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GLOBAL PROBLEMS OF ENERGY MANAGEMENT

Summary:

Global energy economy is in a period of huge transition. Economic development, technological progress accompanied by a large population growth lead to significant increase in energy demand. The availability of energy has a direct impact on the prosperity of the country, but on the other hand overusing it leads to major problems and risks.

This article aims to identify and analyze the fundamental problems of the energy sector of a global nature. Thesis of the article implies that the global challenges of energy management, such as issue of growth in energy demand caused by economic development and population growth in the world, growing dependence on energy imports from politically unstable regions, as well as increasing consumption of non-renewable energy are crucial for the economic and political stability of states, the smooth development of trade in international markets and the welfare of the people.

1. Introduction

The world problems and challenges of the energy sector should be considered globally in three dimensions: ecological, economic and socio-cultural. In this article we will mostly deal with economic and socio-cultural analysis of the problems since the impact of energy economy on environment focusing primarily on the growth of air pollution caused by emissions of gases and particulates produced by burning fossil fuels is the subject of a separate paper and requires detailed discussion. The purpose of the article is also to make an attempt to anticipate the energy sector developments in the upcoming years. This article has been prepared basing on literature of the economics of environmental protection and energy management as well as on the basis of legal acts, the source to develop national and Community institutions dealing with energy.

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2. Energy policy and management

Production and use of energy is the foundation of all living processes and human activity. Energy is a fundamental factor influencing the economic and social development of the world. It is, together with food and air, one of the core material needs humans have. The use of energy facilitated the development of our civilization and shaped the present state of the world economy. Energy and its acquisition is the basis of a distinct branch of economy, which is power industry. Energy management deals mainly with: acquisition, processing and delivery of fuels and energy, use of energy resources, exploitation of energy appliances and planning the development of energy infrastructure as well as managing and streamlining energy production and use. The term *energy management* is often used interchangeably with the term *energy sector or fuel and energy management*. These terms are used broadly, covering economic activity referring to all kinds of fuel and energy [Mikołajewicz 1983, p. 6].

The importance of energy for world economy manifested itself together with the oil crisis of 1973, commonly referred to as *the first energy crisis*. The crisis was caused by the embargo imposed by Arab states on deliveries of oil to Western states combined with rapid increase of its price which caused prices of other fuels to grow as well. At the turn of 1980/1981 there was the second energy crisis, when the world experienced another shock caused by skyrocketing prices of oil and its derivatives. Sudden increases of oil prices and limited delivery of this material by producers united in Organization of Petroleum Exporting Countries (OPEC), especially those from the Middle East, accounted for intensification of various negative phenomena in global economy. Difficulties experienced by many countries in satisfying their energy needs slowed down social and economic development of the world.

Careful management of fuels and energy became a necessity. Many countries initiated long-term actions called energy policies, whose main goal was to solve global problems of energy management.

The aim of sector policies drawn by states is to create conditions of desirable and rational management of resources which guarantees full satisfaction of the needs of economy and its constant development. Energy policy may be defined as a form of economic or administrative influence of public authority organs on energy sector, its structure and the way it functions. Energy policy is a sector policy. It may be understood as economic policy towards energy sector since the processes of management in fuel and energy sector constitute a separate area of activity. Energy policy is applied by public authorities to the sector – from the perspective of economic policy – commonly defined as a strategic sector (or in recent regulations defined as a crisis infrastructure sector). This causes a lot of problems, since any changes taking place in this sector happen simultaneously

in political and economic dimensions. This problem is further complicated as the political, economic and social spheres are closely interrelated. The subjects of energy policy are public authority institutions and organs as well as energy producers. The subject of energy policy in broad sense is energy management, composed of: production and distribution of energy, choice of fuel sources as well as consumption and technologies of energy production.

3. Fuel resources and reserves and energy production and consumption

Presenting world resources and energy demand, we should rely mostly on data prepared by World Energy Council (WEC) and International Energy Agency (IEA), as well as statistics prepared by British Petroleum concern.

Analyzing the resources of energy raw materials and changes in energy production we should bear in mind different forms of energy and types of energy depending on the degree of transforming its carriers. The forms of energy include: current (used in engines, for lighting, in electric and electronic appliances), process heat (mostly high-temperature heat generated by industry), low-temperature heat (hot water, heating the buildings). The latest analyses single out data concerning only the energy subsector which is electro-energy sector, that is a division dealing with production of electric energy. As far as the degree of transforming its carriers is concerned, we have three energy types:

- primary – created from carriers which have not been technically processed: primary energy is obtained from existing energy resources which can be renewable or non-renewable (for example, coal, oil, natural gas, uranium, solar energy, wind energy),
- secondary – created from carriers which were subjected to one or more transformations in technical equipment (for example petrol, heating oil, current),
- final and useful – this is energy received by end-user to satisfy their needs, that is delivered to the user in the form their receivers can take (for example – heating oil in a container).

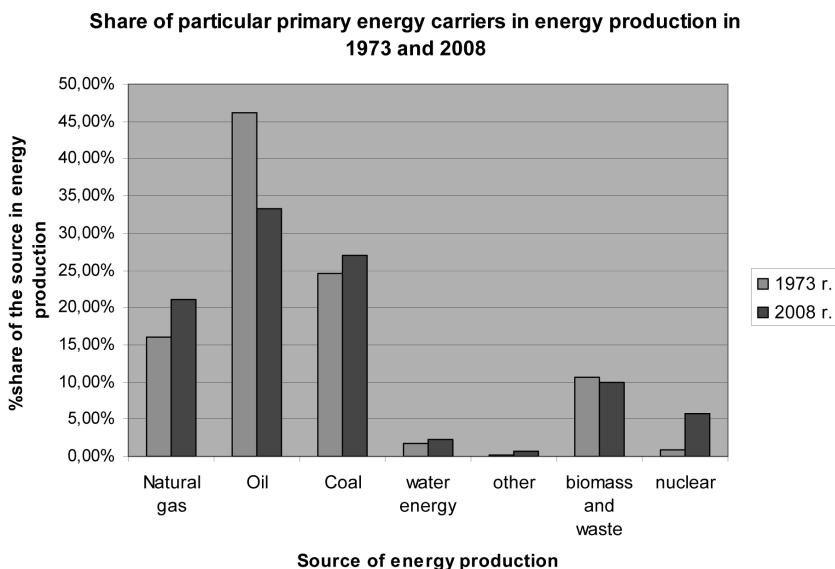
It should be noticed that the reserves that can be obtained have been analyzed in detail and are the foundation of currently developed forecasts of energy supply of the world and particular countries. However, we should remember that geological research of resources and reserves of fossil fuels is not complete, therefore further research, especially concerning resources located in inaccessible part of the globe, will allow us to discover additional, currently unknown, deposits of energy raw materials.

Due to their location, access to particular energy materials is very uneven all over the world. Thanks to its resources which exceed the resources of other

carbohydrate carriers, coal will still remain one of the basic energy carriers. Coal deposits on particular continents have different sizes and different degree of analysis. The main producers of coal are: China, USA, India, Australia, South Africa, Russia and Poland. The biggest producers of brown coal are Germany and Russia. The main oil producers are Russia and Middle East countries, while natural gas is mainly obtained in Russia, USA, Canada, Great Britain and Middle East countries.

Over the past 30 years we have observed changes in the share of particular primary energy carriers in production of energy. The changes in production of particular energy sources are presented in Figure 1.

Figure 1. Share of particular primary energy carriers in energy production in 1973 and 2008



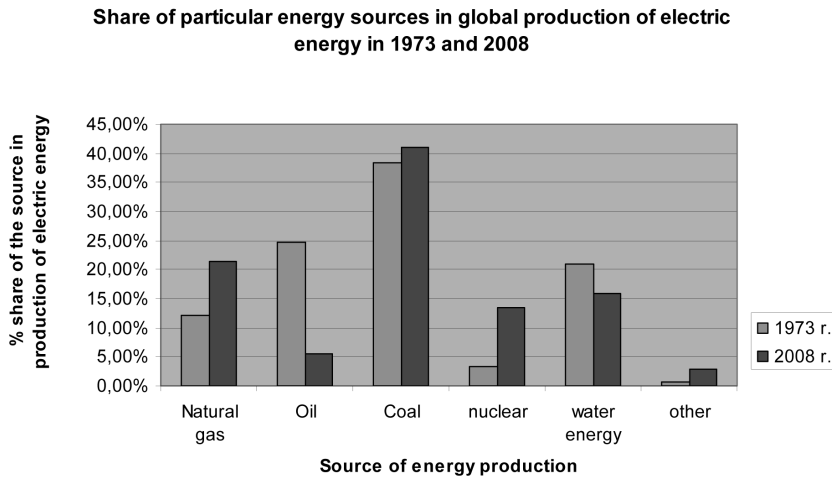
Source: Own elaboration on the basis of data from *Key Word Energy Statistics 2010 IEA*.

The nuclear energy production experienced the fastest growth, though its share in global energy production is still small and in 2008 amounted to 5.8%. Also natural gas production increased, while oil production fell significantly. Coal production enjoyed moderate growth. We can notice growing use of renewable energy sources, but they are not competitive to non-renewable energy sources yet [2010 Survey of Energy Resources. World Energy Council].

Since the beginning of the 1970s we have witness a three-fold increase of the global electric energy production - from 6116 TWh in 1973 to 20093 TWh in 2009 r, of which over a half is produced by OECD countries [BP Statistical

Review of World Energy June 2010]. The changes in the share of particular energy sources in electric energy production in the world in 1973-2009 are presented in Figure 2. The main fuel for the global production of electric energy has been coal, with its share remaining at around 40%. However, the share of other fuels has changed considerably. We can notice a significant decrease of oil share in electric energy production and noticeable increase of natural gas share.

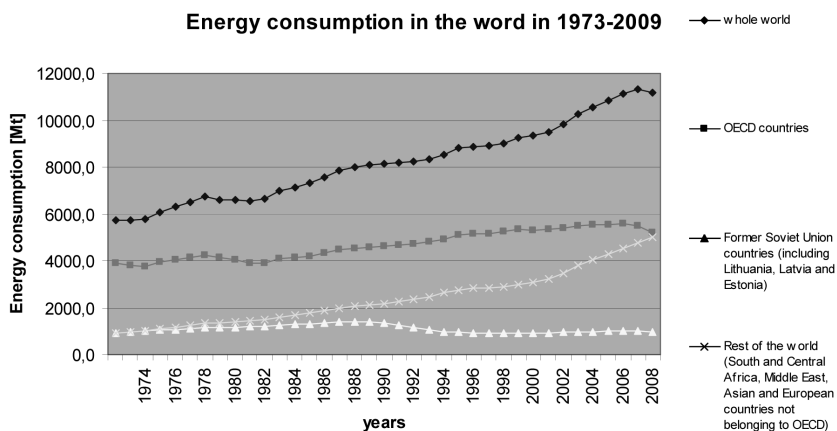
Figure 2. Share of particular energy sources in global production of electric energy in 1973 and 2008



Source: own elaboration on the basis of data from *Key Word Energy Statistics 2010 IEA*.

The share of renewable energy sources in the global production of energy has been systematically growing over the past decade, however, even with the dynamically developing nuclear energy production, it will not be able to cover most of the systematically growing world demand for energy in 30 years' time. According to International Energy Agency world energy consumption in 2030 will grow to 16790 Mtoe [*Key Word Energy Statistics 2010 IEA*]. Planned energy consumption in 2030 will grow by 50% compared to 2009 consumption.

Figure 3. Primary energy consumption in 1973-2009



Source: own elaboration on the basis of data from: BP *Statistical Review of World Energy June 2010*.

Figure 3 clearly shows that in the past 40 years we have witnessed a significant growth of primary energy consumption. Primary energy consumption has increased by nearly 40%, from 3813.1 Mtoe in 1965 to 11194.3 Mtoe in 2009. The biggest share of energy consumption belongs to OECD countries. Then we have China (17.4%), non-OECD Asian countries (11.5%) and former Soviet Union countries (8.5%). There are still huge differences between energy consumption per head in advanced economies and third worlds countries. In extreme cases the consumption is several times lower in the poorest countries than in advanced economies [*Key Word Energy Statistics 2010 IEA*].

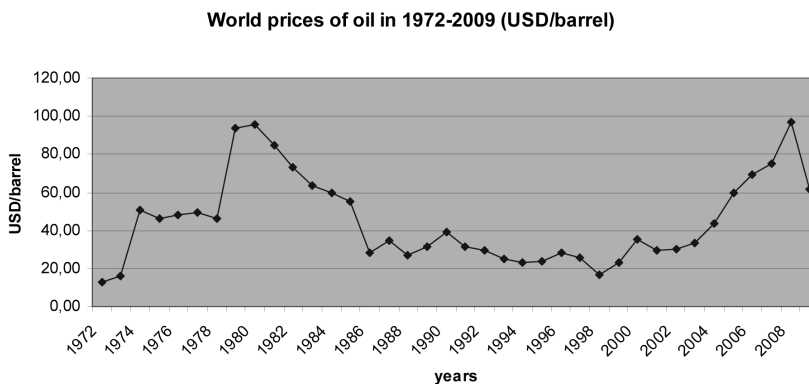
The problem of determining the world resources and reserves of energy materials is a serious global issue of mainly economic type. The new deposits are not always exploitable or the exploitation costs exceed the sales of particular materials. In 2003 oil reserves increased significantly because they also included oil sands in Canada. Contrary to traditional deposits of oil, which under influence of hydrostatic pressure flows onto the surface, the excavation of oil from oil sands takes place in strip mines. This is connected with much higher energy expenses needed to excavate it. Therefore the energy return on energy invested (EROEI) which is the relation of energy contained in the energy material to energy needed to obtain it is in case of oil sands 30 times lower than in case of liquid oil deposits. This accounts for significantly higher costs of the barrel of this material and makes its exploitation unprofitable [H. Manteuffel Szoeg, M. Bukowski 2010 p. 26]. Profitability issues also refer to the exploitation and distribution of unconventional gas and liquefied gas. Due to wider availability of liquefied natural gas (LNG), this material is approaching

a new era. Recently the costs of LNG production and transportation have decreased so much that it is starting to be competitive to natural gas as far as distribution costs are concerned. A very interesting phenomenon is quick growth of unconventional gas deliveries. In 2009 the USA beat Russia and became the biggest world producer of gas due to increasing production of shale gas and gas from coal deposits. The search for unconventional gas in China and Europe (also in Poland) is continuing, however the procedures of its excavation are still being analyzed. The main obstacle in search for oil and unconventional gas is still technology. This means, for example, the necessity of cooperation between independent international entities and state-owned enterprises. Each country is trying to realize this cooperation as well as it can.

4. Oil prices as the main factor of energy prices

Energy prices are largely determined by the market. Electricity, coal, gas and other energy materials have become tradable commodities. The factors influencing their prices are similar to those identified in other commercial markets, for example in stock exchange or commodity markets. The final price is established as a result of the game between supply and demand and market participants. Energy prices determined by the market are the best basis for encouraging investors to invest their capital in such areas as search and exploitation of energy sources or construction and maintenance of power stations. The market is the best basis for balanced energy management, but only when we can propose reasonable prices and attractive profits from invested capital and when investors are ready to supply the energy market with their financial resources (*Raport o światowym rynku energii*. 2005, p. 4). This concerns also competitively organized areas of energy management, such as energy production, trade and sale as well as regulated activity of energy transmission. This capital is vital for billion-dollars-worth investments so that individual and industrial clients could rely on smooth power supply in the future. The costs of production, distribution and use of energy are an important group of costs both for households and enterprises.

Figure 4. World prices of oil in 1972-2009



Source: own elaboration on the basis of data from BP *Statistical Review of World Energy June 2010*.

Global economic growth is connected with prices of materials, especially with prices of oil. Oil is one of the most important sources of energy used in world economy. Prices of other energy sources, including natural gas and coal, are connected with oil prices: if oil prices go up, other energy materials also become more expensive.

Since the 1970s oil prices have fluctuated considerably. As Figure 4 shows, during two oil crises (1973/74 and 1979/80) the price of one barrel of oil soared from around USD 20 to nearly USD 100. In the 1990s the prices plummeted back to around USD 20, while in the period of 1998-2008 it took off again to the level of USD 100. Such big fluctuations were caused by: speculation in global fuel markets, insufficient number of refineries, too quick demand growth in newly industrialized countries, lack of possibilities of obtaining more oil after reaching full production capacity of its sources. The forecast concerning oil prices in the nearest years predict their further growth. Such high prices of oil and natural gas account for considerable flow of financial resources from importing countries, which without remedy actions such as increasing the supply of exporting countries or limiting consumption, may lead to serious disturbances in the world economy (H. Rogal., 2010 p. 366).

Changing prices of basic carriers of primary energy, mainly of oil, not only influence the improvement of energy effectiveness but also, in times of great price fluctuations, in short term negatively affect economic growth indicators. According to the estimates prepared by OECD in 2004, there is an approximate rule enabling us to calculate the influence of oil price increases on the economy of a particular country. A year-long increase of oil prices in the global market by 10 dollars means GDP decrease of 0.3 to 0.5% for industrialized countries.

Taking into account very low growth rates in Europe in recent years, such loss seems to be serious. (*Raport o światowym rynku energii*. 2005, p. 14).

Oil prices are mainly influenced by the supply-demand relation. Oil prices grow when global demand for it increases or when producers – due to whatever reasons – decide to limit the supply. Moreover, a factor significantly influencing the situation in the oil market is political instability of the regions in which it is mined – mostly in the Middle East region. It is enough to fear that due to unrest in the region its supply may be limited to cause instant increase of oil prices. This happened in 1980-1981 (Iraq – Iran war) and in 1990 (the first Gulf War), or at present, due to unstable situation in Libya and other countries of Northern Africa.

5. Diversification of energy sources and increasing energy efficiency as the key to increasing energy security

The efficiency of energy delivery significantly affects the efficiency of economy and determines the satisfaction of the needs of the society. Energy sector is one of key elements of economy, exerting enormous influence on adding value and employment. Availability of energy services and security of energy supply is the basic need of citizens and a vital element in the functioning of industrialized societies. Most advanced economies are implementing the policy of increasing energy efficiency for electrical appliances, which regulates minimum standards of efficient use of energy for an increasing number of appliances. Technologies of limiting fuel consumption and emission of carbon dioxide are key methods, enabling better energy efficiency and lower emission of carbon dioxide. The issue of efficiency is also connected with increasing demand for electricity, which exceeds the capacities of existing energy network. This fact, coupled with a growing number of decentralized energy-generating units, should force operators to perfect their measure taking and monitoring the network structure by implementing state-of-the-art technologies. These issues are closely related to the necessity of modernizing obsolete and badly affecting the environment energy installations.

Economic development depends on regular and constant access to energy materials. Security of energy fuel deliveries and their diversification is the basis of energy security in each country. One of the most effective methods is to diversify the import directions and to increase the number of suppliers. In this way we can minimize the risk of changes in material supplies. We also limit the possibility of exerting pressure on the importer by suppliers. In order to diversify supplies of energy materials to a particular country, it is necessary to create new possibilities of transmitting and transporting energy materials, including electricity.

The economic problem of assuring energy security and the necessity of increasing diversification of energy material supplies also lies in overdependence of a particular economy on supplies of materials from countries with unstable economic situation. Due to political and economic instability of the Middle East and Northern Africa countries, members of Organization of Petroleum Exporting Countries (OPEC) exporting energy materials, countries importing fuels should aim at the biggest possible diversification of the supplies of energy materials, which will result in greater security of supplies. A good example illustrating such actions is *energy solidarity mechanism* introduced by the European Union, reflected in the Regulation of the European Parliament and of the Council concerning the means providing security of natural gas supplies, which came into effect in 2010. The main assumptions concerning energy security are prevention and crisis plans in each EU member country, obligatory announcement of crisis state on the Union level if two countries announce crisis state, taking into account the criteria of geopolitical risk when assessing general risk of gas security of the EU. According to this document, in state of emergency member states are obliged to guarantee access to their storage installations and the European Commission facilitates the realization of such actions [Regulation of the European Parliament and of the Council concerning measures to safeguard security of gas supply and repealing Directive 2004/67/CE].

If we look at the main global energy management problems from the social and cultural point of view (which is a rare position), we should remember about the approval that citizens give to the used techniques of energy production, which plays a decisive role in democratic countries and influences the general level of satisfaction. Another essential issue is the durability and certainty of supplies. Used non-renewable energy materials cause some fears concerning major increases of energy prices among citizens. Analyzing the social and cultural dimension of producing and consuming energy one should take into account the already mentioned fact that significant part of global energy resource, especially oil and natural gas deposits, are in countries defined as *politically unstable states*. Therefore overreliance of industrialized countries on supplies from these regions rich in energy carriers may lead to military conflicts and threaten both energy and political security

6. Energy management of the future

According to demographic forecasts the world population will grow by around which, combined with economic development and improvement of living standards, will further influence increased demand for energy. The biggest growth of energy consumption will take place in countries which now

use up to 0.2 toe/c (toe/c- consumption of energy per capita in one year). These are the poorest countries, with low level of economic development, the so-called *third world countries*. The possible development of these countries will happen at the expense of the environment, with use of obsolete, un-ecologic technologies. In countries with high consumption of energy at the level of over 3.2 toe/c the speed of total energy consumption growth is similar to the population growth rate [Manteuffel Szoegge, Bukowski, op.cit. p. 25]. Forecasts show that in the European Union alone energy consumption in member states will grow by 15% by 2030 compared to 2000. A great part of increased demand for energy will be satisfied with increased share of gas and renewable sources. Some European countries will be extinguishing their old nuclear reactors (for example Germany, Great Britain, Sweden), others are planning construction of new reactors. It is expected that by 2030 the electric energy production will have increased by approximately 50%. EU reliance on imports of gas, oil and solid fuels, already quite big, will further increase [*Key Word Energy Statistics 2010 IEA*].

According to international reports on world energy management, in the nearest decades this sector will develop in the shadow of China, which is tightening its cooperation with countries rich in natural resources. This cooperation will be one of the most important factors determining behavior of the global energy market.

Global revival of the nuclear sector, inspired mostly by China, India and Russia, is a noticeable trend in energy industry. Nuclear energy is considered one of the most cost-efficient technologies allowing us to satisfy the ever-increasing demand for electricity. Moreover, it contributes significantly to energy independence and security of the country. This type of energy production, however, has numerous drawbacks, such as high construction costs, problems of storing nuclear waste and negative attitude of public opinion. What is more, the size of the disaster that took place in Japan in 2011 accounts for an increasing number of voices against the development of nuclear energy. Nuclear energy, being one of the low-emission and most reliable sources of energy, is seen as an attractive alternative in emerging countries. We can talk of nuclear revival especially in Middle East and In China. Kuwait is planning to build 4 nuclear reactors by 2022, while China is planning to increase production capacity to 80GW by 2020 and to 400GW by 2050. In addition, European and North American countries will also be leaders of nuclear energy development [*Annual Energy Outlook 2011*, US Energy Information Administration]. Analyses and reports on the directions of energy sector development were prepared before the catastrophe in the nuclear power station in Japan, therefore global tendencies in development of nuclear energy may change considerably. Renewable sources of energy are to become priority for many countries. Complex strategies of their

development will have to take into account training needs of the employees of this sector. According to the report prepared by Deloitte Energy & Resources, in 2030 solar energy will be the most popular source of renewable energy. The factor explaining this tendency are rapidly decreasing production costs and easy adaptation of the technology in everyday life. According to the report Asia seems the beneficiary of the resources aiming at stimulating better efficiency of solar energy production.

7. Conclusions

Basic global problems of energy sector are mainly: increased demand for energy caused by economic development and population growth, increased pollution of the atmosphere caused by emission of gases and dust created in the process of burning fossil fuels (this issue is analyzed in a separate paper), growing reliance on imports of energy materials from frequently politically unstable regions and growing consumption of non-renewable energy carriers. These issues pose a serious challenge for the governments of countries striving at providing the best conditions for long-term, sustainable development. These issues should become priorities of home and foreign policy in the short and long term. To meet the challenges facing the world energy management, countries must join in creating common energy policies. Such an approach calls for open discussion and long-term plans. Decisions concerning the shape of energy policy in the future should be made independent of current political situation. With 30 or 40 years long investment cycles in energy management, any considerations in shorter periods are impossible or even harmful.

The development of global energy management should be based on rational international discussion, based on technical aspects and on provision of balance between safety of supply, economic efficiency, environment protection issues and planning investments in excavation installations, power stations and energy network. Only then will we be able to create favorable conditions which will ensure safe, competitive and ecological energy supply in the future.

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