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Training and professional development in the field of energy saving in the Ukrainian system of higher education

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Abstract

The article considers actual problems of energy and resource saving in the various aspects of scientific and pedagogical activity. The main components of the organizational scheme of a complex continuous system of education and education in the sphere of energy and resource saving are presented. The universal generalized technological process of teaching in the form of an integral functional is presented, to the minimization of which the task of designing optimal content of training courses should be confined. The corresponding generalized learning content model is presented. The structural-functional model of training future engineers and teachers in the discipline "Fundamentals of energy and resource saving" is offered. The rational sequence and the relationship of the acquisition of basic knowledge and skills in the discipline “Fundamentals of energy and resource saving” is shown. The article formulates a generalized representation of the scientific, technical and scientific and pedagogical results obtained by the authors in the process of implementing the project of creating the system of training and professional development of personnel specializing in energy and resource saving.

Aus- und Weiterbildung im Bereich Energieeinsparung im ukrainischen Hochschulsystem

Zusammenfassung (optional)

Der Artikel behandelt die wichtigen und aktuellen Probleme der Energie- und Ressourceneinsparung in den verschiedenen Aspekten der wissenschaftlichen und pädagogischen Tätigkeit. Die Hauptkomponenten des Organisationsschemas eines komplexen kontinuierlichen Bildungssystems im Bereich der Energie- und Ressourceneinsparung werden vorgestellt. Der universelle verallgemeinerte technologische Prozess des Lehrens in Form eines integralen Funktionsumfangs wird vorgestellt, auf dessen Minimierung die Aufgabe beschränkt werden sollte, einen optimalen Lehrinhalt zu entwerfen. Das entsprechende verallgemeinerte Lerninhaltsmodell wird vorgestellt. Das baulich-funktionale Modell der Ausbildung von angehenden Ingenieuren und Lehrern in der Disziplin "Grundlagen der Energie- und Ressourceneinsparung" wird angeboten. Der rationale Ablauf und das Verhältnis des Erwerbs von Grundkenntnissen und Fertigkeiten in der Disziplin „Grundlagen der Energie- und Ressourceneinsparung“ wird aufgezeigt. In Anlehnung an das vorgeschlagene Modell wurde das Arbeitsmodell einer universellen Laborbasis unter Verwendung der originalen Computergestelle erstellt und es wurden auch die methodischen Unterstützungskits für die Vermittlung des Kurses "Grundlagen der Energie- und Ressourceneinsparung" in den Bildungseinrichtungen von verschiedenen Ebenen entwickelt. In Anlehnung an das vorgeschlagene Modell wurde das Arbeitsmodell einer universellen Laborbasis unter Verwendung der originalen Computergestelle erstellt und es wurden auch die methodischen Unterstützungskits für die Vermittlung des Kurses "Grundlagen der Energie- und Ressourceneinsparung" in den Bildungseinrichtungen von verschiedenen Ebenen entwickelt. Formuliert der Artikel eine verallgemeinerte Darstellung der wissenschaftlichen, technischen, wissenschaftlichen und pädagogischen Ergebnisse, die die Autoren bei der Umsetzung des Projekts zur Schaffung eines Systems zur Aus- und Weiterbildung von Personal erhalten haben, das auf Energie- und Ressourceneinsparung spezialisiert ist.

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resource saving
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personnel professional development
complex continuous system of education

Schlüsselwörter:
Energieeinsparung
Ressourceneinsparung
Personalschulungssystem
berufliche Weiterentwicklung des Personals
komplexes kontinuierliches Bildungssystem

1 Introduction

Given the rapidly progressing energy crisis in the world as a whole and in Ukraine in particular, it can definitely be stated that some of the issues of energy saving and resource conservation that exist and are manifested in all areas of society are highly topical today, namely:

- the problem of the search and implementation of energy-efficient solutions in all sectors of economic activity;
- the problem of training and advanced training of personnel in this area at all enterprises, including the enterprises of the fuel and energy complex (FEC);
- the problem of the practical implementation of the results of scientific research and development in all areas of activity (industrial, educational, housing-communal and household spheres, etc.).

In accordance with the Law of Ukraine “On Priority Directions for the Development of Science and Technology”, energy and energy efficiency are one of the highest short- and long-term priority directions for the development of science and technology in Ukraine [1]. The Law of Ukraine “On Energy Saving” defines the need to educate various strata of the population about the importance of a careful attitude to using fuel and energy resources. Educational legislation ensures compliance with these provisions [2]. So, the Law of Ukraine “On Higher Education” (2014) emphasizes the need to train specialists for priority sectors of economic, scientific, pedagogical, pedagogical and other types of activities [3].

At the same time, problems related to the implementation of scientific results in relevant markets, including marketing research, innovative scientific and pedagogical technologies, investments etc., are added to the general scientific and pedagogical problems.

2 The research period

The aim of this work is a generalized presentation of technical-scientific and scientific-pedagogical results obtained by the authors in the course of the project aimed to create a training system for teachers of the courses "Fundamentals of energy and resource saving in production, utilities, in the service and household fields" (in accordance with the Energy Strategy of Ukraine and the Law of Ukraine on energy conservation [2]).
To achieve this goal in carrying out the work, we used modern theoretical and experimental research methods such as generalization, systematization, synthesis; structural-functional method; modeling methods; interrogative diagnostic methods; pedagogical experiment [4, 5].
Applying the above methods in the implementation process of this research in the scientific and pedagogical direction, we obtained the following scientific and pedagogical results.
A scheme of organization of complex continuous system of education and upbringing in the field of energy and resource savings was developed [6], which includes the following main components:
- primary upbringing and education (in the family, in preschool institutions, in secondary school);
- specialized education in higher educational institutions of the corresponding levels of accreditation;
- advanced training of engineering and pedagogical personnel in the direction of energy and resource savings;
- conducting scientific research in this area;
- promoting and implementing research results in technical and pedagogical markets.

According to the above components, Ukrainian Engineering Pedagogics Academy (UEPA) carried out state budget and contractual research (R&D) (including those commissioned and funded by the Ministry of Education and Science of Ukraine) and the following main results were obtained:

- the primary course "Fundamentals of energy and resource saving" was developed and implemented for all students doing their bachelor's degree in engineering and engineering-pedagogical specialties with appropriate work programs and methodological support;
- models and methods of training were developed;
- a universal laboratory base was created;
- programs of advanced training courses for industrial, housing and utility enterprises as well as for the population were developed and implemented;
- research cycle was completed to develop energy-efficient technologies for energy companies.

A universal structural-functional model of teaching the discipline "Fundamentals of energy and resource saving" to future engineers and teacher-engineers is proposed with the aim of unifying the developed program and course structure (Fig. 1). This model is based on the developed classification of basic physical processes that have a significant impact on energy losses in all types of technological equipment, with the structure of energy losses in various physical processes being presented in Figure 2 [7, 8].

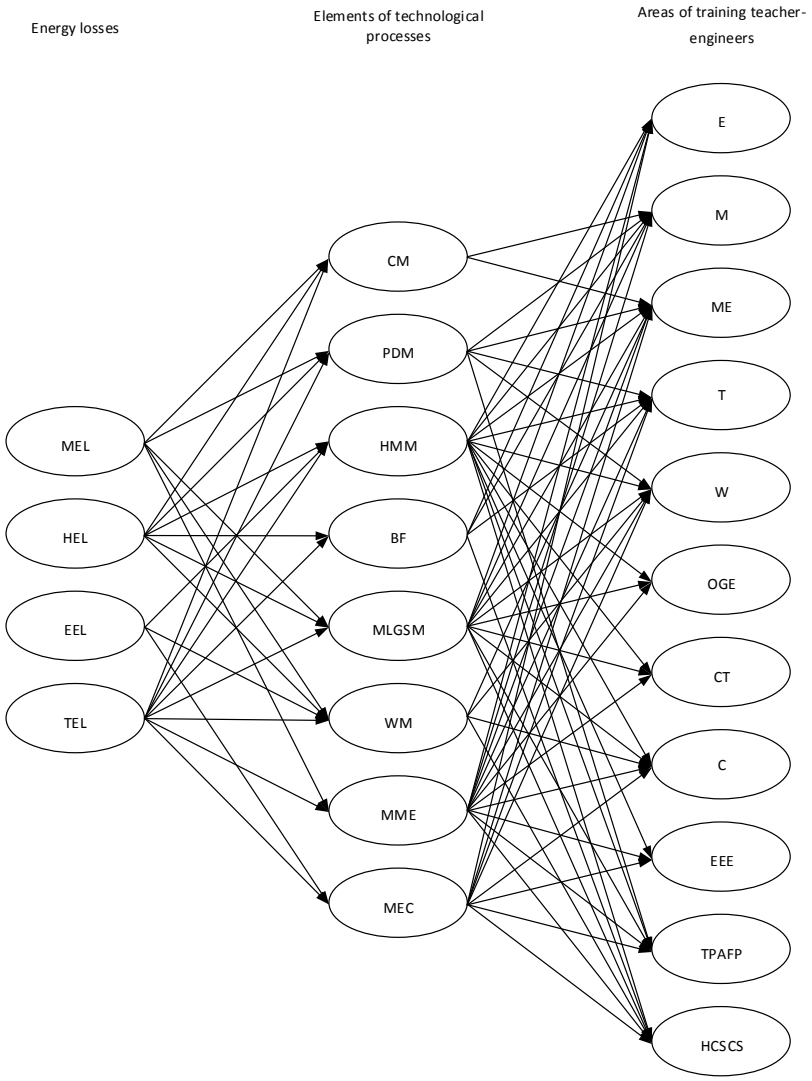

Fig. 1: Structural-functional model of teaching the discipline "Fundamentals of energy and resource saving" to future engineers and teacher-engineers, with the abbreviations meaning the following: MEL – mechanical energy loss, HEL – hydrodynamic energy loss, EEL – electrical energy loss, TEL – thermal energy loss; CM – cutting of materials, PDM – plastic deformation of materials, HMM – heating and melting of materials, BF – burning of fuel, MLGSM – moving liquids, gases, solutions and melts, WM – welding of materials, MME – mechanical movement of elements, MEC – movement of electric current E – energy, M – metallurgy, ME – mechanical engineering, T – transport, W – welding, OGE – Oil and Gas Engineering, CT – chemical technology,

C – construction, EEE – electrical engineering and electromechanics, TPAFP – technologies of production and processing of agricultural and food products, HCSCS – housing and communal services and consumer services.

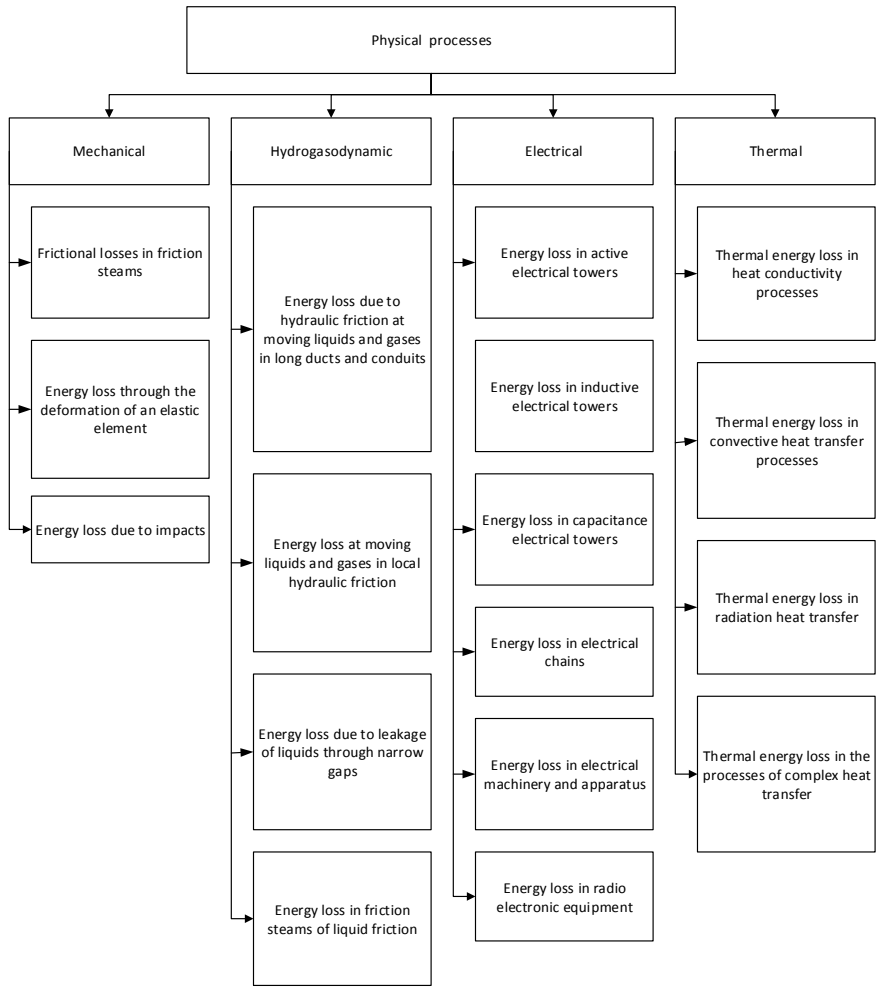

Fig. 2: Kinds of energy loss in various physical processes.

A template for technological process of training in the principles of energy and resource savings in the form of functional integral is suggested:

$$П = \oint_l \{d\,П_{M_i} + d\,П_{ггд_j} + d\,П_{Эk} + d\,П_{Тm}\}, \quad (1)$$

where *l* is a closed area (range) of the technological system, with $dП_{Mi}$, $dП_{ггдj}$, $dП_{Эk}$, $dП_{Tm}$; being separate (elementary) mechanical, hydrogasodynamic, electrical and thermal processes, proceeding in a closed technological area:

$$П_М = \oint_l dП_{M_l}, \quad (2)$$
$$П_{ггд} = \oint_l \cdot dП_{ггд_j}, \quad (3)$$
$$П_Э = \oint_l \cdot dП_{Э_k}, \quad (4)$$
$$П_т = \oint_l \cdot dП_{Т_m}, \quad (5)$$

and l, j, k, m being a number of relevant basic physical processes.
In this way, the engineering tasks of energy and resource savings in the technological process may be reduced to a minimum of the target function, expressing energy consumption (Э) in the whole combination of separate basic physical processes:

$$Э = \min\{\oint_l [d\,Э_{M_l} + d\,Э_{ггд_j} + d\,Э_{E_k} + d\,Э_{т_m}]\} \quad (6)$$

under the prevailing technological and legal-regulatory restrictions on the regime parameters (P):

$$\begin{cases} [P_{M_l}]_{min} \le P_{M_l} \le [P_{M_l}]_{max}; \\ [P_{ггд_j}]_{min} \le P_{ггд_j} \le [P_{ггд_j}]_{max}; \\ [P_{E_k}]_{min} \le P_{э_k} \le [P_{э_k}]_{max}; \\ [P_{T_m}]_{min} \le P_{т_m} \le [P_{T_m}]_{max}. \end{cases} \quad (7)$$

The task carried out in this connection, is to apply the content of training, providing the allocation of specific basic physical processes for each area of specialization in "Vocational education" (2) - (5), belonging to functional (1), to define the related energy consumption in each form of physical processes, with are implemented in the function (6) and to analyze scientific and technical solutions, aimed at minimizing the functional (6), as well as technological and legal and regulatory restrictions for regime parameters of physical processes (7) [9].

Based on the program and structural-functional training model of future engineers and teacher-engineers in the context of teaching the discipline "Fundamentals of energy and resource saving" (Fig. 1), the sequence of acquiring substantive knowledge and skills (as well as their relations) was defined and presented in the form of a structural scheme in the Figure 3.

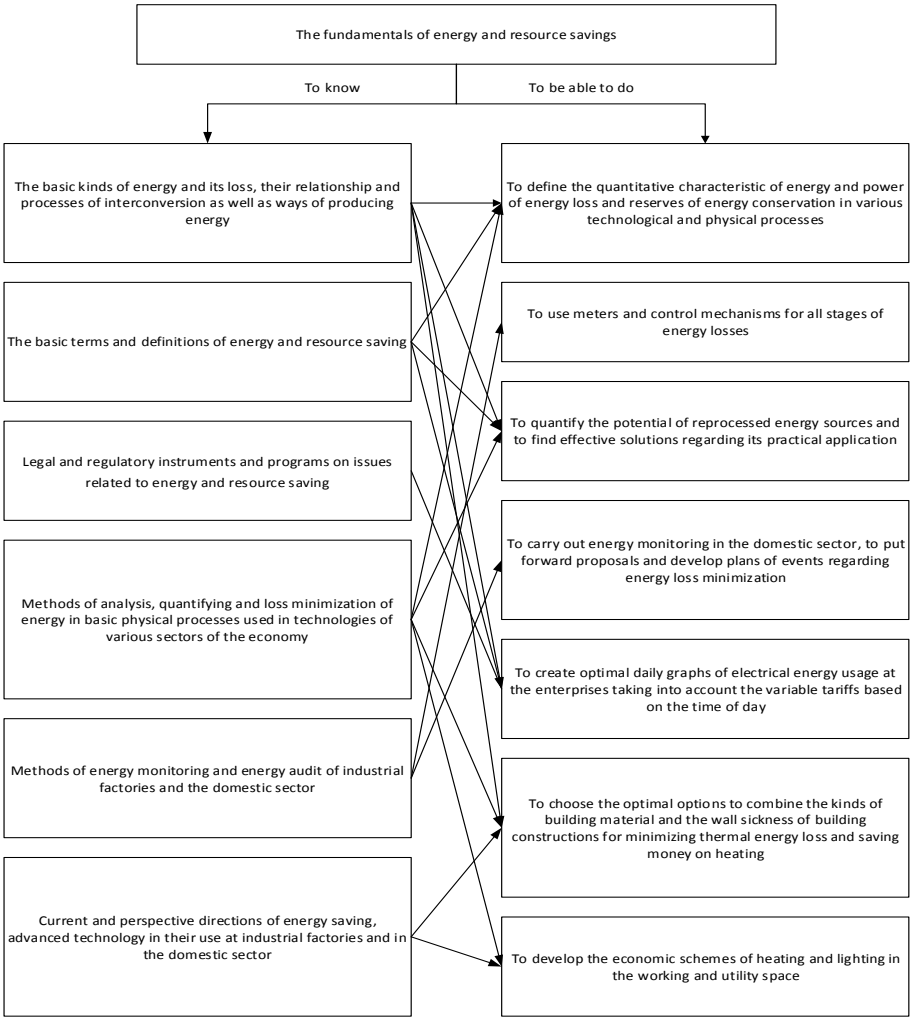

Fig. 3: The sequence of basic knowledge and skills in the discipline "Fundamentals of energy and resource saving".

As part of the implementation of this project, the universal laboratory base of the discipline "Fundamentals of energy and resource saving" was established in UEPA, consisting of the equipment for energy efficiency and the possibility of reducing the energy and resource savings in basic technological processes of the industry, housing and municipal services as well as in the professional services. The teachers and students designed, constructed and stabilized original computerized laboratory boards in order to actually implement the laboratory works, significantly affecting the educational outcomes.

One feature of the development of the course program "Fundamentals of energy and resource saving" is the broad range of engineering and engineering-pedagogics specialties, for which this discipline should be taught. The chart of the areas of specialization "Vocational education» in accordance with types of processes used in technological equipment is presented in Figure 4 [10].

The scientific and technical developments were mainly aimed at creating energy-saving automated process control systems at FEC enterprises.

The scientific and pedagogical issues consisted in the development and implementation of the training programs and methods for the improving qualifications of the personnel of energy companies in the field of energy and resource saving on the basis of Zmievskaia TPP, Kramatorskaia TPP, Zaporizhzhaia TPP, Dobrotvorskaia TPP, etc. Also, in the framework of this area a number of the scientific articles and monographs were published, the results of the work were discussed at the international and regional scientific and practical conferences, the patents for the objects of intellectual property were obtained [11, 12, 13].

Analysis of the existing problems of energy and resource saving in the various areas of the scientific and pedagogical activity showed the real need for conducting the scientific-technical and scientific-pedagogical researches in this direction in all spheres of our society [14].

The following main problems were identified:

- search and implementation of energy-efficient solutions in various fields of activity;
- training and advanced training of personnel in the direction of energy and resource saving at all enterprises of the fuel and energy sector, at the industrial and municipal enterprises, as well as in educational institutions of various levels;
- practical implementation of the results of the scientific researches and engineering developments.

Solving these problems will make it possible to implement the proposed project to create a system of training and advanced training for energy and resource saving.

This work gives a general picture of the scientific, technical and scientific-pedagogical results obtained by the authors in the process of project implementation.

Thus, based on the analysis of the scientific, technical and scientific-pedagogical results obtained by the authors in the course of the project to create a training system for teachers of the courses "Fundamentals of energy and resource saving" in the production, in utilities, in the field of household and services", the following work results in this direction are as follows:

1. A cycle of works was completed on the implementation of the project developed at UEPA to create a system for the training and advanced training of personnel in energy and resource saving in a number of the basic scientific, pedagogical and research aspects.
2. A universal course "Fundamentals of energy and resource saving" was developed and introduced for all basic areas of engineering and engineering-pedagogical specialties with the corresponding full set of the methodological support. The course structure provides for the reduction of the content of training with a view to its application in educational institutions of the lower levels (secondary schools, lyceums, vocational schools, technical schools, colleges) [15].
3. A number of the original training models were developed based on the commonality of the basic physical processes of energy loss as well as the individual technical elements and systems in the structures of technological processes in various industries, in order to ensure the universality and deduction reducibility of the course.
4. A model of a universal laboratory for energy and resource saving with the modern computerized laboratory stands was created and introduced into the educational process. Separate structural segments of this laboratory can be used in educational institutions of the various levels. At some stands, security documents were received as the objects of intellectual property.
5. A cycle of the state budget (by the order of the Ministry of Education and Science) and contractual research was completed in the main scientific, technical, scientific-pedagogical areas of energy and resource saving.
6. A system of advanced training of the executive engineering, technical and operational personnel on the special issues of energy and resource saving in the fuel and energy complex (in particular through the

completed and implemented research in these areas) was developed and is being used at energy generating enterprises.

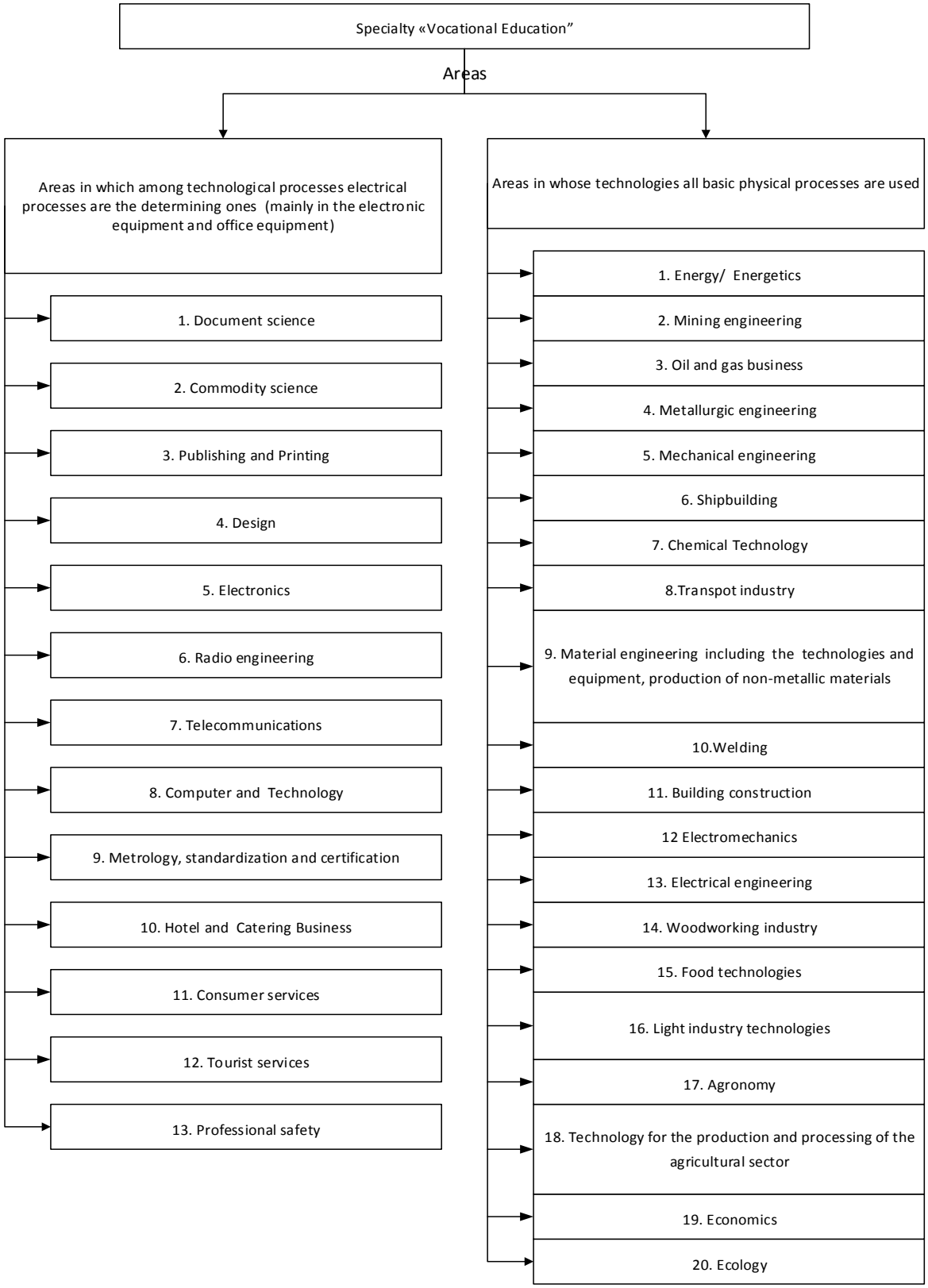

Fig. 4: A scheme of grouping specialty areas of "Vocational education" by the types of processes used in technological equipment.

7. Programs and methodological support for the courses on the basics of energy and resource saving in housing and communal services intended for the workers in the public utilities and other social groups were designed. [16].

Over the past 5 years in the scientific and pedagogical work in UEPA, a series of the funded state budget and contract research has been carried out with a total volume of about 2 million hrn, the subject of which has been scientific, technical, scientific-pedagogical issues of energy and resource conservation.

The subsequent tasks in the scientific and pedagogical plan are to develop and implement special sections on energy and resource saving in particular courses of the particular specialties. At the same time, it is urgent to develop and implement the general course "Energy-saving automated management systems " for all engineering and engineering-pedagogical specialties as this scientific direction allows different enterprises to significantly increase energy and resource savings through using internal reserves without capital expenditure for the basic technological equipment modernization.

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