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Evaluation of economic, social and environmental effects of low-emission energy technologies in Poland – multi-criteria analysis

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Abstract

The study aims to assess the extent to which five low-emission energy technologies contribute to social welfare in the scope of the concept of sustainable development. Heuristic methods: multi-criteria analysis (MCA) and the Delphi method are used to resolve the multi-goal problem of this research. The study reveals that priorities of environmental and economic dimensions are most important, followed by social ones. Renewable energy technologies should be utilized instead of nuclear energy to meet sustainable development policy goals. First place belongs to photovoltaics, followed by biomass and biogas. Wind on-shore and wind off-shore are on third and fourth place respectively.

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1. Introduction

Within the last decades, the exhaustion of classical fossil fuels and the mitigation of climate changes have become major challenges for governments all over the world. In Poland this problem is particularly important because the structure of electricity production is dominated by fossil fuels. First place belongs, and will most likely

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belong for a long time to hard coal and lignite, covering 81% of the demand. The share of other energy sources is small [1].

Poland has considerable potential of renewable energy resources utilization. The climatic conditions are similar to Germany, which is the leader in renewable energy deployment. In Poland there exist on a national level programs for the development of renewable energy sources (RES) and nuclear power, although it seems that for various reasons, successive governments defer implementation of the latter one.

A closer look reveals that there are, in fact, multiple goals of sustainable development paradigm that Polish energy policy intends to accomplish. Several studies have pointed out that specific energy policy goals lead to the choice of specific low-emission energy sources and technologies [2-4]. This research aims to assess various renewable energy technologies and nuclear technology in order to select suitable low-emission energy sources for the accomplishment of different sustainable development policy goals in Poland. There are many analytical methods (belonging to heuristic methods) dedicated to seek optimal solutions for multi-goal problems [5]. Multi-criteria analysis (MCA) and the Delphi method are used to resolve the multi-goal problem of this research.

The organization, for the remainder of this paper, is as follows: a multi-objective framework based on related literature is constructed in Section 2 for assessing the low-emission energy sources in order to reach the goals of sustainable development in three dimensions: economic, social and environmental. The Delphi method is used. Section 3 presents and discusses the results of the MCA study used to assess various low-emission energy technologies. Finally, Section 4 concludes findings of the study.

2. The assessment framework and the Delphi study of low-emission energy technologies impacts

Low-emission energy technologies impacts have been identified on the basis of literature review, in particular: research papers, strategic documents and EU directives, government documents at national level with reference to sustainability, reports of national and international organizations promoting sustainable development or focusing on RES development. One should mention in particular studies [6-8].

Impacts have been identified also on the basis of papers presenting specific primary research, focusing on the problem of choosing energy technologies for the achievement of multi-goal policy objective in economic, social and environmental dimensions [9]-[11].

The analyzed effects in the economic, social and environmental dimensions can be divided into [12]: macroeconomic, distribution, cross-sectoral and connected with the energy system. In the following study all types of impacts were included in the research, the only eligible criterion was the significance of the impact on social wellbeing defined in the context of the sustainable development paradigm.

The Delphi method was used to identify the impacts (criteria used in the MCA study). It belongs to the category of heuristic methods, which differ fundamentally from quantitative methods. They are based on the qualitative assessment of facts, intuition, and above all, on the individual expert scheme of association. The Delphi method was first developed and applied by N. Dalkey and O. Helmer (1963) [13]. It is characterized by the independence of expert opinion, the anonymity of experts, the multi-step nature of the procedure, the agreement and the summation of experts' opinions.

The multi-step procedure is based on well-planned program of successive expert-led surveys. The Delphi procedure forces the majority to go, since the expert in positions other than majority demands not only explanations but also justifications for the position. In this way, extremists are isolated, i.e. stiff persons who do not change their opinions. Repetition causes the extent of the discrepancy to narrow, leading to the agreed opinion of majority of experts.

A preliminary set of effects based on a literature review was verified by three experts in a focus study. Eight experts from the field of environmental and energy economics participated in the first round of the survey. Preliminary list of impacts along with a description of the low-emission energy technologies analyzed was sent to them. The study covered four renewable energy technologies with the highest growth potential in Poland: biomass and biogas, photovoltaic, wind on-shore and wind off-shore; and nuclear power.

In the first round of research, the experts were asked to describe each effect, as these are usually complex interactions, and it was important to understand how each of the effects is understood by experts before weighing

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