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Redefinition of the Role of Asia-Pacific Region in the Global Economy ISSN 1899-3192

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THE CONCEPT OF ENERGY SECURITY – OVERALL ANALYSIS APPROACH

Abstract: The paper is an attempt to gather and analyse different approaches used in practice and literature towards energy security. A definition of this concept that suits best international comparisons has been identified. On the basis of existing literature and own reflections a comprehensive set of indicators was proposed and possibility of quantitative approach towards energy security measurement has been discussed. The indicators may be used for any comparative study of national energy systems made by international security and international relations researchers. The model will prove to be useful also for analyses of Asian economies. The paper is based on international and Polish literature.

Keywords: energy security, definition, energetics, indicators, analysis, measurement.

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1. Introduction

The concept of energy security has been present in scientific literature, political debate and common language for a long time and is being used quite frequently. Despite long history of its use no single definition has been worked out. In consequence almost each paper on energy security starts with an attempt to define the subject. Frequently attempts vary considerably. Moreover there is no single approach towards its analysis or measurement. A common definition, single set of indicators and single method of measurement would definitely be of use for any international relations analyst. For this reason different approaches are gathered in a single paper and common features of this concept are defined. This elaboration has two parallel goals. Firstly it aims at finding the most accurate definition of energy security. Secondly it proposes a comprehensive set of energy security indicators that suit this definition mostly and checks possibilities of assessing energy security level on its basis. Ideally, proposed set of indicators could be of use for international comparisons of energy security levels as well as measurement of changes of energy security in time.

2. Defining energy security

2.1. The concept of security

In the academic handbook K. Żukrowska defines security as "the absence of threat."[1] This broad definition of security was narrowed by J. Czaputowicz in the subsequent chapter of the same handbook where the term security is defined as the "freedom from threats posing a risk for the survival of the state."[2] Such a narrowing tends to eliminate from the definition of security those threats which do not pose a direct risk for the survival of the state. For a researcher who explores issues connected with energy security the former definition proves to be more useful, as it is far more comprehensive and it will more easily encompass such threats as *black out*, i.e. general failures of the energy system, stopping the delivery of electricity to recipients in a given state or its large area. Such an event, if appears as a single occurrence and lasts for a short time, does not necessarily pose a direct risk for the survival of the state, however it is surely an event which can be referred to as a threat to energy security, representing significant problems for people, economy, transportation system, health system and others. Although such situations happened many times in the history they not necessarily led to destabilization of statehood.

2.2. The origins of the concept of energy security

In the classification of security sectors by B. Buzan[3] the concept of energy security is not treated as a separate sector. Among the separate sectors, i.e. military, political, economic, ecological and social and cultural security there are two, namely economic security and ecological security, at the intersection of which the elements of energy security can be sought. B. Buzan states that economic security relates to threats to welfare, free access to markets, financing and natural resources such as crude oil which ensure that the state is developing and its position is maintained. A crucial task regarding ecological security is the provision of food and energy as well as counteracting distortions in the ecosystem.

Placing the issues concerning energy security, i.e. the access to crude oil and other raw materials in the context of the economic security sector can be undoubtedly justified. It is a truism to say that without the access to natural resources, especially crude oil, a modern economy cannot develop itself. A painful lesson was learned

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[1] K. *Żukrowska,* Pojęcie bezpieczeństwa, [in:] K. Żukrowska (ed.), *Bezpieczeństwo międzynarodowe. Przegląd aktualnego stanu*, Wydawnictwo IUSatTax, Warszawa 2011, p. 21.

[2] J.Czaputowicz, Bezpieczeństwo w teoriach stosunków międzynarodowych, [in:] K. Żukrowska (ed.), *Bezpieczeństwo międzynarodowe. Przegląd aktualnego stanu*, Wydawnictwo IUSatTax, Warszawa 2011, p. 69.

[3] B. Buzan, *People, States and Fear. An Agenda for International Security Studies in the Post-cold War Era*, London 1991, pp. 19, 20.

by economies of Western European countries which supported Israel in the Jom Kippur War, for which embargo was imposed on the import of oil from the OPEC (Organization of the Petroleum Exporting Countries). The embargo resulted in the so-called first oil shock in 1973 and the subsequent worsening of the economic conditions. The oil shock demonstrated across the world the significance of crude oil for the economy, but at the same time it proved that the access to energy sources seems to be a more effective weapon than military units. Nevertheless, the significance of the access to crude oil for security purposes was revealed much earlier, i.a. during the Second World War.

However the issue of the access to crude oil and other raw materials constitutes only a part of a wider notion which is energy security; therefore subsequent classifications of security sectors, according to which energy security should be treated separately, prove to be definitely more adequate and close to reality. Placing the constituents of energy security as proposed in the categories according to B. Buzan seems to be unnecessary simplification and may lead to omitting very important elements in the research contexts. Energy security, as the author understands it, constitutes a separate sector and as such it should be the subject matter of the research on security.

Obviously, it does not mean that its connections with economic security or, what is more, ecological security should be negated. Ecological threats the source of which is the human activity appear as a rule within the energy systems of states. Some examples provided involve oil seepage from tankers and oil rigs, emissions of harmful substances into the atmosphere. Both sectors, though mutually connected, should be independently treated in the research on security. More than twenty years have passed since the publication of B. Buzan's book and energy security research have attained its subjectivity, and the majority of handbooks on security published recently contain at least one chapter dealing with energy security.

In the above mentioned handbook[4] K. Żukrowska divides threats on the basis of various criteria, she divides them i.a. into internal and external threats, according to the scale of threat into the threats of unit, region, nation, continent and global, according to the sources of threat into threats resulting from activities of other state, organization, multinational corporation, organized group, according to the criterion of military potential size into symmetric and asymmetric threats, and most of all according to the criterion of the type of threat. According to this criterion security can have many varieties or constituents, such as military, political, economic, social, health, financial, climate, IT, food security or energy security being the subject matter of this elaboration.

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[4] K. *Żukrowska,* Zagrożenia bezpieczeństwa, [in:] K. Żukrowska (ed.), *Bezpieczeństwo międzynarodowe. Przegląd aktualnego stanu*, Wydawnictwo IUSatTax, Warszawa 2011, pp. 36, 37.

As far as the subject matter is concerned, this division is equivalent to the division provided by M. Dubey,[5] as it enumerates basically the same constituents of security. The difference lies in the hierarchy of threats. In the juxtaposition by K. Żukrowska they are enumerated at the same level, whereas M. Dubey first introduces the division into security in the military and non-military dimension, and then divides non-military security into economic, environmental, food and energy security. Hence, he indicates that the military security should be ranked first.

2.3. Energy security – definition discrepancies

Definitions of the notion of energy security provided in the recent two Polish academic handbooks on international security are similar, though not totally identical. In the first handbook, mentioned above, K. Żukrowska claims, following the UN Development Program, that "energy security or security of electric power supply is defined as the availability of energy sources at each time, from different sources, according to the demand for energy from these sources, and in amounts which secure the demand. An indispensable element of energy security is the price which must remain at the level allowing for normal energy consumption by consumers."[6] In the second handbook a shorter approach was suggested, but containing basically the same elements: "energy security […] is a constant availability of affordably priced energy, originating from various sources, meeting adequate quality and ecological parameters."[7] The second definition narrows the notion of energy to energy which meets relevant quality and ecological parameters, but it is not the only difference. The first definition refers to energy sources, the second to the very energy.

In the literature in the world, energy security is defined similarly as in the Polish literature, yet not identically. In the recent book entitled *Energy Security and Economic Development in India*, published by a prestigious think-tank The Energy and Resources Institute, B. Bhaskar suggested a modern and at the same time multithreaded definition. In his understanding "energy security may be defined as the continuous availability of energy in varied forms, in varied quantities, and at reasonable prices without causing hindrance to other securities like social security, food security, and national security of other countries and without detrimental effects on the environment."[8]

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[5] M. Dubey, *India's Foreign Policy. Coping with the Changing World*, Pearson, New Delhi 2012, pp. 1, 2.

[6] K. *Żukrowska,* Bezpieczeństwo energetyczne, [in:] K. Żukrowska (ed.), *Bezpieczeństwo międzynarodowe. Przegląd aktualnego stanu*, Wydawnictwo IUSatTax, Warszawa 2011, p. 397, as cited in *World Energy Assessment*, UN Development Program, New York 2000, p. 113.

[7] K. Pronińska, *Nowe problemy bezpieczeństwa międzynarodowego: bezpieczeństwo energetyczne i ekologiczne*, [in:] R. Kuźniar et al., *Bezpieczeństwo międzynarodowe*, Wydawnictwo Naukowe Scholar, Warszawa 2012, p. 306.

[8] B. Bhaskar, *Energy Security and Economic Development in India. A Holistic Approach*, The Energy and Resources Institute, New Delhi 2013, p. 5.

An alternative definition of energy security by A. Chmielewski refers not as much to the condition but rather to a specific form of activity: "energy security is a multidirectional activity (policy) of the state and enterprises in global and regional dimension, which aims at providing the national economy with adequate amounts of energy raw materials, mainly crude oil and gas."[9] This definition seems to contain a logical error, because it attempts to define two generally separate categories, i.e. certain condition, by a specific activity.

One more definition of energy security is provided by K. Kałążna and R. Rosicki. According to the definition quoted by them, the one applicable by American Energy Information Administration, energy security of state means the ability to sustain its functioning by meeting demand for energy and raw materials.[10]

In Polish government programmes, i.e. in subsequent issues of energy policy of the state: Assumptions for Poland's Energy Policy until 2020[11] and Poland's Energy Policy until 2025[12] a definition derived from the Polish Energy Act[13] or its slight modifications are applicable. According to the statutory definition energy security is a condition of economy which allows for meeting current and prospective demand of recipient for fuels and energy in a manner justified technically and economically, subject to environmental protection requirements. In the currently binding government paper, i.e. Poland's Energy Policy by 2030[14] the definition of energy security was not provided at all, although the very term was used there several times. Most probably it was assumed that the notion has been previously defined in a sufficient way.

It stems from the above mentioned examples that neither science nor administration have worked out a uniformed definition of energy security so far. The author does not intend to try to provide an alternative definition, but he tries to select the most adequate one and append it with a comment. Each of the above mentioned definitions contains disputable elements, but the reality is relatively best reflected by a definition saying that "energy security […] is a constant availability of affordably priced energy, originating from various sources, meeting adequate quality and ecological parameters,"[15] by K. Pronińska.

A reservation must be made, however, that there is no theoretical justification for restricting the categories of states of high energy security levels to those which

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[9] A. Chmielewski, *Bezpieczeństwo energetyczne państwa. Geopolityczne uwarunkowania*, Wydawnictwo M.M., Warszawa 2009.

[10] K. Kałążna, R. Rosicki, *Wymiary bezpieczeństwa energetycznego Unii Europejskiej*, Wydawnictwo Wyższej Szkoły Bezpieczeństwa, Poznań, 2010, as cited in *World Energy Outlook*, Energy Information Administration, Washington 2006.

[11] *Założenia polityki energetycznej Polski do 2020 roku*, Ministerstwo Gospodarki, Warszawa 2000.

[12] *Polityka energetyczna Polski do 2025 roku*, Ministerstwo Gospodarki, Warszawa 2005.

[13] Ustawa z 10 kwietnia 1997 r. Prawo energetyczne, Dz.U. 1997 nr 54, poz. 348 z późn, zm., art. 3 ust. 16.

[14] *Polityka energetyczna Polski do 2030 roku*, Ministerstwo Gospodarki, Warszawa 2009.

[15] K. Pronińska, *op.cit.*, p. 306.

have diversified energy sources. One can imagine a state which has one source of energy sufficient to meet internal demand as well as technology and infrastructure to ecologically generate energy from this source. Such a state could surely be considered as energy secure. In this context the official definition from the Polish Energy Act seems to be better as it does not contain the element of diversification of sources. The reason why this definition was not considered the most adequate was the fact that energy security was referred in it to the condition of economy, which seems to be unnecessary widening of quite a complicated notion. The proposed deletion of the element of diversification from the definition does not mean however that the issue of diversification of the energy sources should be deleted from analyses on energy security. On the opposite, it is a crucial element shaping energy security notion, if considered in line with other factors such as e.g. national level of energy raw materials resources. Individually, it is not an indispensable condition.

Additionally, it is worth coming back to the general definition of the notion of security. For the purposes of consistency, if security was defined as a lack of threat, and energy security is an element of security, then energy security should also be defined in the categories of a lack of threat.

Taking into consideration two restrictions, energy security should be defined as a lack of threat to availability of affordably priced energy, meeting adequate quality and ecological parameters.

2.4. Energy sector in economy – differences in understanding

Apart from the definition issues described above, the adequate approach to the notion of energy security is influenced to a great extent by understanding the notion of energy sector – immanently connected with the notion of energy security. While reading various publications regarding energy sector a conclusion can be drawn that the approach to the constituents of this sector of economy is mutually significantly different. A narrow approach estimates that energy sector is composed solely of the elements of electroenergetic system, i.e. in simple terms power stations, transmission network and distribution network of electricity. A wider approach includes into the scope of energy sector also a part of the mining sector, the products of which are used for production of electricity. The way to understand energy sector in the broadest view involves including in its scope the whole fuel sector (crude oil and gas), mining sector, and obviously the whole chain of production, transmission and distribution of electricity. The last approach is most useful while considering energy security and it will be applicable owing to this.

3. Towards energy security level assessment

3.1. Building a set of energy security indicators

The very definition of energy security is not a sufficient basis of the analysis of this phenomenon, as it is very difficult basing on this definition to differentiate between energy secure state and threatened state. It is also difficult to define the security level on its basis. For this purpose it is necessary to use a wide range of indicators.

In order to build such a set it is very useful to adopt the division of energy security provided by K. Pronińska into four dimensions, i.e. economic, geostrategic, ecological and institutional.[16] The first consists of global energy balance, demand and supply trends on the global energy market, fuel and energy prices and relations between energy consumption and economic growth. The geostrategic consists of security of supplies, guaranteed by the diversification of energy sources, suppliers and transportation routes, the maintenance of strategic reserves, the maintenance of the proper level of self-sufficiency in energy, and in case of exporting states, the security of demand. The ecological dimension of energy security lies within the concept of sustainable development, it refers then to such energy production levels which pose possibly a small degree of threat to ecosystems. It may therefore trigger stigmatization of certain energy raw materials such as coal, and support for others such as various RES, as well as the creation of norms and regulations for side-effects of generating and transporting energy raw materials and the very energy. The last dimension of energy security included in this juxtaposition, i.e. the institutional dimension refers to the existence of domestic and international institutions responsible for working out and implementing the energy security principles, i.e. for instance OPEC or International Energy Agency – IEA.

The division described above is basically congruent with trials to distinguish four aspects of energy security, i.e. guarantee of supplies, economic, environmental as well as political and social aspects, by M. Kaliski and D. Staśko,[17] for the purposes of building the evaluation model of Poland's energy security. Guarantee of supplies can be treated as an equivalent of geostrategic aspect, the political and social aspect partially as an equivalent of institutional dimension, environmental aspect as the equivalent of ecological dimension, and the economic aspect can be undoubtedly associated with the economic dimension. As a matter of fact the above divisions are not identical, with the differences spotted most of all in the indicators applicable to particular dimensions/aspects, nevertheless, the observed conformity indicates that there is a certain canon of thought regarding particular aspects or energy security dimensions. The above convergence is especially important, as the first division

[16] *Ibidem*, pp. 306–308.

[17] M. Kaliski, D. Staśko, *Bezpieczeństwo energetyczne w gospodarce paliwowej Polski*, Wydawnictwo Instytutu Gospodarki Surowcami Mineralnymi i Energią PAN, Kraków 2006, pp. 134–136.

originated on the basis of humanities and the second on the basis of sciences, which can be the reason for applying their compilation in this elaboration.

Security can be studied at various levels. In her classification K. Pronińska[18] suggested that the analysis should be carried out at four levels. The first level relates to a unit, an energy company and a household. The subsequent ones involve national, regional and global levels. Such a classification is disputable, because a unit, a household and an energy company were juxtaposed at one level. In the author's opinion, a joint analysis at the level of a unit and a household is correct, however, in times of globalisation energy companies can be placed at the lowest position at the national level, more adequately they should be analysed at the regional or global level, though it is most appropriate to peruse them separately, as a consequence of which the classification should consist of five rather than four elements.

A security analysis can be alternatively based on the typology of security threats or on the set of energy security indicators. The above quoted K. Pronińska applies the first approach, but the set of energy security indicators was selected by R. Riedel in the paper *Bezpieczeństwo energetyczne we współczesnej securitologii*[19] (*Energy Security in Contemporary Securitology*) and in the above mentioned monograph entitled *Bezpieczeństwo energetyczne w gospodarce paliwowej Polski*[20] (*Energy Security in Fuel Economy of Poland*) and, slightly modified, in the further publication by the same authors entitled *Monitoring bezpieczeństwa energetycznego Polski do roku 2020*[21] (*Monitoring of Energy Security of Poland until 2020*).

Basically, in order to look at the whole picture of energy security of a given state, it would be advisable to compile both approaches. Many elements of this kind of typology were built based on typical opposition.

If therefore in the set of energy security indicators there appears "reliability of energy networks,"[22] then in the typology of threats "technical defects" of these networks will be mentioned for instance.[23] If in the first juxtaposition "stability of supplies" is mentioned, then in the second it will be referred to as "disruptions of supplies by a producer, blocking supplies by a country of transit", or "blocking so called chokepoints."[24] Such a way of preparing both juxtapositions presumably results

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[18] K. Pronińska, *op.cit*., pp. 306–308.

[19] R. Riedel, Bezpieczeństwo energetyczne we współczesnej securitologii, [in:] P. Mickiewicz, P. Sokołowska (eds.), *Bezpieczeństwo energetyczne Europy Środkowej*, Wydawnictwo Adam Marszałek, Toruń 2010, pp. 20–23.

[20] M. Kaliski, D. Staśko, *Bezpieczeństwo energetyczne*…, pp. 137–139.

[21] M. Kaliski, D. Staśko, Monitoring bezpieczeństwa energetycznego Polski do roku 2020, *Polityka Energetyczna* 2007, vol. 10, no. 2, p. 12.

[22] R. Riedel, *op.cit.*, p. 21.

[23] K. Pronińska, *op.cit*., p. 309.

[24] The notion "chokepoints" means geographical locations where due to geopolitical reasons free movement is limited. Such places, restricting free supplies of energy raw materials, include the Strait of Hormuz, the Strait of Malacca, the Bosphorus, the Panama Canal, the Suez Canal.

from the definition of security quoted at the beginning of this chapter understood as a condition of the lack of threat.

Building a set of indicators which will be used for analysing security is a crucial stage of theoretical considerations since it defines the whole structure of research and directly influences the final result which is the evaluation of security and potential proposal to take up actions aiming at improving it. Building a set of indicators is at the same time very difficult.

Fundamentally it constitutes a thought process analogical to a process taking part in minds of representatives of theoretical line of international relations, referred to as behaviourism. At that time attempts were made to separate general, measurable set of ratios which would define the willingness of states to engage in military conflicts. However, the reality appeared to be too complicated to measure it thoroughly and it was not possible to discover the objective reasons of war. The same factors in some historical periods contributed to stability and peace, whereas in others they triggered instability and war. Hence, the input of behaviourism with regard to possibility to explain and most of all to predict conflicts was limited.[25]

The failure of behaviourism in its attempts to measure and explain social phenomena such as military conflicts is not optimistic as it can point at the general weakness of science with regard to attempts to study and predict the security issues. A similar course of events can happen in the case of a set of indicators which was proposed in this elaboration in relation to energy security. One must realize that even the most developed set of indicators will not be exhaustive, and what is more it will not guarantee that result of evaluation prepared on its basis will be unequivocal and accurate. If the task to separate and measure the factors which determine the level of energy security of a given country is difficult but feasible, then however the allocation of relevant weights to particular factors seems to be a task encumbered with a high risk of error. An example can be the above mentioned set of security indicators by R. Riedel. In this juxtaposition one can notice "stability of supplies" and "reliability of networks" side by side. Although the first one is slightly imprecise: it is not clear whether it refers to supplies of raw materials or supplies of energy to final recipients, both factors were adequately distinguished. To indicate which factor is more significant proves to be very difficult. Provided that R. Riedel wrote about supplies of energy raw materials, we may assume that it is a more important factor, since even the most efficient transmission network will be useless if there is no energy inside, and there will be no energy if the stability of raw material supplies is not guaranteed. On the other hand, from the perspective of final recipient ensuring the stability of supplies is useless unless there exists a functioning, efficient energy network. Hence, theoretically it can be assumed that both factors are equally valid. However, other indicators from the juxtaposition by R. Riedel cannot be dealt with in the same manner. The previously mentioned term "energy efficiency" is significant

[25] J. Czaputowicz, *op.cit*. p. 76.

for energy security – it was provided correctly, however it is very difficult to weigh this indicator in relation to others. It is known that thanks to increasing the energy efficiency it is possible to lower the losses of energy system by several percent. Hence, it is not as important indicator as "stability of supplies", nevertheless the question how much less important it is remains unanswered.

In order to realize how difficult task it is to measure energy security one must be aware of the fact that it took almost 40 years for International Energy Agency – international organization established to ensure energy security – to build an analytical model designed to measure this phenomenon. The tool is called Model of Short Term Energy Security – MOSES. Even this model, however, does not attempt to measure all dimensions of energy security. It is limited to vulnerabilities of primary energy sources and fuels. It does not cover electricity nor end use sectors.[26]

The set of energy indicators distinguished below is a compilation and supplement of juxtapositions quoted in this elaboration. They are divided into four groups reflecting different dimensions of energy security distinguished by K. Pronińska, namely economic, geostrategic, ecological and institutional.[27] The supplements of juxtapositions quoted aim at providing more precision and details, they do not however negate any of them. In one case only there is a gap in all juxtapositions, namely they disregard the sphere of security connected with activities of multinational corporations. Presumably, it results from a traditional perception of a state understood as a separate entity and the main entity responsible for guaranteeing energy security, as well as the entity possessing or holding the majority stake in the energy sector enterprises, and the perception of the very energy security as a concept pertaining to the given country. Such an approach is not negated in this elaboration, it is assumed however that in globalization era the activity of international economic entities (private and state-owned) has a significant impact on energy security of particular countries. In order to avoid such an omission a microeconomic dimension of energy security has been introduced in the below juxtaposition. It aims at taking into account the threats resulting from the existence of market structures which distort competitiveness, i.e. state-owned and private monopolies and oligopolies and those connected with penetration of a given energy market by international entities.

A specific weight was not allocated to particular indicators since, as shown above, such a procedure would not have enough chances to defend against justified criticism.

I) economic:
a) macroeconomic in the global scale
   i) global levels of resources of energy raw materials (divided into: crude oil, natural gas, coal, nuclear energy, renewable energy sources)

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[26] *Measuring Short Term Energy Security*, International Energy Agency, OECD/IEA, Paris 2011, pp. 1, 2.

[27] K. Pronińska, *op.cit.*, p. 308.

(1) levels of risk of depleting the resources of particular raw materials in the earth (the risk of "raw materials shock"[28])
ii) the structure of global energy balance
iii) demand and supply trends on the global energy market (divided into: crude oil, natural gas, coal, nuclear energy, renewable energy sources)
iv) price levels of energy raw materials (divided into: crude oil, natural gas, coal, nuclear energy, renewable energy sources) and electricity

b) macroeconomic in the national scale
i) the structure of the national energy balance
ii) national level of resources of energy raw materials (divided into: crude oil, natural gas, coal, nuclear energy, nuclear energy sources)
(1) levels of risk of depleting the national resources of particular raw materials (the risk of "raw materials shock"), i.e. in other words the viability of resources
(2) energy self-sufficiency[29]
iii) concentration of energy-intensive industries[30]
iv) demand and supply trends on the national energy market (divided into: crude oil, natural gas, coal, nuclear energy, renewable energy sources)
v) price levels of energy raw materials (divided into: crude oil, natural gas, coal, nuclear energy, renewable energy sources) and electricity
vi) relations between the consumption of energy and economic growth, and projections of changes in demand for energy in the future (divided into electricity and liquid fuels)
vii) ratio of electricity and fuel prices to income

c) microeconomic
i) ownership structure, activities on the local market and penetration of this market by global economic entities of energy sector, in the context of energy security
(1) activity of *Sovereign Wealth Funds*
(2) activity of state-owned entities of energy sector belonging to other states
(3) activity of multinational energy corporations
ii) level of competitiveness of the national energy market, ownership structure and activity of local economic entities of the energy sector in the context of energy security
(1) threats related to the existence of monopolies, particularly state-owned monopolies
(2) threats connected with the existence of oligopolies

[28] *Ibidem*, p. 309.
[29] M. Kaliski, D. Staśko, *Bezpieczeństwo energetyczne*…, p. 137.
[30] R. Riedel, *op.cit.*, p. 21.

(3) liquidity of economic entities from the energy sector, i.e. the capacity to service short-term liabilities, divided into current liability (including the amount of stock) and quick liability (the stocks are deducted)[31]
(4) net profitability of the economic entities from the energy sector[32]

d) technical
   i) efficiency and reliability of transportation system of the imported energy raw materials to power stations or refineries (divided into crude oil, natural gas, coal)
      (1) level of risk of transportation system failure, including pipeline explosions
   ii) efficiency and reliability of the system of extraction of own energy sources and their transportation to power stations or refineries (divided into crude oil, natural gas, coal)
      (1) level of risk of oil and gas fields explosion
      (2) level of risk of serious accidents in coal mines
      (3) level of risk of social unrest at the locations where energy raw materials are extracted
      (4) level of risk of terrorist or cyber attack on the mining sector
   iii) reliability of the electricity generation system (technical condition and relations of installed capacity to actual capacity) (divided into: crude oil, natural gas, coal, nuclear energy, renewable energy sources)
      (1) level of risk of a serious power station or refinery failure
      (2) level of risk of total halting of supplies (*blackout*)
      (3) level of risk of terrorist or cyber attack on the energy generation system
   iv) reliability of the distribution grid infrastructure, efficiency of operations and removal of malfunctions
   v) level of sophistication, availability and reliability of the liquid and gaseous fuels production and distribution system
   vi) availability of electricity for final recipient (country's coverage of energy network)
   vii) amount of undelivered energy[33]
   viii) time of undelivered power[34]
   ix) adequacy of domestic and foreign investments into energy system in relation to needs (divided into: crude oil, natural gas, coal, nuclear energy, renewable energy sources)

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[31] M. Kaliski, D. Staśko, *Bezpieczeństwo energetyczne*…, p. 138.
[32] *Ibidem*.
[33] *Ibidem*.
[34] *Ibidem*.

x) energy efficiency of the economy (energy intensity)[35]

II) geostrategic:

a) diversification levels of:

i) sources (diversification of energy carrier supply sources)[36]

ii) transmission channels[37]

iii) energy raw materials used for production of energy calculated by applying Stirling ratio[38]

b) share of imported energy fuels in energy balance (import dependency)[39]

c) export dependency

d) stability of energy raw materials supplies[40]

i) level of risk of infringing the contracts on raw materials supplies[41]

ii) existing embargoes on delivery of raw materials to analysed country and risk of imposing embargoes on trading with other countries

iii) level of risk of military conflicts triggering a distortion or stoppage of production and, consequently, the export[42]

iv) risk of blocking supplies of energy raw materials by a transit country

v) risk of blocking the so-called *chokepoints,* located on the energy raw materials transportation routes[43]

vi) level of risk of terrorist or cyber attack on the transmission network, oil terminals, LNG terminals, oil tankers

e) amount, sufficiency and share of reserves of energy fuels and raw materials, i.e. amount of stocks[44]

f) existence and potential capacity of interconnectors with other energy systems, as well as possibility and readiness of external entities to share energy raw materials

III) ecological

a) share of energy obtained from renewable sources in the general energy balance (renewable energy share)[45]

b) emissions of the energy sector – pollution emitted into the environment (CO2 emissions)[46]

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[35] *Ibidem*.

[36] R. Riedel, *op.cit.*, p. 20.

[37] *Ibidem*.

[38] M. Kaliski, D. Staśko, *Bezpieczeństwo energetyczne*…, p. 137.

[39] *Ibidem*; *Measuring Short*…, p. 4.

[40] R. Riedel, *op.cit.*, p. 20; *Measuring Short*…, p. 4.

[41] K. Pronińska, *op.cit*., p. 309.

[42] *Ibidem*.

[43] *Ibidem*.

[44] M. Kaliski, D. Staśko, *Bezpieczeństwo energetyczne*…, p. 137; *Measuring Short*…, p. 4.

[45] M. Kaliski, D. Staśko, *Bezpieczeństwo energetyczne*…, p. 138.

[46] *Ibidem*.

c) amount of combined power generation[47]

d) domestic and international obligations connected with environmental protection

IV) institutional, political and social

a) political environment[48], including political obligations connected indirectly or directly with energy and possibilities of implementing them

b) international obligation connected indirectly or directly with energy and possibilities of implementing them

c) adequacy of priorities of energy strategies of a state with regard to needs and their compatibility with other documents of a strategic nature[49]

d) implementation of energy strategy targets[50]

e) quality of system legislation and regulation[51]

f) social stability

The largest set of indicators, namely "economic" one aims at describing the energy market. Two sets of macroeconomic indicators show availability of energy resources, first in the global scale, second in the national scale. In the globalized world one is closely interlinked with another. Globalization justifies using them both when assessing domestic energy security. The set of microeconomic indicators aims at showing the structure of the energy market and the role of its key players. It should showcase degree of the market openness and competitiveness as well as risks related to free market distortions.

Technical indicators are aimed at describing energy production, transportation and distribution from the point of view of the energy system technical condition and reliability.

Geostrategic indicators show threats to energy security resulting from international situation, level of international cooperation and capacity for energy independence.

The set of ecological indicators is meant to showcase the limits or even threats to energy security posed by desire for environment and climate protection and by international and domestic norms and regulations in this sphere.

The set of institutional, political and social indicators is designed for describing energy security threats posed by political environment, domestic and international legal and normative requirements (other than ecological), as well as demands for energy sector resulting from the level of social and economic development.

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[47] *Ibidem*.

[48] *Ibidem*, p. 139.

[49] R. Riedel, *op.cit*., p. 21.

[50] *Ibidem*.

[51] M. Kaliski, D. Staśko, *Bezpieczeństwo energetyczne*…, p. 139.

3.2. Measurability of energy security indicators

An example of a quantitative approach to the issue of energy security can be the above quoted publication by B. Bhaskar, who analysed two indicators, namely the share of imported energy in the total energy consumption and the share of domestic energy production in the total energy consumption. He claimed that these indicators show the level of energy security.[52] This approach contains a significant error, as these indicators show in reality only the self-sufficiency/independence of the national energy system.

The basic quantitative indicators of energy security were presented in the paper *Rola krajowej infrastruktury paliwowo-surowcowej w kształtowaniu bezpieczeństwa energetycznego Polski*[53] (*The role of national fuel and raw material infrastructure in creating energy security of Poland*). They include: energy supplies diversification, i.e. Stirling indicator, country's energy self-sufficiency, import dependency, export dependency, energy carriers stocks, liquidity of energy enterprises and their net profitability. Other quantitative indicators can be added such as viability of resources and failure rate, i.e. time of undelivered power and amount of undelivered energy.

A set of 30 quantitative indicators is a basis of the IEA's analytical model MOSES, quoted above. Indicators of net import dependence, political stability of suppliers, number of entry points for import and diversity of suppliers are used to measure energy security of fuels and primary energy resources like oil, oil products, gas and coal. Indicators of stock levels or capacity of storages are used for oil, oil products and gas. Moreover series of exclusive indicators designed to measure single energy source are used in this model. Namely proportion of offshore production and volatility of domestic production to measure oil security, number of refineries and flexibility of refining infrastructure for oil products, proportion of offshore production, natural gas intensity for natural gas, proportion of mining underground for coal and annual volatility of production for hydropower. A separate set of indicators is used for nuclear power, namely unplanned outage rate, average age of nuclear power plants, diversity of reactor models and number of nuclear power plants. Each indicator has been given o band of values corresponding to low, medium and high vulnerability. The bands of values are based on the observed ranges in the IEA member states and on expert judgments.[54]

Definitely the most comprehensive approach to energy security research in the analysed publications, matching the quantitative and qualitative analysis methods within a single multidimensional energy security model aggregating the values of both types of indicators in a single coherent assessment expressed in figures was proposed in the monograph *Bezpieczeństwo energetyczne w gospodarce paliwowej*

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[52] B. Bhaskar, *op.cit*., p. 273.

[53] M. Kaliski, D. Staśko, Rola krajowej infrastruktury paliwowo surowcowej w kształtowaniu bezpieczeństwa energetycznego Polski, *Rurociągi* 2003, no. 2–3/32/2003, pp. 4–6.

[54] *Measuring Short*…, pp. 3, 4

Polski (*Energy security in fuel economy of Poland*).[55] Apart from the above mentioned quantitative indicators a series of qualitative indicators was proposed such as diversification of energy carrier supplies, technical and economic condition of the sector, wealth of recipients, investment costs and location of sources of supply, quality of legislation and regulation of the system, political environment, social and economic stability. A numerical value was attributed to each of them.

These publications show that energy security can be approached with the application of quantitative research methods, and it is also possible to build multi-index models combining quantitative and qualitative approach.

3.3. Energy security evaluation on the basis of ratio analysis

Finally, a question must be answered about the possibility of drawing conclusions on energy security level and on the possibility of building a multidimensional model to analyse energy security taking into account and considering all of its aspects in an unequivocal and unquestionable way. The most comprehensive approach to energy security research – *Bezpieczeństwo energetyczne w gospodarce paliwowej Polski*[56] (*Energy security in fuel economy of Poland*) demonstrates that such a possibility exists, nevertheless it is an extremely complicated task, exceptionally laborious and additionally encumbered with a risk of error. First, the proposed mode is based on one of energy security definitions, but as shown above, there are at least several definitions available. An unequivocal evaluation of a phenomenon which is understood in many ways is not possible. Second, the authors point out that the evaluation of many criteria is unavoidably discretionary, and additionally discretion applies with regard to defining relevance (weight) of specific indicators. Such a discretion can significantly affect the final result of the analysis. Third, multi-index character of a quantitative energy security evaluation model is a strength on the one hand and a weakness on the other, since in effect the influence of a single indicator value on the final evaluation is very limited. This may lead to a situation where the worsening of one indicator of energy security will not trigger a change in the general evaluation of security. If accidently this particular deteriorating element consists of political environment indicator, in the case of which the weakest grade is equivalent to open conflict with a neighbouring country, and this conflict was to be escalated into a military conflict, the whole energy security of a state could be seriously exposed to risk. However, the multifactorial model of security analysis may not capture this change. In spite of its limitations, this method is useful and it can be treated as a reference method, particularly in case of comparisons of energy security within a given state in various time-series.

In the case of international comparisons, where the above limitations are accompanied by the issues of availability, comparability and reliability of data,

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[55] M. Kaliski, D. Staśko, *Bezpieczeństwo energetyczne*…, pp. 107–162.

[56] *Ibidem*.

the application of a multi-dimensional model of energy security will be even more difficult. Owing to this, in many elaborations on energy security in international dimension the application of energy security model is avoided, instead an analytical and descriptive method is preferred, matching statistical data with a description and conclusions.

4. Conclusions

The definition of energy security proposed in this elaboration is short, easy and operational. Energy security is simply defined as "a lack of threat to availability of affordably priced energy, meeting adequate quality and ecological parameters." Despite being short it addresses all key elements of the energy security phenomenon. The indicators proposed in the text reflect key elements of this definition. The core of the definition, namely the word "availability" is reflected by all economic, geostrategic and technical indicators. The set of economic indicators also addresses "affordably priced energy." "Adequate quality" is described by technical indicators. "Ecological parameters" are described by ecological indicators.

Unfortunately, one must admit that formulating definitive, unequivocal opinions with regard to such a complicated issue as energy security is extremely difficult and bearing a high risk of error, especially when international comparisons are considered. Alternative analytical models are either too simplistic to reflect complexity of the phenomenon or too complicated to be operational. Hopefully the set of indicators proposed in this text is comprehensive enough to assess energy security in detailed way and in the same time it is not too large to be usable. Proposed set of indicators needs to be tested in practice. Only then it could prove to be useful and valuable.

Being difficult does not mean, however, that international analysis of energy security is not possible at all. It is just on the contrary, one must be aware of the existing limitations. Obviously, it is possible to measure selected indicators and draw relevant conclusions. Such an approach will demonstrate a section of the whole picture, but it will be free of errors resulting from data aggregation. It is also possible to describe the particular qualitative indicators meticulously. Such an approach will allow for a reliable, multi-aspect description of the situation, useful in international comparisons. Unfortunately, it will allow for formulating opinions only at a very general level.

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POJĘCIE BEZPIECZEŃSTWA ENERGETYCZNEGO – PODEJŚCIE DO CAŁOŚCIOWEJ ANALIZY

Streszczenie: W artykule zestawiono różne podejścia do zagadnienia bezpieczeństwa energetycznego, stosowane w praktyce oraz w literaturze naukowej i poddano je krytycznej analizie. Na tej podstawie zidentyfikowano najbardziej trafną definicję pojęcia. W oparciu o istniejącą literaturę oraz własne przemyślenia, udało się zaproponować w miarę kompletny i uniwersalny zestaw wskaźników przydatnych do opisu bezpieczeństwa energetycznego oraz poddano pod rozwagę możliwość kwantyfikacji tych wskaźników. Materiał może posłużyć badaczom bezpieczeństwa międzynarodowego i stosunków międzynarodowych do wykonania analiz porównawczych systemów energetycznych poszczególnych państw. Zaproponowany model badawczy doskonale nadaje się do analizy gospodarek azjatyckich. Artykuł jest oparty na polsko- i obcojęzycznej literaturze przedmiotu.

Słowa kluczowe: bezpieczeństwo energetyczne, energia, wskaźniki, analiza, pomiar.