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From the Restructuring of the Power Sector to Diversification of Renewable Energy Sources: Preconditions for Efficient and Sustainable Electricity Market

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ABSTRACT: Efficient and well-developed power sector enables growth and boost of the economy, competitiveness of the national economy, affects the improvement of living standard of the population and development of society. In this respect, the basic task of the power sector is to ensure quality delivery of electricity to consumers that is secure and reliable, with optimal price of electricity and acceptable dynamics of delivery. Since the beginning of the 1980s until present time, the electric power sector has been facing a series of reforms and related restructuring processes aiming to improve the efficiency of the electricity market. This implies liberalisation and privatisation, and unbundling of power activities by which market competition is introduced in the production and supply of electricity. In the process of developing the power sector, it is necessary that the interests of preserving the environment for future generations are equally important as economic and energy interests of today's generations. In this regard, it is environmentally and economically justified to base the development of power systems on renewable energy sources. Increasing the share of renewable energy sources in the national electricity systems will contribute to an increase in energy and environmental efficiency in production and distribution of electricity and, consequently, energy sustainability of national economies.

Keywords: power sector restructuring; diversification of RES; efficiency; sustainability; environment
JEL Classifications: D24; Q42; Q56

1. Introduction

From an economic standpoint, the energy sector enables performance of basic activities of companies, i.e. forms the basis for functioning and operations of companies and the economy as a whole. As one of the main resources of the present time, energy allows the exploitation of other resources in business cycles, fulfills the needs and satisfies the population in different aspects of life.

Direct and indirect impacts of the power sector on the economy as a whole, and on the living habits of each individual are so strong and diverse that the power sector under the present circumstances determines the nature and intensity of the overall social and economic development. Development of the electricity system creates preconditions for a more efficient and cheaper production, which not only contributes to faster development of existing industries and activities, but also develops diversification of the economic structure of national economies.

For this reason, the purpose of this paper is to analyse the posibilities of improving the efficiency of the electricity market, and increasing the security of electricity supply. Special attention is devoted to the organisational and economic aspects of unbundling of electricity activities, and environmental and economic effects of diversification of energy sources, especially renewable energy.

The paper begins with an overview of reforms, i.e. restructuring processes of the power sector and the consequences on a liberalised eletricity market. Due to high dependency and the need for overall electricity use, the necessity to ensure its safe and reliable supply is emphasised in the paper, in order to meet different people's needs. Thus, renewable energy sources emerge as an important energy resource that enables and promotes diversification of electricity production. Finally, environmental and economic aspects of diversification of energy resources are elaborated on.

2. Organisational Models and Reforms of the Power Sector in Order to Improve Market Efficiency

Business entities significantly vary in terms of organisational structure in the power sector, ranging from high centralisation and vertical organisation to more competitive and disintegrated entities (Shen and Yang, 2012). Although there are market structures in which the supply of electricity is mostly conducted by certain vertically integrated companies that operate at the national level, the contemporary structure of power companies is marked by a different organisational basis. In fact, by the early 1990s, most countries in the world had a monopoly-like, vertically organised electricity activities. This implied a monopoly position of companies in providing electricity. There was a lack of competition and the fact that only one company performed all electricity activities.

Reforms in the power sector represent a dynamic, ongoing process that requires a change in the market conditions and gradual introduction of new businesses to the market. Reforms were launched primarily due to improved technology in the industry and economic reasons as well as political motives. Under the impact of the reforms generated by the restructuring process, i.e. deregulation, liberalisation, decentralisation, and privatisation, and guided by the knowledge that the separation of power activities is considered to be the key factor in the establishment of market competition through non-discriminatory access of businesses to the energy sector, and thus a factor of greater market efficiency, achieving better co-ordination of resources, reduction of costs and, consequently, of prices, this leads to significant changes of the entire sector in the sense of technical, technological, legal, organisational, and particularly of economic nature. (Filippini and Wetze, 2013).

Vertical unbundling of the electricity market appears as a result of industry restructuring process. This indicates the unbundling of vertically integrated companies, i.e. separation of individual activities of the electricity sector such as electricity generation, transmission, distribution, and supply, i.e. sale of electricity. The unbundling of these activities achieves efficient market and competitive relationships in each of the activities in the electricity sector. This encourages competition in the activities in which it is possible, i.e. electricity production and supply.

In other activities, transmission and distribution of electricity, formation of the competition is largely hampered due to the existence of natural monopolies. In such circumstances, a company can act and operate more efficiently, than there are more companies in the market, i.e. when there is competition involved. In this respect, it is necessary to conduct supervision and control, i.e. regulation of such monopoly companies for possible (too) high prices for consumers or insufficient levels of quality and adequacy of provided services.

Each of the activities in the electricity sector contributes to overall costs by providing electricity to the end user. According to research conducted on the example of the United Kingdom, it is stated that the share of the activity of electricity generation in the costs is 65%, electricity distribution 20%, power transmission 10%, and the supply of electricity amounts only 5% of total costs (Steiner, 2001). It can be concluded that electricity generation has the highest share in total electricity costs.

There are different intepretations and views of policy makers, energy experts, economists, lawyers, and other involved participants regarding the justification of the implementation of vertical unbundling of the aforementioned activities. For example, Pollitt (2008) analyses the positive and negative arguments of ownership unbundling of transmission networks in the power sector. Pielow, Brunekreeft and Ehlers state that some economists especially point out significant reservations against unbundling of ownership of electricity activities and argue that the benefits do not outweigh the costs

of ownership unbundling (Pielow, Brunekreeft and Ehlers, 2009). In the period between 1994 and 2008, a research was conducted on the impact of vertical unbundling of the generation from transmission and distribution of electricity on the efficiency of state-owned thermal power plants in India (Cropper, et al., 2011). It is pointed out that unbundling of activities significantly improved average annual usability of thermal power plants and reduced unplanned interruptions of business activities. However, restructuring did not improve the efficiency of the company, which can be concluded from the fact that vertical unbundling has not yet encouraged independent electricity producers to enter the market as was the case in the USA, for example. On the other hand, extensive research of the effects of vertical unbundling of electricity activities, especially electricity transmission in the EU Member States, indicate that a higher level of separation (the highest form represents ownership unbundling) leads to lower electricity prices (Copenhagen Economics, 2005).

Historically, the first country in the world in which reforms were launched in order to open and privatise the electricity sector was Chile. In 1982, electricity laws were introduced that functionally separated the activities of production, transmission, and distribution of electricity and, in addition to privatisation and other regulations, the market of electricity generation was created on a contract basis (Galetovic and Muñoz, 2011). In Europe, the United Kingdom was the first country that set the legal framework in 1989 (*The Electricity Act*) for the restructuring and privatisation of the electricity industry. This act covers a change of ownership, from state to private, introduction of competing power activities, independent regulatory authorities, etc. (Simmonds, 2002). It is believed that the United Kingdom was the first EU country that initiated energy reforms and largely transformed its power sector in comparison with other EU Member States. Presently, nearly all European countries are in the final stage of the process of unbundling of electricity activities and complete opening of the market (Granić, 2010).

When European communities were established and developed, and ultimately, when the European Union was established, a need emerged for a single internal European market. The creation of a single European internal electricity market took place in several stages, and this is an ongoing process. Therefore, energy directives were implemented, i.e. „energy regulations packages“ in 1996, 2003, and in 2009, with the goal of completing the creation of the single European electricity market through vertical unbundling of electricity activities, conducting further liberalisation and market opening, but also introduction of the provision of *public service obligations,* which implies the necessity of a secure and reliable electricity supply as a public service which also has to be provided in competitive market conditions (Pollitt, 2012; Public service obligations, 2004). Electricity markets in the EU Member States are presently relatively well-developed, and several regional electricity markets were created in addition to individual national markets, while the ultimate goal is to create a single internal electricity market (Granić, 2010).

It is believed that one of the main incentives for the introduction of reforms and restructuring of the electricity sector is the view that electricity generation no longer has the characteristics of a natural monopoly, i.e. reduction of average cost while increasing production volume due to technological progress, i.e. improvement of technologically-managed processs in the electric power plants (Kagiannas, Askounis and Psarras, 2004). Technology development has enabled efficient electricity generation also with small generators (with small power capacity) (O'Mahony and Vecchi, 2001). Therefore, by reducing the economy of scale in electricity generation, competition could be established between electricity producers. This restructuring has affected the transformation of centrally coordinated monopoly companies to deregulated liberalised markets consisting of competing power companies in the generation and sale of electricity (Kagiannas, Askounis and Psarras, 2004). This, of course, does not mean that deregulation or liberalisation eliminated large monopoly market „players“, but only that conditions were created for gradual opening of the market, i.e. entry of new companies, electricity producers. New producers must be provided with the possibility of delivery of electricity they produce, and large (integrated) monopoly companies should not deny them access to the existing transmission infrastructures that are still mainly owned by large state-owned companies. (Banks, 1996).

Although it is assumed that restructuring primarily implies introduction of competition, and competition increases cost efficiency in production and reduces prices for consumers, there are also conflicting views regarding introduction of competition in electricity generation. Kwoka states the assumptions, that he believes are wrong, on how a re-organised electricity sector should work (Kwoka,

2008). The basic viewpoint advocates the fact that competition could emerge with the existing (large) producers on the market and that entry of new companies would occur when and where this would be necessary. Furthermore, free market principles i.e. existence of competition would eliminate the need for regulatory measures, and the market would replace national regulatory authorities. All of the above should ensure adequate and sufficient electricity supply, reduce production costs, and protect the consumers from high prices and extra profit. These assumptions are not confirmed, and the reason for it is the view that, in reality, the power sector cannot be equated with other network industries[1] and that it certainly cannot be systematically competitive. However, although competitive market is a characteristic of electricity generation, and today there are several national producers that produce the largest share of electricity, there is the view that the above-mentioned market does not participate with a sufficient number of actual participants who could impose competition in the industry (Kwoka, 2008). Also, certain factors such as the high level of capital equipment, sophisticated technology or long-term return on investment, can further complicate the entry of new companies in the industry, resulting in the lack of competitiveness of electricity generation.

The emergence of liberalisation has fundamentally changed the framework in which investment decisions are made and evoked some concern about the potential significant reduction of investments in electricity infrastructure. Taking into consideration the growing electricity consumption and the necessity to replace old, dilapidated power plants, some projections show that Europe could face a severe shortage of electricity, unless extensive investments were made in the electricity industry (Pierre, et al., 2006). It may seem paradoxical, but current processes of deregulation and liberalisation of the electricity sector may cause difficulties in the operation of the power system and thereby affect the impossibility of a reliable and secure supply of electricity, which also creates some uncertainty of market participants, consumers and investors (Chevalier, 2006).

3. The Concept of Security of Electricity Supply

The concept of security of electricity supply has become one of the key issues in an open, liberalised electricity market in the past few years (Pierre, et al., 2006). In order to achieve adequate security of electricity supply, it is necessary to acceptably ensure smooth functioning of the entire production process, and, ultimately, the power consumption. First of all, this implies the use of sufficient energy resources in order to produce electricity in the planned volume (Denona Bogović, Cerović and Maradin, 2012). Today, there are different sources of energy, i.e. energy resources used to generate electricity. In order to further ensure reliable and secure electricity supply and affect the stability of the power system, it is necessary to include various energy sources in electricity generation. Diversity, i.e. diversification[2] of energy resources, that appears as only one of the elements of security of energy supply, may be increased by using a wider range of energy resources, application of new production technologies and geographic dispersion of manufacturing plants and primary energy resources (Parliamentary Office of Science and Technology, 2003; Grubb, Butler and Twomey, 2006). The greater the diversification of electricity production, the less likely it is that there will be a disruption in the functioning of the entire power system if one form of energy (energy resource) at a specific time cannot transform and deliver electricity. It is also stated that adequate diversification of the energy system is more environmentally friendly and that it contributes to sustainable development (Li, 2005).

Historically, diversification of energy resources could be realised by using different forms of fossil fuels, i.e. coal, oil, natural gas and other artificially produced types of fuel. Due to the scarcity of natural resources of fossil origin, their use must gradually decrease. Restrictions on the use of fossil fuels can be solved by improving energy efficiency, i.e. by introducing new technologies and tehnological processes by using less energy in the production of a large number of products and services. Energy efficiency and climate protection, effectiveness of demand management and meeting other environmental requirements, are some of the objectives of environmental protection implemented in the EU energy directives from 2003 (Sandøy, et al., 2004).

[1] Network industry is defined as any industry that participates in the transfer of people, products or information between the two areas using a certain type of physical network or infrastructure (van der Linden, 2005).

[2] Although they are perceived as synonyms, diversification is referred to as a broader concept (Grubb et al., 2006).

Power system must find a way how to produce stable and continuous electricity from scarce energy resources. One of the possible solutions is introduction, application and improvement of alternative energy sources like renewable energy sources. Renewable energy sources (RES) can be defined as any energy resource that can regenerate naturally at a rate comparable to or faster than the rate of consumption of that resource or as a permanent resource that is abundantly available in nature (van Vliet, 2012). Using renewable energy sources such as energy obtained from the wind or the sun, apart from the fact that it leaves the option of using fossil fuels in the future, significantly contributes to the environmental aspect of sustainability, because it does not pollute the environment (Denona Bogović, Cerović and Maradin, 2012; Maklad, 2014). In the provision of energy services, renewable energy sources participate with zero or near-zero per cent of greenhouse gases emission and other air pollutants (United Nations Development Programme, 2000). Negative externalities caused by pollution from the combustion of conventional, fossil fuels are one of the main arguments for the promotion of electricity generation from renewable energy sources. It is also emphasised that renewable energy sources can improve the security of energy supply and have an impact on the creation of new work places (Borenstein, 2011). Renewable energy sources, as environmentally friendly energy resources, will in the future become even more important, because they are unlimited and provide additional energy forms along with the existing conventional power plants, primarily because of continuous and stable procurement of energy resources. This is also expressed because fossil fuels have a large share in total costs of electricity generation (especially in gas power plants), and each fluctuation in fuel prices or the market uncertainty may cause difficulties in the generation and/or price of electricity (Söderholm, 2000).

4. Diversification of Renewable Energy Sources: the Importance of Traditional and Sustainable Renewable Energy Sources

Renewable sources include solar energy, wind energy, hydropower, geothermal energy (heat of the Earth), energy derived from biomass (plant matter), and ocean energy that can be divided into wave energy, tidal energy, i.e. the energy of ocean currents, and other (Armstrong and Hamrin, 2000). It is estimated that approximately 19% of total world energy consumption was supplied from renewable energy sources in 2011 (REN21, 2013). In this sense, their role is increasing, and assuming the possibility of their diversification, it becomes even more important.

4.1. Diversification of Renewable Energy Sources in Order to Ensure Reliable and Secure Electricity Supply

Biomass, as a renewable energy, is considered to be the most important energy source in some developing countries (Goldemberg and Coelho, 2004). Biomass energy can represent a strategic energy resource, not because it is renewable, but because it is available almost everywhere, and, unlike other renewable sources, it can be stored. Also, its use emphasises ecological benefits and increase in social and economic development, but only when it is used in a sustainable manner. The so-called „modern“ or „sustainable“ biomass refers to the use of agricultural, processing or forest leftovers and solid biowaste for the production of electricity and/or heat, as well as transport fuel. On the other hand, „traditional biomass“ (transformed) produces energy in an unsustainable way, and often for non-commercial purposes (Goldemberg and Coelho, 2004). Wood fuel as biomass, used with a low level of efficiency for cooking or heating in rural parts of developing countries represents unsustainable management of forest energy resources. Thus, only „sustainable“ renewable energy sources are considered „newer“ renewable sources.

At the present stage of technological development, *hydropower* is considered the most important renewable energy source, which is also the only one competitive to fossil energy resources. However, overall hydropower does not fully meet the criteria of renewable energy sources. In relation to the available power, hydroelectric power plants can be divided into large and small. Large hydroelectric power plants require construction of dams and have a negative effect on the environment due to changes in the entire eco-system and essentially do not group among „newer“ renewable energy sources (Maradin, Ponikvar and Cerović, 2013). Although large hydroelectric power plants provide nearly 17% of world electricity, the contribution of small hydroelectric power plants to the world generation of electricity is very small (REN21, 2013). A generally accepted value of small hydroelectric power plants is of maximum installed capacity of up to 10 MW (Paish, 2002). Interest in building small hydroelectric power plants has been increasing because it is simple to build them,

maintain them and operate them, and they have been gaining significance in the functioning of the electricity sector in developed countries.

Considering only the use of „newer" renewable energy sources, the world consumption of electricity is almost negligible, amounting to only about 2%. However, if we also add thermal energy obtained from „modern" biomass, solar and geothermal sources, then the share of energy increases to 6% (REN21, 2013). It is expected that production and consumption of energy from renewable energy sources will greatly increase in the following decades, primarily due to development and improvement of new technologies of renewable energy sources and gradual reduction of prices of production units, which will result in additional expansion of renewable energy sources to new markets. It is considered that this will compensate for a lack of energy due to a large increase in energy consumption, and coal, as one of the major polluters, will be substituted with renewable energy (Fridleifsson, 2003). It is estimated that the share of renewable energy sources in the total world energy consumption will amount to approximately 35% by 2030, i.e. that renewable energy sources can provide up to 40% of primary energy in 2050, or even up to 80% in 2100 (Panwar, Kaushik and Kothari, 2011; Fridleifsson, 2003).

Ocean energy, also called sea energy, contains enormous amounts of energy and has the potential to provide large amounts of electricity that can meet total world demand several times (Pelc and Fujita, 2002). However, from all the renewable energy sources, ocean energy is at the initial stage of development and long-term and significant financial investments must precede its commercialisation and wider application. (Zabihian and Fung, 2011).

Although *geothermal energy* is categorised as a „newer" renewable source, its exploitation has been known since ancient times. Commercial generation of electricity from geothermal sources began a century ago, but its use grew significantly only in the past few decades. Given its enormous potential, the current world-wide use of geothermal energy represents a very small share in the generation of electricity or thermal energy directly (Fridleifsson, 2003).

Solar energy is a largely used energy source among renewable energy sources (Liu, Perng and Ho, 2013). Although the sun and its radiation are the primal source of energy in the entire world from which almost all other energy sources are derived, from the aspect of sustainability of the source, solar energy can be used for the generation of electricity and/or heat. Although there is a variety of technologies to produce electricity, the most commonly used are solar photovoltaic systems in which electricity is produced as a direct result of the conversion of energy of sun rays, creating the so-called photovoltaic effect, which is commercially used in industry and households since the mid-20th century. (Lesourd, 2001). Photovoltaic system of electricity generation is a valuable additional source of energy to conventional power industry, it provides energy to those areas in which the electricity network is underdeveloped, such as remote places or islands. In these market niches, photovoltaic electricity has already become economically competitive to conventional energy.

Although renewable energy sources represent a small share in the total energy consumption, solar photovoltaic systems and installed capacities of wind power plants that are connected to the power grid are considered the fastest growing energy sources, with the share of as much as 30% per year (United Nations Development Programme, 2000; de Oliveira and Fernandes, 2012). *Wind energy* can be an adequate solution for many of the challenges and difficulties associated with today's energy because it is naturally created in the atmosphere and cannot be spent. As a clean energy source, wind energy is the most appropriate and one of the most advanced and promising renewable energy sources (Ilkılıc, 2011). Moreover, wind energy is currently considered the most exploited alternative energy source (Kabalci, 2013).

4.2. Ecological and Economic Aspects of Diversification of Energy Resources

The general definition of energy as the ability of a given system to perform work implies that the optimal availability of sources of usable energy is a *conditio sine qua non* of stability of growth and differentiation of the global social and economic complex. In the present circumstances, stable and secure energy supply is a precondition for the normal functioning of the entire social and economic infrastructure, and since the current capacities of only labour-intensive activities are not nearly sufficient to meet the needs of modern society, the shortage of usable energy would lead to a global state of economic and existential uncertainty.

Given the prevalence of energy in the processes of social reproduction, electricity is arguably the most important form of energy used by mankind. Electricity is a source of productivity that has no

alternative; therefore, without intensification of the flow of electricity through the economic system, no world economy can achieve an increase in economic activities (Apergis and Payne, 2011), and, consequently, the greater exploitation of the energy potential of natural resources for its production and distribution. The problem is that global electricity production is dominated by fossil fuels, especially coal (IEA, 2013), whose combustion results in generation of negative externalities for the society, in the form of excessive pollution of all environmental components and accelarated depletion of natural resources.

In order to determine the fundamental causes of energy and environmental inefficiency of power systems that depend on fossil fuels, it is necessary to examine their interrelationship with the environment through the basic laws of physics. All energy flows on Earth, including electricity flows, are determined by the immutable laws of thermodynamics. The first law of thermodynamics refers to the occurrence of residuals of energy flows and is directly linked to the problem of environmental pollution, while the second law of thermodynamics, the law of entropy, is directly connected with the problem of scarcity of energy resources (Smith and Smith, 1996).

The first law of thermodynamics says that total energy and matter in the universe is finite. Energy cannot be created nor destroyed, but can only transform from one form into another. This means that total quantity of matter/energy that is entered into any production process must be equal to the quantity of matter/energy after this production process (Bryant, 2011). For example, in the process of burning fossil fuels to produce electricity, it comes to heat release and emission of waste which is equivalent to a highly organised forms of matter and energy contained in the fuel, whereby 2/3 of the used energy source is converted into greenhouses gases that are released in the atmosphere (Solmes, 2009). This energy balance points to the fact that fossil power plants are, in fact, inefficient in the conversion of primary energy into electrical energy, because most of the primary energy is transformed into harmful emissions that burden the absorbtion capacity of the environment.

The harmful environmental effects of energy processes in fossil power plants bring into question justification of developing power systems solely through the construction of these power plants. According to the first law of thermodynamics, pollution of the environment is an inevitable consequence of burning fossil fuels. Therefore, even if modernisation of the existing and building of new modern fossil power plants reduce the amount of emissions per unit of produced electricity, the cumulative effect of increasing the production from such a power systems ultimately represents further increase in the emission of greenhouse gases. In this regard, decarbonisation of the power system can be achieved only by increasing the share of renewable energy sources in the structure of electricity production.[3]

Despite international initiatives that promote „clean“ energy and environmentally friendly energy development (Agenda 21, Copenhagen Climate Change Conference, EU's 3X20 objectives, etc.), fossil fuels are still in the focus of energy strategies of many countries, especially developing countries. The reason is the high cost of building of plants for the exploitation of renewable sources, because of which the prices of renewable energy sources is not competitive with fossil fuels (Kaggwa, Mutanga and Simelane, 2011). However, according to the social cost principle, it is completely wrong to use „the lowest price“ as the main criterion of selecting electricity sources. Taking into account the negative effects of climate change caused by antropogenic activities resulting in emissions of greenhouse gases (The World Bank, 2010), investments in energy projects that contribute to the concentration of greenhouse gases in the atmosphere basically have immeasurably high social

[3] Although most renewable sources are completely neutral in terms of greenhouse gas emissions, if we take into account the total emission of greenhouse gases in the entire sector of renewable energy sources, some renewable sources have a quasi-neutral impact on the environment. Critics of renewable energy sources often point out that production and installation of devices for converting solar energy into electricity, as well as their disposal at the end of life, result in significant emissions of greenhouse gases. However, numerous studies have shown that total emission of greenhouse gases over the life cycle of fossil power plants significantly exceed the emissions produced in the life cycle of solar power plants (cf. WNA, 2011). Besides, critics of renewable energy sources emphasise that intensification of the exploitation of biomass will also increase greenhouse gas emissions. However, the amount of CO2 that is released upon combustion of biomass is approximately equal to the amount of CO2 taken from the atmosphere during its growth; hence, the use of biomass results in much less damage to the environment than the use of fossil fuels.

opportunity costs.[4] In this context, the destruction of priceless natural service of world ecosystems to obtain „cheap" electricity is *per se* ineffective.

Except for the fact that directing the power industry to create opportunities for the use of fossil fuels contributes to global environmental problems, the second law of thermodynamics indicates that such long-term development paradigm can jeopardise the security of electricity supply. The second law of thermodynamics states that the total entropy in isolated systems is constantly increasing, i.e. usable energy is continuously converted into useless. In order to reduce the entropy in a natural or a man-made system, it is necessary to ensure introduction of energy into this system, which directly increases the entropy in its surroundings. Given that the process of entropy is irreversible, satisfying the continuously growing global energy needs implies (inevitable) reduction of energy potential of the Earth[5] (Denona Bogović and Čegar, 2012).

If current energy trends are put in the context of the above-mentioned laws, it is clear why the diversification of energy resources is imposed as a strategic priority in all national economies. This is also indicated by the alarming growth structure of primary energy supply at the global level which has doubled in the past 40 years. Despite technical and technological development, today's share of renewable sources in the total world's supply of primary energy is almost identical to that of 40 years ago, and oil, coal and gas still account for the largest share of energy production (81,6%) (IEA, 2013). Since the availability of fossil fuels is limited in time, it is clear why there is a need in the power sector for alternative energy sources. The development of renewable energy sources cannot only reduce dependence on imported electricity, but can also reduce dependence on imported fossil fuels that threaten the energy sustainability of world economies due to their geopolitical concentration.

5. Conclusion

There are attempts to substitute conventional forms of energy with alternative energy due to their scarcity and environmentally negative externalities. Alternative energy is increasingly competitive to fossil energy resources. Diversification of energy resources, especially in terms od renewable energy sources, has been gaining importance in the past few years in developed world countries. In addition to restructuring and opening of the market, diversification of energy resources, with an emphasis on renewables, is considered one of the fundamental preconditions for secure and reliable supply of electricity and the efficiency of the power sector.

In the long term, sustainable economy can only exist in a sustainable symbiosis with the natural system; therefore, upholding the laws of nature and natural limits of economic growth is the only option that will ensure the human civilisation long-term survival on Earth. In terms of electric power, this implies abandoning of development paradigm that was based on unrestricted exploitation of fossil resources and requires the creation of preconditions for more intensive use of renewable energy sources. Diversification of energy sources in favour of renewable energy sources will reduce the environmental externalities of the electricity sector and ensure the highest level of beneficial effects of electricity.

[4] For environmental goods that do not compete on the market, there is no visible price on the basis of which one can determine the value of their condition at the beginning and in the end of the analysed economic period. Due to the fact that, in the making of investment studies, generally used are categories, concepts and methods for determining the value of economic conditions and trends that are the results of market transactions, such documents cannot provide quality information on the overall environmental externalities of a specific investment project, i.e. may provide false guidelines for decision-making. Ignoring contemporary environmental problems such as climate change, frequent environmental disasters, pollution of all elements of the environment, endangering biodiversity, and overexploitation of natural resources, are certainly one of the major shortcomings of mainstream economic analytics.

[5] The energy potential of Earth consists of renewable and non-renewable energy sources. Non-renewable energy sources are limited by the quantity of their reserves hidden under the ground. Renewable energy sources are limited to available reserves of metal and other minerals needed to build the infrastructure necessary for the exploitation of renewable energy sources.

References

Apergis, N., Payne, J. E. (2011), *A dynamic panel study of economic development and the electricity consumption-growth nexus*. Energy Economics, 33(5), 770-781.

Armstrong, A.J., Hamrin, J. (2000), The Renewable Energy Policy Manual, United States Export Council for Renewable Energy, Washington, USA, http://www.oas.org/usde/ publications/Unit/oea79e/begin.htm

Banks, F.E. (1996), *Economics of Electricity Deregulation and Privatization: An Introductory Survey*. Energy, 21(4), 249-261.

Borenstein, S. (2011), The Private and Public Economics of Renewable Electricity Generation. Energy Institute at Haas, Working Paper 221R, Berkeley, California, USA

Bryant, J. (2011), *Thermoeconomics – A Thermodynamic Approach To Economics*. Second Edition, VOCAT International Ltd

Chevalier, J. (2006), *Security of energy supply for the European Union*. European Review of Energy Markets, 1(3)

Copenhagen Economics (2005), Market Opening and Performance in Electricity, in: Market Opening in Network Industries: Part II Sectoral Analyses, Copenhagen Economics for DG Internal Market, European Commission, http://ec.europa.eu/internal_market/economic-reports/docs/2005/part_ii_sectoral_ analyses_en.pdf

Cropper, M.L., et al. (2011), Estimating the Impact of Restructuring on Electricity Generation Efficiency: The Case of the Indian Thermal Power Sector. National Bureau of Economic Research, NBER Working Paper No. 17383, Cambridge, Massachusetts, USA, http://www.nber.org/papers/w17383

Denona Bogović, N., Cerović, Lj., Maradin, D. (2012), *The security of electricity supply as the determinant of sustainable development*. Marketing and Management of Innovations, 3(2), 254-265.

Denona Bogović, N., Čegar, S. (2012), *Education principles in a model of strong sustainability*. Problems of Education in the 21st Century, 44.

de Oliveira, W.S., Fernandes, A.J. (2012), *Optimization Model for Economic Evaluation of Wind Farms - How to Optimize a Wind Energy Project Economically and Technically*. International Journal of Energy Economics and Policy, 2(1), 10-20.

Filippini, M., Wetze, H. (2013), The Impact of Ownership Unbundling on Cost Efficiency: Empirical Evidence from the New Zealand Electricity Distribution Sector. EWI Working Paper, No 13/06, Institute of Energy Economics at the University of Cologne (EWI).

Fridleifsson, I.B. (2003), *Status of geothermal energy amongst the world's energy sources*. Geothermics, 32, 379-388.

Galetovic, A., Muñoz, C.M. (2011), *Regulated electricity retailing in Chile*. Energy Policy, 39, 6453-6465.

Goldemberg, J., Coelho, S.T. (2004), *Renewable energy—traditional biomass vs. modern biomass*. Energy Policy, 32, 711-714.

Granić, G. (2010), Kako promišljati energetsku budućnost. Energetski institut Hrvoje Požar (Energy institute Hrvoje Požar), http://www.eihp.hr/hrvatski/projekti/clanci/energetska_trzista.html

Grubb, M., Butler, L., Twomey, P. (2006), *Diversity and security in UK electricity generation: The influence of low-carbon objectives*. Energy Policy, 34, 4050-4062.

IEA. (2013), Key world energy statistics 2013. Retrieved from http://www.iea.org/publications/freepublications/publication/KeyWorld2013.pdf, 6, 24.

Ilkılıc, C., Aydın, H., Behcet, R. (2011), *The current status of wind energy in Turkey and in the world*. Energy Policy, 39, 961-967.

Kabalci, E. (2013), *Design and analysis of a hybrid renewable energy plant with solar and wind power*. Energy Conversion and Management, 72, 51-59.

Kaggwa, M., Mutanga, S., Simelane, T. (2011), Factors Determining the Affordability of Renewable Energy. A Note for South Africa. Retrieved from http://www.ai.org.za/wp-content/uploads/downloads/2011/12/No-65.-Factors-Determining-the-Affordability-of-Renewable-Energy.-A-note-for-South-Africa.pdf

Kagiannas, A.G., Askounis, D.T., Psarras, J. (2004), *Power generation planning: a survey from monopoly to competition*. Electrical Power and Energy Systems, 26, 413-421.

Kwoka, J. (2008), Barriers to New Competition in Electricity Generation, American Public Power Association, http://appanet.cms-plus.com/files/PDFs/BarrierPaper 0604.pdf

Lesourd, J.-B. (2001), *Solar photovoltaic systems: the economics of a renewable energy resource*. Environmental Modelling & Software, 16, 147-156.

Li, X. (2005), *Diversification and localization of energy systems for sustainable development and energy security*. Energy Policy, 33, 2237-2243.

Liu, S.-Y., Perng, Y.-H., Ho, Y.-F. (2013), *The effect of renewable energy application on Taiwan buildings: What are the challenges and strategies for solar energy exploitation?*. Renewable and Sustainable Energy Reviews, 28, 92-106.

Maklad, Y. (2014), *Quantification and Costing of Domestic Electricity Generation for Armidale, New South Wales, Australia Utilising Micro Wind Turbines*. International Journal of Energy Economics and Policy, 4(2), 208-219.

Maradin, D., Ponikvar, N., Cerović, Lj. (2013), Renewable Electricity in Croatia and Slovenia from the Aspect of the EU Energy and Climate Targets for 2020. Economic Integrations, Competition and Cooperation, University of Rijeka, Faculty of Economics, Rijeka, 1-15.

O'Mahony, M., Vecchi, M. (2001), The Electricity Supply Industry: A Study of an Industry in Transition. National Institute Economic Review, 177, 85.

Paish, O. (2002), *Small hydro power: technology and current status*. Renewable and Sustainable Energy Reviews, 6(6), 537-556.

Panwar, N.L., Kaushik, S.C., Kothari, S. (2011), *Role of renewable energy sources in environmental protection: A review*. Renewable and Sustainable Energy Reviews, 15, 1513-1524.

Parliamentary Office of Science and Technology (2003), Security of Electricity Supplies, Number 203, London, UK, http://stoft.com/metaPage/lib/UK-2003-09-England-NETA-reliability.pdf

Pelc, R., Fujita, R.M. (2002), *Renewable energy from the ocean*. Marine Policy, 26, 471-479.

Pielow, J.-C., Brunekreeft, G., Ehlers, E. (2009), *Legal and economic aspects of ownership unbundling in the EU*. Journal of World Energy Law & Business, 2(2), 96-116.

Pierre, I., et al. (2006), Security of Electricity Supply - Roles, responsibilities and experiences within the EU, Eurelectric – Union of the Electricity Industry, Brussels, Belgium, http://www.eurelectric.org

Pollitt, M.G. (2012), *The role of policy in energy transitions: Lessons from the energy liberalisation era*. Energy Policy, 50, 128-137.

Pollitt, M.G. (2008), *The arguments for and against ownership unbundling of energy transmission networks*. Energy Policy, 36(2), 704-713.

Public service obligations (2004), http://ec.europa.eu/energy/gas_electricity/ interpretative_notes/doc/implementation_notes/2004_01_16_public_service_ obligations_en.pdf

REN21 (2013), Renewables 2013 Global Status Report. Renewable energy policy network for the 21st century, Paris: REN21 Secretariat.

Sandøy, P., et al. (2004), Report on Public Service Obligations. Eurelectric – Union of the Electricity Industry, Brussels, Belgium.

Shen, D., Yang, Q. (2012), Electricity Market Regulatory Reform and Competition – Case Study of the New Zealand Electricity Market in: Wu, Y., Shi, X., Kimura, F. (eds.), Energy Market Integration in East Asia: Theories, Electricity Sector and Subsidies, ERIA Research Project Report 2011-17, Jakarta: ERIA, 103-139.

Simmonds, G. (2002), Regulation of the UK Electricity Industry, Centre for the study of regulated industries – Industry brief. http://www.bath.ac.uk/management/cri/pubpdf/ Industry_Briefs/Electricity_Gillian_ Simmonds.pdf

Smith, C.E., Smith, J.W. (1996), *Economics, Ecology and Entropy: The Second Law of Thermodynamics and the Limits to Growth*. Population and Environment, 17(4), 309-321.

Solmes, L. A. (2009), *Energy efficiency: Real time energy infrastructure investment and risk management.* Dordrecht: Springer, 8.

Söderholm, P. (2000), *Fuel flexibility in the West European power sector*. Resources Policy, 26(3), 157-170.

Steiner, F. (2001), Regulation, Industry Structure and Performance in the Electricity Supply Industry. OECD Economic Studies No. 32/I.

The World Bank (2010), World Development Report 2010: Development and Climate Change. The World Bank Group. Washington DC, 200.

United Nations Development Programme (2000), World energy assessment: Energy and the challenge of sustainability, http://www.undp.org/content/dam/aplaws/publication/en/publications/environment-energy/www-ee-library/sustainable-energy/world-energy-assessment-energy-and-the-challenge-of-sustainability/World%20Energy%20Assessment-2000.pdf

van der Linden, J. (2005), Network industries: main issues, definitions and economic significance, in: Reforming Network Industries: Experiences in Europe and Belgium; Highlights of Conference "The Lisbon Strategy: a Motor for Market Reforms of the Network Industries", Belgian Federal Planning Bureau, European Economic and Social Committee, Belgian Central Economic Council, http://www.plan.be/admin/uploaded/ 200605091448014 .OPNI2006en.pdf

van Vliet, B. (2012), Renewable Resources, in D. Southerton, Encyclopedia of Consumer Culture, SAGE Publications, Inc., Thousand Oaks, California, USA, 1212-1214.

WNA (2011), WNA Report: Comparison of Lifecycle Greenhouse Gas Emissions of Various Electricity Generation Sources. World Nuclear Association. Retrieved from http://www.world-nuclear.org/uploadedFiles/org/WNA/Publications/Working_Group_Reports/comparison_of_lifecycle.pdf

Zabihian, F., Fung, A.S. (2011), *Review of marine renewable energies: Case study of Iran*. Renewable and Sustainable Energy Reviews, 15, 2461-2474.