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THE NEGATIVE EXTERNALITIES OF THE ELECTRICITY INDUSTRY AND THE SUSTAINABILITY

The article evaluates negative externalities of the electricity industry and possibilities for the sustainable development. The concept of negative externalities of the electricity industry and evaluation and internalization of the negative externalities are reviewed from the viewpoint of principles of environmental economics and sustainable development.

Key words: economy, sustainable development, externalities, electricity industry.

Introduction

The relevance and the main problem. The growing demand for electricity energy cause not only positive effects on society, but one of the most sore problems is still negative effects on the environment. Very important issue is the negative impact of energy production and use on environment. Though the current fossil energy resources are enough to maintain global economic growth but the increased rates of their use will have hard environmental, economic and technological consequences, first of all because of the climate change problem as "the greenhouse effect" is the major problem related to modern energy sector. The externalities concept have better application in solution of environmental problems on theoretical level mostly by investigating the economic and environmental efficiency of application of specific instruments in achieving the optimum of social welfare [34, p.63]. However, the externalities of electricity production are unvalued to all costs of the electricity production. An internalization of the externalities into the decision-making process is an important process of assessing advantages and disadvantages of the various electricity production methods. Until now, both in Lithuania and in the EU there is no single policy how to internalize external costs – in individual countries there are attempts to evaluate the costs and solve this problem by using various control measures.

The main research **problem** in this article is possibilities to internalize externalities of the electricity industry.

Research object is the negative externalities of the electricity industry and need to solve them for possible sustainable development of this industry.

The aim of the research is *on the theoretical externalities basis to do their internalization analysis and to create internalization methodology of external costs, archiving sustainable development of the electricity industry.*

The following **objectives** were set in order to reach the aim:

- to systematize the problems of theoretical aspects, which are associated to the external costs and the ways of internalization;

- to stress the importance of the sustainable development concept for the evaluation and internalization of the negative externalities;
- to value external electric power production costs of Lithuania.

Research methods used were systemic analysis of scientific literature, general and logical analysis, evaluation, generalization, comparison and abstraction.

Theoretical aspects of external costs and their internalisation, including sustainable development aspects

The external costs concept was initiated by A. Marshall [21] and further developed by A. C. Pigou [25], K. W. Kapp [18] and T. Scitovsky. After analysis of the different modern authors (K. J. Arrow [1], T. Tietenberg [36], S. J. Callan, J. M. Thomas [6], A. Roma [28], T. Sundqvist [35], U. Sankar [30], P. Beer, F. Friend [3], E. Croci [12], L. Hurwicz [17], B. Baarsma, J. G. Lambooy [2], H. S. Rosen [29], J. H. Keppler [19], D. Pearce [24], A. Owen [23], P. Cerin, L. Karlson [7]) opinions on the problems of the external costs definition in scientific literature, it is possible to make conclusion, that although the main features of the external costs are similar, there is the lack of emphasizing all important moments.

The externalities in energetic is the impact, which is unvalued in production costs, compulsory, leading to additional costs and the inefficient allocation of resources for the participants of economical practice as well as third parties, if there is not agreed to its existence and impact of compensation. It can be concluded that the efficient distribution of resources can be achieved only when the negative external costs are included in the process of economic analysis because the market itself is not perfect and it can not assess.

The importance of the sustainable development concept for the evaluation and internalization of the negative externalities must be stressed. For the purpose of further analysis it is useful to compare three interpretations of sustainable development (*economic*, *ecologic*, and *social*) found in contemporary literature [10, p.32-33]. At the same time, it is necessary to understand, that the conformity and usage of which to perceive sustainable development is not an easy task, as the three proposed elements of sustainable development *have to be equally assessed*.

1) **The economic** *sustainability* element is based upon R. Solow's [31; 32; 33] amplified *theory on capital convertibility* and *Hicks-Lindahl concept of maximum income, which can be acquired by saving essential wealth (capital) resources for the benefit of future generations*, (implementing the principle of fair distribution among generations). Economic sustainability seeks to maximize the flow of income and consumption that could be generated while at least maintaining the stock of assets (or capital), which yield beneficial outputs [13; 20]. The main goal of implementation of sustainability principles is safeguarding of an optimal amount of general capital (or sum of different kinds of capital) for the future generations.

2) **The ecological** approach to *sustainable development* pays most attention to *stability of biological* and *physical systems* and refers to C. Holling's et al. [14; 15; 16] scientific works. According to this approach *the primary task of economic development is to determine the natural systems limits for various economic activities*. In this case, the vitality of sub-systems becomes essential in the critical view of global stability of the total ecosystem. Thus, the significance of *preserving biological variety* is emphasised here in order to secure balanced nature, elasticity of ecosystems at a global level and their ability to adapt to changes in biosphere, as well as ability to secure future possibilities.

3) People-oriented the **social-cultural** sustainability concept *reflects the interface between development and dominating social norms and strives to maintain the stability of social systems*. Social sustainability seeks to reduce vulnerability and maintain the health of social and cultural systems, and their ability to withstand shocks [8; 5; 27]. Socio-cultural sustainability requires at least the preservation of certain *critical* components of *social capital*, the latter being understood as the ability of the society to solve social, economic, and environmental problems, and to be active in forming the development of the whole system [4]. It should be emphasised, that in a context of sustainable development, the role of social problems in a society is very important and most quickly understandable factor, which might have more influence on economic activity in a short run. (Ecological problems, according to the authors' view, show up in a long term and are often of a global character; this determines secondary understanding of ecological problems among separate individuals, regardless of their influence on a whole society).

4) The implementation of the policy of sustainable development requires the evaluation of the **organization** (**institutional**) *sustainability* dimension, since effective, properly functioning institutions are essential for sustainable development in the realization of the social, economic, and environmental aims set by the society. *Institutional* structuring of ecologically sustainable programs implies making normatively-oriented decisions on various levels of social institutions and organizations concerning alternative scenarios of development by combining various functional decisions that take into account the environmental requirements [9, p.286]. The ignorance of *institutional dimension* is one of the biggest shortages of management of implementation of society sustainable development.

Discussed four interpretations of sustainable development (*economic*, *ecologic*, *social*, and *institutional*) can be visualized by the "***prism of sustainability***". The sustainable development concept can be presented as ***pentahedron*** of sustainable development dimensions by integrating the fifth sustainability dimension – **ethical** or as ***sextahedron*** then sixth dimension – **space** – is integrated.

Considering the fact that *not a single* reference presented a feasible definition of *sustainable development* which could incorporate all aspects of the sustainable development concept and provide no ideal understanding of this concept, it is thought appropriate to use the definition provided in *Brundtland commission's report "Our Common Future"* [22], which discloses the

idea of *sustainable development* best. It postulates that ***sustainable development is the kind of development, which satisfies the current needs without endangering the future generations to satisfy their own***. This definition of sustainable development is the most frequently cited one and seems to be more exhaustive than the majority of others. The essence of Brundtland's commission's statement is *fair distribution of natural resources both among different generations and among the present generation of people from the first, the second, and the third world, and finding a positive consensus between the environmental, the social, and the economic dimensions of environment* [10, p.30].

The economic evaluation of energy production usually involves only the financial costs (inputs) values, excluding the impact for the environment (ecological dimension) and the effects on society (social dimension). So, the instrumentation of sustainability must be not only the public interests' subject but also companies' interests, while internalizing sustainability to the company level. The analysis shows that one of the most important aspects, while instrumenting sustainability, is the institutional practice. While this element is not included to the classical definition of sustainability [22], but the institutional aspect is the crucial in the combination of all sustainability aspects in energy. The policy of the sustainability instrumentation in energetic is directly dependent on the realization of the institutional aspect and its operational efficiency.

External costs emerge than firms and households do not take into account their all production costs. The essence of energy market failures related to environmental issues elimination lays in the concept of external energy costs integration seeking to reflect all social costs of energy supply. For the externalities internalization very important is the question of monetary evaluation. The internalization process is possible only when there is ability to evaluate these monetary methods accurately.

The internalization of negative external costs is very important for the electric energy, which is produced using fossil fuel in order to increase the renewable energetic in the balance of consumed electricity. Normal energetic has a major advantage – lower costs. So, this is one of the market barriers to renewable energy spreading. (From other side, the most important element of the long-term scenario should be converting the current sources of energy to *renewable* (*sustainable ones*), as sustainable development cannot be guaranteed without transforming the global energy system into the sustainable one). A. D. Owen [23] refers to the external costs, as a market barrier, which must be overcome internalizing external costs of the traditional energetic.

The main instruments, which are internalizing the external costs, are based on A. C. Pigou and R. Coase opinions. A. C. Pigou [25] proposes for cost internationalization to use the taxes (so-called *Pigouvian taxes*), which compensate the damage caused by pollution. In this way, in turn, the so-called *Pareto optimum* can be secured. A. C. Pigou maintains that the existence of the external costs is a sufficient consideration for the Government intervention.

It is necessary to distinguish between private and social effects. In the case of private effects in process of their internalization very important role can be allocated for the negotiation between parts causing effects and experiencing these effects. This was emphasized by non-interventional school which paid attention on *Coase theorem* [11]. Under the *Coase theorem*, when there are externalities, the parties, which cause and experience these externalities, can agree on the conditions under which the payment of externalities is done and the efficiency is ensured. The market cannot react to the negative external influences of business, if there are no "*property rights*" to natural resources. (A "property right" can be defined as a set of rules specifying the use of scarce resources and goods). Consequently, neither construction of new markets nor the turning of negative business externalities into internal ones is possible unless all the natural resources are managed under property rights. According to the "property rights" approach, adequately defined exclusive property rights provide the possibility to transform the public good/environmental quality into a private good, thus allowing optimal environmental allocation is independent of the initial distribution of property titles. When using a scheme of private property rights to natural resources, all the benefits and costs belong to the same economic agent and then the market can ensure that the opportunity costs of the resource use will be determined by situation, and some resources will not be used in the economy. But we must say, that for a sustainable life-support system of the natural environment, an efficient property rights structure is conceptually (as well as practically) untenable [34, p.63]. Although the R. Coase approach is close to a free market approach, it requires the state intervention, which could encourage and support the negotiations, for the efficient operation.

Analysis particular groups of internalization instruments and separate instruments shows that the main groups of environmental instruments are divided into economic instruments and comand - control instruments (by A. C. Pigou approach), and voluntary agreements (according to R. Coase approach).

The main measures seeking to mitigate negative energy impact on environment are internalization of external costs in energy prices by implementing pollution taxes or emission permits systems and removing of energy subsidies for fossil fuels in socially responsible way [34, p.94].

Therefore the main aim of sustainable energy development is to ensure that energy production and use would guarantee long-term human development, economic growth, and ecological sustainability by protecting stable institutions which would ensure global security. The main principles of environmental policy which should be met by implementing goals of sustainable energy development are: precaution and prevention principles, "polluter pays" and "profitable not to pollute" principles, social partnership, publicity, subsidiary, switching to educative environmental impact measures and international cooperation. The most important of them is precaution principle. This principle should be met than implementing each environmental or other policy measure [34, p.95].

Evaluation external costs for Lithuania

Than burning fossil fuel the creation of secondary product is inevitable. This product assumes emissions of pollutants into atmosphere. Therefore besides private energy costs external energy costs associated with the negative impact of pollution on human, agriculture crops, building materials exists as well. These costs typically are not included in the market price of energy and are referred as external. These costs should be evaluated and integrated in the price of energy.

The methods for the evaluation of external costs are deeply discussed in monograph [34]. The impact pathway assessment approach, consisting from four steps was advocated in this monograph for external energy costs evaluation in Lithuania: 1. Source characteristics; 2 Air dispersion of pollutants; 3. Impact evaluation; 4. Monetary evaluation external costs.

The first step is to evaluate source characteristics. In the next step using atmospheric dispersion models the incremental changes in ambient air concentrations of pollutants are assessed. In the next step the physical impact of incremental changes of pollutants concentrations in the atmosphere is calculated. The monetary damage estimates for endpoints have been calculated using adjustment of European and USA values for Lithuania.

In the R. Pusinaite PhD dissertation [26] was designed other theoretical model of the externalities evaluation and done the calculation of the externalities costs. Calculations are made by choosing a methodology that evaluates the recent discoveries of the fields like energetic, health, environment, adapting them to Lithuania. As the externalities evaluation requires participation of different experts in the elaboration of the evaluation methodology, for the calculations are already chosen a methodology, which itself includes the most appropriate evaluation methodology of external costs.

The theoretical analysis showed that for the internalization of the external costs is necessary to know a precise costs value. The evaluation of the externalities and the further internalization is impossible without this element. The externalities evaluation and conversion into monetary values is one of the most pressing issues of the modern environmental economy, analyzed during interdisciplinary studies. After calculating values, the question of the external costs internalization becomes a little easier, but leaving new problem – what instruments of internalization to choose. To solve this question there was created the theoretical model of the externalities internalization and made the methodology, whereby the case of Lithuania will be analyzed.

For realizing the proposed by R. Pusinaite theoretical model there were chosen methods which present the selection methodology of the external costs (see table 1; [26, p.89-90].

Table 1. The selection methodology of the external costs internalization methods

The aim of the research	Methods and instruments of the research	Expected results	Defended statements
Theoretical justification of the external costs internalization	Scientific literature analysis, synthesis, comparison, induction, deduction, a summary, abstraction.	Structuring and summary of the treatment to the external costs evaluation and internalization.	For the internalization of the externalities, generated during the electricity production process, the best is to use the economic instruments which are best determined by calculating and evaluating the externalities.
The methodology development and application of the external costs evaluation.	The adaptation and adjustment of EcoSense model to Lithuania.	The calculation of the external energy costs in Lithuania.	EcoSense model, developed during the ExternE projects, the best suits for the evaluation of the external costs in Lithuania's power sector.
The need of the external costs internalization.	SWOT analysis of the external costs internalization in Lithuania.	SWOT of the external costs internalization in Lithuania.	Lithuania external costs are not fully internalized into the electricity price.
Multi-criteria decision analysis of the external costs internalization instruments.	The experiment of Conjoint Choice analysis.	The set of the external costs internalization instruments.	The externalities internalization in companies depends on public preferences and political will.
	The evaluation of the internalization instruments influence of the external costs for the rates, applying mathematical models.	The determination of weights of the internalization instruments evaluation criteria.	
	The computer multi-criteria decision making	Internalization instruments grading under the goodness.	

The aim of the research	Methods and instruments of the research	Expected results	Defended statements
	model.		
The strategy formation of the external costs internalization in Lithuania.	The summation of the experiment, multi-criteria decision analysis, SWOT analysis results.	Recommendations of the external costs instruments development for Lithuania.	

Implementing the selection methodology, there was selected the evaluating methodology which the best calculate externalities. According to the characteristics (of the impact areas, the original data sources reliability, fuel cycle evaluation, coordination with other methodologies), evaluating the discussed methodologies and their advantages and disadvantages, there was chosen the methodology that can accurately calculate the external costs. The evaluation is made by calculating scores for each methodology, the maximum score is 3 and 0 – the lowest score. A evaluation showed that the best methods are those that are used by the latest energy projects which evaluate external costs. Although the life-cycle assessment (LCA) got the most valuating scores but this methodology, evaluating the externalities of electricity production, is used more as a complementary method in conjunction with the bottom – up approach.

Adapting the externalities methodology EcoSense for Lithuania, were calculated external costs in Lithuania. Summarizing the advantages and disadvantages of the main use externalities evaluation methods, the calculation of the externalities was done using a mathematical EcoSense system which internalizes the methodology of bottom – up and the basic principles of LCA. This model was adapted for Lithuania with new technological, environmental data, also there were selected the dose – response functions and monetary values.

These external costs are calculated by the year 2005 emissions to the atmosphere and the quantity of electricity; calculated by the EcoSense software system, evaluating specific Lithuanian data. The externalities evaluation is presented in Table 2 [26, p.117].

Table 2.

External cost of electricity generation in Lithuania

	Lithuanian PP	Vilnius CHP	Kaunas CHP	Mažeikiai CHP	Ignalina NNP
Total external cost in electricity sector , €	10.200.000	11.500.000	60.900	9.380.000	59.400
External cost €/ kWh	0,009506	0,003595	0,000088	0,058625	0,000006
External cost *Lt cnt/ kWh*	3,282	1,241	0,030	20,242	0,002

Under the estimated data, can be seen that the different power plant have different the externalities. The biggest external costs are generated in Mažeikiai CHP.

According to the evaluation of external costs by methodology, proposed in monograph [34, p.142], external energy costs in Lithuania in 1999 amounted 3,4-13,2 millions USD. The biggest part of these costs was accumulated at Lithuanian thermal power plant because this plant was responsible for the biggest share of total atmospheric emissions in energy sector.

Conclusions

1. After analyzing and systemizing different authors‘attitudes towards the internalization of the external costs, was found that the question of the negative externalities in the economy is not fully analyzed and the internalization possibilities are not fully disclosed, while analyzing traditional A.C. Pigou and R. Coase attitudes.

2. the externalities is a significant cost of production, forced, leading to additional costs and the inefficient allocation of resources for the economic impact of the transaction participants and third parties, if its existence and impact of compensation is not agreed. The efficient distribution of resources can be achieved only when the negative external costs will be internalized in commodity price.

3. Energy sector impact on the environment and market imperfections, associated with unvaluation of the negative effects of production costs have led to new necessary decisions, leading to energy sustainability, search. The evaluation and internalization of the externalities can directly to resolve the

issue of environmental sustainability in energetic and the monitoring and evaluation sustainability of this constant aspect.

4. Having analyzed externalities integration, was separated (excluded) three approaches: free-market approach, the need for government intervention and property rights. Analysis showed that mostly benefits of internalizing the external costs give the government intervention based instruments: economic, command - control and voluntary agreements.

5. On the ground of theoretical analysis, was created external costs internalization model and a way how the external costs can be internalized into the production costs. The created methodology for the adaptation of the model provides researches techniques for creating the strategy of the external costs internalization.

6. Applying EcoSense mathematical model, linking together in itself the best methods of calculating the "bottom up" and life-cycle assessment, were estimated external costs in Lithuania. External costs were estimated for Lithuanian PP, Vilnius CHP, Kaunas CHP, Mažeikiai CHP bei Ignalina NNP. The largest external costs are generated at Mažeikiai CHP, the lowest – at Ignalina NNP.

7. External energy costs in Lithuania in 1999 amounted 3,4-13,2 millions USD. The biggest part of these costs was accumulated at Lithuanian thermal power plant.

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