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PHILOSOPHICAL APPROACH TO ENGINEERING EDUCATION UNDER THE INTRODUCTION OF THE SMART GRID CONCEPT IN RUSSIA

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Abstract. The development of power industry in the world today is driven by two main trends: the search for renewable energy sources and their use and the energy efficiency which require the development of smart grids. This paper brings up the issue of staff training for professional development of the Smart Grid technology and for use of its elements by customers in households. The problem of consumer readiness for the use of smart meters was studied. It was revealed that the considerable part of the respondents was not familiar with the definition of Smart Grid. That required the development of communication skills by energy engineering students and their social activity as well. The reasons mentioned make actual the following elements of engineering education: social responsibility, stress resistance, ability to forecast the future.

1 Introduction

Today, there are a number of trends in electric power sector, which are significant for national development in Russia: 1. Pursuant to the Russian Government's Directive No. 511-r dated April, 3, 2013, the objects of the distributed energy generation and smart grids to be developed in the near future; 2. In pursuance of the Federal Law No 261-FZ «On energy saving and improvement of energy efficiency and on amendments to certain legal acts of the Russian Federation» as well as the State Program of the Russian Federation «On energy efficiency and energy saving for the period until 2020», the system of measures is proposed, which are aimed at energy efficiency improvement in the housing and utilities sector and the reduction of harmful emissions into the atmosphere by 10-15% per cent as well. Both presented tendencies suppose the development of objects related to the alternative sources of energy and introduction of the Smart Grid technology. Supporting a number of authors, it should be accepted that there is no unambiguous definition of the Smart Grid. But we will not dwell upon the clarifying the definition within this paper. We will just emphasize essential components, which are universal for different interpretations, those are energy infrastructure and information technology integrated in a single system. Integration of both components mentioned above provides implementation of intelligent functions at all network levels: generation, monitoring, consumption, power network software. In Russia, energy efficiency and continuous operation have been emphasize

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at the current stage [1]. To quote Vladimir Sofyin, Director of Technology Development and Innovations at RosSeti: «These should be self–healing power networks with the high-level control» [2]. However, these networks can hardly become the smart ones in themselves, without skilled staff. So, training of the staff is required who will be able to develop such technologies on the one hand, and implement them both at professional and domestic levels on the other hand. The problem of training the staff for active exploring the Smart Grid technology is the topic of this paper.

2 Results and discussion

Philosophical approach to the study of any phenomena provides its coherent view, its nature and its relationship with the other elements of the world. The way of achieving the subject concept can be provided by definition of a problem in the context of ontology-, gnoseology- and axiology–based approaches. Ontological aspect helps cover the question about basics of existence, functioning and evolution of a subject. Gnoseological aspect implies the development of methodology for studying the object. Axiological aspects provides the definition of the value and purpose of the object of interest and ethical aspect of its use. The basis for this research is axiological aspect. Its applying helps make actual the values of the smart power system members: energy consumers, system operators, power producers, manufacturers of electrical equipment, developers and suppliers of software and hardware, universities, and standards setting organizations. The initial point in the provided system of participants in the Smart Grid is universities, where the training of the staff for Smart Grid is provided. The endpoint is every man both as an energy consumer and as a consumer of manufactured products as well. Let us clarify the significance of two selected groups which are participants in the Smart Grid functioning. It makes most sense to start from the individual as a consumer of manufactured products who is the ultimate aim of the power system improvement.

The consumer readiness for implementing this technology is the first–level priority problem. Positive effects of following factors lead a customer to accept a new technology: economic benefit provided by this technology, solution of everyday domestic problems, usability, public recognition. Such values as self interest and public recognition form the basis of all these factors. Let us consider the values mentioned through the lens of the factors which determine the consumer acceptance of a technology.

Economical benefit, solution of domestic problems and usability of a technology are based on such a value as self interest; public recognition is based on following moral values such as responsibility for the environment and next generations. To detect the consumer readiness for the Smart Grid implementing in households based on the specified factors, a pilot survey was conducted with participation of following demographic groups: Engineering students and post– graduate students between 20 – 25 years of age, pensioners (without reference to employment), aged 55 – 75, employed population at the ages from 25 to 54. The first question was aimed at assessment of the respondent awareness of the Smart Grid technology: Did you know the meaning of the «Smart Grid» definition? Answers: «Yes», «No». 68% of «yes» answers were among the student group, while 87 per cent of the group of pensioners answered «no», and 73 per cent of respondents in the group of employed people provided «no» answers. The next questions were related to assessment of consumer readiness to install smart meters as an element of the smart grid: «Choose a statement that applies and its reasons»:

«I am ready to install smart meters because a) this helps reduce the energy charges; b) this provides the monitoring of energy consumption; c) this provides the reduction of emissions into the environment; d) the use of modern technologies in all spheres of life is an uptodate solution; e) this is not a variant for me».

«I would not be willing to set smart meters because: a) the cash profit is low, so the installation costs could not be covered soon; b) it makes possible to control my electricity consumption by other people; c) it lowers the level of personal comfort in daily life; d) using modern devices (PC, telephone, tablet) is rather difficult for me; e) this is not a variant for me».

«I am cautious about this offer because: a) I am short of relevant information; b) this endangers my energy security because of involving the tools of process control; c) it violates my privacy since the information becomes publicly available; d) this is profitable not for me, but for the state; e) this is not a variant for me».

269 respondents (in equal proportion from each demographic group) participated in the survey. When drafting the survey, a hypothesis was suggested that a large portion of people who are able pay would choose for “I would not agree to install smart meters”. This is resulted from the current situation with payments for housing and utility services in Russia (energy charge is a part of them) which involves the rapid increase of rates for the supply and sometimes, poor quality service. So, it is possible to make the assumption that the cost reduction would be a prevailing objective for a consumer. Some background here: the electricity rates have been eightfold increased since 2000 (with the income growth of population in 11 times), but the overall structure of tariff increase for housing and utility services brings us to the conclusion that the growth rate of population incomes are lower than tariffs rates (e.g. the rates for hot water supply have been increased in 21 times, for heating – in 18 times) [3]. Despite the reduction of energy costs due to the smart grid introduction, both Russian and foreign authors point out that the net profit from the smart grid operating is low for households [4], [5], [6], [7,8]. The data from the previous research were used to develop the questions. To formulate the questions [9]. Based on the above, it is fair to say that the desire of the ordinary person to reduce necessary expenses can hardly facilitate the Smart Grid application in households. This hypothesis was confirmed. The essential part of population able to pay (76%), these are pensioners and employed people, ticked the variant «I would not be willing to install smart meters». That was caused by minimal profit and short – term financial expenses that confirmed the first hypothesis. Here, the reduction in Russian population' s income in 2015 should be taken into account, which caused the consumer concerns about the continuously increasing charge for energy. Analyzing the survey results, the attention should be paid that most respondents are not aware of the Smart Grids. So, the education for people about the nature, opportunities and positive aspects of the Smart Grid should be provided.

A modern engineer does more than just develops a technology for humans. By means of the technology he develops the individual to some extend. Modern power engineer has an impact on the human values which are primarily considered by an individual when forming the energy efficiency and environmental protection as elements of human world view. This process results in reshaping the value system in society. Generally, transformation of value system is a long–term process that is due to human pursuit of stability. Therefore, engineers face the situation when society is not ready for technology introduction at the moment. Expediting the technology adoption is possible by means of mass media where its positive and negative aspects are clarified to consumers with accessible means. This means that the engineer should have good communication skills, be aware of methods for distributing information, learn basics of psychology and human behavior, take into account cultural conditions and human worldview. Moreover, the engineer is to be ready to suspend the technology development if the society is not willing to accept the technology at that point, or if there is a negative impact of this technology on the consumer or his living environment.

Thus, the survey results showed that the problem of training the engineers, who are/ will be involved in the smart grid development, should be formulated. This issue is topical not only for Russia but also for other countries as evidenced by a significant number of scientific research journals on this problem – Research in Science and Technological Education, European Journal of Engineering Education, International Journal of Technology and Design Education, etc. Mostly, the foreign as well as national research refer to professional competences that should be trained by future engineers. For instance, the Association for Engineering Education of Russia provided a number of expert workshops on engineering education in Russia during the period 2010 to 2014. We defined key results in the context of the topic discussed. Engineering graduates are demanded to meet the following requirements of employers: critical thinking, problem solving, teamworking, ability to prove their ideas, generating and adopting innovative ideas [10]. From our opinion, the professional requirements to engineers involved into the development and control of smart grids should be amplified with humanitarian competences and personal characteristics and include them into professional competences. Power industry is a social branch because it is aimed at social needs. The life of a modern man much depends on uninterruptable power supply that requires an immediate response of staff in case of power system failure. Responsibility, processing the large amounts of information, abnormal situation management, coordination of staff work – all the functions are referred to the minimum requirements for the staff in energy sector and require from a power engineer the stress-resistance.

The stress–resistance is determined by natural skills of an individual, his psychological background and his involvement into something more than just an immediate task. In this context, the consciousness of the true goal in his activity appears essential for a future engineer. The survey conducted at Tomsk Polytechnic university among the 2nd – year students and the 1st – year graduates revealed that 82% of respondents consider as the main purpose of their activity either the self – profit (which should be regarded as a supplementary purpose, not as a goal in engineering activity, in our opinion) or the technology improvement (which also should not be considered as a goal in itself). The questions were aimed at the students' awareness of the way that the results of engineering impact the development of different industries, the social and spiritual components of human life and human physiology. The questions like those caused difficulties for students. Most of them left that question unanswered. Further discussion with students demonstrated that the 2nd year students already realized their professional responsibilities, but the impact of the developed technology on society and people was not considered by students as a critical problem during their studying at university [11]. This shows that at this time, students are not socially responsible for the results of their activity. We consider social responsibility as the awareness of the fact that the subject of any engineering activity is an individual whose problems are to be solved by engineers. Modern engineers facilitate a solution to physiological, private, social, economy, political problems of society. We outline some of them: life safety; development of the technology that ensures the physical survival and comfort; development of the technology that helps reduce the physical work for the human; development of the technology to minimize the negative impact of civilization on the environment; development of the technology that ensures healthy lifestyle or extends the quality lifestyle, or compensates congenital or acquired physical handicaps; development of facilities that boost personal self-fulfillment and human creativity; development of the entertainment industry providing the leisure and pastimes.

For the engineer working in the smart energy branch, the social responsibility should be classified as a professional competence, not as a general non-technical skill as the modern energy engineering is aimed at meeting the basic human needs: physiological and safety ones. The staff responsible for the power system maintenance should consider the failures in the system, first of all, as a disorder in the consumer life and activity, but not as technical faults or job-related problems. The social responsibility of an engineer also involves the awareness of the way that the developed technology impact the environment, society and people. This is no doubt that there is a number of positive aspects in the smart system introduction, i.e., the use of renewable energy sources, changing the consumer conscious attitude from «I consume energy» to «I save and produce energy». Thus, a consumer becomes an active participant in the power system and accepts a part of responsibility for its functioning. Here, we might face with specific features of a modern Russian man, who is used to the situation when most problems in his life are solved by the state. Today, the low level of civil liability in Russian society can be an actual obstacle to the technology development. In our opinion, this problem implicates the forming of two competencies for a power engineer: 1) the ability to understand and take into account characteristics of the social environment where the technology to be developed and introduced; 2) the social activity when clarifying the specifics of the technology introduced.

The Results of the consumer survey bring us to the conclusion that consumers are wary of the smart meters due to lack of trust in the technology which makes them worry about their personal data security. 68% of respondents ticked the variant «I am careful of this offer» because it disturbs private life since the information becomes publicly available. That fact emphasized the ethical aspect in engineering activity, which includes the following components here: recognition of the private information priority as a component of the engineering ethics. Practical realization of the engineering ethics considers the process of decision making. E.g., a decision on the choice between the self-profit and the welfare of another person. Here is the following question to be raised: «What basics and rules are followed by a person in decision making?» The worldview values are the basis. A value is the personal or the sociocultural significance of objects or phenomena. A value includes qualitative and quantitative characteristics. A qualitative characteristic is the public evaluation of an object or a phenomena with regard to the ideal state (e.g. Kant's categorical imperative). Quantitative characteristics are defined by a human evaluation. When evaluating, a person follows different values, which often contradict each other. Furthermore, when making decision, the engineer should take into account that several groups of people, often with dispersed interests, are interested in his decision. As

the power engineers have to deal with the personal data of consumers, the ability to identify the interests of different groups and estimate their positions with regard to the universal values becomes a key professional competence for the engineer involved in the development and maintenance of the smart grids.

The rational decision-making is only possible if a subject follows a holistic vision of the future (perspective). In modern literature, a vision of the future or perspective is studied as ideas of a person about life goals and plans, as a worldview structure which enables a person to set their own goals and plan the future [12]. Within the philosophical approach to the specified category, the human ability to provide a vision of the future considering technological, social and personal aspects becomes a life issue. The forecasting of the future is essential for implementing the social responsibility principle since it requires ambitious goals and the clear vision how these goals to be achieved. The pilot survey among the 1st–year graduates at Tomsk Polytechnic university demonstrated that only 20 percent of respondents had the holistic view of the future including technological, professional, family, and leisure aspects. Estimating the significance of the future in relation to their life, students provided the following variants: 50 percent answered that they had high expectations about the future and they aimed at achieving their goals, 22% considered that the things would gradually come round and the life should take its natural course, and about 5% of respondents did not worry about the future but live in the present. It should be noticed that most students surveyed (72%) provided emotionally positive estimations of their future. Other respondents (28%) demonstrated the ambivalence in estimating their future. The analysis of the survey results revealed that the students' plans projected for the future met their personal interests and values, i.e., students seek to find the basis for the future in their values. Referred to the features of the students' visions of the future, it should be noted that the respondents in that group better tend to see themselves as the core of everything that occurs in their lives.

In summary, the studying of the students' attitude to the future revealed that the students' vision of the future was realistic that indicated the pragmatism of the youth today. Their long-term perspectives were connected with traditional values such as the personal growth in a profession and family. The obtained results afforded a suggestion that the commitment to creative work and to the responsibility for the development of the society should be included in the education of modern young people.

3 Conclusion

Power engineering today is developed on the principles of the energy efficiency and the use of the renewable energy sources. The introduction of the smart grids requires, on the one hand, the consumer readiness, and the training of the qualified staff, on the other hand. The conducted pilot survey afforded a conclusion that the most part of population in Russia was not aware of the opportunities of the smart grid elements for the households. Furthermore, the survey demonstrated that the benefit was not the reason for the smart meter installation in the household as that was long-term and implicit. The phylosophical approach to engineering education highlights the following competences of engineers involved in the smart grid operation: stress resistance, social responsibility, communication skills, social activity, forecasting of the future.

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