AVAILABILITY AS A DIMENSION OF ENERGY SECURITY IN THE REPUBLIC OF SERBIA

by

Boban S. PAVLOVIĆ * **and Dejan D. IVEZIĆ**

Faculty of Mining and Geology, University of Belgrade, Belgrade, Serbia

Original scientific paper
DOI:10.2298/TSCI160923303P

There is a range of modern approaches and models in literature for the evaluation and determination of energy security, which are based on different parameters and indicators. For most of them, a common characteristic is emphasizing the availability of energy, as an important dimension for ensuring energy security. In this paper, concise overview of Serbian energy sectors is given and appropriate energy indicators are defined and determined. Selected indicators provide insight into the main components that characterize availability – security of supply, self-sufficiency, diversification of energy sources, the level of renewable energy use, and technological maturity. Besides calculation of energy indicators, the aim is to investigate and establish the relationships among components of availability of energy in Republic of Serbia, and to provide some recommendations for the policy makers to develop efficacious measures for enhancing energy security. Therefore, analytic hierarchy process methodology is applied to analyse collected data, to reveal cause – effect relationships, and to prioritize components of availability mutually. Conclusion is that the main activities in Serbian energy sector should be directed to improvement of energy efficiency, increase the use of renewable energy sources and diversification of energy sources and energy imports directions.

Key words: *availability of energy, energy indicators, energy security*

Introduction

The increase of world population, along with the growth of quality of life, certainly leads to increasing demand for energy. Consumers around the world are facing with the problem of security of supply, volatility of energy prices, environmental degradation caused by energy activities, and other risks that may jeopardize general social stability and economic development. Integration of all these problems leads to an issue of energy security.

For this reason, there is a tendency to formulate and develop models that should establish correlations between the various factors of energy security, and finally, link them into a logical system. Multi-dimensional nature of energy security is the starting point of various scientific studies dealing with energy issues [1]. In many of these studies, availability of energy is pointed out as the most important dimension and with the greatest influence on the overall energy security [1-7]. In essence, availability represents the physical presence of energy resources, as well as possibility of the community to use these resources. Within the availability, there are numerous influential components whose individual contribution and effects should be evaluated.

* Corresponding author, e-mail: boban_pavlovic@hotmail.rs

In this paper the review the existing literature in the field of energy security is given, as well as the analysis of thematic framework and dimensions of energy security. The focus is on a single dimension of energy security – availability. Availability is analysed using components proposed and described in [1]. However, instead of complex fuzzy approach, each component of availability is analysed by using selected set of indicators. Analytic hierarchy process (AHP) methodology is proposed and implemented for analysis of obtained indicators, their interactions and specific importance to availability performance. The proposed procedure for availability indicator determination and their evaluation by AHP is implemented for determination of availability – as a dimension of energy security in Serbia.

Concept and dimensions of energy security

Very often energy security has different meaning in different situations and to different people. Definitions of energy security vary from continuous supply of oil to the environmentally acceptable and financially affordable energy. The variety of meanings and interpretations may seem confusing and impractical from the standpoint of empirical approaches, but as some authors have pointed out [2], it might not be necessary. In some cases, it may mean that one and the same concept has different forms under different conditions.

Energy security has traditionally been associated with the securing of access to oil supplies and with impending fossil fuel depletion [3]. Today, International Energy Agency (IEA) defines energy security as *the uninterrupted availability of energy sources at an affordable price* [4]. Although IEA definition is widely accepted, different countries have the different interpretation of the concept. In addition to that, energy security has to involve main values and principles of a specific national energy policy [5]. Nowadays, energy security is also closely involved with other issues, such as security of infrastructure, equality of access to modern energy technologies, energy efficiency, and climate change mitigation [6].

The Asia Pacific Energy Research Centre (APERC) [7] defines energy security as the ability of an economy to guarantee the availability of energy resource supply in a sustainable and timely manner with the energy price being at a level that will not adversely affect the economic performance of the economy. Thus, there are several factors that can influence the energy security [7]:

– the availability of reserves, both indigenously and by foreign suppliers,
– the ability of an economy to acquire supply to meet projected energy demand,
– the level of an economy's energy resource diversification and energy supplier diversification,
– the accessibility to resources, in terms of the availability of related energy infrastructure and energy transportation infrastructure, and
– geopolitical relations.

In order to provide a framework for identifying, measuring and managing vulnerabilities of an energy system, energy security can be defined as a low level of vulnerability of the vital components of the energy system, *i. e.* energy sources, infrastructure, technological development [2]. Vulnerabilities represent combinations of exposure to risks and resilience capacities.

If the premise that energy security requires an interdisciplinary approach is accepted, energy security can be defined as equitably providing available, affordable, efficient, environmentally neutral, proactively governed, and socially acceptable energy services to end-users [1]. This definition meets the requirements for the actualization of the topic, because energy security is not based strictly on a secure supply of oil, but also on other sources of energy (*e. g.* coal, natural gas, renewables, and nuclear energy). Besides, it emphasizes the different nature and origin of threats to some energy system, as well as the long-term perspective of sustainable development and environmental protection.

Many studies developed multi-dimensional approach for conceptualizing energy security and determination of energy indicators [1-6]. Selection of data used for indicators determination primarily depends on the vision of a multi-dimensional concept of energy security, and from the selection of critical dimensions for functioning of the energy system and its safety.

In APERC report on energy security in Asia [7], availability and affordability are merged with acceptability and accessibility, as four main dimensions of energy security, also known as *the four As*. So called, *the four As* has become well known throughout the scientific literature in the field of energy. Many studies have conceptualized energy security by liberally adding or modifying existing model of *the four As*.

Availability and its indicators

Availability, as a dimension of energy security, is very often highlighted as the most dominant dimension of energy security [3-5]. Based on the analysis of reviewed scientific papers within a period of 40 years in 22 countries [6], availability was the most frequently used dimension of energy security (81% of articles), rather than affordability (51%), efficiency (34%), and environmental acceptability (26%). Availability was considered by using broad definition as *diversifying the fuels used to provide energy services as well as the location of facilities using those fuels and minimizing dependence on foreign suppliers*.

Following this definition, availability is analysed in this paper by five distinct components, as it was suggested in [1]: security of supply, self-sufficiency, diversification, renewable energy sources, and technological maturity. For each of these components, appropriate indicator or a set of indicators should be determined. Their purpose is to provide synthesized information about availability's component and to evaluate their significance, to assist in the process of defining the objectives of energy policies, and to monitor the implementation of activities aimed to improve level of availability.

Security of supply

Security of supply (SOS) determines an ability of the specific energy system to depend on its own resources in energy production, and shows its import dependency. The SOS may be represented by the ration of net imports and total available primary energy consumption (SOS_1) within a given year.

The second indicator of SOS is the ration of the stocks of critical fuels and corresponding annual fuel consumption (SOS_2). The purpose of this indicator is to measure the availability of national stocks of critical fuels with respect to corresponding fuel consumption [8]. A fuel stock over fuel consumption represents a type of a *response* indicator that might be important to countries in critical fuel supply situations, such as world oil crisis, disruptions of natural gas distribution systems, *etc.* [8].

Self-sufficiency

Self-sufficiency (SS) can be defined as the ability of energy system to rely on indigenous reserves and resources in energy production. It can be measured by the ration of reserves to annual production (SS_1).

The purpose of this indicator is to determine the availability of national energy reserves with respect to corresponding fuel production. Reserves are generally defined as identified (demonstrated and inferred) resources that are economically recoverable at the time of assessment. Those are quantities that geologic and engineering information indicates that can be recovered with reasonable certainty in the future, from known or identified energy resources and under existing economic and technical conditions [8]. Values of this indicator represent the number of remaining years until the exhaustion of reserves, with the current level of consumption

Another indicator for measuring SS can be the ration of resources and production (SS_2). Resources are generally defined as concentrations of naturally occurring solid, liquid or gaseous material in or on the Earth's crust in a form that makes economic extraction potentially feasible. Total resources include reserves, and hypothetical and speculative undiscovered resources [8]. The values of this indicator represent the number of remaining years until the exhaustion of resources assuming the current level of consumption.

Diversification

Diversification (D) reflects the diversity of used energy sources for energy supply, and the ability to mitigate the risk caused by overdependence on several major energy sources. It can be measured by a diversity index of the possible energy resources for supply, such as the Shannon index (also known as a Shannon-Wiener index). Shannon's index accounts for both abundance and evenness of the presented energy sources [1].

Renewable energy sources

Renewable energy sources (RES) indicators measure the share of [8] RES in total primary energy supply (TPES) (RES_1) and the share of RES in total final consumption (TFC) (RES_2). The TPES is calculated as the sum of primary production and import, less to the sum of export, stock changes, bunkers, and statistical difference [9]. The TFC from RES is calculated as the sum of gross final consumption of electricity from RES, gross final consumption of energy from renewable sources for heating and cooling and gross final consumption of energy from renewable sources in transport [10].

Technological maturity

Technological maturity (TM) can be measured by the set of indicators of efficiency of energy conversion and distribution [8]. Fossil fuel efficiency for electricity generation (TM_{1a}) is defined as the gross production of electricity (including own use of electricity by power plants) from fossil fuel power plants relative to fossil fuel inputs. Ration of TFC of electricity and the sum of TFC of electricity and losses is electricity transmission and distribution efficiency (TM_{1b}), while gas distribution efficiency (TM_{1c}) is a ration of TFC of natural gas and the sum of TFC of natural gas and losses.

As an indicator of efficiency of energy use in selected national economy, energy intensity (TM_2) is commonly used [11]. This indicator is calculated as the ration of energy use (TPES) and economic output (GDP) of selected country [8].

Dimensions of availability and adopted indicators are presented in tab. 1.

Availability of energy in Serbia

Security of supply

As an indicator of the ability of the energy system to depend on its own resources in production, and how much is dependent on imports, SOS may be represented by the ration of net imports and total available primary energy consumption (SOS_1) within a given year [9]. For the purpose of this paper, data from the Energy Balance for 2014 are used:

Table 1. Indicators of availability dimensions

Security of supply	Self-sufficiency	Diversification	Renewable energy sources	Technological maturity
SOS_1 – ration of net imports and total available primary energy consumption within a given year SOS_2 – ration of the stocks of critical fuels and corresponding fuel consumption	SS_1 – ration of reserves to production SS_2 – ration of resources and production	D – diversity index of the possible energy resources for supply – Shannon index	RES_1 – RES share in TPES RES_2 – RES share in TFC	TM_{1a} – efficiency of electricity generation TM_{1b} – electricity transmission and distribution efficiency TM_{1c} – gas distribution efficiency TM_2 – energy intensity

$$\mathrm{SOS_1} = \frac{\text{Net imports}}{\text{Total primary energy consumption}} = 0.28335\,(28.3\%) \tag{1}$$

The second indicator of SOS that can be used is the indicator of stocks of critical fuels per corresponding fuel consumption (SOS_2). In case of Serbian energy system, which is dependent on imported oil and natural gas, this indicator is very important because it shows the ability of the country to maintain strategic stocks of critical fuels – oil [12] and natural gas [13].

$$\mathrm{SOS_2(Oil)} = \frac{\text{Oil stock}}{\text{Oil consumption}} = 0.086\ (8{,}6\%) \tag{2}$$

$$\mathrm{SOS_2(Natural\ gas)} = \frac{\text{Natural gas stock}}{\text{Natural gas consumption}} = 0.2227 \quad (22.3\%) \tag{3}$$

This indicator for the oil sector is also related to Serbian obligation (as the Contracting Parity in Energy Community) to form and maintain compulsory oil reserves in accordance to Directive 2009/119/EC [14]. This directive imposes an obligation to maintain minimum stocks of crude oil and/or petroleum products corresponding, at the very least, to 90 days of average daily net imports or 61 days of average daily inland consumption, whichever of the two quantities is greater. If obligations from this Directive were applied on the case of Serbia, according to current oil stock, the following results are obtained:

$$\text{Average consumption of oil} = \frac{\text{Oil consumption}}{365\ \text{days}} = 8.493\ \text{t/day} \tag{4}$$

$$\frac{\text{Stock of oil}}{\text{average consumption of oil}} = 31\ \text{days} \tag{5}$$

It can be concluded that, with present level of oil stocks, Serbia meets the needs for consumption of oil for 31 days, or 1/3 of necessary amount.

Self-sufficiency

In case of Serbia, SS_1 indicator considers reserves of coal, oil, and natural gas (NG), and provides a relative measure of the time that proven reserves [15] would last if production and consumption were to continue at current levels (2014) [9].

$$\mathrm{SS_{1(C)}} = \frac{\text{Estimated coal reserves}}{\text{Coal consumption per year}} = 149\ \ \text{years} \tag{6}$$

$$SS_{1(O)} = \frac{\text{Estimated oil reserves}}{\text{Oil consumption per year}} = 8.3 \quad \text{years} \tag{7}$$

$$SS_{1(NG)} = \frac{\text{Estimated NG reserves}}{\text{NG consumption per year}} = 7 \quad \text{years} \tag{8}$$

The SS_2 indicator considers resources of coal and aggregated resources of oil and natural gas.

$$SS_{2(C)} = \frac{\text{Estimated coal resources}}{\text{Coal consumption per year}} = 689 \quad \text{years} \tag{9}$$

$$SS_{2(O+NG)} = \frac{\text{Estimated oil and NG resources}}{\text{Oil and NG consumption per year}} = 29.6 \quad \text{years} \tag{10}$$

Except in the case of coal, it is evident that Serbian SS is very low and additional activities in oil and gas exploration should be undertaken.

Diversification

Diversity index provides more information than simply the number and amount of energy sources used. It serves as valuable tool to quantify diversity in a community and describe its numerical structure [16]. The index is calculated as the proportion of individual energy sources*, n,* relative to the total number of energy sources, *N*:

$$H = -\sum_{i=1}^{n} \left(P_i \ln P_i \right), \quad P_i = \frac{n}{N} \tag{11}$$

The higher value of Shannon index, the greater is the diversity of observed groups of elements. Results of Shannon index for diversity of energy resources for Serbia in 2014 [9], and for few European countries are presented in tab. 2 [17]. It is evident that Serbia is within a group of countries with lower level of diversity, primarily due to highest share of coal in primary energy mix.

Table 2. Shannon diversity index for some European countries

European country	Poland	Serbia	Greece	Slovenia	UK	Hungary	Germany	Austria
Shannon index	1.15	1.22	1.26	1.40	1.42	1.48	1.51	1.52

Renewable energy sources

The total technical potential of renewable energy in Serbia is estimated at 5.65 Mtoe per year. Out of this potential, about 35% is already being used – mostly energy from hydropower and biomass [15]. The RES_1, as an indicator, refers the share of RES in TPES [9]:

$$RES_1 = \frac{\text{Share of RES in TPES}}{\text{TPES}} = 0.15 \ (15\%) \tag{12}$$

Table 3 shows the share of RES in TFC for selected years [10], as the RES_2 indicator. Presented results indicate that additional effort is necessary for achieving of binding 27% share of renewable energy in gross final energy consumption in 2020, according to National Renewable Energy Action Plan [18].

Technological maturity

The current state of technological maturity in Serbia can be measured by indicators of efficiency of energy conversion and distribution (TM_1).

Table 3. Overall shares of RES in TFC in 2009, 2012, and 2013

	2009	2012	2013
Share of RES_2 (%)	21.2 %	20.27 %	19.10 %

Thermal power plants efficiency:

$$TM_{1a} = \frac{\text{Gross production of electricity}}{\text{Fossil fuel inputs}} = 0.34 \quad (34\%) \tag{13}$$

Combined heat and power plants efficiency. For the purpose of calculating the efficiency of energy transformation for combined heat and power plants, aggregate data of produced electricity and heat was used:

$$TM_{1b} = \frac{\text{Gross production of electricity and heat}}{\text{Fossil fuel inputs}} = 0.699 \quad (69.9\%) \tag{14}$$

Electricity transmission and distribution efficiency:

$$TM_{1b} = \frac{\text{TFC of electricity}}{\text{Sum of TFC of electricity and losses}} = 0.835 \quad (83.5\%) \tag{15}$$

Gas distribution efficiency:

$$TM_{1c} = \frac{\text{TFC of NG}}{\text{Sum of TFC of NG and losses}} = 0.981 \quad (98.1\%) \tag{16}$$

Analysis of TM indicators shows relatively low efficiency of electricity production in thermal power plant (TPP) and combined heat and power (CHP) facilities, although production in CHP facilities is very modest. Electricity network efficiency is low, primary due to high distribution losses.

As an additional indicator, it can be used indicator of energy intensity – TM2 (ration of energy sector parameters with parameters of economic and social development of a country). Data for 2014 are used in calculation [11].

$$TM_{2a} = \frac{\text{TPES}}{\text{Unit of GDP}} = 0.31 \quad \text{toe/1000 US\$} \tag{17}$$

Using same methodology for determination of TM_{2a}, it is formed tab. 4 with values of TM_{2a} for some European countries [11-19].

Table 4. Values of TM_{2a} for some European countries

Country	Greece	Slovenia	Hungary	Bulgaria	Germany	Austria
Values of TM_{2a} (toe/1000 US$)	0.1	0.13	0.16	0.31	0.08	0.07

Values of TM_{2a}, presented in tab. 4, indicate that Serbian energy intensity is high. Such result is the consequence of the inefficient use of energy resources, but also the low economic productivity of the country and low GDP level. Modification of the value of this indicator can be done if GDP is converted from the real national currency at purchasing power parity (PPP), for the base year (2014) to which the national currency was deflated (measured in 1000 US$) [11]:

$$\text{TM}_{2\text{b}} \frac{\text{TPES}}{\text{Unit of GDP}\left(\text{PPP}\right)} = 0.14 \text{ toe/1000 US\$} \tag{18}$$

The determination of significance of availability components by AHP method

The aim of the application of AHP method is to detect the contribution of each component individually within dimension of availability. The final rating of components provides insight into the current situation and emphasizes components that should be improved in order to achieve higher level of energy security.

To make direct comparison of components, it is necessary to use a scale of numbers (Saaty's scale of relative importance) [20]. Saaty's scale of relative importance includes number from 1 to 9, where number 1 represents equal importance, number 9 represents extreme importance one component over another, and other values (2-8) are in between that range. One always enters the whole number in its appropriate position and automatically enters its reciprocal in the transpose position [21].

For this purpose, the only one criterion for comparing the components is defined. That is individual contribution of each component to the availability of energy, as a dimension of energy security in Serbia.

Based on analysis of the Energy Balance of Serbia, Energy Sector Development Strategy of Serbia [9-15] and calculated indicators from this study, the initial pairwise comparison matrix for the components of availability is formed, tab. 5.

Table 5. Pairwise comparison matrix

Components	SOS	SS	D	RES	TM
Security of supply	1	1/6	1/4	1/5	1/3
Self-sufficiency	6	1	4	3	4
Diversification	4	1/4	1	1/3	2
Renewable energy sources	5	1/3	3	1	3
Technological maturity	3	1/4	1/2	1/3	1

Once the initial pairwise comparison matrix is built, it is possible to derive the normalised pairwise comparison matrix, A_{norm}. Each element of the column of the initial matrix is divided by the sum of the elements of the same column:

$$A_{\text{norm}} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}, \quad i, j = 1, \cdots, n \tag{19}$$

Next step is to determinate the criteria weight vector, w_i, which is built by averaging the entries on each row of the normalised pairwise comparison matrix, A_{norm}:

$$w_i = \frac{1}{n} \sum_{j=1}^{n} a_{ij}, \quad i, j = 1, \cdots, n \tag{20}$$

Obtained values of the criteria w_i, as a results of application of AHP method are given in tab. 6. They indicate that SS, defined as ability of energy system to rely on its own reserves and resources in energy production, is the most important component of availability of energy in Serbia. According to characteristics of other components of the availability of energy in Serbia, it can be concluded that the share of RES in TPES/TFC is more important than other components (SOS, D, TM), because it consequently affects the growth of SS. In the other words, pillars of availability of energy in Serbia, and its energy security are indigenous energy production and use of fossil fuels, primarily coal, and renewables – hydro and biomass.

Table 6. Results of individual significance of components

Components of availability	SOS	SS	D	RES	TM
Criteria weight, w_i	0.0475	0.4552	0.1423	0.2536	0.1195
Individual significance	≅ 4.7%	≅ 45%	≅ 14%	≅ 25%	≅ 12%

Discussion

Based on previously presented results of selected indicators, it is possible to make a brief overview of the current state and perspectives of energy security in Serbia.

The import dependence of Serbia is 28%. It is not large in number, but it is very noticeable in imports of oil and natural gas, especially if currently estimated remaining reserves (8.3 years for oil, 7 years for natural gas) and resources (29.6 years for oil and natural gas combined) are taken into consideration. The SOS is especially affected in the natural gas sector because of import dependency on one supplier (Russia) and only one supply route through Hungary.

The reserves and resources of coal provide some certainty in SS of the energy system of Serbia. If production and consumption remain at current level, the period until the exhaustion of coal reserves is 149 years (without Kosovo), and 689 years until the exhaustion of coal resources.

However, the weak point of coal utilization in Serbia is the efficiency of energy conversion. Efficiency for electricity generation from coal is about 34%, which is below the average efficiency of modern thermal power plants in Europe. With additional 83.5% of electricity transmission and distribution efficiency, it leads to only 28% of total efficiency in primary energy source use.

The share of renewable energy in final consumption is currently around 20%. Hydropower and traditional biomass (firewood) have the largest share in the renewable energy mix. The use of the other RES is still modest. If it is known that currently is being used about 35% of the total RES potential, further improvement in using renewable energy is certainly possible.

Implementation of AHP method and lower values obtained for individual significance for SOS, technological maturity and diversification indicate their currently limited contribution to the availability of energy in Serbia. Therefore, the mentioned components can be identified as a weak spots that need to be strengthened in order to improve energy security of Serbia.

Conclusions

In many countries of the world, energy security is one of the priorities of national security. Over the years, different types of energy indicators have been proposed with the aim to monitor and evaluate strategies for the improvement in availability of energy and overall level of energy security. Sets of indicators of security of supply, self-sufficiency, diversification of energy sources, renewable energy sources use and technologycal maturity, proposed in this paper, leads to a broader and deeper understanding of the problem of energy availability of selected energy system, while application of AHP methodology in detecting the contribution of each component individually within a dimension of availability helps in defining of priority actions and creation of adequate policy instruments and measures.

For evaluation the availability of energy in Serbia, proposed sets of indicators were calculated and AHP method was implemented for prioritization of availability components. Assessment of obtained indicators and their comparison show that in order to improve availability, the main activities in Serbian energy sector should be directed to:

- Improvement of energy efficiency, primarily in electricity production and distribution
- Increase the use of RES
- Diversification of energy sources used in energy transformation, as well diversification of imports directions

These activities have simultaneous positive effects to different dimensions of availability. Besides rising of technological level of energy sector, improvement of energy efficiency, and consequently less energy consumption for the same quality of goods or services, has positive effect to SOS and SS. Increase of RES using for electricity and heat production improves SOS decreasing the import dependency, with significant introduction of contemporary technologies and wider applications of different energy sources (biomass, biogas, solar, wind, geothermal). Diversification of energy imports is mainly connected to import of natural gas. Establishing interconnections with the neighbours (Bulgaria, Croatia, Romania, *etc.*) should open possibilities for natural gas supply from some of planned international gas routes (*South Corridor* projects) and liquefied natural gas terminals.

Nevertheless, the planning of energy security on the basis of sustainability and equal respect for economic, environmental, and social aspects is the best way to achieve the objective of improving values of the presented indicators. Each well-weighed investments in education, building of new energy infrastructure and facilities, as well as improvement of existing one, can only bring benefits in terms of security and quality of life to the whole society.

References

[1] Ren, J., Sovacool, B. K., Quantifying, Measuring, and Strategizing Energy Security: Determining the Most Meaningful Dimensions and Metrics, *Energy*, *76* (2014), Nov., pp. 838-849
[2] Cherp, A., Jewell, J., The Concept of Energy Security: Beyond the Four As, *Energy Policy*, *75* (2014), Dec., pp. 415-421
[3] Kruyt, B., *et al*., Indicators for Energy Security, *Energy Policy, 37* (2009), 6, pp. 2166-2181
[4] ***, Statistics, International Energy Agency, https://www.iea.org/publications/freepublications/publication/WEO_2014_ES_English_WEB.pdf
[5] Yergin, D., Ensuring Energy Security, *Foreign Affairs, 85* (2006), 2, pp. 69-82
[6] Brown, M. A., *et al*., Forty Years of Energy Security Trends: A Comparative Assessment of 22 Industrialized Countries, *Energy Research & Social Science, 4* (2014), Dec., pp. 64-77
[7] ***, A Quest for Energy Security in the 21st century, 2007, Asia Pacific Energy Research Centre, http://aperc.ieej.or.jp/file/2010/9/26/APERC_2007_A_Quest_for_Energy_Security.pdf,
[8] ***, Energy Indicators for Sustainable Development: Guidelines and Methodologies, 2005, International Atomic Energy Agency, http://www-pub.iaea.org/MTCD/publications/PDF/Pub1222_web.pdf
[9] ***, Energy Balance of the Republic of Serbia in 2014 (in Serbian)., Statistical Office of the Republic of Serbia, http://webrzs.stat.gov.rs/WebSite/repository/documents/00/02/03/47/SB-607-BILTEN_ENERGETIKE_2014.pdf
[10] ***, Progress Report on Implementation of the National Renewable Energy Action Plan of the Republic of Serbia (in Serbian), 2014, Ministry of Mining and Energy of the Republic of Serbia, http://www.mre.gov.rs/doc/efikasnost-izvori/Progress%20Report%20on%20NREAP%20_SERBIA%202014_ENG_FINAL.pdf?uri=CELEX:32009L0028

[11] ***, Serbia 2014 – Data, World Bank, http://data.worldbank.org/country/serbia
[12] ***, Storage, Public Enterprise Transnafta, http://www.transnafta.rs/en/home/dev_projects/storage/
[13] ***, Underground Storage Banatski Dvor (in Serbian), Public Enterprise Srbijagas, http://www.srbijagas.co.rs/projekti/podzemno-skladiste-gasa-banatski-dvor-sa-gasovodom.86.html
[14] ***, Directive 2009/119/EC, 2009, European Community, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:265:0009:0023:EN:PDF
[15] ***, Energy Sector Development Strategy of the Republic of Serbia for the Period by 2025 with Projections by 2030 (in Serbian), 2016, Ministry of Mining and Energy of the Republic of Serbia, http://mre.gov.rs/doc/efikasnost-izvori/23.06.02016%20ENERGY%20SECTOR%20DEVELOPMENT%20STRATEGY%20OF%20THE%20REPUBLIC%20OF%20SERBIA.pdf
[16] Beals, M., *et al*., Diversity Indices: Shannon's H and E, The Institute for Environmental Modeling, University of Tennessee, Knoxville, Tenn., USA, 2000
[17] ***, UK Energy Sector Indicators 2012, Department of Energy & Climate Change UK, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/65900/6801-uk-energy-sector-indicators-2012.pdf
[18] ***, National Renewable Energy Action Plan of the Republic of Serbia (in Serbian), 2013, Ministry of Mining and Energy of the Republic of Serbia, http://www.pks.rs/SADRZAJ/Files/Energetika/Nacionali%20akcioni%20plan%20za%20obnovljive%20izvore%e20energije%20NAPOIE.pdf
[19] ***, Energy Balance Sheets 2014 Data, European Union, http://ec.europa.eu/eurostat/documents/3217494/7571929/KS-EN-16-001-EN-N.pdf/28165740-1051-49ea-83a3-a2a51c7ad304
[20] Saaty, T., Decision Making with the Analytic Hierarchy Process, *International Journal of Services Sciences*, *1* (2008), 1, pp. 83-98
[21] Ishizaka, A., Clusters and Pivots for Evaluating a Large Number of Alternatives in AHP, *Pesquisa Operacional, 32* (2012), 1, pp.87-102

Paper submitted: September 23, 2016
Paper revised: November 4, 2016
Paper accepted: November 6, 2016