A Geopolitical Review of Definitions, Dimensions and Indicators of Energy Security

INVITED PAPER

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***Abstract*—Energy is an economic, ill-distributed and expensive good, subject to price fluctuations. Energy security arose as a problem of the oil crises of the 1970s, and it has become a matter of national security, although its definition depends on geographical location, natural resource endowment, international relations, political system, economic disposition, and ideological perceptions. Although there is no universally accepted definition of energy security, a succinct way to approach it is through the four As: availability, affordability, accessibility (to all), and acceptability (from a sustainability standpoint). Energy security may be measured by numerous indicators, with no single accepted methodology being ideal for all historical and geopolitical circumstances. Dimensions of the concept of energy security include: the environment, technology, demand side management, socio-cultural and political factors, human security, geopolitical considerations, and the formulation of energy security policy. Alternatively, energy security may be considered to have five dimensions that may be broken down into 20 components, as follows: (a) availability, i.e. security of supply and production, dependency, and diversification; (b) affordability, i.e. price stability, access and equity, decentralization, and low prices; (c) technology development, i.e. innovation and research, safety and reliability, resilience, energy efficiency, and investment; (d) sustainability (environmental component), i.e. land use, water, climate change, and air pollution; and (e) regulation, i.e. governance, trade, competition, and knowledge of sound regulation. Energy security contains multiple components, including: geography, nuclear energy, economy, society, environment policy and political institutions. There are many energy security indicators and indexes that include different dimensions and attributes, such as the Herfindahl-Hirschmann Index, the Oil Vulnerability Index, the Vulnerability Index, the Aggregated Energy Security Performance Indicator, the US Energy Security Risk Index, the Energy Architecture Performance Index, and the Energy Trilemma (or Sustainability) Index. The paper is rounded up with a short discussion of the geopolitical role of energy security.**

Keywords*—*energy security, Eastern Mediterranean, Middle East, energy security indicators, energy security indexes, geopolitics.

I. Introduction

Energy has been essential throughout human history, crucial for economic development and human security. According to the latest BP Statistical Review of World Energy [1], global primary energy consumption increased by 1% in 2016, following a growth of 0.9% in 2015 and 1% in 2014. Yet, energy is an economic, ill-distributed and expensive good, subject to price fluctuations, with repercussions in many domains of life. With energy being the "precondition of all commodities, a basic factor equal with air, water, and earth" (E. F. Schumacher, Nobel laureate economist, 1977), energy security is paramount to human security [2], and has become an increasingly popular concept for policy makers, entrepreneurs and academics.

Energy security can be viewed as a public good for societies, and the lack of its sufficient provision is associated with disruptions of oil, gas and electricity, and severe consequences for societies, economies and individuals. Consequently, energy security is a political issue combining the concepts of high and low politics.

This research reviews the energy security research literature, including its theoretical underpinnings, its definition, its conceptual dimensions, selected indicators, and resulting geopolitical considerations.

Concerns about energy security first arose in the early 1970s in Europe, Japan and the US, as the first oil crises uncovered the vulnerability of developed economies to oil price shocks. The International Energy Agency (IEA) was created in 1974 by the countries of the Organization for Economic Co-operation and Development (OECD), so as to promote energy security among its member countries, through collective response to physical disruptions of energy supplies (e.g. by holding stocks equivalent to at least 90 days of net oil imports). Energy security became a matter of national security for many developed countries in the aftermath of the oil shocks of 1973. The late and great Kenneth Waltz argued that there is a continuity of strategies of the major western states in energy geopolitics, and he predicted that the oil shocks, provoked by the Arab export embargo, would not cause any change of power in the West [3].

Energy security is a field dominated by a traditional approach to security, and means different things to different countries. The differentiation is based on their geographical location, their natural resource endowment, the status of their international relations, their political system, their economic disposition [4], and their ideological views and perceptions [5]. Approaches to energy security differ between countries, depending on the structure of the energy system and historical experiences. This is observed in the various strategies chosen by the different member states within the European Union (EU), e.g. the degree of reliance on Russian gas and the diverse historical experiences from the Cold War that have led to different approaches to energy security ([6] as cited by [7].

Energy security is argued to be part and parcel of security, and thus it should be high on the policy agenda for countries across the world. The Copenhagen School of security studies has described a four level approach to international politics: the international (system), the regional (sub-system), the national (unit), and the internal (sub-unit) [8]. Energy security needs to be investigated at these four levels: globally, to ensure adequacy of resources; regionally, to ensure that networking and trade can take place; at country level, to ensure national security of supply; and finally at a consumer level, to ensure that consumer demand is satisfied.

II. A REVIEW OF THE ENERGY SECURITY LITERATURE

It was during the 1970s that energy security arose as a problem in the research literature. In the first oil crisis of 1973, oil embargoes by the Organization of Arab Petroleum Countries (OAPEC) shook the oil importing countries to the core, while the second oil crisis shot up international oil prices above $30/barrel, which amounts to $100/barrel in current values [9]. The year 1974 was a milestone for the energy security concept, and as a response to the 1973 oil embargo, the OECD established the IEA. During that period, international energy security still largely meant oil security. According to IEA [10], in 1979 oil shared as much as 86% of the world energy trade, and the Middle East supplied 58% of the internationally traded oil. Consequently, by the end of 1970, energy security was a high priority issue on the policy agenda, in view of its significance for the whole economy.

A. Theoretical discourse of energy security

According to the dominant strand of the International Relations (IR) theory in the study of security, energy resources are an intrinsic interest regarding states survival, ensuring *"military might, economic development and social stability"* [11]. In its dual core perspective [7], as an object and subject of foreign policy, energy security can be an instrument of state foreign policy (energy statecraft) via using energy resources to pursuit foreign policy objective, so as to preserve its *"energy infrastructure, resource availability, and stability of energy demand"* [11]. On the other side of the spectrum, it may be regarded as an end of foreign policy, connecting with the inter-state struggle for energy resources.

By examining energy security as a part of a state's foreign policy formation-implementation, one has to discern its main analytical and theoretical perspective. The mainstream theoretical approaches in the field of IR (Realism, Liberalism, Marxism and Constructivism) operate as a synthetic optical lens. They are differentiated or bound with each other through the dilemmas and questions posed at their center stage, giving concrete and eclectic images of international relations. Just as any other lens, that separates and stresses some characteristics of the natural world while marginalizing others, so are the theories of IR crystallized by the different angles of watching the international phenomena [12]. To be more specific, their differences lie on: (a) diverse focal points of the international system (i.e. Realism focuses on the political-strategic aspect, Liberalism on economy-institutions and Marxism on the social aspect); (b) assorted levels of analysis, i.e. Realism-Neorealism on the state-system level, Liberalism on the intrastate level and Marxism on the interstate and individual level, [13]; (c) varied ontological objects–actors, on which they base their analysis (i.e. Realism on states, Liberalism on individual and Marxism on classes); and (d) differing value on normative concepts of state behavior, i.e. international law, obligation and ethics, international morality, international institutions [14].

Despite the fact of theoretical pluralism, presented by various theoretical approaches [15] and the strategic importance of energy in international relations, both as a factor of national power and as an instrument of state foreign policy (energy diplomacy) it is noteworthy to mention the limited application *"of IR theories to understanding energy- and mineral-related conflicts and modes of collaboration and competition."* In particular, we can find the bulk of IR literature on energy issues in policy-orienting journals like Foreign Affairs, Foreign Policy, Washington Quarterly etc., by explaining and understanding the relationship between energy security with interstate conflict and cooperation. The intact thinking about energy issues *"is implicitly theoretical, with the main arguments and policy prescriptions underpinned by certain fundamental theoretical assumptions"* [16].

To understand the strategic value of energy commodities, as tools of state foreign policy, we have to discern the significance and influence of domestic factors. Along with the constraints and opportunities of systemic scope and the former's diverse impact on the latter's operation. Under this condition the theoretical framework of neoclassical realism "can be a useful analytical choice" to evaluate the efficacy energy statecraft in terms of foreign policy objectives [11].

Neoclassical realism combines elements from both classical realism (the tragic nature of international politics) and neorealism (anarchic international system & structural constraints are the primary drivers of states actors) and is based on the following premises [17]:

- The acknowledgement of the confrontational nature on international politics which derives from the anarchic organizational principle of the international system. Thus, international politics is defined in terms of the distribution of power.
- The consequence of the distribution of power in the international system and, in particular, the role of relative power. From a realist perspective the political leaders' perception and estimates of relative power and domestic constraints emerge as major determinants if the interaction between structural elements and foreign policy. The increase in a state's relative power is expected to result in its enhanced international influence.

- The defining impact of systemic factors – geography, distribution of power, the balance between offensive and defensive capabilities – on state's political-strategic behavior.
- The significance of political leadership in the determination and prioritization of national objectives, and subsequently, in the formulation and implementation of foreign policy.
- The importance of state-centric national power and its significance for the formulation of grand strategy. State power is the sum total of the various societal power sources that the government can utilize for the attainment of its political objectives. As a result, "the capabilities of a state depend on how broad the state is and if it possesses sufficient capacity to carry out its wishes" [18].

B. Defining energy security

Chester [20] and Vivoda [21] highlight the polysemic and multi-dimensional nature of energy security. Chester suggested that the term has risen high on the policy agenda of governments because there is a complex system of global markets, a vast cross-border infrastructure networks, and a small group of primary energy suppliers. Manson, Johansson and Nilsson [22] have described the energy security as a dynamic concept, with a perspective that depends on the time frame analyzed.

According to Winzer [23], the attempts to define energy security have varied over time due to challenges in the realm of energy policy. Different countries may define energy security differently, in relevance to their own energy situation, and their vulnerability to energy supply disruptions. Countries not only differ in their definition of energy security, but also in the way they address energy security challenges [4].

Some authors [24, 25] point out that the term of energy security is not clearly defined, consequently there is no universal concept of energy security. Taking into consideration the absence of a clear definition [26, 27], energy security has become an umbrella term for many different policy goals [23]. A multiplicity of concepts and dimensions enter the realm of energy security. Chester [20] aptly described energy security as *"slippery"* and *"polysemic."* The diversity of definitions is shaped by the perspective and nature of different countries, and their place in the energy chain and the complex global energy system.

Countries are divided into three groups: producers/exporters, who wish to ensure reliable demand for their commodities; consumers, who commonly aim towards diversity of energy supply, so as to maximize their security; and transit states, who are the essential bridges connecting producers/exporters with their markets [4]. Given the above differentiation among countries, there are two important terms for energy security: security of supply (for the consumers), and security of demand (for the exporters). For energy exporting countries, security of demand is equally important to security of supply [7].

According to Sovacool [28], there are at least 45 different definitions of energy security that share a great deal of similarity among them, and lead to difficulties in terms of the operationality of the concept. Ang, Choong and Ng [29] identified 83 energy security definitions in the literature. As pointed out by Cherp and Jewell [30], a classic definition of energy security is provided by Yergin [31], who visualized energy security as the assurance of *"adequate, reliable supplies of energy at reasonable prices,"* adding a geopolitical component by qualifying that this assurance must be provided *"in ways that do not jeopardize national values or objectives."* Yergin's definition identifies *"national values and objectives"* as the assets to safeguard energy security.

The International Energy Agency (IEA), a pioneer institution in energy security and the most important multinational platform, defines energy security as the *"uninterrupted availability of energy sources at an affordable price,"* and considers it to have a long-term and a short-term aspect. The IEA has restated the definition through the years to characterize energy security as the adequate, affordable and reliable supply of energy. Long-term energy security relates to *"timely investments to supply energy in line with economic developments and environmental needs."* Short-term energy security relates to "the ability of the energy system to react promptly to sudden changes in the supply-demand balance" [32-34].

In 2000, the European Commission [35] referred to energy supply security as *"the uninterrupted physical availability of energy products on the market, at a price that is affordable for all (private and industrial) consumers, while respecting environmental concerns and looking towards sustainable development."* This was an extension of the IEA definition involving the inclusion of environmental and sustainability issues.

Definitions of energy security [24, 25, 27, 35] mainly use the term availability to imply stable and uninterrupted supply of energy. Other authors [36, 37] use the term reliability for energy infrastructure. Accessibility has been at the center of the energy security debates and policy approaches into the 21st century [38]. As a further extension to the original IEA definition of energy security, the Asia Pacific Energy Research Centre [27] highlighted the four As of availability, affordability, accessibility (to all), and acceptability (from a sustainability standpoint), and defined energy security as *"the ability of an economy to guarantee the availability of the supply of energy resources 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."* Cherp and Jewell [30] compared the 4 As to the five As of access to health care (availability, accessibility, accommodation, affordability and acceptability). The first two As (availability and affordability) constitute the classic approach to energy security (20th Century), while the latter two (accessibility and acceptability) reflect certain contemporary concerns (21st Century) e.g. fuel poverty and global climate change.

C. Dimensions of energy security

The historical discourse on energy security has shown that it encompasses a number of dimensions. According to Kruyt et al. [26], the bulk of the recent literature on energy security seeks to classify energy security concerns into dimensions, even if this classification has been criticized for lacking transparency, being systemically unjustified, and arbitrary [39].

The IEA considers energy security to have three components: reliable and uninterrupted supply; affordable and competitive supply; and accessible or available supply (http://www.iea.org/topics/energysecurity/subtopics/whatisenergysecurity). Furthermore, the IEA has proposed the energy security measurement tools of: physical availability that account for geopolitical energy security; pipe-based import dependence; power system reliability; and market power [20]. A study by the U.S. Chamber of Commerce [40] presented four dimensions of energy security: geopolitical (energy imports, particularly from politically unstable regions); economic (high energy intensity and trade imbalances); reliability (adequacy and reliability of infrastructure); and environmental (related to the carbon intensity of the energy systems).

In the words of Cherp and Jewell [39]: *"there are three perspectives on energy security, namely those of sovereignty, robustness and resilience."* Alhajji [41] differentiated between six dimensions of energy security: economic, environmental, social, foreign policy, technical and security. Vivoda (2010) listed seven salient energy security dimensions (environment, technology, demand side management, socio-cultural or political factors, human security, international elements like geopolitics, and the formulation of energy security policy) and 44 attributes of energy security.

Sovacool and Mukherjee [2] considered energy security to comprise five dimensions that may be broken down into 20 components, as follows: (a) availability, i.e. security of supply and production, dependency, and diversification; (b) affordability, i.e. price stability, access and equity, decentralization, and low prices; (c) technology development, i.e. innovation and research, safety and reliability, resilience, energy efficiency, and investment; (d) sustainability (environmental component), i.e. land use, water, climate change, and air pollution; and (e) regulation, i.e. governance, trade, competition, and knowledge of sound regulation. To this end, Sovacool and Mukherjee [2] assembled 320 simple indicators and 52 complex indexes of energy security.

In a study for the evaluation of energy security in the Asia Pacific, Sovacool [28] listed 20 dimensions of energy security identified by experts. For each dimension (availability, dependency, diversification, decentralization, innovation, investment, trade, production, price stability, affordability, governance, access, reliability, literacy, resilience, land use, water, pollution, efficiency, and greenhouse gas emissions) a number of metrics and indicators was presented.

Putting energy security dimensions into perspective, Radovanović, Filipović and Pavlović [42] pointed out that it is not possible to develop a unique methodology of assessing energy security because each country has a different wealth of energy resources. The use of these resources differs in: the type and intensity at different points of development; climate; geopolitical position; demographic indicators; economic growth; and strategic priorities, which depend on the historical, social and political social conditions [18]. Furthermore, Radovanović, Filipović and Pavlović argued that all countries try to improve their energy security by increasing energy efficiency, improving the stability of energy systems, reducing energy vulnerability, and increasing self-sufficiency.

D. *Energy security indicators*

The conceptualization and formulation of energy security dimensions is the first step for an analysis of energy security. These dimensions must be complemented by indicators which should relate to the dimensions, and seek to quantify the identified energy security risks and concerns [39]. The aggregation of indicators allows the comparison between energy security risks and policy trade-offs.

The interest in measuring energy security results not only from its rising prominence, but also from its increasing complexity. Many indicators are available in the literature, based on the perspective of the user [43]. The literature on the indicators of energy security is quite extensive [24, 44-47] and may be a useful tool for monitoring, measuring, and evaluating the current and future effects of energy security on the economy, the society, and the environment. Indicators for energy security are necessary to link the concept with model-based scenario analyses in the context of addressing policy issues related to affordable energy and climate change [26].

Chester [20] suggested that there are quantitative and qualitative approaches to the measurement of energy security. Threats to energy security are short-term (operational), and long-term (related to adequacy of sources, transit, storage and delivery). The literature reviewed by Chester suggests that the quantifiable energy security indicators have the potential of being analytically helpful, and are necessary to assess the consequences of alternative development scenarios.

Various studies [2, 32, 42, 44] have proposed a wide variety of energy security indexes, either to compare performance among countries or to track changes in a country's performance over time. In these studies, some indicators are first identified based on specific considerations or theoretical framework. This is followed by data collection, normalization, weighting, and aggregation of the chosen indicators to give one or more composite energy security indexes. A quick review of these studies has shown that there are large variations in the choice of indicators [29]. Radovanović Filipović and Pavlović [42] applied Principal Component Analysis to assess the impact of individual indicators on an energy security index. According to this research, energy intensity, GDP per capita, and carbon intensity have the greatest impact on energy security.

Sovacool [28] defined an index with 20 dimensions and 200 attributes. In subsequent work, Sovacool and Mukherjee [2] reduced the number of dimensions to five and the number of attributes to 20. Sovacool et al. [44] applied the index to a set of countries, and found that Japan had the highest energy security index among the 18 countries considered. The impact of the Fukushima nuclear accident on Japan's energy system and economy, hints at the difficulties that may be encountered when attempting to construct robust energy security indexes.

Ang, Choong and Ng [29] reviewed 53 studies that deal with energy security indicators, and found the number of indicators examined to vary from a few to more than 60. About two-thirds of the studies employed no more than 20 indicators. Their research identified that there are two major types of studies that use energy security indicators: those that deal with performance over time, and those that compare performance among countries with no significant difference in the number of indicators used.

Turning to specific indexes, the Herfindahl-Hirschmann Index determines the degree of a certain country's dependence on a certain supplier, and may be used as an indicator that indirectly points to the energy security of a country [42]. The Supply/Demand Index for the long-term security of supply (SD Index) [48] has been designed on the basis of expert assessments on all possible relevant aspects of the SOS, and covers demand, supply, conversion, and transport of energy in the medium to long-term [26]. It is a composite indicator (i.e. an index) that comprises 30 individual indicators, and considers the characteristics of demand, supply and transport [42]. According to Kruyt et al. [26], the basic difference with other indicators, is that the SD Index attempts to grasp the entire energy spectrum, including conversion, transport, and demand (since a decrease in energy use lowers the overall impact of supply disruptions).

The Oil Vulnerability Index (OVI) [49] is an aggregated index of oil vulnerability, based on seven indicators: ratio of value of oil imports to GDP; oil consumption per unit of GDP; GDP per capita; oil share in total energy supply; ratio of domestic reserves to oil consumption; and exposure to geopolitical oil supply concentration risks, measured by net oil import dependence, diversification of supply sources, political risk in oil-supplying countries, and market liquidity. According to Radovanović, Filipović and Pavlović [42], the OVI is a comprehensive composite indicator that manages to consider economic indicators, import dependence, and political stability.

The Vulnerability Index [50] is a composite indicator which considers five indicators: energy intensity; energy import dependency; ratio of energy-related carbon emissions to the total primary energy supply (TPES); electricity supply vulnerability; and lack of diversity in transport fuels [42]. The six-factor Risky External Energy Supply [46] is entirely supply-oriented, and considers solely the level of diversification, with particular emphasis given to the assessment of transport safety of energy generating products [42].

The Aggregated Energy Security Performance Indicator (AESPI) [51] has been developed by considering 25 individual indicators representing social, economic, and environmental dimensions. The indicator ranges from zero to 10, and requires time series data for its estimation. The advantages of AESPI is that it not only assists in knowing the past energy security status of a country, but also helps in assessing the future status considering the energy policies and plans, thus enabling monitoring the impacts of policies. The Socio-economic Energy Risk is a composite index that considers the following indicators: energy source diversification, energy resource availability and feasibility, energy intensity, energy transport, energy dependence, political stability, market liquidity, and the GDP [42].

The US Energy Security Risk Index [40] is a complex composite indicator obtained based on 83 individual indicators assessing geopolitical indicators, economic development, environmental concerns and reliability [42]. The Energy Development Index (EDI) [33] is composed of four indicators, each of which captures a specific aspect of potential energy poverty: per capita commercial energy consumption, which serves as an indicator of the overall economic development of a country; per capita electricity consumption in the residential sector, which serves as an indicator of the reliability of, and consumer's ability to pay for, electricity services; share of modern fuels in total residential sector energy use, which serves as an indicator of the level of access to clean cooking facilities; and the share of population with access to electricity. This index was intended as a simple composite measure of the progress of a country or region in its transition to modern fuels, and of the degree of maturity of its energy end use [52].

The Energy Security Index is composed of two indicators (ESI_{price}, ESI_{volume}) that measure the energy security implications of resource concentration, from the viewpoint of both price and physical availability [24]. ESI_{price} is a composite measure of the diversification of energy sources and suppliers, and the political stability of exporting countries, while ESI_{volume} is a measure of the level of dependence of natural gas imports.

In what constitutes an interesting concept, the "energy trilemma" is defined as balancing the trade-offs between three major energy goals, namely energy security, economic competitiveness, and environmental sustainability [29]. The dimensions of energy trilemma are defined by WEC [37] as follows: (a) energy security: effective management of primary energy supply from domestic and external sources, reliability of energy infrastructure, and ability of energy providers to meet current and future demand; (b) energy equity: accessibility and affordability of energy supply across the population; and (c) environmental sustainability: encompasses achievement of supply and demand-side energy efficiency, and development of energy supply from renewable and other low-carbon sources.

The Energy Architecture Performance Index (EAPI) was proposed in 2010 by the World Energy Forum (WEF), and was modified the next year into the Energy Sustainability Index [53]. EAPI is a composite index based on a set of indicators divided into three basic categories (energy security, energy equity, and environmental sustainability), the so-called Energy Trilemma Index [42].

The Energy Trilemma Index, formerly known as the Energy Sustainability Index, was first introduced in 2009, ranking close to 90 countries. This ranking has been expanded to include 130 countries and greater detail about the performance of countries on the specific trilemma dimensions by adding a balance score, and an index watch list to indicate countries that are expected to display trend changes in the next few years [29]. The Index 2.0 methodology uses a set of 34 indicators and approximately 100 data sets to rank countries on their trilemma performance (compared to 23 indicators and 60 data sets in the current index methodology; [37].

III. Energy Security and Geopolitics

The paper is rounded up with some thoughts on the geopolitical role of energy security globally and in Europe.

The concept of energy security is central to the study of geopolitics. Vivoda [21] pointed out the following issues that have made energy security an emerging area of focus in international relations: high energy prices; the increasing demand for geographically concentrated resources; the threat of resource scarcity and depletion in the foreseeable future; and concern for the likely social and political effects of climate change.

Citing 2009 BP data, Vivoda [21] argued that the following 10 largest regional economies consume 61% of the world’s energy, producing 54% of the world’s Gross Domestic Product (GDP), and emitting 66% of the world’s carbon dioxide (CO_2): United States, Canada, Mexico, Russia, China, India, South Korea, Japan, Australia, and Indonesia. These data show a major geopolitical disconnect: the world’s top four oil consumers, China, Japan, India and the US account for 42% of the world’s oil demand, but control only 4% of global oil reserves. Vivoda asserted that energy security concerns among these four major powers have the potential to cause power competition so intense that may translate into open confrontation, especially in the Asia-Pacific region, the world’s fastest growing energy consumer and a strategically vulnerable region of paramount importance for global stability and development. Vivoda also observed that the world’s top ten regional economies are characterized by very different energy efficiency and carbon intensity values, citing as examples: Japan being four times as efficient as Russia, and four times as efficient as China; the economies of Russia, China and India being five to six times as carbon intensive as Japan; and the inefficient use of energy (with a high carbon intensity), creating energy-related pollution in Russia, China and India. Consequently, the growth of energy use in the Asia-Pacific region, particularly in China and India, is likely to have profound impacts on the energy world, and may carry major geopolitical consequences.

The current global attention to energy security is mostly explained by the new emerging giants of the world economy and their rising energy demand. According to 2015 data for the global primary energy consumption, the market share of oil (33%) was followed by coal (29%), natural gas (24%), hydroelectricity (7%), nuclear energy (4%) and renewable energy (3%). The picture is somehow different for the European Union (EU28, including the United Kingdom): oil maintains the pole position (35%), but natural gas overtakes coal (22% and 16% respectively) and the share of renewable energy is 13%. with upwards trends revealing the strong commitment of the EU28 to environmental protection rationale.

The total gross inland energy consumption in the EU28 is slightly above 1600 Mtoe [54] and is not expected to change significantly in the next decade, as the savings due to the wider use of energy efficient technologies are expected to balance the increased energy demand due to the upgrade of the quality of living standards, especially in the new member states of the European Union. This consumption corresponds to 3.2 tons of oil equivalent (toe) per capita, although there are countries over 5 toe per capita [55], which is closer to the corresponding number for the United States (about 6.9 toe per capita).

Although most EU28 countries produce energy, the overall level of consumption exceeds the production level, making EU28 a major energy importer, especially of oil and natural gas. Securing the EU28 energy supply is of great geopolitical importance [54]. These supply and demand imbalances are shown in Figure 1. To this aim, emphasis has been given on the diversification among forms of energy, energy suppliers and routes of energy supply. The natural gas market is an indicative example: the total production of the EU countries covers about one third of the total demand and the number of gas suppliers is small, with Russia being between the two major suppliers. Furthermore, the European countries have failed in having a common negotiating position against Russia, allowing the gas provider to gain better terms by negotiating each country individually [57].

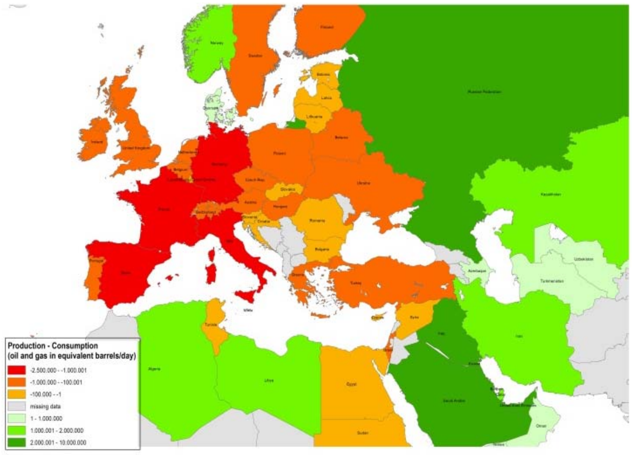

Fig. 1. Oil and natural gas supply and demand imbalances between EU28 and the other countries of the wider region (map composed by authors based on 2016 BP data)

Unless new gas fields are discovered, the local EU gas production is not expected to be much higher in relation to today's production levels. On the contrary, a reduction in the gas production cannot be excluded. The 2010-2015 statistical data reveal that the total natural gas local production in EU is currently declining [54]. Gas is imported from non-European Union countries namely Russia, Norway, Algeria and other countries [58] through pipelines or in LNG form. Russia is a dominant gas supplier contributing about a third of the total gas imports. European Union and Russia have strong interdependencies as Russia is the major gas supplier to EU while European Union is a major customer of Russian gas [59]. However, the reliability of Russia as the major supplier of gas to European Union is disputable as, in the past, during the cold conditions of 2012 winter that attacked the entire Europe [60], significant problems in gas supply were created as the domestic Russian gas consumption was increased and export capabilities were reduced. Problems also arose in 2005 and 2009 due to the Russian-Ukrainian crisis [61].

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