy sources; search for data in the information environment of domestic and world resource repositories, record information about the environment for further use; prepare speeches with audiovisual support.

Methods of conducting: «round table», problem, verbal, visual, independent work of students on preparing speeches.

Tasks to be solved based on the results of the lesson (teacher and student reports):

- determine the harm to the environment from the use of oil and gas;
- list the disadvantages of the operation of power plants;
- determine the directions and regions of use of solar, wind, geothermal, bioenergy, tidal energy.

Content of the lesson.

Teacher: In today's world, faced with increasing energy consumption and concern for the environment, alternative energy sources are becoming increasingly important. Instead of traditional sources (coal and oil), humanity is looking for new ways to meet its energy needs, using more sustainable and environmentally friendly methods. Alternative energy

sources use energy that occurs as a result of natural processes: sunlight, wind, water movement and geothermal phenomena.

In addition to the fact that oil, gas and their derivatives harm the environment, they are also non-renewable.

Advantages of using alternative energy sources:

- reduction of greenhouse gas emissions: CO₂ and other harmful substances, which contributes to the fight against climate change;
- energy independence: allows countries to become less dependent on oil and gas imports, increasing energy independence;
- creation of new jobs and contributes to economic growth.
- conservation of natural resources: allows for the conservation of natural resources that are depleted by traditional energy production.

Alternative energy sources have great potential to become an important part of the energy system and help reduce dependence on traditional energy sources such as oil and gas (Triniti, 2024).

Student reports:

1st student: Solar energy is obtained by converting sunlight into electricity using solar panels, or photovoltaic cells. They use the photoelectric effect to generate an electric current: when light falls on a solar panel, electrons are “knocked out” of the atoms of the material, which creates a current.

Solar energy is used to produce electricity in regions of the planet where there are the most sunny days. They can be installed on the roofs of residential buildings, commercial buildings, solar farms and other places. Currently, there are technologies that allow solar panels to be used even in places where there is not much sunlight, or in winter. And the excess accumulated solar energy is stored in large-capacity batteries. Solar energy has a wide range of uses, depending on the number of solar panels: from small private houses to industrial complexes and even entire settlements.

2nd student: Wind energy is obtained using wind turbines (wind power plants), which have giant blades that rotate under the influence of the wind. This rotation generates mechanical energy, which is then converted into electricity using generators.

Wind power plants are located in open areas, coastal areas, as well as on offshore platforms, where the winds are strong and stable enough. Electricity produced using wind turbines is popular among a wide range of consumers, from households to industrial enterprises.

Advantages of wind power plants: renewable - wind energy is renewable and does not run out; low emissions - electricity production using wind turbines leads to lower greenhouse gas emissions compared to traditional energy sources; low operating costs - after installing a wind power plant, operating costs are usually low.

3rd student: Geothermal energy is obtained by using the heat contained in the Earth's interior. Two main types of geothermal power plants are used to produce it:

- steam plants – water or steam is extracted from deep wells and used to drive turbines;
- water turbine plants – hot water rises to the surface and is used to generate steam.

Geothermal reservoirs are found in different parts of the world, but are most common in regions with high hot springs, such as Iceland, New Zealand, Fiji and Kenya.

Advantages of geothermal energy: renewable – geothermal energy is a renewable energy source; low emissions – geothermal energy production is associated with lower CO₂ emissions compared to traditional energy sources; production stability – geothermal power plants can operate continuously, regardless of weather conditions, which allows for stable energy production.

4th student: Bioenergy (biofuels) uses the energy contained in organic materials, such as plants and waste. The two main types of biofuels are obtained from different raw materials:

- biodiesel – produced from vegetable oils or animal fats,
- ethanol – obtained from sugar or starch plants: sugar cane or corn.

The process of producing biofuels includes fermentation, distillation and other technological steps.

Biofuels are used in transport, mainly in the form of biodiesel and ethanol, which can be added to conventional fuels. They are also used to produce electricity and heat in specialized power plants.

Advantages of biofuels: renewable – biofuels are produced from organic materials that can be renewed through crop rotation and other agricultural methods; reduced emissions – the use of biofuels can lead to lower greenhouse gas emissions compared to traditional fuels; waste utilization – biofuels can be made from agricultural and forestry waste and residues.

Student 5: Tidal energy uses the natural movement of the tides, caused by the attraction of the moon and the sun, to generate electricity. Technologies used to extract this energy include buoys and platforms that move with the tides, turbines placed on the seabed, or systems that use waves to generate energy.

Tidal energy is usually used on coasts and in places where there is a large difference in the level of the tides. Extraction structures can be located in marine or coastal areas. Any consumers located near the coast, including residential or industrial establishments, hotels, marine infrastructure, etc., can use the energy obtained from the tides.

Advantages: constant availability: the tides are a stable and predictable source of energy, and this allows electricity to be generated without interruption; high efficiency: compared to other renewable energy sources, tidal energy can be quite efficient due to the significant density of water and high current speeds.

Student presentations expressing opinions on the use of different types of energy, substantiating ideas, proposals.

Summing up.

Optional classes make it possible to activate students' cognitive activity in studying the experience of implementing energy-efficient and energy-saving technologies in construction, develop analytical thinking, and a responsible attitude towards the environment. In the future, it is planned to study the levels of development of energy-efficient competence of students.

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