into the engineering education system; 2) achieving the discussed objective is through integrated curricula (IC); 3) engineering task involves the objective, content and further mathematical research within the framework of IC; 4) selecting an engineering task initially depends on the teaching requirements of mathematics and then professional interests, i.e. the engineering task is based on the mathematical tools, which, in its turn, should be rather "saturated" and informative in accordance with the learning outcomes; 5) engineering task should be simple and understandable for a 1-2 year student, while the results of the mathematical research-illustrative, assuming conceptual interpretation and possible empirical verification; 6) questions in didatics should also be included, for example, application of problem-based learning technology or other of active learning methods; 7) the author recommends the described task division into propaedeutic (preparatory instruction) and creativity, indicating different elements of student self-assessement.

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Competences of Management and Engineering Staff in the Sphere of En-ergy Conservation as a Base for Retraining Program Design

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Demand for personnel capable of making innovative decisions and designing innovative facilities conditions the necessity for training managerial and engineering staff. The offered programs of three types based on the energy conservation competence models of managerial and engineering staff con-tribute to the solution of professional problems and development of compe-tences in planning, design, production, and implementation in the conditions simulating professional activity.

Key words: competencies of energy conservation, management and engineering personnel, requirements, retraining programs, design.

Energy use and conservation problems are urgent all over the world. Experts have noticed the common regularities: less energy use in comparison with the predicted one, dependence of energy use on the rate of production development, continuous growth of energy resource utilization, in the developed countries – low usage of renewable energy sources. Energy consumption tends to decrease, which indicates high rate in energy conservation. In Russia energy conservation problems were not so urgent due to availability of great amount of resources, low population density in some regions, an increase in the energy intensity of the gross product in the first half of the 20-th century, which has had consequences so far [1].

Nevertheless, economic, ecologic, moral and other factors condition the specific character of energy conservation problem and urgency to solve it in Russia. To solve this problem one needs to take a number of engineering and management decisions that would require corresponding qualification of both managerial and engineering staff. It updates the issue of managerial and engineering staff retraining in terms of their energy conservation competence development. The given problem is one of the crucial ones which has to be solved in the course of the CDIO international project.

The foundation of the managerial and engineering staff retraining program rests on a competence-based approach. The competences present both a foundation and a goal (expected outcomes) of retraining syllabus implemen-tation.

Traditional competence models of managerial and engineering staff are based on classical foundations: requirements of the Federal State Educational Standards (FSES), job description, research in competences and their empirical study [2 – 10].

To examine the competences the standards of the majors 140400 – Electric Power and Electrical Engineering and 140100 Thermal Power and Thermal Engineering were studied [7-10]. According to the standards and a survey among engineers the developed traditional competence model of managerial and engineering staff in energy conservation includes the following competence units grouped in terms of similar activity types:

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- state and local policy implementation in the sphere of energy conservation and energy efficiency enhancement;
- thermal technology and thermal facilities service;
- thermal and electric energy generation;
- energy audit and certification at the public sector and housing-municipal sector enterprises;
- energy management;
- energy conservation in the heat and water supply systems;
- energy conservation in the energy supply and lighting systems;
- electric energy consumption records;
- energy resource consumption management;
- energy consumption measurement devices and methods;
- energy consumption, record keeping, and distribution systems service.

Hence, only competences of traditional energy source operation were revealed from the regulatory documents. In addition to them, for the purpose of energy conservation the competences of design and alternative energy system utilization has become in demand. Use of alternative sources are accompanied by a great deal of risks as they involve real processes and phe-nomena that do not depend on a human being: periodicity of energy supply, irregularities of process that can result in, for instance, global warming, absences of legal foundation for the use of alternative energy sources, risks of macroeconomic imbalance and limited resources.

Some risks can be overcome if hybrid sources are used. Utilization of hybrid sources is conditioned by the fact that many alternative sources are significantly limited in use. To remove the disadvantages, one needs to com-bine them achieving a synergetic effect. The use of hybrid sources is also connected with the fact that the energy supply of a unit is often convenient by utilizing not one, but several energy types. Besides, hybrid complexes are capable of controlling an energy supply providing energy in different volumes, for example, in different time of a day-and-night. Hybrid systems facilitate duplication of operations when one of the systems does not provide enough energy.

The analysis of alternative energy sources and traditional competence models allowed us to distinguish the following groups of innovative energy conservation competences that are not available enough for managerial and engineering staff in different branches of industry.

First, let us consider the competence related to the use of simple alternative energy sources. Here we can distinguish the same competences as for traditional sources of energy. The corresponding groups can be renamed as the:

- competences of state and local policy implementation in the sphere of alternative source utilization;
- facility operation and maintenance (collectors, mini-hydropower stations, tidal, wave, waterfall power stations, etc. – depending on a type of alternative energy);
- generation of alternative energy;
- energy audit and certification at the public and housing-municipal enterprises;
- energy management;
- energy conservation in the systems of alternative supply;
- electric energy consumption records;
- energy consumption management;
- energy consumption measurement devices and methods;
- energy consumption, record keeping, and distribution systems service.

Crucially new competences are developed in the hybrid systems which are intended for the optimal synthesizing of different sources in the most efficient way from the point of view of energy conservation. Among them there are the following competences:

- plotting schemes and hybrid systems meeting the requirements of complete facility functioning in the condition of maximum energy conservation;
- design of relevant hybrid systems;
- certification and energy audit of hybrid systems;
- application of hybrid systems;
- operation of measurement devices and methods of energy consumption;
- energy consumption records in hybrid systems – both in general and by elements.

In the sphere of energy management in a hybrid energy supply there appear the competences of interaction with intelligence hybrid systems. Intelligence hybrid systems can provide «self-analysis» of possibilities, limitations, interdependence of elements and units.

Intelligence hybrid systems (IHS) can reveal the necessity of changes in the scheme, desirable sequence of elements, their interchangeability and dependence. The engineer (bachelor or master) has to acquire the corresponding competences. One might group the competences as follows: IHS design, IHS development, IHS functioning service, analysis of functioning and proposed decisions, assessment of changes introduced and improvement measures.

Special attention should be paid to formation of research competences to work with IHS, since development, design, and testing of hybrid systems requires research at each operation and every stage of performance.

In fact, application of IHS means functioning anergatic intelligence system where the potentials of human intelligence and «the intelligence» of equipment and software are combined. The managerial and engineering staff should be ready for being incorporated into this supersophisticated system.

Due to its high complexity – the given competence can serve as a basis for development of not only separate module of the retraining syllabus but also the whole program for managerial and engineering staff.

Competence model built on scientific foundations, i.e. using four bases (FSES, duty regulations (or something similar), research in competences, empirical research in competences), is a key prerequisite for design, performance, and assessment of learning outcomes (quality) of managerial and engineering staff retraining.

When designing the syllabus – it is necessary to take into account that Further Professional Education (FPE) syllabuses are to be flexible and dynamic. Their flexibility is conditioned by a great number of factors: local, technological, economic, cultural, psychological, scientific etc. Hence, it is not reasonable to suggest compulsory syllabuses promoting competence development of managerial and engineering staff in the sphere of energy conservation.

It makes sense to design a generalized retraining syllabus, preferably in modules, to have an opportunity of its changing to different extent depending on the above mentioned factors.

We suggest three versions of generalized programs: traditional; for development of innovative competences in operations with the alternative and hybrid sources and development of innovative competences in energy conservation in hybrid intelligence systems.

Traditional syllabus «Professional retraining and qualification upgrade of the specialists in the sphere of energy conservation and energy efficiency» was developed and tested by us at South-Ural State University (SUSU) on the basis of the Common Use Center.

According to the competence groups there distinguished the retraining syllabus modules of alternative and hybrid power issues.

The syllabus «Hybrid power intelligence systems» is intended for experienced and highly qualified managerial and engineering staff, preferably with an engineer's qualification or a master degree.

The programs have the following peculiarities.

The syllabus modules correspond to the competence groups revealed by us. For instance, module «Devices and methods

of energy consumption measurement. Engineering systems of energy record, distribution, and consumption» is developed for fostering the energy consumption measurement competences listed above.

Among the modules there are compulsory modules for everyone (invariant part), for instance, module «State and local policy in the sphere of energy conservation and energy efficiency», and variable ones which are chosen by employers for their workers in case of insufficient development of corresponding competences.

The outcomes of retraining courses depend significantly on how the syllabus is implemented in practice, i.e. forms and methods of its performance. At present the fact that one should apply interactive techniques, as well as methods simulating professional problem solutions have been recognized and specified at legal-regulatory level.

Hence, we recommend arranging academic environment based on the requirements even stricter than to those for arrangement of the principle academic process to realize FPE syllabuses.

The first necessary requirement is for teaching staff. In FPE syllabuses the most highly qualified staff has to participate, they also have to take upgrading courses on issues of innovative teaching techniques.

The second necessary requirement refers to forms and techniques of FPE academic process. To implement these syllabuses we suggest using special «practice grounds» – academic and research and «natural» centers like at SUSU and other universities including foreign ones.

The third requirement is subject-subject technique of teachers' and students' interaction in the retraining (or upgrading) syllabus at which students do not perceive information given by a teacher inactively, but gain it by themselves actively, thus solving real professional problems.

Such a way of designing and realizing retraining and upgrading syllabus for managerial and engineering staff allows introducing the potential of staff preparation for competences of «conceiving», «designing», «implementing», «operating» all together, but not separately. It permits us to consider the suggested approach as a modern one meeting the CDIO program requirements.

METHODOLOGICAL SUPPORT OF CDIO IMPLEMENTATION

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