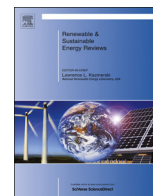




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## Sustainability assessment of electricity market models in selected developed world countries



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## ABSTRACT

The paper focuses on the impact of electricity market opening on sustainability of electricity market models. The paper aims to identify what electricity market organization models are the best ones based on the established sustainability criteria. The sustainability criteria include the main sustainability aspects of power sector (economic, social, and environmental). The methodology has been designed to evaluate organisational models of electricity market, which allows performing an extensive evaluation, encompassing all aspects of sustainable development. The evaluation methodology, which has been designed for the evaluation of energy market organisation model, provides the basis for the identification of indicators that have the most significant impact on sustainability; also it lays down the premise for the establishment of critical values and possible changes and the analysis of reasons for the changes in sustainability. The paper applies developed model for sustainability assessment of electricity market models in several world countries having different electricity market organisation structures. The selection of 12 developed world countries (11 of them are OECD countries) from various continents was made based on availability of fully liberalized electricity markets in these countries. The proposed assessment allows to review and compare electricity market models in terms of achieving main targets of sustainable power sector development.

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**Abbreviations:** UK, United Kingdom; EU, European Union; OECD, The Organisation for Economic Co-operation and Development; EIA, The U.S. Energy Information Administration; IEA, The International Energy Agency; EMSI, Electricity Market Sustainability Index; GDP, Gross domestic product; SPSS, Statistical Package for the Social Sciences;  $R^2$ , Determination coefficient;  $p$ , The statistical importance of coefficients;  $\alpha$ , Level of importance. The traditional value of importance in research is selected ( $\alpha=0.05$ ); TPA, The third-party access; The US, The United States; R01, Separation of production from transmission); R02, Access of third parties; R03, Competitiveness of the Wholesale Trade; R04, Competitiveness of the Retail Trade; R05, Quality of Regulation; R06, The type of ownership; N07, Share of the hydropower; N08, Share of the nuclear energy; N09, Gross domestic product (GDP)

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## 1. Introduction

More than 30 years have passed since the publication of the article on energy market restructuring [1], 25 years since the United Kingdom (UK) began to design its innovative and comprehensive electricity sector privatization, restructuring for competition and regulatory reform program in the energy sector. Gradually, more and more other countries especially EU member states have followed the UK's lead and introduced comprehensive electricity sector reform programs. Other countries have introduced less comprehensive and consistent reform programs as compared with those in the EU countries. Still the main principles of energy market opening have been followed.

Liberalization of power sector is going on around the world. It began in 1989 in England and in 1992 in the United States. It quickly spread not only in Europe and North America, but also reached South America, Australia, New Zealand and, most recently, some Asian and African countries. During the last 30 years most developed countries have also gone through reasonably comprehensive privatization, restructuring and deregulation programs in sectors that were previously regulated monopolies and/or state-owned: airlines, transportation, telecommunications, natural gas, railroads etc. Although these reforms have not always proceeded without controversy or led to precisely the results predicted, the general trend of public policy has continued to support liberalization in sectors that were once dominated by regulated legal monopolies. In many countries power sector reforms are incomplete, either moving forward slowly with considerable resistance or moving backward, despite the success of these reforms in the UK, other EU countries and the Nordic countries, Australia, New Zealand, etc.

Power sectors almost everywhere on earth evolved with vertically integrated monopolies that were either state-owned or at high regulation level. The main components of electricity supply – generation, transmission, distribution and retail supply – were integrated within electric utilities. These companies in turn had de facto exclusive franchises to supply electricity to residential, commercial and industrial retail consumers within a defined geographic area. The performance of these regulated monopolies varied widely across countries.

Power sector performance in developed countries was generally much better than in developing countries [2,3], but high operating costs, ineffective investments and high retail prices of electricity stimulated pressures for changes that would reduce electricity costs and prices. The main reform goal has been to create new institutional arrangements for the power sector that provide long-term benefits to society and to ensure that an appropriate share of these benefits are conveyed to consumers through lower prices, reliability of supplies and higher service quality.

The benefit of liberalization of electricity market relies on creation of competitive wholesale electricity markets to provide better incentives for controlling operating costs of new and existing generating capacities, to encourage innovation in power supply technologies. Creation of retail market allows consumers to choose the retail power supplier offering the price/service quality combination that best meet their needs and increase competition among electricity producers and suppliers.

Significant portions of the total costs of electricity supply – distribution and transmission – would continue to be regulated as legal monopolies. Accordingly, regulatory arrangements governing the distribution and transmission networks have generally been viewed as an important complement to the introduction of wholesale and retail markets to supply consumer energy needs.

Regulation of distribution and transmission companies combined with the application of performance-based regulation imposes hard budget constraints on regulated network utilities

and provides better incentives for them to reduce electricity costs and improve service quality [4–6].

Although the power sector is rather specific and has features that are not typical to other sectors, yet the same economic laws are applied as in other economic activities. The same motives of people prevail in the electricity market – there are those, who produce, supply, transfer or sell electricity and expect to earn as much as possible, and there are others who use electricity and want to buy it as cheaply as possible. Market allows the best match of the desires of two parties, where business people are forced to compete, reduce prices and improve their operational efficiency in order to attract more customers, whereas buyers have the opportunity to choose the suppliers, who are offering the best conditions and can save expenses on electricity consumption.

Looking at the whole country's level of energy sector, objectives in decision-making are multiple and are in conflict with each other: to minimize the costs, minimize the impact on the environment, ensure reliability of energy supply, guarantee energy independence and quality of performance, etc. Therefore, multi-criteria analysis or multi-criteria evaluation, which provide an opportunity to evaluate all important issues for decision-maker, when economic, environmental, social and other indicators are combined and choose the best solution, taking into account all of them, are applied during the adoption of strategic decisions related to electricity market development. While making decisions in the power sector, it is necessary to ensure that adopted decisions coincide with the main policy objectives set for power sector.

The concept of "sustainable development" or "sustainability" was first used in early 1980 seeking to imperatively reconcile economic development and environmental protection issues. Sustainable development has been defined in many ways, but the most frequently quoted definition is from *Our Common Future*, also known as the Brundtland Report in 1987: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [7]. Since then sustainable development has become an example of dynamic social, economic, technological and environmental indicators, which allow moving towards a better life. Future generations having more knowledge, more innovative technologies and different needs will perceive sustainable development goals in their own way based on their cultures and values. Therefore, problems, issues and objectives related to sustainable development must be regularly updated [8].

Appropriate and reliable supply of energy at the affordable price, in safe and environmentally friendly manner and in accordance with social and economic development needs is the main task of sustainable development. Electricity is essential in order to eliminate poverty, improve human welfare and raise the level of living. There are many countries, which do not have a reliable and secure electricity supply; thus, their economic development is very limited. Meanwhile, the degradation of the environment is typical for other countries where electricity is available to everyone. Some authors argue that sustainable development is about achieving a balance between environmental, economic and social aspects, over time and spatial horizons that require interdisciplinary actions in decision-making [7,9]. Sustainable development today has become one of the main criteria and the evaluation scale for the adoption of individual decision and formation of country policies.

Theoretical aspects related to liberalization of electricity market are analysed by many scientists [10–14]. Many different liberal electricity market price formation methods and individual pricing methodologies are analysed [15–21] etc. Although a great number of studies on electricity market liberalization of individual regions and markets can be found in the scientific literature [22–29]; however, there is a lack of studies on how the selected electricity

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