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ENERGY SECURITY INTENSIFICATION DETERMINANTS IN THE CHAINS OF FINAL ENERGY VALUE CREATION

Kucęba R., Pabian A., Bylok F.*

Abstract: Presently, in the times of various threats and frequent economic, social and political crises – Energy Security Intensification is of key importance for the constant development of the Global Society. Energy Security is the term that cannot be unequivocally defined and determined in the global grasp. In the economically, ethnically, culturally and socially diversified world there are different views as well as the awareness concerning sources of possible threats and crises. Various threats that can have influence on possible critical situations depend on the regional division. The following threat factors can be distinguished here: resource ones, technological ones, social ones, economic ones and political ones. Geographical differentiation of the above mentioned determinants makes it necessary to adopt a multidimensional attitude to the notion of energy security as well as ecological and economic security.

Key words: energy security, global society, value chain.

Introduction

First part of the present paper introduces definitions and essential issues concerning energy security in the global perspective. It shows different approaches to this notion for various regions, economically well-developed ones being energy resources importers as well as underdeveloped ones being dependent on external energy resources suppliers. The author turns particular attention to the sources of energy threats and crises that ensue from, among other things, the policy of the countries - primary energy owners – that own resources such as natural gas and oil; limited size of their resources and reserves as well as climatic changes. The above mentioned sources stimulate the importance of energy security as a global priority. Thus, the author attempts to unify the definitions of energy security, taking into consideration regional differentiation of energy security intensification determinants. This part of the paper shows the nature of energy security analysis and creation in individual chains of final value creation, such as:

- energy resources supplies (primary energy);
- secondary energy production and transfer;
- primary/secondary energy use.

The proposed approach generates bidirectional information flow in the final energy value chains, in respect to energy security intensification, between energy enterprises - final energy supply party (energy resources providers and producers,

* **Eng. Robert Kucęba, PhD, Assoc. Prof. Arnold Pabian, Assoc. Prof. Felicjan Bylok,** Czestochowa University of Technology, Faculty of Management
✉ corresponding author: robertk@zim.pcz.czest.pl

energy resources providers, secondary energy producers, transmission and distribution enterprises) and consumers – final energy demand party (final energy receivers).
In addition to this, obligatory limitations were introduced in the individual chains of final energy value concerning cost minimizing and energy consumption, energy objects efficiency growth, primary and final energy use minimizing in all areas of human existence and reducing negative influence on the environment and winning social acceptance at the same time.
The second part of the paper contains defined energy security intensification determinants in the particular chains of final energy value creation – energy for final users. They were determined on the basis of the established periodicals and the survey "Energy Security Intensification Determinants" conducted in the representative respondent group (B&R experts in the examined field).
In accordance with the assumptions of energy security presented in the first part of the paper determinant were aggregated in four spatial perspectives, such as: economical, technical, ecological and social ones.

Energy security terminology in the aspect of final energy value creation

According to the energy regulations energy security is defined as such economy state that enables to satisfy current and future demand of the energy and fuel receivers, in a way that is technically and economically justified, respecting the regulations of environment protection [9].
The subject literature contains various elaborations and detailed interpretations of the above mentioned notion. The presented economy state cannot be unequivocally defined due to different perception of this notion by global energy market participants. This is particularly true in case of different time horizons of consideration, heterogenic instruments, which stimulate its fulfillment from the business and political point of view [7]. The energy security notion is widened in the aspect of minimizing its negative influence on the conditions of social life [2].
The energy security definition also comprises the following aspects [1;7;8]:

- reliability of different energy forms supplies, in the amount that satisfies the demand in the specific region; various,
- reliability of securing supplies for final recipients,
- reliability of key infrastructure and its elements to provide the recipients with energy,
- minimizing individual countries and regions economies sensitivity to political and social instability of main energy resources producers,
- treating global security in the grasp of regional security.

The aim of the present paper is to unify the definition of security, taking into consideration the above listed elements in order to realize the assumptions defined in the abstract of the paper. Due to the necessity of including all the stages of final

energy creation and its value, the author introduces the definition of energy security in the system approach.

This means contemporary and future energy demand satisfying in all the links of the final energy creation chain for final consumer. In these links primary energy is acquired, secondary energy is produced; it is transported and distributed, processed into final energy and consumed (used).

In this grasp, there are obligatory limits introduced in the individual links of the final energy creation chain. They concern minimizing costs and energy intensity, energy objects efficiency growth, minimizing primary and final energy use in all the areas of human existence, minimizing the negative influence on the environment and being socially acceptable at the same time.

It must be stated, however, that at present, in the times of economic development, the demand for energy in all its forms is still growing while natural resources of primary energy are limited. Thus, the basic antidote against the threats that may have a negative influence on energy security is decreasing economy energy intensity (indirectly its capital intensity, work intensity and time intensity) in all processes taking place in the individual links of the final energy creation value chain. This supports the conception of the system approach to energy security.

In this context, an individual approach to the energy security in the individual links of the created energy value chain seems reasonable. Moreover, as the definition treats energy security as the economy state, the author proposes its individual, autonomic interpretation in the individual links of the final energy value chain. These include: acquisition and supplies of energy resources; energy production and transport; final energy intensity (primary, secondary – used by final recipients). In this aspect the author introduces three compatible, integral phases of energy security, such as:

- fuel supplies security (energy resources),
- security of secondary energy production and transport (e.g. final energy),
- security of primary/secondary energy use (used by final recipients).

Security of fuel acquisition and supplies means securing reliable and stable supplies of energy resources acquired and transported with the use of low energy- and capital-consuming technologies. The size of the supplies should guarantee satisfying the demands, at accepted by the economy and society prices, assuming optimum use of the national energy resources, including Renewable Energy Sources (RES), and through diversification of supplies sources (imported resources).

Security of secondary energy production and transport in turn, means securing reliable secondary energy production (e.g. electricity), its stable and uninterrupted supplies in the transmission and distribution networks, preserving quality parameters and socially acceptable prices, with the maximum use of national energy and energy-saving resources, low capital-consuming, environmentally friendly technologies, in the production processes.

Security of primary/secondary energy use is an equally important condition, which directly comprises actions concerning optimum primary/secondary energy use, in the low energy-consuming environment (place of use environment infrastructure), according to the individual needs, using energy-saving, low capital-consuming and environmentally friendly technologies.
Energy security, in its system grasp, is considered in all energy sub-systems, where final energy value for the final recipient-consumer is generated.

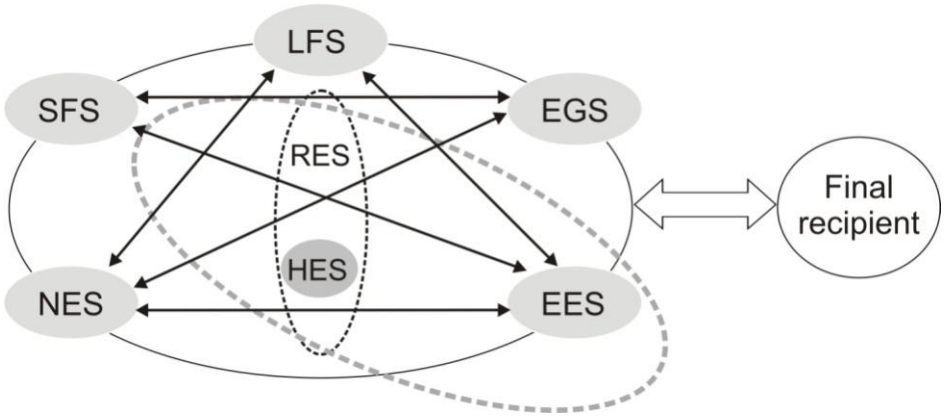

Figure 1. Network of mutual connections of energy sub-systems
Source: Own analysis

Basically, there are five sub-systems distinguished in the Energy System, in all scales of economic space. These include: SFS – solid fuels sub-system, LFS – liquid fuels sub-system, EGS – sub-systems in which processes of energy resources acquisition, processing, transport and use are realized. EES – electro-energy sub-system, in turn, as well as NES – nuclear energy sub-system, are sub-systems of secondary energy – electricity – production, transport, distribution and use. In the local perspective (e.g. micro-regions) of the Energy System additional sub-systems are distinguished. These include: HES – heat-energy sub-system, RES – renewable energy resources sub-system. The RES sub-system generated and functioning in the regional perspective belongs to the group of secondary energy – heat - production, transport, distribution and use. The HES sub-system is also an interesting one. There are both, primary energy acquisition, processing and transport, as well as secondary energy production, transport and distribution processes realized in it [3].
Figure 2 presents a simplified graph of the created final energy value chain (on the example of creating electricity value), taking into consideration its basic links and phases of energy security growth in individual sub-systems. In this grasp basic groups and enterprise groups in the links of the chain of energy value creation for the final recipient.

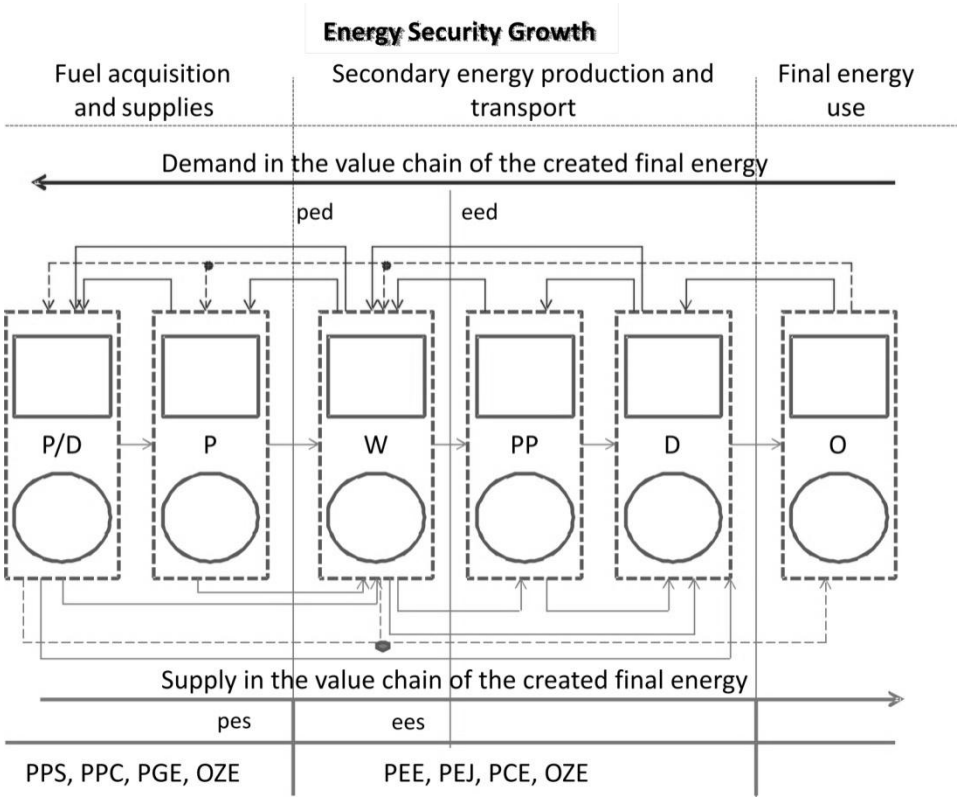

Figure 2. Value chain of the created final energy, including energy security growth
Source: Own analysis

Where: P/D – Enterprises that realize processes of energy resources acquisition and distribution, P- Enterprises that realize processes of primary fuels treating and processing, W – Enterprises producing secondary energy – electricity, PP – Enterprises that transport electricity, D- Enterprises that realize processes of electricity distribution, O- Final electricity recipients, pes- primary energy supply, ees- electricity supply, ped – primary energy demand, eed – electricity demand

Determinants of energy security intensification including dispersed generation

Individual stages of energy security growth in the system grasp are autonomous, because they require an individualized approach, with respect to their planning, coordination, organization, realization and securing energy for final recipients – consumers. The autonomy of the individual states results from their peculiar, multi-criteria growth determinants.

Energy security growth determinants in its particular phases were defined on the basis of the literature study of the legislative documents as well as interviews in the

enterprises in the area of energy acquisition, energy production, transport, distribution and supplies.
According to the legislative definition of energy security [9], growth determinants were determined in the following four categories: economical, technical, ecological and social ones.
All the defined determinants in the individual phases of energy growth for final recipients were evaluated by selected experts in the field of energy management and energy security. They were listed in tables 1-3, accordingly to the particular phases of energy security growth: fuel acquisition and supplies, secondary energy production and transport, primary/secondary energy use. In order to preserve a synthetic form of the results and limit the introduction of low relevance weight determinants a quantitative criterion of the repeated expert choices was defined by the author.

Table 1. Energy security growth determinants – acquisition and supplies

Fuel supply security	Regionalization / Determinants	Global perspective
	Economic	Diversification of energy resources and sources of their acquisition; Decreasing GDP's energy-intensity in the processes of energy resources output, processing and transporting; Development of competitive primary energy markets; Bigger use of Renewable Energy Sources (RES) including bio-fuels in the energy resources balance; Managing fuel tariffs and their optimization in order to increase the number of the investments in the studied area; Creating energy fuels portfolios, including Renewable Energy Sources (RES);
	Technical	Use of innovative technologies of energy resources output and transport; Building fuel warehouses big enough to ensure supply continuity, in the situations of energy threats and depressions in particular;
	Ecological	Decreasing natural environment degradation, the influence of output sources environment on local fauna and flora; Pollution decrease, both air and water;
	Social	Zero energy economic growth without the increase of primary energy demand; Competitive laws, particularly in the area of hydrocarbon fuels distribution and transport and using Renewable Energy Sources (RES).

Source: own analysis

Table 1 presents growth determinants concerning fuel acquisition and supplies in a chronological order and according to subsequent phases of energy security growth.

The presented energy security growth determinants in the phase of energy resources acquisition and supplies, in four criteria categories, let us observe their mutual compatibility and convergence. In the economic aspect, the nature of the energy resources and their sources diversification must be emphasized, simultaneously minimizing GDP's energy-intensity, in the individual elementary processes concerning energy resources, connected with their acquisition (excavation in case of fossil fuels), processing and transport. Economic growth determinants are directly connected with the technical elements, the implementation of reliable, low energy-consuming and low capital-consuming innovative technologies in particular. They should be implemented in the individual processes of energy resources acquisition and supply. According to the experts minimizing energy-intensity of the power industry through the implementation of innovative technologies contributes in the ecological aspect to minimizing the negative influence of the energy sector on environment, and directly on natural environment degradation of primary energy sources surroundings – decrease in air and water pollution, including subsoil waters. Highly correlated energy security growth determinants stimulate conditions for strengthening energy subjects' competitive position, operating in the area of fuel acquisition and supplies - with social acceptance.

Table 2 presents energy security growth determinants concerning secondary energy production and transport.

Table 2. Energy security growth determinants – secondary energy production and transport

Secondary Energy Security	Regionalization / Determinants	Global perspective
Production and Transport	Economical	Decrease of GDP's energy-intensity In the processes of energy production, transport and distribution; Vertical and horizontal consolidation in the field of production, transport and distribution; Satisfying customers' electricity demand at optimum cost of its production, transport and distribution; Developing competitive mechanisms as the main means of energy prices rationalization; Search for and implementing effective tools of electricity balancing on futures markets, including intra-day ones; Individual cost of energy supplies identification and allocation;

		Creating floating spot market and futures markets of electricity; Diversifying energy production sources, transport and distribution – designing portfolios of energy, energy production sources as well as transport and distributive sources, in reference to secondary energy quality improvement.
	Technical	Increase of secondary energy efficiency production – building highly-effective production units; Increased production of electricity produced in highly-effective technology Cogeneration; Increased number of emergency sources of energy production; Limiting network losses during transport and distribution through modernization of present and building new highly-effective networks, distribution stations; Development and growth of dispersed generation sources in the Energy System, including micro-generation – using local energy sources; Development and growth of Renewable Energy Sources (RES) in the Energy System; Transborder networks development; Extension and demonopolization of transmission and distribution networks stimulating dispersed energy development; Transmission and distribution networks modernization so as to decrease their damage vulnerability and energy losses in these networks.
	Ecological	Limiting water and natural environment contamination; Limiting power industry's negative influence on fauna and flora; Limiting CO_2 emission in the amount that is technically attainable, balancing the demand and the supply; Limiting SO_2, NO_x and dusts emission to the levels that ensue from the present and future regulations at global and European Union's level; Change of energy production structure towards low-emission technologies and increased importance of conjugated and dispersed sources; Minimizing negative influence of the electro-magnetic field in the transmission lines on the environment; Implementing technologies of capturing and storing CO_2, for example CCS technologies.
	Social	Social acceptance of environmental subventions; Social acceptance of infrastructural changes in the area of energy production and transport;

		Zero energy economic growth without increased the demand for primary energy in the secondary energy production processes.

Source: own analysis

Presented in Table 2 energy security growth determinants in the area of energy production and transport in economic aspect concern GDP's energy-intensity minimizing, in the discussed range. Moreover, they show the nature of competitiveness improvement as the main means of energy prices rationalization. In this aspect, the improvement of competitiveness means balanced competition development in the area of secondary energy production, transport and distribution, simultaneously acting against the negative influence of natural monopolies, as well as balancing other energy enterprises interests (producers, transmission enterprises, distributors) with the interests of final recipients [5]. Increased competitiveness enhances the actions to improve energy effectiveness. The improvement of competitiveness may constitute an accelerator of GDP's energy-intensity minimizing, energy prices rationalization, with simultaneous creation of secondary energy production and transport sources portfolios, which is connected with their diversification. Creation of secondary energy production and transport sources portfolios guarantees beginning of floating spot market as well as electricity futures markets, balancing energy on futures markets, including intra-day ones, and identification with allocation of secondary energy supplies individual costs.

The significant importance of competition growth balancing is attributed to technical determinants of energy security growth in the area of secondary energy production and transport. In the area of creation of secondary energy production sources portfolios, which is connected with the diversification of production sources, particular importance is attributed to:

- energy sources number growth in highly-effective cogeneration,
- increased number of emergency energy production sources,
- increased number of dispersed energy sources, micro-generations using local energy sources, including Renewable Energy Sources (RES).

The increased number of installations of the mentioned sources in the Energy System directly influences secondary energy production growth, especially electricity. Moreover, it increases diversification level of the secondary energy production sources in the system. Particular attention in the process of secondary energy production sources diversification is assigned to the growth of Renewable Energy Sources (RES) share in the secondary energy production balance. RES growth is stimulated through the legislative guidelines: global, European Union's and national ones. Secondary energy production sources diversification differentiates producers as well, in relation to production costs, production energy-intensity, and electricity production effectiveness.

In the area of transport and distribution sources energy portfolios creation in turn, technical growth determinants are (table 2):

- transboarder networks development,
- extension and demonopolization of transmission and distribution networks stimulating dispersed energy development,
- transmission and distribution networks modernization so as to decrease their damage vulnerability and energy losses in these networks,
- building intelligent networks in the distribution area, for example SmartGrid.

Effectiveness improvement in the area of energy production, transport and distribution, implementing highly-effective, low-emission technologies together with transport and production sources diversification, limit energy's negative influence on the environment. This primarily concerns (table 2):

- natural environment contamination,
- energy's harmful influence in the area of production and transport on fauna and flora,
- limiting CO2 emission in the amount that is technically attainable, balancing the demand and the supply,
- limiting SO2, NOx and dusts emission to the levels that ensue from the present and future regulations at global and European Union's level.

Table 3. Energy security growth determinants – primary/secondary energy use

Primary/Secondary Energy Use Security	Regionalization / Determinants	**National perspective**
	Economical	Decreasing GDP's energy-intensity in the process of energy use by final recipients; Final recipients Energy providers diversification as a decisive factor in energy prices rationalization; Identification and allocation of individual sources of final energy use costs by final recipients; Adjusting energy tariffs to the final user characteristics; Rational energy use so as to minimize the costs; Final energy sources diversification in order to satisfy final recipients needs;
	Technical	Using innovative highly-effective final energy receivers; Decreasing environment infrastructure's energy-intensity; Using low-emission technologies by final energy recipients; Using automatic control and regulation technologies in order to adjust optimally energy use to the needs

		of the users; Using energy hybrids, including use of RES; Developing emergency power sources so as to increase the reliability of final energy supplies and use;
	Ecological	Limiting emission of dusts, waste and CO_2; Using energy receivers minimizing their negative influence in the process of use on user's environment and natural environment;
	Social	Social acceptance of energy prices and tariffs with simultaneous energy-intensity minimizing; Social acceptance of practices and actions concerning energy effectiveness improvement; Rational energy use; Increasing energy saving by final recipients through the use of energy-saving receivers in the energy-saving environment; Increased effectiveness of final energy use.

Source: own analysis

Ecological determinants presented in Table 2 include installation of innovative technologies of capturing and storing carbon dioxide, for example CSS technologies (Carbon Capture and Storage). It must be emphasized here that ecological determinants are compatible with technical and economical determinants, which affects energy security growth in the area of energy production and transport. At the same time, in the social aspect, the generated security growth determinants should be fully accepted by the society. This concerns particularly investments of secondary energy production, transport and distribution sources diversification and infrastructural changes in this area.

Table 3 shows energy security growth determinants in the area of primary/secondary energy use.

In the aspect of primary and secondary energy use by final recipients superior meaning is attributed to the actions that aim at minimizing GDP's energy-intensity. This decreases final energy use costs, which at this stage, can be both primary and secondary energy [6]. Cost minimizing is connected not only with the energy-intensity minimizing, but also with its rational management and use of energy-saving appliances – in the energy-saving environment. Thus, a closed loop is created here, between energy-intensity minimizing – energy effectiveness increase – rational energy use – management and minimizing the costs of its use. In this loop energy growth security determinants join and affect themselves: technical and economic ones, cushioning negative influence of the energy industry on the natural environment, surroundings and social life conditions. A vital element of growth, in the light of energy use, is free access to competitive final energy suppliers and sources.

In table 3, in the technical aspect, energy security growth element was introduced. It concerns backup energy sources development at final recipients, in order to increase final energy supplies and use reliability. In the technical aspects, necessity of diversifying energy sources for final recipients was indicated, which can be done through installation and use of Renewable Energy Sources (RES). These sources, as direct energy carriers, can works as autonomous ones or in energy hybrids, integrated with non-renewable energy sources. Energy security growth determinants, in the ecological aspect, similarly to the rest of the energy growth links, concern limiting: CO2 emission, generating harmful for the user environment dusts and waste – final recipients and the natural environment.
The presented growth determinants in all criteria categories are compatible in the phase of ensuring energy use security, they join and affect themselves – they require social awareness and acceptance.

Summary

To sum up, economic, technical, ecological and social determinants in individual autonomous phases of energy security growth interact and affect themselves. They are convergent, compatible and integral. Strong relationships among individual conditions of energy security must be emphasized here. Relationships among autonomous states taking place in the individual links constitute one common system – final energy value chain, in the light of energy security. The increase in their integration level, compatibility and convergence affect synergically the value of the final product's value and energy security, considered in this context as an integrated system.

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DETERMINANTY INTENSYFIKACJI BEZPIECZEŃSTWA ENERGETYCZNEGO W ŁAŃCUCHACH TWORZENIA WARTOŚCI ENERGII FINALNEJ

Streszczenie: W referacie przedstawiono aktualne zagadnienia z zakresu bezpieczeństwa energetycznego. Zaproponowano systemowe podejście definiowania i analizy bezpieczeństwa energetycznego. Na podstawie badań empirycznych wyznaczono: ekonomiczne, społeczne, ekologiczne oraz techniczne determinanty intensyfikacji bezpieczeństwa energetycznego. Determinanty intensyfikacji bezpieczeństwa energetycznego zestawiono, w poszczególnych ogniwach łańcucha tworzenia wartości energii finalnej dla konsumentów, wprowadzając fazy wzrostu bezpieczeństwa omawianego sektora gospodarczego.

能源安全在最终能源价值创造链中的影响效应加剧

摘要：在经济，种族，文化和社会多元化的世界中对于危机和潜在威胁存在着不同的看法。能够导致可能危机情况的多种威胁取决于不同的区域划分。威胁要素可以被分为以下几种：资源，**技**术，**社会**，经济和政治。