THE ROLE OF EUROPEAN UNION (EU) REGIONAL ENERGY POLICY IN ENHANCING ENERGY SECURITY AND ITS IMPLICATIONS FOR THE ASIAN REGION

By

SUH, Yun Ji

THESIS

Submitted to
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ABSTRACT

THE ROLE OF EUROPEAN UNION (EU) REGIONAL ENERGY POLICY IN ENHANCING ENERGY SECURITY AND ITS IMPLICATIONS FOR THE ASIAN REGION

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Historically, energy policy has been a national issue as it is closely related to national security and sovereignty. However, since the oil shock in the early 1970s, it has become a transnational issue that requires collective efforts to tackle any vulnerability that could happen to energy importers. This paper identifies the benefits of regionally integrated energy policy with regards to enhancing energy security. It is based on the EU's experience, the world's largest energy importer. By showing energy security index that reflects seven factors from the dimension of availability and adaptability of energy system, I conclude that regional energy policy largely helps to improve EU's energy security level by advancing its inter-border infrastructure capacity, market integrity and sharing common standards and regulations. In light of these findings, I propose that the Asia region could consider the practices followed in the EU in formulating regional energy policy that include energy efficiency standards, which does not require immediate physical infrastructure connection or large amount of capital investment. Due to the given limitation of governance structure and geographical barriers, it seems appropriate to consider an establishment of a sub-regional level standard.

Keywords: *Energy security, energy efficiency, regional energy policy, the EU, Asia*

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Abbreviations

EU	European Union
EC	European Commission
IEA	International Energy Agency
MOSES	Model of short-term energy security
ECSC	European Coal and Steel Community
EEC	European Economic Community
USSR	Union of Soviet Socialist Republics
ECT	Energy Charter Treaty
EURATOM	European Atomic energy Community
TEU	Maastricht Treaty on European Union
CEEC	Central and Eastern European Countries
ADB	Asian Development Bank
Mtoe	Million tonnes of oil equivalent
TPES	Total Primary Energy Supply
TAP	Trans-Adriatic Pipeline
PCI	Projects of Common Interest
TEN-E	Trans-European networks for energy
TYNDP	Ten-Year Network Development Plan
CEER	Council of European Energy Regulators
VTP	Virtual Trading Pont
NEEAP	National Energy Efficiency Action Plan
GHGs	Greenhouse gases
OPEC	Organization for Petroleum Exporting Countries
HAEA	Hungarian Atomic Energy Authority
ASEAN	Association of South-East Asian Nations
SAARC	South Asian Association for Regional Cooperation
EAS	East Asia Summit
EEPR	European Energy Program for Recovery
EEE-F	European Energy Efficiency Fund
GDP PPP	Gross Domestic Production Purchasing Power Parity
JRC	Joint Research Center
E3P	European Energy Efficiency Platform

Ⅰ. Introduction

Energy security has been a very important concept for a nation. Long time ago, it meant a stable oil supply for armies in the wake of wars (Cherp and Jewell, 2011). Thus, energy security of a nation was a barometer of its power in international relations . As the energy system is getting complex and multi-dimensional, however, the importance of energy security has increased and its definition becomes more comprehensive. Now, the concept of energy security not only refers to the physical availability of energy resources, but also includes the economic and environmental aspects of energy access. For example, the International Energy Agency (IEA) defines energy security as "the uninterrupted availability of energy sources at an affordable price". The IEA suggests a Model of Short-term Energy Security (MOSES) as an energy security model with multiple dimensions (IEA, 2011) (Table 1.1).

Table 1.1 Dimensions of energy security addressed in MOSES

	Risk	**Resilience**
External	Risks associated with potential disruption of energy imports	Ability to respond to disruptions of energy imports by substituting with other suppliers and supply routes
Domestic	Risks arising in connection with domestic production and transformation of energy	Domestic ability to respond to disruption in energy supply, such as fuel stocks.

Source: IEA, 2011

Originally, a energy policy had been domestic issue closely related to its national security and sovereignty. However, since the global oil shock in the early 1970s, internationally collective efforts have been necessary to reduce the vulnerability of energy importing countries. Two serious disruptions of Russian gas supply to the EU in 2006 and 2009 had raised serious concerns over the energy security in the EU, the world's largest energy importer. Consequently, the EU has made both horizontal and vertical efforts to improve its energy security.

The EU is the most active supra-national governance system, which cooperates to build shared policy framework across diverse economic sectors including the energy field. Some scholars argue that the EU provides member states the capacity to manage geo-economic risks with regards to the energy supply (Raines and Tomlinson, 2016). Since the EU highly relies on Russia for its energy supply, it is critical to have negotiation power via its collective response towards any threat from Russia's resource nationalism or resource weaponization under the banner of "Strong Russia". Meanwhile, De Jong and Egenhofer (2014) assert that the EU-driven policy might not fit into every single member state. However, I argue that the EU has a reasonable extent of flexibility to formulate its energy policy at the national level as the EU elects to use 'directives' in the energy sector. The directive is set to share a common goal across the EU but it gives each member state a discretionary authority to design its national level regulations. Lucas (2014) claims that regional cooperation based on common energy policy is enhancing national energy security. Whereas previous studies have emphasized the importance of energy security with focusing on the conceptual analysis of regional energy policy, have paid little attention to practical evidence that shows the effectiveness of regionally integrated energy policy. Therefore, this paper intends to show the role of regional energy policy in enhancing of the EU energy security.

The analysis is conducted in two aspects of energy, which are energy supply and energy demand. For the supply side, this research focuses on how the EU manages stable access to gas and oil. In demand side, this research sheds light on energy efficiency that implies using less energy for producing same or larger amount of economic output by utilizing advanced technology. In addition, this research draws implications that are applicable to the Asian region, which has experienced the largest energy demand growth currently.

This research intends to answer following research questions: 1) How has the EU's regional cooperation strategy in the energy sector been evolved? 2) How has the EU improved its resources availability? 3) How does the EU manage the demand side to curb its energy demand growth? 4) What are the effects of EU-level energy security policy? and 5) What are the implications for the Asian region currently pursuing regional cooperation? I will argue that the regional energy policy of the EU has improved its member states' energy security, particularly, through the advanced energy efficiency standard at the regional level aimed at controlling energy demand side.

This paper is divided into three sections. First, I present a thorough literature review on energy security and regionally integrated energy policy, particularly that of the EU. Second, I investigate the effectiveness of EU energy policy by showing the trend of energy security in EU member states with the security index, which reflects multiple indicators of energy availability and adaptability. Lastly, I propose policies and measures that could be applied to the Asian region. I will now proceed to review of the secondary literature on the topic of energy security and regionally integrated energy policy. This research will be carried out using a case study method.

Ⅱ. Review of literature

The concept of energy security

Energy security is an evolving concept. The notion of energy security emerged in the early 20th century as a term that indicates oil supply protection, which is vital for the modern armies and economies (Cherp and Jewell, 2011). However, over the recent decades, it has evolved into a comprehensive concept that includes all aspects of the energy system. Now, it even reflects the constraints of energy supply related to environmental regulations for tackling any externalities of energy consumption. As mentioned above, it may be useful to refer to the International Energy Agency (IEA) in defining contemporary concept of energy security; "the uninterrupted availability of energy sources at an affordable price" (2013, page 4). Yergin (2006) asserts that energy security also exists in a broader context; in the world of increasing interdependence, energy security will depend on how countries manage their relations with one another. Therefore, energy diplomacy is one of the important categories among energy policy dimensions.

Labanderia and Manzano (2012) identify that the discussions over the energy security issues have heavily focused on the supply side. Particularly for the energy importing countries, such as EU member states, securing energy supply is naturally a matter of concern on their agenda (Energy Charter Secretariat, 2015). The fundamental effort to improve energy security in terms of energy supply is to diversify supplying sources and routes. In a view of demand side, energy efficiency is the most important way of managing and restraining the growth of energy consumption (IEA, 2016). Metcalf (2013) suggests that reducing energy consumption could improve energy security. Considering that energy is a fundamental component of economic growth, the reduction of energy consumption could affect economic output. Consequently, it is critical to determine ways to maintain or improve economic output while using less energy, so-called "energy efficiency".

Energy security largely relies on external factors rather than internal factors. Jonsson et al (2015) assert that the economic interdependency among countries provides incentives to cooperate each other. However, energy resources are not a pure commodity but rather a strategic source of geopolitics or even a weaponized tool for maximizing a nation's interest. Therefore, the over-dependency upon a certain energy exporter could increase the vulnerability of energy importer.

Regional energy policy

A brief look at the history of regional energy policy discussion helps to understand better the issue of energy security. The dominant international energy security system was established with the IEA in the wake of the oil crisis in 1973. The establishment of the IEA aims for ensuring coordination among the industrialized countries in the event of a disruption in oil supply (Yergin, 2006).

Another important factor that had affected energy security discussion was the trend of deregulation of energy supply from the 1980s to the 1990s in Europe. Keppler (2007) claims that the involvement of private actors in energy supply causes energy insecurity since the liberalized market does not always provide efficient energy supply. Since the energy sector has been largely dominated by the state-owned giants, it is not easy to see either the radical change in the energy market nor the transparency. Rather, the energy sector needs some extent of government intervention, as it is not a pure market commodity but a strategic resource of the nation.

In the contemporary context, energy security issue includes the matter of climate change and universal access. Cherp and Jewell (2011) maintain that many countries are pursuing an integrated approach to address energy security challenges with the recognition of the needs of energy transition towards the low-emission system. It seems reasonable to conclude that the needs of knowledge sharing with given complexity of energy system have enhanced supra-national level cooperation in the energy sector, particularly under the new climate regime.

Regional governance of the EU

The foundation of regional community within the EU was initiated by the establishment of European Coal and Steel Community (ECSC) in 1951. The underlying motive behind the formation of ECSC was ‘Peace’ since the steel and coal was a fundamental source of warfare. Since the formation of the European Economic Community (EEC) in 1958, the economic integration of the member states had been accelerated. In addition, it gave equal negotiation position for Europe as a whole in relation to the United States (U.S.). The concerns on the political risk of former USSR (Union of Soviet Socialist Republics) countries off set the security improvement of the EU that was expected along the establishment of the European Energy Charter (EEC) in 1991. The European Energy Charter (EEC) was followed by the Energy Charter Treaty (ECT) in 1994 (Sodupe and Benito, 2001).

Since the formation of European Atomic Energy Community (EURATOM) in 1957 and ECSC in 1958, there has been a long vacuum in terms of regional cooperation within the sector of energy until the 1980s. Integration of energy sector has been slower than that of other economic sectors, such as trade and financing due to the nationalized energy system run by state-owned energy giants in each member state. Moreover, the enlargement of the EU prevented advancement of energy sector. Sodupe and Benito (2001) argue that the Energy Charter Treaty (ECT) will not be able to prevent the increase of important dependency of the EU. However, they have emphasized that the economic recovery of eastern European countries may increase the energy demand. Therefore, the European energy policy shall consider the transfer of technologies, which allows more efficient use of energy to the new eastern members.

The EU faces several limitations while carrying integrated policies. The European Energy Charter (EEC) had largely focused on the supply side. However, the concerns about increasing energy demand, storage and transmission infrastructure, transit security and energy poverty had become new agendas. Consequently, the EU needed more advanced approach than the European Energy Charter (EEC). Since more eastern European countries, which used to be the parts of USSR and emitted a large amount of pollutants became the member states of the EU, the EU needed to persuade those countries into complying the EU environmental regulations with a fund for making them progress.

EU energy policy

The European Commission ("Commission") has put efforts to formulate policies that can work across the member states. The EU is the one of the active regional policy makers for energy security measures. The main drivers for the EU-level energy policies include; (a) the enlargement of the EU membership with energy importing member states, (b) a trend of increasing energy imports and its price and (c) gas supply disruption, such as the Russia-Ukraine gas crisis. Energy security issue became more significant due to the newcomers, which used to be highly dependent on Russia. The Maastricht Treaty on European Union (TEU)[1] signed in 1992, enabled the EU to improve cross-border energy infrastructure through the program, called ‘Trans-European Networks (TENs)’ and increased the EU’s ability to act for mitigating external impact (Wallace, Pollack and Young, 2014).

The number of the EU member states has increased from 15 in 2004 to 27 in 2007. The most recent addition to the EU was Croatia in 2013. The enlargement of the EU gave the

[1] The TEU represent a new stage of integrated Europe. TEU introduced the concept of European citizenship, strengthened the power of the European Parliament and established economic and monetary union (EMU).

Commission the energy policy entrepreneurship. New member states' greater dependency on Russian gas and low reliability of Russian energy supply increased concerns about energy security issues (Maltby, 2013). New member states were usually less enthusiastic about radical approaches for climate change mitigation, as they were relatively poor and fossil energy intensive economies. For example, Poland that joined the EU in 2004, generates 95% of electricity from coal.

The continuous counterargument against the EU-level energy policies was related to member state’s sovereignty. The EU had already formulated regional energy policies since the 1960s. The European Commission's "'Community Energy Policy" in 1968 described concerns about energy dependency. It claimed that the lack of integration in energy arena was considered as a “dangerous trend”. In addition, it asserted that those dangers could be resolved only with "community energy policy which fully integrates the energy sector into the common market", as it would mitigate “risks from the great dependence of the Member States on imports and from insufficient diversification of the sources of supply" (European Commission, 1968; Maltby 2013). The oil crisis in the early 1970s underlined both of the anxieties over vulnerable energy supply and the inadequacy of securing energy supply for the EU, while energy policy design and implementation remained at the national level or within the inter-governmental context.

Until the 1990s, the policy recommendations formulated at the Commission level were mostly ignored by the member states (Maltby, 2013). Notwithstanding, the Council of the EU started to put a focus on the 'Concept of Community Solidarity' in the field of energy policy. The concept of community solidarity includes larger integration, free from barriers to trade of energy. The 2003 "European Security Strategy" referred energy dependence as a special problem, as the EU is the largest importer of oil and gas in the world.

Historically, member states have defended their sovereignty while discussing EU-level energy strategies. As they wanted to keep their own authority to decide their own energy policies and protect their national industries to achieve economic development. To some extent, the supra-nationalism in the energy sector has been accepted by the member states as a measure for improving each state's and regional energy security while not paying much attention to shared benefit among the member states.

Although the discussion of regional energy governance in the EU has been initiated long ago due to high level of energy imports, it was largely hurdled by the sovereignty frames. Notwithstanding, the Council of the EU continuously put a focus on the concept of 'Community Solidarity' that emphasizes collective approach in order to achieve common interest. These have important implications for this study. For the EU, regional integration of energy policy is not something new but an on-going discussion with its acknowledged importance for a long time. Moreover, a shared economic and political context among member states largely helps the development of the common framework within the energy sector.

The EU has repeatedly emphasized 'solidarity' among its energy policy packages and once again within the package, called 'Clean energy for all Europeans' issued in the November, 2016. This package includes two major schemes, which are de-carbonization and Europeanization. The 'Europeanization' refers to a move from national approaches towards the regional and EU-wide frameworks. The desirability of the Europeanization of energy system is well transposed into the EU's target model of the electricity system. The target model reflects desire for cross-border trading in order to foster price competition as well as to provide better back-up service in case of the power shortages.

Limitations and opportunities of EU energy policy

The EU's strategies for diversifying its energy source with LNG imports, building more storages and pipeline infrastructures and expanding renewable energy production are consistent with both member states' energy policies and the EU-level regulations or directives. However, different perspectives on regional integration still remain. Austvik (2016) argues that the EU member states have been implementing somewhat polarized energy policies. Austvik rightly draws attention to the different focuses across the EU. Western European countries' energy policies have been more focused on the completion of a single market and climate change while paying less attention to security and foreign policy. In contrast, central and eastern European countries (CEEC) tend to highlight a supranational and common EU responsibility for strengthening its position in relation to Russia. Wallace, Pollack and Young (2014) argue that energy security is the weakest part of the EU energy policy triangle[2] with given fragmentation within the EU. At the same time, they assert energy security is the sector that has the biggest gap between potential and realized performance. Smaller states have more interest in building one EU voice in the energy sector, particularly in respect to Moscow. However, the CEEC is still cautious to show 'anti-Russian' stance, as they are still part of Soviet institutions and alliances. In particular, Baltic States (Estonia, Latvia and Lithuania) have unique position since they are still linked to the Russian power grid while not fully integrated to the EU's main electricity grid yet.

De Jong and Egenhofer (2014) argue for the adequacy of EU's energy policy, termed as 'energy schengenisation[3]'; lessons from energy sector can be applied to other member states or non-energy sectors in order to bridge the gap between the EU and the national level. Furthermore, regional energy policy could advance the way of applying and implementing global objectives by setting regional guidelines at the EU level. De Jong and Egenhofer's

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[2] Internal energy market, energy security and efforts to develop a low-carbon economy

[3] The Schengen Agreement came into effect in 1995 removed border check among its members and allowed foreign visitors to travel throughout the Schengen Area using one visa. (Economist, 2015)

argument makes a valid point about the role of knowledge sharing under the common governance structure, which will foster the universal development across member states. According to the research of Booz & Co (Newbery et al, 2013), greater integration of gas market in Europe will likely produce economic benefits from the price effects as well as improve security of supply. For example, pertaining to the electricity market integration, although full integration will require a large amount of financial investment in transmission capacity, this would be much cheaper than the further investment in generation capacity without integration transmission networks.

Energy security in Asia

Regional energy dialogue is not only a matter for the EU. Over the coming decades, Asia will be the core of the energy discussion. Lucas (2014) asserts that Asia would be responsible for the largest part of emission reduction while responding to its rapid energy consumption growth. Asia shows high economic growth despite its limited oil or gas reserves. It seems reasonable to assume that energy security will be the top priority issue for the Asian region who need to ensure a stable response towards increasing energy demand while pursuing energy transition under the new climate regime.

Lee, Park and Saunders (2014) define key vulnerabilities of Asia's energy security in three aspects: physical energy supply, environmental sustainability and accessibility. They encourage formation of regional markets and an infrastructure system to overcome challenges in relation to mentioned aspects. Even though Asia represents world's largest coal reserves, it largely relies on imported gas and oil supply. In other words, Asia has a high vulnerability to the external resource price fluctuation. Moreover, environmental deterioration is inevitable due to growing energy demand without substantial energy portfolio transformation. Meanwhile, Asia hosts the majority of energy-poor population. Over 700 million people in

Asia have no proper access to electricity, but rely on solid fuels, which may hinder further socio-economic development and cause health and environmental problems (ADB, 2017).

The Asian Development Bank (ADB, 2009) highlights the necessity of regional cooperation in the energy sector, as it is an effective way to address energy security. The ADB has identified important factors for regional cooperation in terms of technical and policy compatibility. Unlike the EU, Asia has no strong governance regime at the supranational level. Therefore, the regional cooperation should be established with careful consideration of higher sovereignty in Asia. This research intends to draw lessons from the EU's case that can be applied to Asia.

This study primarily focuses on identifying the benefits of regionally integrated energy policy with respect to enhancement of energy security. This study does not attempt to analyze all the EU member states. Instead, it seems appropriate to limit the study to selected member states: the Czech Republic, France and Hungary. Practical considerations pertaining to data availability lead to the selection of suitable cases, among the EU-28 members based upon the following considerations; (a) suffering relatively high disruption over the Russia-Ukraine gas crisis in 2006 (b) differ in shape of energy mix and (c) shows variance with regards to energy challenges.

The energy price data is not comprehensive thus this study excludes price factor for establishing energy security index. As data are available up to 2014, the EU indicators include the U.K. The U.K. is the second-largest oil producer and third largest gas producer in Europe (Froggatt, Raines and Tomlinson, 2016). The effect of Brexit on the energy sector would be the subject of future research.

Ⅲ. Supply side

Ⅲ-Ⅰ. Gas supply security

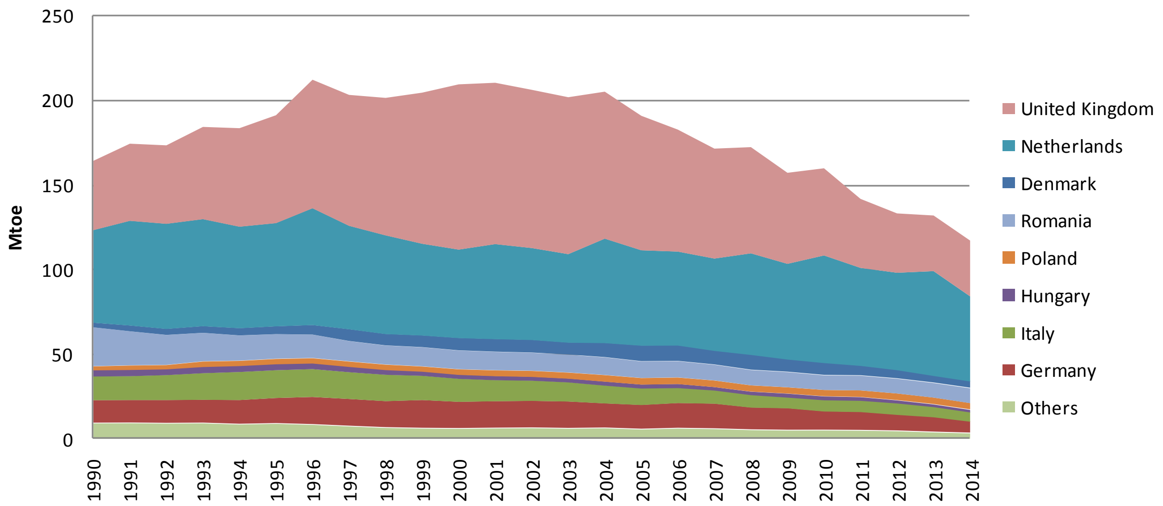
Natural gas accounts for 15.2 % (117Mtoe) of the EU energy supply in 2014. Gas plays a significant role for heating as well as for the petrochemical industry. The EU gas self-sufficiency in 2014 was 34%, making it highly dependent on imports from abroad (IEA, 2016). The EU gas imports heavily rely on Russia, though the levels of dependency vary across the EU member countries. The 2006 and 2009 Russia-Ukraine gas crisis raised concerns over gas supply security in the EU. Majority of the EU member states import gas for more than 70% of its inland consumption. Denmark and Netherlands are the only two net exporters of natural gas. The overall gas supplies are vulnerable in many aspects, such as lack of diversity of sources, suppliers and routes, lack of preventive and emergency measures. More importantly, the level of interconnection and the possibility of reverse flowing are the keys in assessing the security of gas supply.

Vulnerable gas supply – The Ukraine-Russia Gas crisis

The geopolitical crisis between Ukraine and Russia, in 2006 and 2009, raised concerns over domestic gas imports of Ukraine and security of transited gas supplies to Europe via Ukraine. The crisis started with the disagreement between Moscow and Kiev over the price of Russian gas sold to Ukraine. The disruption caused huge economic damages as it halted industry production in Hungary (EUR 70 million), Slovakia (EUR 1 billion) and Bulgaria (EUR 255 million) (IEA, 2014). The impact of disruption was even worse due to the severe winter and the high dependency on a single supplier, Russia. Thanks to the reverse flow interconnection capacity, some part of missing volume could be transported from the gas storage of Austria, Germany and Italy. The gas crisis proved the benefit and importance of reverse flow capacity, which requires less investment compared to the cost of building new gas pipelines.

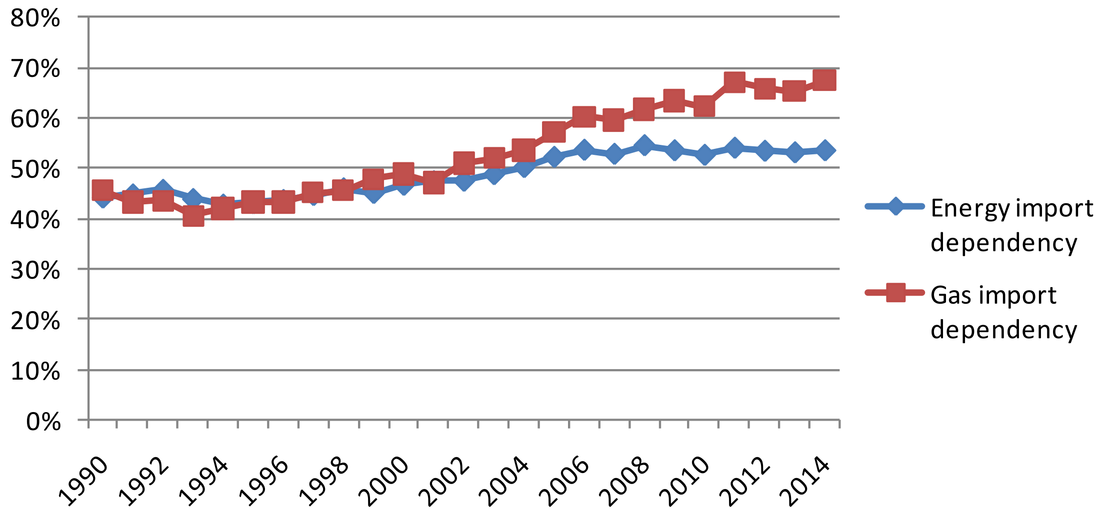
The weaknesses identified through the crisis were low coordination among countries with regards to emergency measures, lack of infrastructure and west-east transmission capacity, and insufficient access to storage of LNG terminals in eastern part of the Europe. Ukraine still remains as the most important transit point in terms of gas supply towards Europe, approximately 15% of European gas supply is delivered via Ukraine through the 'Brotherhood pipeline' (IEA, 2014). During the 2009 gas crisis, the storage capacity of EU, (20% of domestic demand), played an important role in mitigating the risk. Even though energy efficiency regulations are expected to restrain demand for heating, natural gas is likely to remain as a critical source of energy for industries, buildings and will continue to play an important role as an alternative fuel in the transportation sector.

Figure 3.1 EU natural gas production, 1990-2014



Source: Eurostat

Figure 3.2 EU energy import dependency and gas import dependency



Source: Eurostat

The EU's collective response to gas supply security

Infrastructure – pipeline

According to the regulation for the security of gas supply (EU 994/2010), the EU member states are required to have a bi-directional capacity (or reverse flow) at each cross border interconnection point. The reverse flow capacity is one of the most reliable methods to provide gas supply where needed. According to the European Commission, the share of reverse-flow cross-border interconnection points within the EU has increased from only 24% in 2009 to 40% in 2014. The majority of capacity came from commercial projects that were incentivized by the market demand. Compare to 2009, four more borders became bi-directional; Germany-Denmark, Italy-Austria, Greece-Bulgaria and Romania-Hungary. The Commission promotes reverse flows in the interconnections by emphasizing benefits of the security of supply, which outweigh the cost of an investment. The Commission argues that this is the quickest way to meet the gas demand in a situation of supply disruption that originated out of the EU.

Owing to the historic division between Eastern and Western Europe, the gas delivery points for the Western gas markets are located at the border of Germany (Waidhuas; Germany and Czech Republic border, Mallnow, Germany and Poland border) and Austria. The gas delivery points of Eastern Europe are located at the borders between Ukraine with Hungary, Poland, Romania and Slovak Republic. The Trans-Adriatic Pipeline (TAP) will enable Southern gas corridor to access gas production in Azerbaijan. TAP will bring gas to Europe through Greece, Albania and Italy. The construction of TAP started in 2016 and is expected to be completed by 2020 (tap-ag, 2017).

Figure 3.3 Map of Trans-Adriatic pipeline

Source: tap-ag.com

During the 2009 Ukraine gas crisis, the necessary amounts of gas were available within the EU market. However, it was impossible to deliver those amounts to the member states located in the eastern side of Europe (Nuria Rodríguez-Gómez, Nicola Zaccarelli and Ricardo Bolado-Lavin, 2015). In order to minimize any further supply disruption, the EU made the N-1 rule on top of securing reverse capacity. The N-1 rule mandates the member states that rely on a single import pipeline to have underground storage facility or other types of essential infrastructures. The rule is aimed at providing at least 30 day gas supply for households and other vulnerable consumers, such as hospitals. The number of member states that comply with the N-1 rule has increased up to 20 out of 25 in the end of 2013. Three member states, Sweden, Luxembourg and Slovenia, with relatively small and isolated gas market have been excluded from the rule. The N-1 infrastructure standard is an important parameter to show the entry capacities of the gas transmission system while keeping balanced level of concentration in the pipeline. In addition, the N-1 rule is a key in a selection of PCI (Projects of Common Interest)[4]. The N-1 rule has been a measure for assessing each member states' resilience.

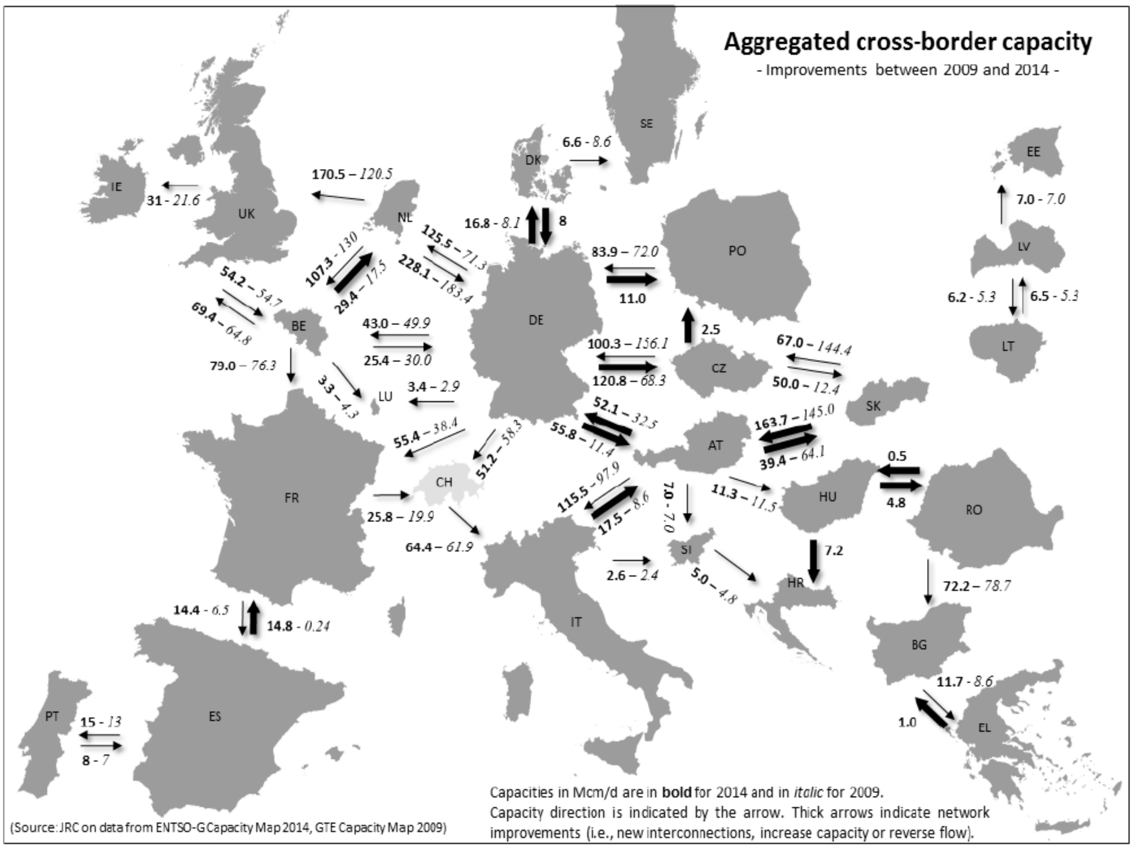
Table 3.1 Number of interconnection points with reverse flow

	2009	**2014**
Number of cross-border interconnection points in the EU	49	53
Number of bi-directional interconnection points	12	21
Number of unidirectional interconnection points	37	32

Source: European commission

[4]The European Commission adopted a list of 248 key energy infrastructure projects in October 2013. PCIs should benefit from faster and more efficient permit-granting procedures and improved regulatory treatment. To be included in the list of PCIs, a project has to deliver significant benefits for at least two member states, contribute to market integration and further competition, enhance security of supply and reduce emission.

Figure 3.4 Aggregated cross-border gas transmission capacities



Source: Rodríguez-Gómez, Zaccarelli and Bolado-Lavín (2015)

Expansion of domestic storage capacity could be an alternative to the reverse flow. However, building and operation of a gas storage facility are costly. According to the IEA (2014), the cost of underground gas storage is five to seven times more expensive than underground oil storage, due to the high capital cost of the cushion gas[5]. The cost of LNG storage facility is far more expensive than other facilities, maximum ten times of the cost of stocks in oil tanks and fifty times more expensive than the cost of underground oil storage. Apart from the monetary cost, the construction of gas storage facility normally requires a large amount of time for permitting, financing and construction, which could increase the soft

[5] The volume of gas that should remain in the storage to provide the required pressurization

cost of the project.

The EU strengthens its efforts for cross-border infrastructure development both within the regulatory framework of the "Third Energy Package” and within the framework for Trans-European networks for energy (TEN-E). The EU-wide grid planning is based on the EU-wide Ten-Year Network Development Plan (TYNDP). In addition to the implementation of the Third Energy Package, the European Commission adopted the "Energy infrastructure package" in 2011. The trans-Europe energy networks are governed by the Energy infrastructure projects of four corridors (Table 3.2), which was included in the Projects of Common Interest (PCI) list[6].

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[6] European Commission has list up 195 key infrastructure projects in order to make integrated EU energy market. PCIs may have the benefit of using fast-tracked planning and permission to project completion. The EU provided funding in order to attract private investors.

Table 3.2 Europe priority gas corridors, included in the PCI list

Project	Description
North-South Gas Interconnection in Western Europe ("NSI West Gas")	- Aims to diversify supplying routes and increase short-term gas deliverability - The project allows reverse flow between Ireland and the United Kingdom. Also between Portugal, Spain, France and Germany
North-South Gas Interconnection in Central Eastern and South Eastern Europe ("NSI East Gas")	- Encourages regional connections between and in the Baltic Sea region, the Adriatic and Aegean Seas, the Eastern Mediterranean Sea and the Black Sea - Allowing reverse flow between Poland, Czech Republic and Slovakia, linking the LNG terminals in Poland and Croatia - Allowing gas to flow from Croatian LNG terminal to neighboring countries - Allowing gas from the Southern Gas Corridor to flow through Italy towards the North-Eastern Europe - Allowing development of underground gas storage capacity in South-Eastern Europe
Southern Gas Corridor ("SGC")	- For gas transmission from the Caspian Basin, Central Asia, the Middle East and the Eastern Mediterranean Sea and the Black Sea
Baltic Energy Market Interconnection Plan in Gas ("BEMIP Gas")	- Aims to end the isolation of the three Baltic States and Finland. At the same time, end their dependence on a single supplier while ensuring internal grid infrastructures in the Baltic Sea region.

Source: European Commission; IEA

Table 3.3 Development of energy packages

	First energy package	**Second energy package**	**Third energy package**
Adoption	1996 (electricity) and 1998 (gas)	2003	2009
Implementation	1998 (electricity) and 2000 (gas)	2004	2011 (Unbundling requirements by 2012)
Market opening	Gradual and restricted (Gas) Minimum 20% of market to be opened to competition by 1998; 28% by 2003; 33% by 2018 (Electricity) 30% of supply to large users and distributor to be competitive by 2003	100% - Supply to all non-residential electricity and gas consumers to be open to competition by 2004 and all residential consumers by 2007	-
Third-party access	Negotiated, Regulated or Single Buyer - Choice of three models (regulatory, negotiated, sole supply) all allowing refusal of access on grounds of lack of capacity	Regulated access only - Mandatory regulated TPA[7]. Tariffs (or tariff methodologies) to be approved by a national regulator	Strengthened TPA applied to all TSO[8]s, DSO[9]s
Market regulation	Any competent authority	Independent National Regulator	Coordination of regulators by ACER
Unbundling of TSOs	Accounting - TSOs and DSOs are required to have separate identity and accounts, and subject to information barriers and non-discriminatory obligations, but are allowed to be part of groups with interests in generation, supply , production etc.	Legal - TSOs and DSOs also required to have separate legal form	Ownership - TSOs and DSOs are required to be under separate ownership or managed by an independent system operator, subject to stringent restrictions on intra-group influence
Network Development			Ten year Network Development Plans - Coordination of TSOs by ENTSO-E[10] and ENTSO-G[11]

Source: Harrison and Mordaunt (2012). Mergers in the energy sector. Clifford Chance

[7] Third party administrator
[8] Transmission system operators
[9] Distribution system operators
[10] European Network of Transmission System Operators for Electricity
[11] European Network of Transmission System Operators for Gas

Market Integration

The energy market integration has been understood as a critical path towards achieving the goal of European energy policy in terms of competitiveness, energy security and environmental protection. Despite long and active discussions on the issue of the energy market integration, a fully integrated market is yet to be formulated. The primary objective of the EU energy market integration is to ensure fair market access, high service quality, as well as the consumer protection.

The formation of integrated gas market expected to contribute to formulating balanced tariff while lowering the end-user gas prices, which may result from market competition. The main idea of an integrated market is to enforce cooperation for a collective response to potential supply crisis through re-distribution of assured resources. The discussion on integrated market initiated in the early 2000s, stagnated until the mid-2000s. The member states have a tendency to encourage their domestic energy companies' to forge mergers in order to protect their internal position. Thus, the market formation or competition was not active enough within the EU. The price of natural gas had varied widely, across the member states, maximum three times difference. According to the European Commission energy statistics, the price of natural gas for households in Sweden (EUR 0.113 per kWh) was more than three times compared to the price that was charged in Romania (EUR 0.033 per kWh). This means that the end user market was far from the desired level. In addition, the market was largely dominated by small number of giant players.

The core of the EU energy policy has been the liberalization of the energy market, which used to run on monopolistic dominance systems. To achieve market liberalization, it is essential to ensure the potential market access of new player. Therefore, the EU tried to eliminate vertically integrated system in the energy market to remove potential monopolistic dominance and this was the most controversial agenda of the "Third Energy Package". The

Russian government and Gazprom[12] have opposed the third energy package. Gazprom claimed that third energy package could hinder the investment towards the planned expansion of Nord Stream in its second phase. The EU, however, assessed the Nord Stream to go against the third energy package, which required separation of production, sales and supply system of energy. The third energy package maintains to prevent a market domination of players such as Russia's Gazprom.

Flexibility of gas market

In 2011, the target model for the European gas market was suggested by the Council of European Energy Regulators (CEER). The gas target model suggested a vision of interconnected entry-exit zones with Virtual Trading Point[13]s (VTPs). The model stipulates that these large wholesale gas hubs would need to meet following conditions of Table 3.4.

Table 3.4 Conditions for gas hub

Category	Index	Level
Liquidity	Churn rate[14]	Over 8
Competitiveness	HHI[15]	Below 200
Large in volume	Total gas demand per year	At least 20 bcm
Diversification of supply	Number of supply sources	At least 3 origins

The implementation of the target market is a challenge for Western Europe as well as it seems to be too ambitious for Eastern and South Eastern Europe, where gas trade and diversification level is lower among other member states. Enhanced cross-border operation in

[12] Russia's largest gas company. Gazprom was established in 1989 with the conversion of former Soviet Ministry of Gas Industry into a corporation. Although it is a private company, the Russian Government holds a majority stake in the company.

[13] VTP is a type of market place where gas is traded. Gas can be traded after entry and before exit, within the market area. The virtual trading points enable an efficient and liquid trade of gas.

[14] Multiple of traded volume to the physical throughput. The churn rate is used by traders as a 'snapshot; of a market liquidity.

[15] Herfindahl-Hirschman Index (HHI) is a commonly used indicator for market concentration. HHI calculated by squaring the market share of each supplier in the market, can range from zero to 10,000 (100% market share).

European gas market with the merger of a small entry-exit zone or balancing zones are implemented in some regions; between Germany and the Netherlands, Luxembourg, Belgium and Austria. In Central West European markets, gas market integration has been successful and led to an increase in trade and liquidity, with higher churn rates of four to six (IEA, 2014).

On top of that, the Commission continuously asks for the deletion of the clause for banning change of LNG unloading port from the LNG contract. The Commission interprets the banning clause is a serious barrier to creating the fully integrated energy market in the EU.

Ⅲ-Ⅱ. Oil Supply Security

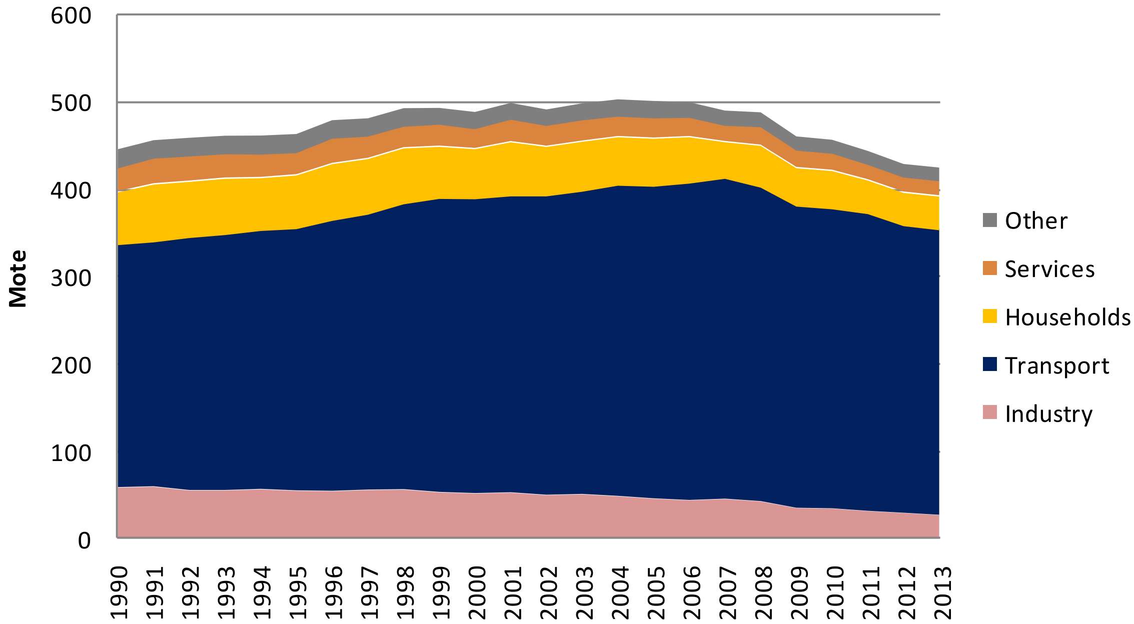
Oil has been dominant resource of the EU representing over 30% of Total Primary Energy Supply (TPES). Russia is the largest oil exporter to the EU, accounts for approximately one-third of the oil imports. Oil security has become an issue owing to the notably fallen domestic production while the demand has kept increasing. The crude oil import dependency in the EU reached its peak, 88%, in 2012 and Russia accounted for 35% of total imports. The supply of Russian oil, transited via Belarus, interrupted in 2008. In addition, supply through Ukraine interrupted in 2014 due to the crisis brought on by the annexation of Crimea.

The landscape of global oil market affects the EU. The oil trade is shifting to Asia to meet its growing demand stemming from Asian emerging countries' rapid economic development. Further changes would occur following Britain's exit from the EU since the U.K has been the largest crude oil producer among the EU member states (European Commission, 2014). The second largest producer is Denmark but has a diminishing production capacity. Despite encouraging transport fuel shifts, the dominance of oil based vehicle usage is expected to remain until the 2030s (IEA, 2014).

Gupta (2008) draws attention towards policies aims to lowering market risk, which is more governed by indigenous factors compared to the supply risk; the internal factors such as oil intensity and paying capability are comparably easy to address, compared to the external issues such as a geopolitical concerns. Gupta also suggests that the best way to lower oil vulnerability is to reduce overall oil dependence by improving oil efficiency in the long term.

Wider cooperation at the international level, such as IEA's emergency oil sharing structures, would also reduce oil supply vulnerability. The greater inclusion of the large oil consumers, such as China and India would be relevant to mitigate further global oil security risk. In addition, developed countries are expected to invest more in research and development sector to come up with advanced technologies that would curb oil consumption growth as well as the environmental impacts.

Figure 3.5 Petroleum products consumption by sector, 1990-2013



Source: Eurostat

Oil emergency stock piling policy

The origin of the European oil stock obligation dates back to 1968, as a result of the council directive (68/414/EEC[16]) and has remained without any major changes until the 2000s. In 2009, the trend of oil price increase had been the main factor of pulling the directive amendment. Moreover, it aims to make the oil stockpiles more efficient. The oil stock obligation is to intensify control of oil reserves and allow private oil companies to hold its stock anywhere within the EU with due regard to physical accessibility.

According to the most current oil stock rule, European Council Directive (2009/119/EC), the member states are obliged to hold emergency crude oil or petroleum products stock. Member states, including net exporters, are required to store 90 days of net imports or 61 days of consumption[17], whichever is higher. Furthermore, minimum one-third of obligation shall be in the form of petroleum products with reflecting consumption pattern of each state.

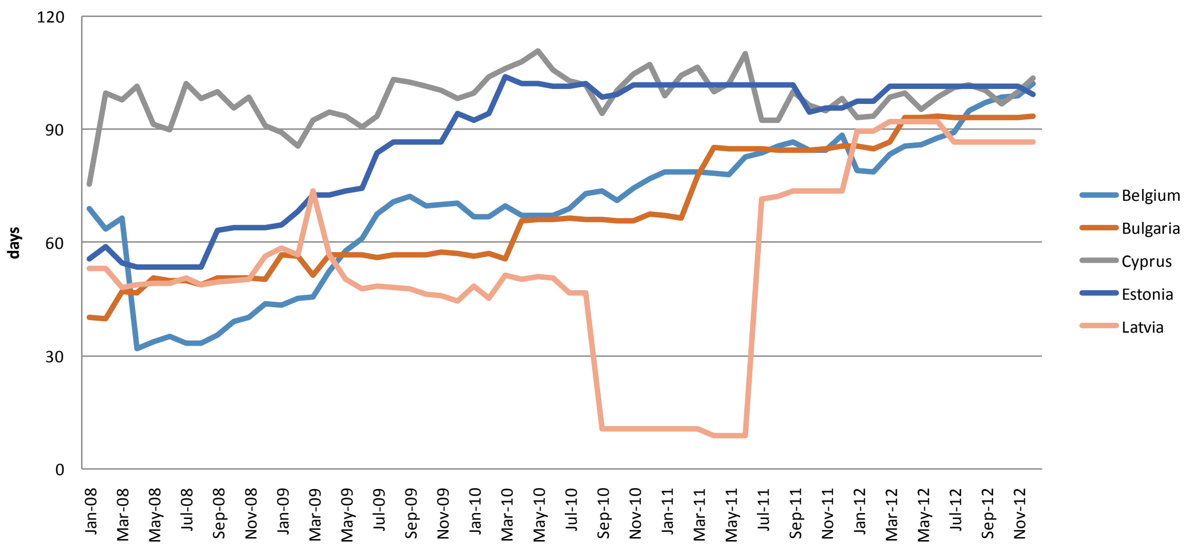
Each member state is supposed to transpose the directive into the national legislation by the end of 2012. Member state is obliged to release these stocks in an emergency supply disruption conditions. The EU would give two-year transition period for non-IEA member countries, which covers petroleum products consumption fully by imports. One of the objectives of the directive is to enhance convergence between the EU and IEA system. As previous directive (2006/67/EC) defines stock holding obligation on the basis of average daily inland consumption, while the IEA calculate it upon the net imports amount of oil and petroleum products. The oil stock monitoring is in charge of the EU, in the meantime, the IEA and EU will coordinate closely. The EU has clearly stated that their willingness to cooperate with IEA for the response to any oil supply disruption. Hence, this is an approach

[16] It imposes obligation on member states of the EEC to maintain minimum crude oil and/or petroleum products.

[17] Denmark, Estonia, Romania (and U.K) are eligible for 61 days of consumption reserve

to ensure the preparedness across the member states. Despite there were no significant changes in the EU28 oil stock levels, some member states notably increased their oil stock level so that they can be aligned with the EU-level requirements. Overall preparedness of oil stock level in case of emergency has improved by the revised oil stock directives.

Figure 3.6 Oil stock holding of selected member states (January 2008 - December 2012)



Source: European Commission

Again, the European Council underlined the importance of integrated energy policy in the Council meeting in March 2007. Thus, the Council decided to pursue greater collaboration in terms stockholding mechanisms among member states. The directive stated that it should be possible to hold oil stocks at any location across the EU. The Commission will recommend stock release by all member states in a case of the IEA's decision invite member states to release the stocks. In addition, Commission asked member states to prepare contingency plans to implement in the event of major supply disruption. The Commission has firm authority to order a release of emergency stock based upon consultation with the Coordination group, which consist of representatives of member states.

Table 3.5 Comparison of EU and IEA stock holding system

	EU	**IEA**
Stock Holding Obligation	90 days of net imports or 61 days of inland consumption Whichever is greater	90 days of net imports (of the previous year)
Category	Based on consumption of three product groups[18]	Based in net imports of oil and oil products (excluding Naphtha)
Calculation	Crude oil is recalculated to product equivalent	Product stocks are converted into crude oil equivalent
Dead stock	4% (average naphtha yield)	10%
Penalty	Infringement procedure	No legally empowered penalty
Monitoring	Monthly reporting and assessment	Monthly reporting and quarterly assessment

Source: Diverse sources including IEA publications

[18] Three product groups; gasoline, Naphtha for gasoline production and middle distilled & heavy fuel oil

Table 3.6 Oil supply vulnerability of the EU

	Share of EU oil imports (2005)	Share of EU oil imports (2015)	EU spending on crude oil		Identified geopolitical risks
			billion dollars	million tonnes	
Russia	30%	30%	$57.4 bn	157.9 Mt	- Political instability following the annexation of Crimea and involvement in the Syria conflict
Nigeria	3%	8%	$17.6 bn	44.8 Mt	- the militant group Boko Haram controls large territories in the country and this has led to internal conflict in recent year s
Saudi Arabia	10%	8%	$16.1 bn	43.2 Mt	- Saudi Arabia is currently facing geopolitical tensions with Iran - Neighboring countries, such as Yemen, face particularly high risk of terrorism and conflict
Iraq	2%	7%	$13.1 bn	39.4 Mt	- the terrorist group, so-called Islamic State, controls large part of the country, including many of the country's oil filed
Libya	11%	3%	$5.6 bn	15.1 Mt	- Intense fighting continues in a number of area and there remains a high risk of terrorist attacks

Source: A study on oil dependency in the EU, Cambridge Econometrics (July, 2016)

Ⅲ-Ⅲ. Energy diplomacy

The consistent and successful efforts of the EU have resulted in building its oil stockpile and energy infrastructure. However, given the unequal distribution of oil and gas resources globally, pushes energy diplomacy into prominence. Schubert, Pollack and Kreutler (2016) assert that geopolitics has forced the EU to move its agenda of energy policy to the top while having some controversy internally, particularly in view of the alternative energy mix such as hydropower and nuclear.

Table 3.7 EU Energy policy typology

Internal	**External**
Establishing the internal energy market ▪ Common market principles ▪ Liberalization ▪ Deregulation and re-regulation ▪ Intra-EU networks and infrastructures ▪ Harmonizing energy taxes ▪ Subsidies Nuclear power politics Developing new energy technologies Research funding ▪ Subsidies, feed-ins etc.	Common external energy policy ▪ Reducing external dependency ▪ Ensuring secure energy supplies from abroad (energy supply security) ▪ Diversifying suppliers/supplies ▪ Pipeline politics and LNG ports ▪ Rule export/energy diplomacy
Multidimensional	
Reducing greenhouse gas emission / Combating climate change	

Source: Schubert, Pollack and Kreutler (2016) Energy Policy of the European Union (page 16)

Bulmer and Padgett (2004) define the EU as a "massive transfer platform" since the EU is a tool for exchanging policy between member states. The outcome of policy transfers, though, is highly dependent on the concerned issue. According to Bulmer and Padgett's study, it has been noted that the problem-solving agenda tends to result in better policy transfers as opposed to abortive policy transfers, which occur in the absence of crisis or problems. Youngs (2007) argues that energy security has certainly being a part of the EU foreign policy.

In addition, the EC states that energy security policy "must also be consistent with the EU's broader foreign policy objectives, such as conflict prevention and resolution, non-proliferation and promoting human rights". (European Commission, 2006; Youngs, 2007). The EU launched its “Action plan for energy diplomacy” in July 2015. Federica Mogherini, the Foreign Policy Chief of the EU, maintains that collective action of member states would benefit all member countries.

Lowering its dependency on Russia has been a long-lasting discussion in Western Europe which entails two major aspects. Firstly, how to reduce Russian share in the imported energy sources and the other to diversify import routes while keeping Russia as a dominant energy supplier. EU-Russia energy dependency is mutual. Russia is the dominant source of EU's energy imports while energy exports income (mainly towards Europe) represent around 70% of Russia's government budget (European Parliament, 2015). Russia, in turn, put efforts to diversify their exports destination as the EU continuously looks for an alternative supply sources other than Russia. In 2014, Russia signed a 30-year gas supply contract with China, which amounted to 30 bcm (billion cubic meters) per year that will be delivered via the new pipeline. However, Europe still remains as a major market of Russia as the contracted amount of one fifth of usual deliveries to Europe.

Russia’s abundant energy resource was a key to its foreign policy while playing a major role in maintaining its political power, so-called ‘resource nationalism’. Normally, gas is supplied through pipelines, which require a huge amount of capital investment over a long development period. Therefore, it is difficult to switch the gas to other alternative sources in a short time. Collective efforts required in price negotiation for greater bargaining power and consequently having more competitiveness. The European Parliament states that the prices of imported gas from Gazprom vary widely across the member states. For example, Germany pays EUR 24/MWh while Lithuania - entirely depend on Gazprom for gas supply - and

Bulgaria pays EUR 38/MWh and EUR 43/MWh each (European Parliament, 2015). The gas price difference across member states are more result from the bilateral relationship with Russia rather than the actual cost differences. Particularly for those vulnerable countries, which does not have alternative gas supply sources other than Russia, are in an unfavorable position. Hence, they tend to pay higher price without negotiation power (Kim, 2016).

Ⅳ. Demand side

Energy efficiency

EU Energy efficiency target

The directive 2012/27/EU on energy efficiency (EED) founded a framework of measures for the promotion of energy efficiency in the EU. The member states set targets in terms of absolute level of primary energy consumption and final energy consumption by 2020. Also the energy saving target of 9% by 2016 had been set under the directive 2006/32/EC on energy services (ESD). The EU directive 2012/27/EU required each member states to transpose agreed targets into their national law by June 2014. In addition, the European Commission has decided to have a non-binding target of at least 27% energy efficiency goal by 2030. The energy security package states that demand side measures shall play a significant role in terms of maintaining energy security by reducing demand when faced with supply disruption while at the same time efficiently using the given resources. The Energy Efficiency Directive (EED) was formulated in response to concerns that the EU was not going to achieve 20% energy efficiency by the target year of 2020. The EED requires member states to do the following.

Table 4.1 EED requirement for the member states

Energy saving target	Set indicative energy saving target at the national level that in line with the EU wide 2020 target.
Heating/Cooling system assessment	Carry thorough assessment on energy efficiency of heating and cooling system. By 2015, member states are required to identify and implement cost-effective solutions.
Assess energy efficiency potential	Assess the energy efficiency potential of power and gas infrastructure. The result of assessment will be reflected to the network infrastructure improvement plan, which should be drawn by June 2015.
End-use energy saving	Make energy providers obliged to set energy saving target which equivalent to 1.5% of annual sales during the period of 2014-2020.
Metering & Billing	Assure to have accurate energy consumption metering and billing so that users can make clear decision on their energy consumption.
Public sector	Set relevant rule for make central governments' procurement following high-efficiency products.
Financing	Establish national financing program for energy efficiency measures.

Source: IEA (2014). In Depth Review, European Union

As repeatedly mentioned in diverse policy discussions, lowering import dependence has been the EU's main focus in energy arena. In that regards, energy efficiency improvement is critical for ensuring not only its energy security but also its productivity and economic competitiveness. The Commission defines energy efficiency as "an energy source in its own right". In addition, the Commission identifies the transport and building sectors as critical to advancing European energy efficiency, since 75% of European dwellings are classified as energy inefficient. Majority of the imported gas is used for heating and cooling of buildings. Therefore, improving energy efficiency in those sectors would consequently reduce dependency on external gas supplies.

The EU's gas demand is falling as it peaked in 2010 (447 Mtoe) and that of 2014

(343 Mtoe) was the lowest since 1995 (Jones, Dufour and Gaventa, 2015). This downward trend of gas demand is owing to the following reasons; (1) structural transformation of European economy, (2) changing consumption patterns and (3) large improvement in energy efficiency. Around 75% of European gas demand comes from six major member states; Germany, U.K., Italy, France, the Netherlands and Spain (E3G, 2015). In other words, the majority of gas demand comes from countries with advanced energy technology. The gas demand has been falling across all major sectors; power, industry and residential. In the residential sector, energy efficiency improvement is the leading cause of curbing the gas demand growth via improving heating and cooling efficiency of old dwellings. According to the Commission's report, for every 1% improvement in energy efficiency, the EU gas imports would be lowered by 2.6% (European Commission, 2014, COM (2014) 502 Final). Hence, the advanced energy security will improve overall energy security directly by reducing dependency.

Table 4.2 Final energy consumption by sector

Sector	2005	2013	Description
Total	1,186	1,105	
Industry	327	277	Decreased by 15% - Industry sector actively reformed its structure between 2008 and 2012 and energy efficiency contributed for positive impacts in terms of the cost-efficiency - Significant difference in energy intensity remains across member states; maximum seven-folds between Bulgaria and Denmark/Ireland - EU supports energy efficiency improvement in energy sector through financial/fiscal measures
Residential	306	296	Decreased by 3% - Large progress in space heating - Reduced energy consumption can be explained with energy efficiency standards for buildings, appliances and heating system - EU supports renovation of the building stocks - Supporting measure include grants and subsidies
Services	144	153	Increased by 6% while the added value in this sector increased by 11% - Since the service sector expected to grow further, member states need to tackle the increase of energy demand in this sector
Transport	370	349	Decreased by 6% - Around 40% of decrease might due to the economic crisis while remaining 60% is owing to the efficiency enhancement

Source: European Commission (2015). Energy efficiency progress report

In 2013, the EU member states established national energy efficiency target. The detailed sectoral approach was reflected in the 2014 National Energy Efficiency Action Plan (NEEAP), which includes final energy consumption reduction targets of residential, services, industrial and transport sector. Although the sum of the national targets amounted to a mere 17.6% energy saving by 2020, the data trends forecasted an optimistic outcome of reaching or exceeding the target.

The achievement of efficiency targets is highly interrelated with the climate target fulfillment. Given the importance of energy efficiency not only within the energy sector but also in the environmental sector, the EU actively supports efficiency improvement through various financial support schemes. The European Structural and Investment Funds (ESIF) are the dominant source of financing the energy efficiency sector. It accounts for the largest share of the budget in the current financial period 2014-2020. A total amount of EUR 13.3 billion out of EUR 45 billion has been allocated in the field of energy efficiency work in public and residential buildings. EUR 3.4 billion shall be used for backing the business sector with a focus on more than 50,000 small and medium sized firms (European Commission, 2015). The EU is expected to encourage private financing while, at the same time, increasing its allowance for the efficiency sector in the form of loans, guarantees and equity.

Table 4.3 Cost and Benefits of a range of different energy efficiency targets

Energy efficiency objective (%)	Primary Energy consumption in 2030 (Mtoe) ** Gross inland energy consumption excluding non-energy use*	Fossil fuel imports cost (Average annual 2011-2030 in EUR billion)	Net gas imports in 2030 (bcm)
27	1 369	447	267
28	1 352	446	256
29	1 333	444	248
30	1 307	441	237
35	1 227	436	204
40	1 135	434	184

Source: European Commission (2014). Communication from the Commission to the European Parliament and the Council

According to the IEA's data (2016), the EU represents nearly half of the energy import saving in the world in 2015 thanks to the energy efficiency improvement measures. The reduced energy imports decreased the energy imports bill by 10% or US $27 billion in 2015. The IEA asserts that public policy is vital in enhancing energy efficiency level. The energy efficiency policies not only aim to save energy but consequently advance energy security with reduction of emissions from the energy sector. The EU has actively suggested plans to improve its energy efficiency particularly in the sector of heating and cooling, which represented around half of the energy consumption in the EU.

Ⅴ. Data Analysis

Methods

Several studies on energy security propose approaches to assess the energy security level through different analytical methods. Ang, Choong and Ng (2014) surveyed 104 research papers in order to identify scholarly analytical methods that were conducted in the domain of energy security. Radovanovic, Filipovic and Pavlovic (2016) suggest an energy security index that is an equation with six different indicators in order to assess the level of energy security. Brown, Wang, Sovacool and D'Agostino (2014) use the concept of z value to estimate the level of energy security across the four different dimensions, i.e availability, affordability, energy and economic efficiency and environmental stewardship.

This analysis will evaluate the performance of the EU-28 and selected member states employing seven (7) energy security indicators with the use of z-score (Brown, Wang, Sovacool and D'Agostino, 2014). The z-score represents the normalized distance of the data point from the mean in terms of standard deviation. This analysis mainly focuses on the availability and adaptability of the energy system. With regards to weightage of each factor, it is more or less equal, with slightly higher emphasis on resource availability.

Availability means reliable access to fuel with the focus on reducing foreign fuel dependency. The following five factors were chosen to be used; self-sufficiency, the share of renewable in TPES, the share of nuclear in TPES, oil self-sufficiency and gas self-sufficiency. Adaptability indicates the improved energy intensity while reducing environmental impact. Energy intensity (toe/Thousand GDP PPP) and Carbon emission intensity (kg CO_2/ GDP PPP) were chosen as representative factors for this analysis. Data for the EU (28 member states, including the U.K) was available from 1990 till 2014 (EU established in 1993); while selected member states' data were available from 1973 till 2014.

Country selection

As stated earlier, the paper delves into three member states, France, Hungary and the Czech Republic. Practical considerations pertaining to data availability lead to the selection of suitable cases, among the EU-28 members based upon the following considerations; (a) suffering relatively high disruption over the Russia-Ukraine gas crisis in 2006 (b) differ in shape of energy mix and (c) shows variance with regards to energy challenges.

Table 5.1 Analyzed factors and data sources

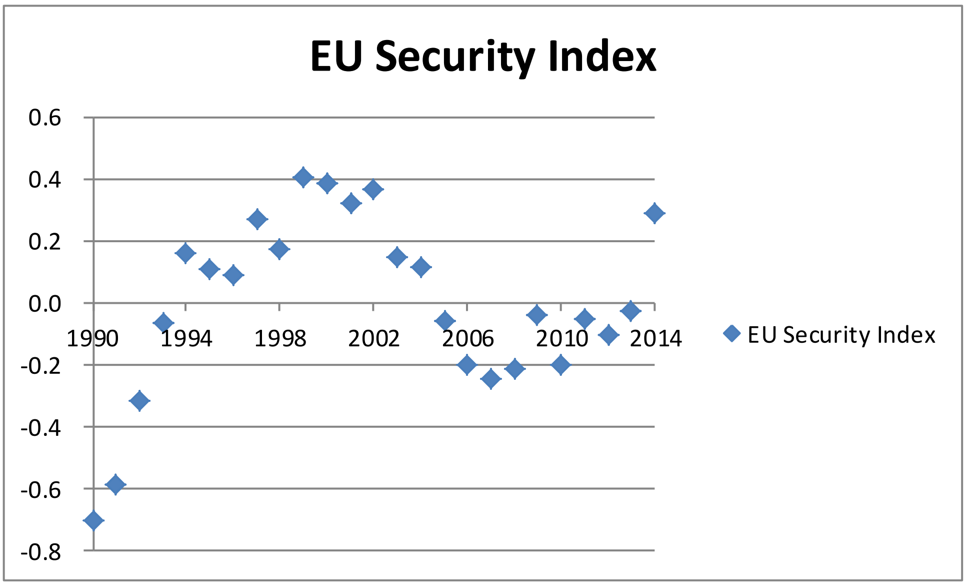
Dimension	Factor	Unit	Wight	Data source
Availability	Self sufficiency	-	15 %	IEA
	Share of renewable in TPES	-	15%	IEA
	Share of nuclear in TPES	-	15%	IEA
	Oil self-sufficiency	-	15%	IEA
	Gas self-sufficiency	-	15%	IEA
Adaptability	Energy intensity	toe/thousand GDP 2010 USD PPP	12.5%	IEA
	Carbon emission intensity	kg CO2/ GDP 2010 USD PPP	12.5%	IEA

Results & Key findings

Evaluated energy security index revealed that the current energy security level has improved in the EU and selected member states compared to the base year. The security enhancement is noticeable in the adaptability dimension owing to the marked improvement of both carbon and energy intensity. In contrast, the availability sectors showed mixed results. In spite of the considerably large renewable or nuclear share, the oil and gas self-sufficiency has continuously declined. Due to the decreased indigenous production of fossil fuels, and the EU member states have had to increase their oil and gas imports to meet the demand.

In light of these findings, this paper advocates the role of a demand side approach in reinforcing energy security via regional level engagement. The EU's energy policy is largely focused on the energy security enhancement under the banner of 'solidarity'. By providing an integrated market and governance system, the EU aims to stabilize energy supply, as well as reduce greenhouse gases (GHGs) emission and improve its energy efficiency.

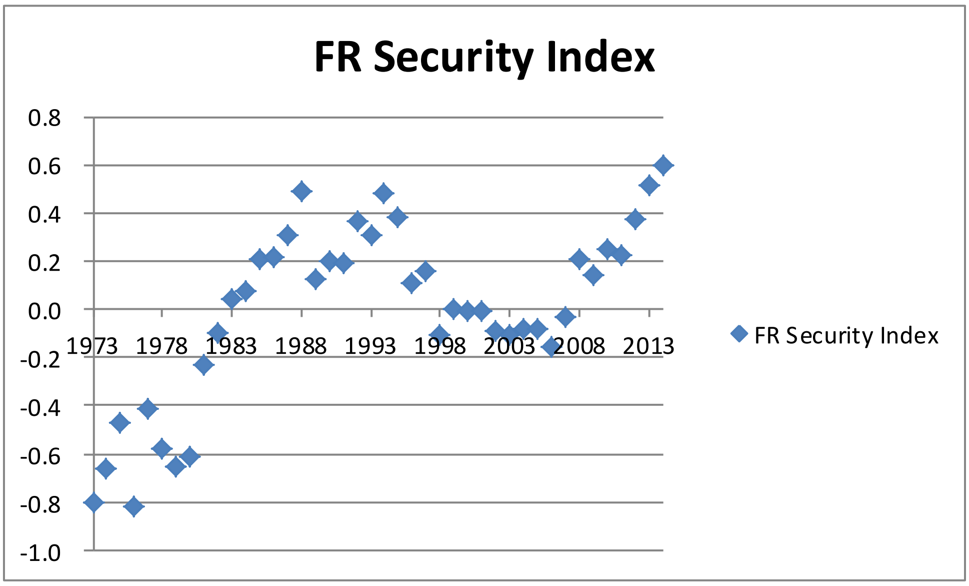
(1) EU (1990-2014)



The EU energy security index over the period of 1990-2014 shows that the energy security of the EU in 2014 has improved compared to 1990 while suffering around the economic crisis in late 2000s. Since the OEPC (Organization of Petroleum Exporting Countries) oil embargo in the early 1970s, European countries had been through an energy re-structuring program, mainly privatization and liberalization of energy sector in the 1980s and 1990s.

Oil and gas self-sufficiency has continuously dropped over the analyzed period, largely due to the expansion of the EU, with accession of energy importing countries. Irrespective of the continuous decrease in self-sufficiency, the renewable and nuclear share had improved. In addition, carbon intensity and energy efficiency have largely improved under the EU directives. The EU ardently propagates for energy efficiency and carbon emission mitigation, backed with multiple EU level policies. The energy security index shows a positive trend from 1990 to early 2000s. It, however, decreased from the early 2000s through the late-2000s mainly due to decreased indigenous production.

(2) France (1973-2014)

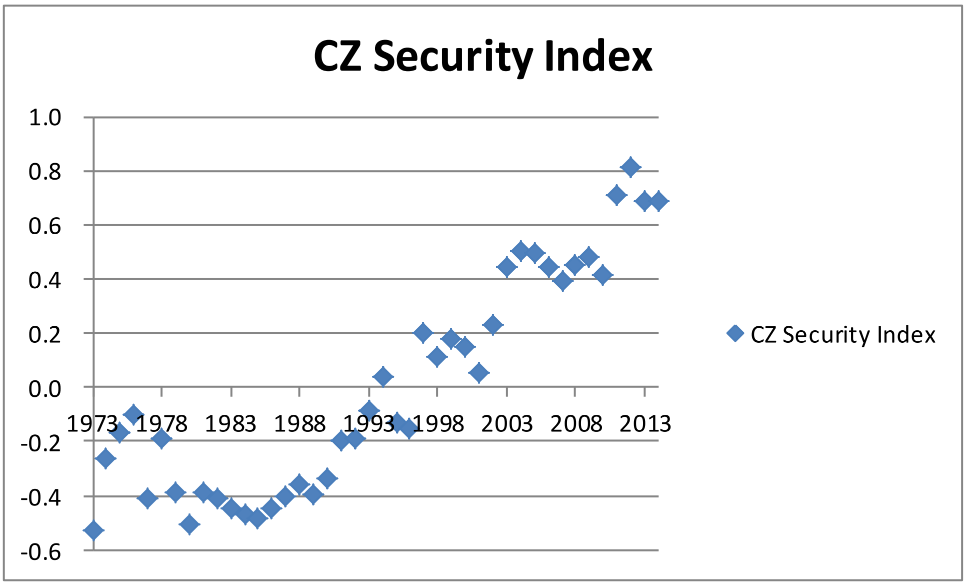


France's energy security index of 2014 significantly improved compared to the early 1970s. It shows a notable increase since the 2000s when the EU level energy policies were actively implemented. Although France depends almost entirely on importation for its oil and gas supply, it largely improved its self-sufficiency owing to the substantial increase of the nuclear share in energy supply. France is an exceptional country in terms of its use of nuclear energy, which accounts for over 75% of the electricity supply in France. Consequently, France's self-sufficiency, arguably the highest among the net energy importer EU member states, stood at more than 50%. However, following the debate over the safety of nuclear plants, since the Fukushima accident in Japan in 2011, the French government decided to scale down the share of nuclear in its energy portfolio. Therefore, renewable sources should play an important role in filling the gap. France has set an ambitious goal for increasing the share of renewable sources, under the EU Directive 2009/28/EU, by 27% in 2030, while the current share is at 22.5% as of 2014.

France has witnessed substantial progress in its energy and carbon emission intensity. It has actively engaged in implementing the EU directives for improving energy efficiency. As France had dedicated all its efforts to the supply side since the oil crisis in the early 1970s, the initial action for demand control started comparatively late. Furthermore, over the 1980s, a lower oil price enabled the French government to abandon its energy conservation program. In the 1990s, France noticed diminishing energy efficiency with the increase of industrial and commercial energy consumption (Brown et al, 2014). France actively put its efforts to improve energy efficiency. Recently France has adopted the NEEAP[19] under the EU Directive 2012/27/EU. French government's efforts are mostly geared toward residential and building sectors in order to improve the energy consumption of aged dwellings.

[19] The member states need to submit NEEAP (National Energy Efficiency Action Plan) every three years.

(3) Czech Republic (1973-2014)



The Czech Republic shows significant improvement across all figures excepting self-sufficiency. The significant improvement of Czech Republic's energy security index is largely explained by its growing reliance on renewable and nuclear energy. The share of renewable energy in TPES has increased from its marginal level in late 1980s to above 9% in 2014 (IEA, 2016). In addition, it expected to reach between 17% and 22% by 2040 (European Commission, 2016). The expansion of nuclear energy is one of the major mainstays of Czech's energy plan particularly in view of the need to secure energy and replacement of aging power generation facilities. In 2014, nuclear accounts for 32.5% of country's power generation while expected to be grow to represent over 50% of power generation by 2040. Nevertheless, the overall self-sufficiency of the country has decreased mainly due to the increased energy demand, a result of economic expansion. The Czech Republic is the third-largest net electricity exporter in the EU, behind France and Germany while importing nearly all of its oil and gas demand from Russia.

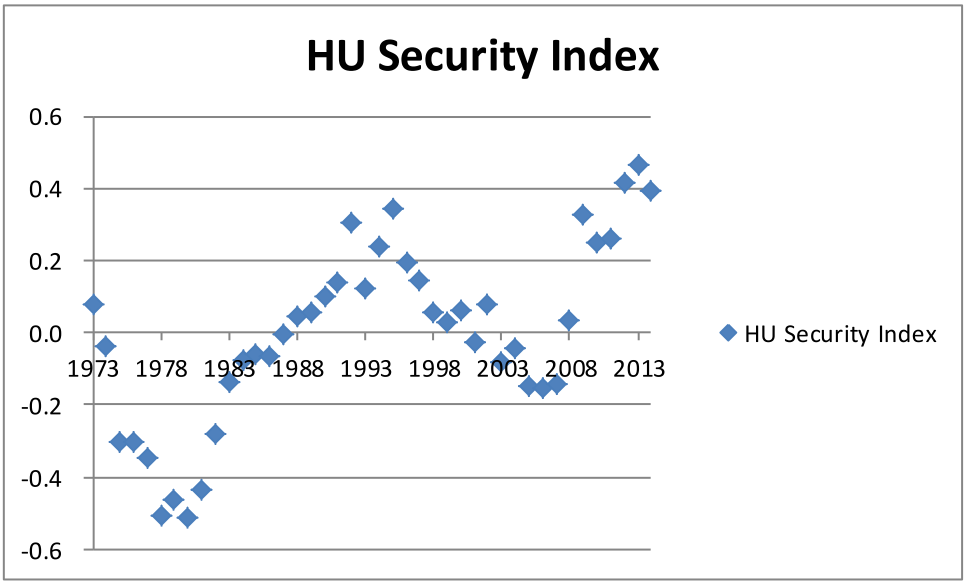
In terms of energy efficiency, Czech economy uses more energy to generate unit economic output compare to the other member states. This is due to the substantial role of manufacturing, which accounted a quarter of total value added in 2014, in Czech economy. Thus, the Czech Republic takes advantage of EU programs in order to improve its energy efficient infrastructure. The EU allocated EUR 2 billion to Czech Republic for its energy efficiency improvement, which amounts to 1.4% of total GDP of the country (European Commission, 2016).

The Czech Republic's approach towards energy security had focused on the preferential use of domestic resources, mainly for coal. However, the availability of coal has been limited recently due to concerns over climate change. The Czech government had to respond to increasing international pressure to curb their coal exploitation as set out in their original plan (IEA, 2010). The Czech Republic's efforts to reduce energy supply vulnerability include resource diversification and expansion of infrastructure. The reverse flow capacity from Germany and high storage withdrawal from Norwegian supplies helped the Czech Republic to respond to the 2009 Ukraine gas supply disruption. The Russia-Ukraine gas crises warned the Czech Republic about the potential of future crisis. The Czech Republic government planned to increase gas storage capacity and development of interconnections with neighboring countries to enlarge the volume of reverse flow.

Unlike other post-socialist countries, the Czech Republic has a different position on energy policy. The Czech Republic made huge efforts to diversify its energy supply source over the 1990s. Since the Czech Republic considers Russia as an unreliable energy supplier, constantly preparing for the sudden disruption of energy supply. The Czech Republic is one of the member states which actively engaged in EU energy diplomacy towards Russia (Misik, 2016). Misik asserts that the Czech Republic believes that the state is able to handle the energy challenges to a high degree, thanks to its diversification efforts since the 1990s. However, within the framework of the EU level energy policy, the Czech Republic is not able to fully pursue their preferences and bring in their energy concerns.

Since joining the EU, in 2004, the Czech Republic actively engaged in implementing regional energy policy. Those efforts have well transposed into the Czech Republic's long-term energy plan, so-called "State Energy Concept (SEC)". With given environmental limitations on using domestic coal reserves, Czech government decided to focus on expanding nuclear and renewable energy share so that they can stay aligned with the EU energy managements system under the new climate regime.

(4) Hungary (1973-2014)



Hungary's energy security in 2014 has improved compared to the base year of 1973. However, the historical trend has fluctuated more compared to the other selected countries. Since the mid-1980s, natural gas has been the largest energy source in Hungary. In 2014, it accounted for over 30% of TPES. Hungary plays an important role in advancing natural gas market integration in Central Europe and the country has been the most active member state in terms of cross-border infrastructure development. Hungary aims to advance its import capacity while diversifying its import routes and sources.

Table 5.2 Hungary cross-border gas interconnections

Project	Length	Capacity	Status of project
Hungary-Romania	47 km	1.4 bcm/year	Operational since 2010
Hungary-Croatia	206 km in Hungary	6.5 bcm/year	Operational since August 2011
Hungary-Slovakia	115 km (94 km in Hungary, 21 km in Slovakia)	5 bcm/year	Operational since July 2015
Hungary-Slovenia	TBD	1.3 bcm/year (estimated)	Discussed over the joint cabinet meeting i n January 2016

Source: European Commission and diverse media reports

Despite its increasing share of renewable and nuclear energy, Hungary's self-sufficiency has declined over time as imports increased in order to meet its rising energy demand. Hungary still needs to come up with strategies to diminish its vulnerability to gas and oil imports. It currently spends around 6% of its GDP on energy product imports, which is twice than the EU average. Hungary is trying to lower its import dependency by supporting renewable deployment and energy efficiency technologies.

In December 2014, the Hungarian Atomic Energy Authority (HAEA) signed a new cooperation agreement with Russia's Rosatom (the Russian nuclear state authority), updating the one from 2001, to maintain nuclear electricity generation capacity in the long -term as part of its efforts to improve its self-sufficiency.

Hungary has significantly reduced its carbon emission intensity, which was largely due to decreased production across all economic sectors including energy, industry and agriculture, brought on by slowing down of national economy. Hungary needs to be careful about controlling its carbon emissions in a scenario of high prosperous economic expansion with a consequent rise in energy demand.

Ⅵ. Implications to Asian regions

Southeast Asia

Energy consumption in Southeast Asia is projected to grow by 80% between 2015 and 2040 (IEA, 2015). Unlike the EU, the Southeast Asian countries do not benefit from an umbrella organization which could formulate centralized policies on energy related issues. Although the matter has been repeatedly discussed in the regional cooperation for Southeast Asia, no policy has been formalized nor any concrete action been taken. This is mainly due to the highly diverse economic, political and cultural environment of Southeast Asian countries. The largely different characteristics of each state consequently affect different shape of energy demand and supply patterns.

It seems likely that the region would face high economic growth accompanying rapid urbanization. These changes naturally affect the pattern of energy consumption as well. For example, rapid urbanization will expectedly foster the deployment of a contemporary energy system in the cities. In terms of the size, the energy demand in Southeast Asia is expected to increase rapidly at least by 4% per year through 2016-2020 and maintain the growth trends onwards (Zamora, ASEAN Member States, 2015). The growth rate of ASEAN (Association of South East Asian Nations) energy demand is higher compared to the world energy consumption projection of growth by 1.6% per year between 2011 and 2030 (BP, 2013). Thus, the improvement of energy efficiency has drawn much attention to lowering the pace of energy demand growth. In a broader context, untapped potential of efficiency improvement has remained. For example, the building energy code mostly remained as a voluntary option while not harmonized across the states. The IEA maintains that "close collaboration in policy planning and implementation of building energy codes could deliver significant benefits across the regions through sharing resources such as research into performance levels, capacity building, design and rating tools, and compliance monitoring" (WEO Special Report, 2015, p.34). The one factor that should be considered cautiously for the energy efficiency improvement is inviting financial investors to this region. Usually, energy efficiency improvement requires technological advancement, which is reliant on the upfront investment for research and development.

Kanchana and Unesaki (2014) identify three features of ASEAN energy system in their research. First, ASEAN has diversified its energy mix. While some of the ASEAN member states hold abundant fossil fuel resources, the rest of the member states rely heavily on imports. Second, the gap between comparatively more-developed and less-developed countries exists in terms of energy system. Lastly, the carbon emission of ASEAN is noticeably high in the world. This could be partially due to its robust economic development. However, the energy system in ASEAN has not fully modernized yet. Part of the carbon emission of ASEAN member countries is coming from the traditional cooking stoves, for instance, which require high coal consumption due to their low efficiency.

The fossil fuel dependency in ASEAN region has remained high due to the increasing demand that comes from growth of production capacity and infrastructure development. The declining fossil fuel reserve combined with the rapid demand growth will threaten the energy security of this region. Concerns for insufficient endowment draw attention to reducing energy intensity and curbing demand growth. Despite recent discoveries of oil reserve in the South China Sea, it only enables near-term capacity relief (Tongsopit et al, 2015). As such, this region cannot sustain or pursue its development without increasing energy imports. The agenda of formulating regionally integrated energy system while encouraging efficient energy trading and energy consumption reduction is critical in the Asian region.

Tongsopit (2015) argues that ASEAN needs a more active approach in order to improve its energy security. He specifically suggests the following; ASEAN would need more intensive exploration activities, increasing stakes in investment outside of ASEAN, increasing oil stockpiling, and securing long-term energy supply contract. His research highlights the need for regional scale coordination in regards to the energy planning. In addition, he emphasizes ASEAN's potential to reduce energy consumption at least by 15% by 2035 while keep pursuing its socio-economic development. This implies that energy efficiency improvement could improve overall energy security. The ASEAN adopted "Vision 2020" in 1997, on the 30th Anniversary of ASEAN and it includes the initiative for energy cooperation. The "Vision 2020" emphasizes the necessity of integration of electric grid and natural gas pipeline while underlining energy efficiency, conservation and use of renewable energy.

Urbanization and Energy

According to the recent IEA report ‘Energy Technology Perspective 2016’, cities account for two-thirds of energy demand while representing 70% of carbon dioxide emissions. For emerging economies, urbanization is a critical path as it could modernize the energy service and improve its living standard. The IEA forecasts that in the two-degree scenario, the urban energy demand among non-OECD countries would grow by approximately 40% between 2013 and 2050. Notwithstanding, the carbon intensity of those cities are expected to be notably reduced while the urban economies more than quadrupled. Usually, urban area hosts the largest share of population and facilities including industrial ones. Therefore, it affects the largest part of the energy demand and related environmental concerns. The response towards the urbanization does not only mean supply of basic needs but also the provision of those needs in ways that align with overall energy transition and sustainable development goal, in a broader context. Asia currently and will continue to face rapid urbanization. Therefore, the urban area would play an important role in energy transition towards low-carbon system specifically via having energy efficient building, transport system and industrial processes (IEA, 2016). Therefore, the region of Asia, which carries the largest part of emission reduction responsibility, at the same time, has the largest potential to improve energy efficiency, consequently the energy security. The cooperation between national and local governments shall be implemented while supra-national governance performing as a platform for knowledge sharing and research and development (R&D) investment. The urban energy policy does not exist alone but is bundled with the comprehensive urban development plan. Thus, both vertical and horizontal cooperation are important to carry the energy transition by implementing appropriate urbanization strategies including sharing best practices, expertise and guidance.

Limitations

Non-integrated market

The discussion over the energy market integration in ASEAN (Association of South-East Asian Nations) together with its dialogue partners, Korea, Japan, China and India, started decades ago. However, detailed context or policies are yet to be formulated. The region of Asia needs to consider its given geographical and political limitations, such as North Korea and the bilateral relationships with China and its neighboring countries.

The relatively stiff energy market of Asia generated the so-called "Asian Premium" in the LNG (Liquefied Natural Gas) market. The largest LNG importers are concentrated in Northeast Asia region. Korea, China, Japan and Taiwan collectively represent over 60% of the world LNG imports. However, despite a large amount of import demand, the price in the Asian region is somewhat higher considering its import scale, which is called "Asian premium". The formation of the Asian premium is mainly due to the absence of relevant gas market within this region while having marginal domestic reserves. The lack of regional gas infrastructure also affects the price premium. The old paradigm of LNG pricing, which is linked to the oil price, still remains. In addition, prohibition of unloading port change makes the LNG market even stiffer. Thus, the countries in the Northeast Asia should not only compete for the LNG with its neighbors but also need to cooperate to build regionally integrated infrastructure, and consequently, a market for it. Korea, Japan and Taiwan have a clause of forbidding any change of the unloading port in their LNG contract. The formal reason for including this clause is to assure the sales. However, the substantive purpose of the clause is to prevent the reselling of LNG and becoming a competitor for the original seller. Unlike the EU, Asian countries are fragmented via existing geographical barriers. Therefore, even though it achieved integrated market, there should be some limitation in a degree of freedom to choose a supplier, due to the geographical barriers. The improved flexibility of LNG supply shall improve the price competitiveness while removing Asia premium.

Political challenges in South Asia

The region of Asia has a far less homogenous energy system and supply/demand profile compared to the EU. In addition, there hardly is any cross-border energy infrastructure due to the geographical, political and economic barriers that have existed throughout history. Huda and McDonald (2016) maintain that political challenges are the biggest hurdle for the regional energy cooperation in South Asia. For example, despite having South Asian Association for Regional Cooperation (SAARC[20]), this region is known for its lack of integrity. Hence, the SAARC achieved marginal connection among its member states. The agenda of regional energy cooperation has been studied by several scholars who have collectively picked up the major impediments of political challenges (Viotti and Kauppi, 2012; Huda and McDonald, 2016). The background of political challenges is mainly due to

[20] Member States of SAARC are; Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka.

the large country’s bilateral relationship with its neighbors. India is a typical example in the South Asian region, not only limited to that of Pakistan but also with other smaller nations. India's stance toward other nations made a fractured geopolitical landscape, which is dominated with mistrust and conflicts. Moreover, India prefers to build a bilateral relationship with smaller countries rather than having a regional platform or pursuing multilateralism. That is because India wants to maintain its influence on smaller neighboring nations.

Other than India, the remaining countries are unable or unwilling to form a multilateral platform for cooperation in the energy sector. Nepal's serious political instability put regional cooperation behind its national issues. The Kingdom of Bhutan has less interest in energy sector, rather focusing more on preserving its nature environment. Huda and McDonald (2016) present the needs of change narrative to show the importance of energy cooperation through an expert interview.

It might be relevant to remind that the South Asian region highly suffers from energy poverty, lack of access to the modern energy or electricity. In order to have a more stable and wider electrification system, a cooperative scheme is needed. As such, it is necessary to show the needs of energy cooperation in a different way compared to the conventional one. For example, it can be achieved by showing the socio-economic benefits of having a better energy system rather approaching via diplomatic agenda.

Lucas (2014) suggests three major dimensions that are technical, official and political for implementing supra-national cooperation. It is crucial to have a relevant structure to operate infrastructure and market in an efficient way. Many obstacles and conflicts could be raised over the discussion on supranational energy governance structure. Moreover, Asia and Europe have a very different history in terms of the relationship with neighboring countries.

Even though the EU has been attempting to build a concrete regional governance structure, the energy sector has remained as an area of sovereignty as it is closely or directly related to the national security, not only in aspects of physical defense but also in that of economic sovereign power.

Like any other sectors where supranational-level integrated policy has been discussed, state sovereignty is a major hurdle in creating a supranational governance system. The gap in energy diplomacy strategy comes from the different level of preference for policy autonomy. Any attempt to form a regulatory framework based upon common energy policy should respect the historical evolvement of the sovereignty institutions of each member state. Furthermore, energy cooperation discussion should consider the different endowment level of each state. Countries with sufficient endowment and those without usually have different aspects and interest among the region. The resource-poor countries tend to enhance its security of energy supply and efficiency while resource-rich countries tend to secure captive demand and stable revenue from it.

Suggestions

The East Asia Summit (EAS[21]) suggests energy market integration comprising liberalization of energy trade, investment as well as domestic energy markets. It also proposed a development of regional energy infrastructure and institutions as a governing structure. The EAS has a positive outlook in regards to the market integration that could help in reducing the development gap while optimizing the use of energy resource and the implementation of climate policy (Aalto, 2014).

As shown from the analysis of EU's energy security index, the potential of greater

[21] The East Asia Summit is a forum held annually since 2005. It was initiated with 16 South / East / Southeast Asian countries and currently expanded to 18 member states with accession of the United States and Russia.

energy system integration lays in the field of climate/energy efficiency functions of institutions. Energy conservation and emission reduction measures will decrease the imports of energy and this will help to improve energy security.

Funding for developing advanced technology

The use of shared efficiency standard may realize its impact at maximum if it could utilize certain incentive schemes, such as access to the R&D sources, concessional loans or grant aid. These can be a tool for eliminating financial and technical bottlenecks to energy efficiency, particularly for the SMEs that have limited access to financing and energy efficient technologies.

The European Commission with approximately EUR 4 billion funds called European Energy Program for Recovery (EEPR), which aims to finance key energy projects including gas, electricity infrastructure projects, offshore wind project and carbon capture and storage projects. In addition, the European commission has launched the fund for energy efficiency improvement called European Energy Efficiency Fund (EEE-F). The EEE-F offers financial products such as loans, guarantees or equity participation to energy efficiency investment by other local, regional or national authorities. Moreover, the EU put collective efforts into the R&D sector with its research and innovation program called Horizon 2020, which provides EUR 56 billion of funds towards energy projects between 2014 and 2020. This fund is eligible for the projects related to improvement of clean energy technologies; smart energy networks, tidal power, and energy storage.

Collectively formed funds are beneficial for each state as they reduce the burden of technology investment by sharing financial cost and human capital. The advanced technology developed via shared investment could be widely utilized among member states. As stated above, energy efficiency improvement depends upon advanced technology that requires upfront investment to be developed. Thus, sharing the hard and soft cost of energy technology advancement will result in benefit sharing while reducing burden.

In terms of the corporate R&D, Asia is the top destination accounting for 35% of the total or about US $166 billion, followed by North America and Europe (Fortune, 2015). However, R&D spending is dominated by IT and automobile conglomerates while hardly see any energy firms on the top 20 list. Moreover, still the dominant portion is concentrated among Korea, Japan, China and India. They are capable of managing state-owned R&D investment thanks to relatively stable and large economy. Other than advanced Northeast Asian countries, the majority of Asian countries face a dilemma as they have strong motivations to grow upon innovation while suffering from insufficient human capital, infrastructures, well-developed markets and investment resources to pursue it. Therefore, the building of relevant governance system is critical in order to enhance the energy technology development by having a collective R&D program.

Long-term building of policy and knowledge sharing platform

The energy sector has been the least active area in terms of policy integration in the EU. Despite the long-term approach since the 1960s, a fully merged energy market is yet to be established. Taking this into account, Asia needs to build its long-term vision and relevant platform for exchanging ideas and having discussions. Most Asian countries fall into the dilemma of using fossil fuels, as they face rapid economic development and feel the pressure of emission reduction from the international society. Starting from identifying common concerns, goals and interest, this region can share policies and approaches to achieve common target.

In April 2016, the EU Joint Research Center (JRC) launched European Energy Efficiency Platform (E3P), which aims to facilitate knowledge sharing among policymakers, industry, researchers and government. The E3P will particularly focus on supporting the conception, implementation and monitoring of energy efficiency policies in Europe via providing a platform for collaborative work such as data hub. This would be a good approach in the region of Asia as well since it does not require immediate physical infrastructure connection or huge investment to build the platform.

Energy poverty alleviation via deployment of renewable energy

One of the unique features of Asian energy system is prevalent energy poverty. Around 700 million people in Asia do not have proper access to modern energy or electricity. They are vulnerable not only in terms of energy access but also in view of socio-economic development. People who are suffering from the lack of electrification highly rely on traditional biomass fuels such as wood, crop, waste and other forms of biomass. The traditional biomass has adverse effects not only on health but also in deforestation and greenhouse gas emission. It is obvious that the region of Asia needs wider provision of energy system so that it can reach a better living standard as well as to advancing its energy security level.

In the past, when there was no need for accounting for emission reduction agenda, the electrification or energy provision was simple. The European approach to improve energy security has been a way of making a transition within the existing energy system. However, in a view of the region of Asia, the meaning of energy security is more of building an appropriate energy system within existing political and economic context. Given the limitations of geography, economic and technical standard, the provision of energy system does not need to stick to the grid extension type with large-scale fossil fuel plant. It might be more feasible to consider the stand-alone renewable application in the immediate power supply or in a medium term. Hence, energy poverty alleviation can be reached without a significant increase of energy imports.

Oil stockpiling

As a net oil importer and as a region facing the fastest economic growth, oil stockpiling would play a crucial role in energy security in the region of Asia. Oil stockpiling has been proven as an effective way to mitigate serious crisis due to disrupted oil supply, particularly among the OECD (IEA) member countries. In addition, it would be relevant to build the oil stockpiles within the region of Asia following the international or EU mechanisms. It could enhance the security level since most Asian countries are not part of IEA yet. Asian economies have similar positions in the world oil market; a large importer while having marginal domestic resources. The insufficient cooperation among those states created an Asian premium in the oil market. The stock piling mechanism should accompany the building of sufficient stock infrastructure as well as the building of trust among states in order to alleviate the Asian premium. Sharing collective reserve can achieve greater benefits than the sum of state level acting alone. The relevant legal provisions under legally empowered governance system and successful government-industry relationships are required to implement a regional oil stockpiling system.

ASEAN member states already agreed on an establishment of regional oil stockpiling framework, called ASEAN Petroleum Security Agreement (APSA). APSA is a framework for transferring stockpiled oil during the supply disruptions. However, there have been no actual emergency exchanges. There were some identified limitations in this framework, which includes the lack of legitimacy while also relying on voluntary and commercial manner. One of the issues in advocating regional stockpiling is security. Some countries are reluctant to have their stock in other state's territory. Thus, having legitimate regional governance system is crucial in terms of protecting each member state's energy security.

Cross-sectoral infrastructure development

Energy security is not a single layer agenda. It is a multi-dimensional topic that requires layers of approach to improve it. Therefore, it needs to be collectively assessed through a comprehensive infrastructure development plan. For example, the urbanization plan shall consider how it will manage the heating and cooling system of newly developed facilities. In the meantime, the transportation system will be developed in order to carry commuting population from the newly developed city while minimizing carbon emission from the transportation sector. Lessons learned from earlier development shall be shared across the borders and sectors.

Ⅶ. Conclusion and Discussion

The purpose of this paper has been to identify the benefit of regionally integrated energy policy in terms of enhancing energy security. This paper has established that regional energy policy has improved the energy security of the EU in the following aspects. First, the EU has taken an active approach to building integrated infrastructure and market systems for advancing oil and gas availability. Thus, this in some ways helps to curb the growth of import dependency and the vulnerability of energy supply while also responding to the increasing energy demand. Secondly, the share of nuclear and renewable energy has increased over time as part of efforts to increase self-sufficiency in the EU. Despite the controversial argument on the use of nuclear energy, particularly since the 2011 Fukushima accident in Japan, nuclear energy has been a dominant alternative to fossil fuels in aspects of energy security, as the resource is relatively well-dispersed across the world compared to fossil fuels. Lastly, energy efficiency improvement under EU's strong standard largely contributed to the energy security enhancement. The proven technologies and regulations help to reduce energy consumption. This research suggests practical evidence of energy security improvement in the EU, and it has furthered our understanding of the opportunities in integrated energy policy. This understanding will provide a basis for formulating and implementing further regional energy policy not only in EU but also in other regions.

In particular, this paper has provided a historical trend of energy security index, which reflects multiple factors from both supply and demand sides. This paper has found that the availability dimension has proven to be a hurdle of marginal domestic reserve while the demand keeps increasing. Notwithstanding, the EU has been a pioneer in regards to developing energy efficiency technology, together with an implementation of strong efficiency standard across multiple sectors such as buildings, transportation and industry. As such, the improved efficiency plays an important role in curbing increasing demand while promoting the use of renewable energy that contributes to managing an imported fossil fuel use.

This paper has also presented a convincing case for the benefits of regional energy policy by using the Czech Republic's case as an example. The country has been continuously improving its energy security level since the oil shock in the 1970s. In addition, France and Hungary also show a higher level of energy security over the 2000s, when the EU level energy policy was most actively enacted (Annex A). However, there is a certain limit to this research, as this paper does not take the different level of economic capability or fuel price level of each member state into account. While previous studies largely focused on supply side approach to lower the vulnerability of conventional resource supply, this research shows that the EU's approach to improve energy efficiency and expand renewable energy has contributed to the advancement of its energy security.

In light of these findings, I propose that the region of Asia should take the practices of the EU that does not require immediate physical infrastructure connection or huge capital investment when formulating regional policy. Energy efficiency targets, which include lighting standards, heating/cooling efficiency standards, and transportation fuel standards, could be a good example. Due to the given limitation of governance structure and geographical barriers, it seems appropriate to consider the establishment of sub-regional level standards. Given this, energy policy makers ought to think more about how to pursue soft regulations such as knowledge sharing and formation of funds for promoting energy R&D in the region of Asia. In addition, it is important to consider the energy poverty issues particularly for South East Asia. Relevant energy security policy will address not only the energy poverty but also the socio-economic development in this region. This paper establishes that the EU's energy dialogue has a long history at least since the 1960s. Therefore, Asia needs to formulate the platform for energy discussion with a long-term view in mind, which would help to define common interests and goals among the neighboring countries. The regional integration is neither the only nor the most powerful solution to improve energy security, especially since there is no other regional governance body that has as strong an influence as the EU. However, as witnessed throughout this paper, the sharing of advanced policy, infrastructure, market and knowledge platforms will surely advance energy security.

Annex A. Major EU regulations/directives regarding energy security

Resource	Regulation/Directive	Description	Result
Gas	Gas supply regulation (994/2010/EU)	- EU member states are obliged to have bidirectional capacity at each cross border interconnection points - N-1 Rule	- Reverse-flow at the cross border interconnection points within the EU has increased from 24% in 2009 to 40% in 2014 - Those member states, which are dependent on a single import pipeline are obliged to have underground storage facilities
	Internal gas market directive (2008/92/EC) Common rule for the internal market (2009/73/EC repealing 2003/55/EC)	- Increase gas market liquidity and cross-border trade	- The target model encourages price convergence through hub-based trading. However, only seven member states have hub pricing as of 2015
Oil	Oil stock obligation directive (2009/119/EC)	- Member states are required to hold minimum emergency stock of oil and/or petroleum products to amount that part with 90-days of net imports or 61-days of inland consumption, whichever is higher	- Member states which were hold marginal level of oil stock, such as Bulgaria, Belgium, Estonia and Latvia, has largely improved their oil stock level
Renewable	Renewable energy directive (2009/28/EC, amending and subsequently repealing 2001/77/EC and 2003/30/EC)	- Set goal of achieving 20% renewable energy share by 2020 - Each member state is required to formulate NREAP (National RE Action Plan) to shows detailed measures to achieve the target	- Member states show meaningful progress towards the goal. As of 2014, EU 28 has over 15% of renewable supply and eight member states over achieved its goal
Energy Efficiency	Energy efficiency directive (2012/27/EC, Amending 2009/125/EC and 2010/30/EU, repealing 2004/8/EC and 2006/32/EC)	- Set binding goal of reaching 20% energy efficiency by 2020 and non-binding goal of at least 27% energy efficiency by 2030	- Carrying significant role in enhancing energy efficiency in the sectors of building ,transport and industries

Annex B.

European Union 28

z value	+	+	+	+	+	-	-		
Weight	15%	15%	15%	15%	15%	12.5%	12.5%		
Dimension	Availability					Adaptability			
Year	Self sufficiency	Share of renewable in TPES	Share of nuclear in TPES	Oil import dependency	Gas import dependency	Energy intensity	CO2 emission intensity		EU Security Index
1990	1.080	-1.071	-2.808	-0.040	0.811	1.540	1.645		-0.70
1991	0.828	-1.004	-2.129	-0.040	1.028	1.504	1.645		-0.591
1992	1.080	-0.913	-1.328	0.161	1.136	1.250	1.435		-0.315
1993	1.080	-0.798	-0.254	0.363	1.244	1.263	1.225		-0.066
1994	1.332	-0.766	-0.249	1.170	1.244	0.980	1.015		0.160
1995	1.332	-0.774	-0.367	1.170	1.028	0.994	1.015		0.107
1996	1.080	-0.751	0.041	0.968	1.028	1.109	1.015		0.089
1997	1.080	-0.656	0.633	0.968	0.919	0.791	0.596		0.268
1998	0.575	-0.608	0.346	0.968	0.702	0.594	0.386		0.175
1999	0.828	-0.580	0.866	1.371	0.594	0.294	0.176		0.403
2000	0.575	-0.505	0.740	1.170	0.594	0.046	-0.034		0.385
2001	0.323	-0.485	1.068	0.766	0.486	0.050	-0.034		0.322
2002	0.323	-0.517	1.418	0.766	0.377	-0.072	-0.034		0.368
2003	-0.182	-0.398	1.004	0.565	-0.056	-0.024	-0.034		0.147
2004	-0.434	-0.283	1.066	0.161	-0.056	-0.147	-0.243		0.117
2005	-0.686	-0.129	0.692	-0.242	-0.490	-0.286	-0.243		-0.062
2006	-1.191	0.021	0.380	-0.645	-0.707	-0.509	-0.453		-0.201
2007	-1.191	0.291	-0.643	-0.444	-0.924	-0.852	-0.663		-0.247
2008	-1.191	0.524	-0.483	-0.847	-0.924	-0.928	-0.873		-0.213
2009	-0.939	0.928	-0.164	-0.847	-1.032	-1.028	-1.082		-0.044
2010	-1.191	1.189	-0.511	-1.049	-1.249	-0.906	-0.873		-0.199
2011	-1.191	1.280	0.232	-1.452	-1.357	-1.278	-1.292		-0.052
2012	-1.191	1.704	-0.272	-1.654	-1.466	-1.297	-1.292		-0.108
2013	-1.191	2.013	-0.137	-1.654	-1.466	-1.384	-1.292		-0.031
2014	-0.939	2.290	0.858	-1.654	-1.466	-1.703	-1.712		0.290

European Union 28 (continued)

raw data	+	+	+	+	+	-	-
Weight	15%	15%	15%	15%	15%	12.5%	12.5%
Dimension	Availability					Adaptability	
Year	Self sufficiency	Share of renewable in TPES	Share of nuclear in TPES	Oil self sufficiency	Gas self-sufficiency	Energy intensity	CO2 emission intensity
1990	0.580	0.044	0.126	0.220	0.550	0.140	0.381
1991	0.570	0.045	0.130	0.220	0.570	0.140	0.374
1992	0.580	0.048	0.134	0.230	0.580	0.136	0.360
1993	0.580	0.051	0.140	0.240	0.590	0.136	0.354
1994	0.590	0.051	0.140	0.280	0.590	0.132	0.343
1995	0.590	0.051	0.139	0.280	0.570	0.132	0.337
1996	0.580	0.052	0.142	0.270	0.570	0.134	0.338
1997	0.580	0.054	0.145	0.270	0.560	0.129	0.322
1998	0.560	0.055	0.143	0.270	0.540	0.126	0.312
1999	0.570	0.056	0.146	0.290	0.530	0.121	0.298
2000	0.560	0.058	0.145	0.280	0.530	0.117	0.289
2001	0.550	0.059	0.147	0.260	0.520	0.118	0.287
2002	0.550	0.058	0.149	0.260	0.510	0.116	0.281
2003	0.530	0.061	0.147	0.250	0.470	0.116	0.283
2004	0.520	0.064	0.147	0.230	0.470	0.115	0.276
2005	0.510	0.068	0.145	0.210	0.430	0.112	0.269
2006	0.490	0.071	0.143	0.190	0.410	0.109	0.260
2007	0.490	0.078	0.138	0.200	0.390	0.104	0.249
2008	0.490	0.084	0.139	0.180	0.390	0.103	0.241
2009	0.500	0.094	0.140	0.180	0.380	0.101	0.232
2010	0.490	0.101	0.139	0.170	0.360	0.103	0.235
2011	0.490	0.103	0.143	0.150	0.350	0.097	0.222
2012	0.490	0.114	0.140	0.140	0.340	0.097	0.220
2013	0.490	0.122	0.141	0.140	0.340	0.096	0.214
2014	0.500	0.129	0.146	0.140	0.340	0.091	0.201
Max	0.590	0.129	0.149	0.290	0.590	0.140	0.381
Min	0.490	0.044	0.126	0.140	0.340	0.091	0.201
Mean	0.537	0.071	0.141	0.222	0.475	0.117	0.287
Median	0.550	0.059	0.142	0.230	0.510	0.116	0.283
STD	0.040	0.025	0.005	0.050	0.092	0.015	0.053

Czech Republic

z value	+	+	+	+	+	-	-		
Weight	15%	15%	15%	15%	15%	12.5%	12.5%		
Dimension	Availability					Adaptability			
Year	Self sufficiency	Share of renewable in TPES	Share of nuclear in TPES	Oil self sufficiency	Gas self-sufficiency	Energy intensity	CO2 emission intensity		CZ Security Index
1973	0.506	-1.017	-1.194	-2.467	3.092	1.658	1.275		**-0.529**
1974	1.616	-0.936	-1.194	-2.467	2.983	1.002	1.107		**-0.263**
1975	1.616	-0.936	-1.194	-0.293	1.568	1.075	1.163		**-0.166**
1976	1.477	-0.976	-1.194	-0.293	2.221	1.111	1.201		**-0.104**
1977	1.200	-0.936	-1.194	-1.018	1.350	1.293	1.287		**-0.412**
1978	1.616	-0.976	-1.194	-0.293	1.241	0.874	1.122		**-0.190**
1979	1.061	-0.936	-1.194	-1.018	1.568	1.184	1.322		**-0.391**
1980	0.922	-0.936	-1.194	-1.018	0.479	0.892	1.056		**-0.505**
1981	0.922	-0.936	-1.194	-0.293	0.588	0.929	1.095		**-0.390**
1982	0.922	-0.976	-1.194	-0.293	0.479	0.929	1.091		**-0.412**
1983	1.061	-0.976	-1.178	-0.293	0.044	0.874	1.072		**-0.445**
1984	0.922	-1.017	-1.093	-0.293	-0.065	0.874	1.051		**-0.473**
1985	0.783	-0.976	-1.000	-0.293	-0.174	0.874	1.030		**-0.487**
1986	0.783	-0.976	-0.704	-0.293	-0.283	0.856	0.948		**-0.446**
1987	0.783	-0.936	-0.365	-0.293	-0.283	0.984	0.949		**-0.405**
1988	0.783	-0.936	-0.260	-0.293	-0.391	0.765	0.795		**-0.360**
1989	0.645	-0.976	-0.185	-1.018	-0.391	0.382	0.475		**-0.396**
1990	0.228	-0.324	-0.181	-1.018	-0.391	0.492	0.199		**-0.339**
1991	0.645	-0.406	-0.114	-0.293	-0.391	0.619	0.298		**-0.199**
1992	0.228	0.043	-0.072	-0.293	-0.609	0.492	0.189		**-0.191**
1993	0.506	0.083	-0.001	-0.293	-0.500	0.346	0.119		**-0.089**
1994	-0.050	0.247	0.071	0.431	-0.500	0.054	-0.115		**0.037**
1995	-0.466	0.083	-0.018	-0.293	-0.500	-0.146	-0.267		**-0.127**
1996	-0.605	0.043	0.003	-0.293	-0.609	-0.201	-0.347		**-0.151**
1997	-0.466	0.124	-0.037	1.880	-0.609	-0.146	-0.370		**0.198**
1998	-0.744	0.247	0.065	1.156	-0.609	-0.274	-0.486		**0.112**
1999	-1.021	0.410	0.177	1.156	-0.609	-0.620	-0.665		**0.177**
2000	-0.882	0.247	0.133	1.156	-0.609	-0.584	-0.534		**0.146**
2001	-1.021	0.328	0.208	0.431	-0.609	-0.602	-0.609		**0.052**
2002	-1.021	0.410	0.568	1.156	-0.718	-0.620	-0.723		**0.227**
2003	-0.882	0.328	1.131	1.880	-0.609	-0.584	-0.724		**0.441**
2004	-0.744	0.450	1.125	1.880	-0.609	-0.675	-0.821		**0.502**
2005	-1.160	0.532	1.012	1.880	-0.609	-0.966	-1.008		**0.495**
2006	-1.160	0.613	1.076	1.156	-0.609	-1.112	-1.126		**0.441**
2007	-1.160	0.817	1.084	0.431	-0.609	-1.294	-1.189		**0.395**
2008	-1.160	0.899	1.171	0.431	-0.609	-1.440	-1.311		**0.454**
2009	-1.021	1.266	1.392	-0.293	-0.500	-1.495	-1.330		**0.480**
2010	-1.438	1.470	1.333	-0.293	-0.609	-1.403	-1.332		**0.411**
2011	-0.882	1.755	1.453	0.431	-0.500	-1.567	-1.378		**0.707**
2012	-0.605	1.959	1.656	0.431	-0.500	-1.567	-1.435		**0.816**
2013	-1.299	2.366	1.741	-0.293	-0.500	-1.586	-1.490		**0.687**
2014	-1.438	2.366	1.752	-0.293	-0.500	-1.677	-1.581		**0.690**

Czech Republic (continued)

raw data	+	+	+	+	+	-	-
Weight	15%	15%	15%	15%	15%	12.5%	12.5%
Dimension	Availability					Adaptability	
Year	Self sufficiency	Share of renewable in TPES	Share of nuclear in TPES	Oil self sufficiency	Gas self-sufficiency	Energy intensity	CO2 emission intensity
1973	0.85	0.002	0	0.00	0.36	0.341	1.127
1974	0.93	0.004	0	0.00	0.35	0.305	1.083
1975	0.93	0.004	0	0.03	0.22	0.309	1.098
1976	0.92	0.003	0	0.03	0.28	0.311	1.108
1977	0.9	0.004	0	0.02	0.20	0.321	1.131
1978	0.93	0.003	0	0.03	0.19	0.298	1.087
1979	0.89	0.004	0	0.02	0.22	0.315	1.140
1980	0.88	0.004	0	0.02	0.12	0.299	1.069
1981	0.88	0.004	0	0.03	0.13	0.301	1.080
1982	0.88	0.003	0	0.03	0.12	0.301	1.079
1983	0.89	0.003	0.001	0.03	0.08	0.298	1.073
1984	0.88	0.002	0.007	0.03	0.07	0.298	1.068
1985	0.87	0.003	0.013	0.03	0.06	0.298	1.062
1986	0.87	0.003	0.032	0.03	0.05	0.297	1.040
1987	0.87	0.004	0.054	0.03	0.05	0.304	1.041
1988	0.87	0.004	0.061	0.03	0.04	0.292	1.000
1989	0.86	0.003	0.066	0.02	0.04	0.271	0.915
1990	0.83	0.019	0.066	0.02	0.04	0.277	0.841
1991	0.86	0.017	0.071	0.03	0.04	0.284	0.868
1992	0.83	0.028	0.073	0.03	0.02	0.277	0.839
1993	0.85	0.029	0.078	0.03	0.03	0.269	0.820
1994	0.81	0.033	0.083	0.04	0.03	0.253	0.758
1995	0.78	0.029	0.077	0.03	0.03	0.242	0.717
1996	0.77	0.028	0.078	0.03	0.02	0.239	0.696
1997	0.78	0.03	0.076	0.06	0.02	0.242	0.690
1998	0.76	0.033	0.082	0.05	0.02	0.235	0.659
1999	0.74	0.037	0.089	0.05	0.02	0.216	0.612
2000	0.75	0.033	0.087	0.05	0.02	0.218	0.646
2001	0.74	0.035	0.092	0.04	0.02	0.217	0.627
2002	0.74	0.037	0.115	0.05	0.01	0.216	0.596
2003	0.75	0.035	0.152	0.06	0.02	0.218	0.596
2004	0.76	0.038	0.151	0.06	0.02	0.213	0.570
2005	0.73	0.04	0.144	0.06	0.02	0.197	0.521
2006	0.73	0.042	0.148	0.05	0.02	0.189	0.489
2007	0.73	0.047	0.149	0.04	0.02	0.179	0.472
2008	0.73	0.049	0.154	0.04	0.02	0.171	0.440
2009	0.74	0.058	0.169	0.03	0.03	0.168	0.435
2010	0.71	0.063	0.165	0.03	0.02	0.173	0.434
2011	0.75	0.07	0.173	0.04	0.03	0.164	0.422
2012	0.77	0.075	0.186	0.04	0.03	0.164	0.407
2013	0.72	0.085	0.192	0.03	0.03	0.163	0.392
2014	0.71	0.085	0.192	0.03	0.03	0.158	0.368

Czech Republic (continued)

	Availability					Adaptability	
	Self sufficiency	Share of renewable in TPES	Share of nuclear in TPES	Oil self sufficiency	Gas self-sufficiency	Energy intensity	CO2 emission intensity
Max	0.930	0.085	0.192	0.060	0.360	0.341	1.140
Min	0.710	0.002	0.000	0.000	0.010	0.158	0.368
Mean	0.814	0.027	0.078	0.034	0.076	0.250	0.788
Median	0.820	0.029	0.076	0.030	0.030	0.261	0.789
STD	0.072	0.025	0.065	0.014	0.092	0.055	0.266

France

z value	+	+	+	+	+	-	-	
Weight	15%	15%	15%	15%	15%	12.5%	12.5%	
Dimension	Availability					Adaptability		
Year	Self sufficiency	Share of renewable in TPES	Share of nuclear in TPES	Oil self sufficiency	Gas self-sufficiency	Energy intensity	CO2 emission intensity	FR Security Index
1973	-1.861	0.379	-1.890	-0.442	2.441	2.392	2.397	-0.805
1974	-1.954	0.595	-1.886	-0.442	2.293	1.596	2.011	-0.660
1975	-1.769	1.456	-1.842	-0.442	1.851	1.132	1.716	-0.468
1976	-2.046	0.056	-1.877	-0.442	1.556	1.331	1.928	-0.820
1977	-1.769	1.779	-1.853	-0.442	1.630	0.867	1.643	-0.412
1978	-1.861	0.918	-1.750	-0.442	1.556	1.066	1.655	-0.577
1979	-1.861	0.595	-1.678	-0.442	1.262	1.132	1.566	-0.656
1980	-1.677	0.379	-1.492	-0.442	1.114	0.999	1.335	-0.609
1981	-1.030	0.487	-1.085	0.442	0.967	0.668	0.883	-0.227
1982	-0.937	0.702	-1.028	0.442	0.893	0.204	0.651	-0.096
1983	-0.568	1.025	-0.738	0.442	0.819	0.336	0.482	0.045
1984	-0.106	0.595	-0.377	0.442	0.672	0.535	0.336	0.075
1985	0.079	0.702	-0.184	1.326	0.304	0.800	0.211	0.208
1986	0.264	0.487	0.031	1.326	0.009	0.734	0.068	0.217
1987	0.356	0.918	0.071	1.326	-0.065	0.734	-0.049	0.305
1988	0.356	0.810	0.159	2.209	-0.212	0.270	-0.175	0.487
1989	0.449	-0.913	0.289	1.326	-0.212	0.270	-0.167	0.128
1990	0.449	-0.590	0.323	1.326	-0.286	0.137	-0.260	0.199
1991	0.449	-0.159	0.318	1.326	-0.286	0.535	-0.120	0.195
1992	0.634	0.379	0.411	1.326	-0.286	0.270	-0.231	0.365
1993	0.726	-0.159	0.582	1.326	-0.286	0.469	-0.338	0.312
1994	0.818	0.272	0.624	1.326	-0.212	-0.062	-0.424	0.485
1995	0.818	-0.159	0.640	1.326	-0.360	0.071	-0.417	0.383
1996	0.726	-0.482	0.632	0.442	-0.507	0.469	-0.348	0.106
1997	0.726	-0.697	0.703	0.442	-0.507	0.005	-0.451	0.156
1998	0.449	-1.020	0.575	-0.442	-0.655	-0.062	-0.398	-0.106
1999	0.541	-0.805	0.622	-0.442	-0.655	-0.393	-0.505	0.001
2000	0.634	-1.236	0.735	-0.442	-0.728	-0.592	-0.593	-0.007
2001	0.541	-1.020	0.682	-0.442	-0.728	-0.526	-0.612	-0.003
2002	0.541	-1.774	0.776	-0.442	-0.728	-0.592	-0.665	-0.087
2003	0.541	-1.666	0.754	-0.442	-0.802	-0.459	-0.650	-0.104
2004	0.541	-1.666	0.758	-0.442	-0.802	-0.592	-0.699	-0.080
2005	0.541	-1.666	0.767	-0.442	-0.876	-0.658	-0.721	-0.079
2006	0.541	-1.774	0.804	-1.326	-0.802	-0.990	-0.811	-0.158
2007	0.541	-1.128	0.770	-1.326	-0.876	-1.255	-0.892	-0.034
2008	0.541	-0.374	0.756	-0.442	-0.876	-1.255	-0.912	0.212
2009	0.541	0.056	0.685	-1.326	-0.876	-1.321	-0.939	0.145
2010	0.634	0.702	0.723	-1.326	-0.876	-1.255	-0.939	0.253
2011	0.818	-0.267	0.923	-1.326	-0.949	-1.653	-1.114	0.226
2012	0.726	0.918	0.803	-1.326	-0.949	-1.653	-1.111	0.371
2013	0.818	1.779	0.780	-1.326	-0.949	-1.719	-1.095	0.517
2014	1.096	1.564	0.988	-1.326	-1.023	-1.984	-1.246	0.599

France (continued)

raw data	+	+	+	+	+	-	-
Weight	15%	15%	15%	15%	15%	12.5%	12.5%
Dimension			Availability			Adaptability	
Year	Self sufficiency	Share of renewable in TPES	Share of nuclear in TPES	Oil self sufficiency	Gas self-sufficiency	Energy intensity	CO2 emission intensity
1973	0.25	0.077	0.0213	0.02	0.47	0.167	0.440
1974	0.24	0.079	0.0220	0.02	0.45	0.155	0.406
1975	0.26	0.087	0.0288	0.02	0.39	0.148	0.380
1976	0.23	0.074	0.0234	0.02	0.35	0.151	0.398
1977	0.26	0.09	0.0271	0.02	0.36	0.144	0.373
1978	0.25	0.082	0.0431	0.02	0.35	0.147	0.374
1979	0.25	0.079	0.0542	0.02	0.31	0.148	0.367
1980	0.27	0.077	0.0832	0.02	0.29	0.146	0.346
1981	0.34	0.078	0.1465	0.03	0.27	0.141	0.306
1982	0.35	0.08	0.1553	0.03	0.26	0.134	0.286
1983	0.39	0.083	0.2005	0.03	0.25	0.136	0.271
1984	0.44	0.079	0.2565	0.03	0.23	0.139	0.258
1985	0.46	0.08	0.2865	0.04	0.18	0.143	0.247
1986	0.48	0.078	0.3200	0.04	0.14	0.142	0.235
1987	0.49	0.082	0.3262	0.04	0.13	0.142	0.224
1988	0.49	0.081	0.3399	0.05	0.11	0.135	0.213
1989	0.5	0.065	0.3601	0.04	0.11	0.135	0.214
1990	0.5	0.068	0.3654	0.04	0.1	0.133	0.206
1991	0.5	0.072	0.3647	0.04	0.1	0.139	0.218
1992	0.52	0.077	0.3790	0.04	0.1	0.135	0.208
1993	0.53	0.072	0.4056	0.04	0.1	0.138	0.199
1994	0.54	0.076	0.4122	0.04	0.11	0.13	0.191
1995	0.54	0.072	0.4147	0.04	0.09	0.132	0.192
1996	0.53	0.069	0.4134	0.03	0.07	0.138	0.198
1997	0.53	0.067	0.4245	0.03	0.07	0.131	0.189
1998	0.5	0.064	0.4047	0.02	0.05	0.13	0.194
1999	0.51	0.066	0.4119	0.02	0.05	0.125	0.184
2000	0.52	0.062	0.4295	0.02	0.04	0.122	0.176
2001	0.51	0.064	0.4212	0.02	0.04	0.123	0.175
2002	0.51	0.057	0.4358	0.02	0.04	0.122	0.170
2003	0.51	0.058	0.4324	0.02	0.03	0.124	0.171
2004	0.51	0.058	0.4331	0.02	0.03	0.122	0.167
2005	0.51	0.058	0.4344	0.02	0.02	0.121	0.165
2006	0.51	0.057	0.4402	0.01	0.03	0.116	0.157
2007	0.51	0.063	0.4350	0.01	0.02	0.112	0.150
2008	0.51	0.07	0.4328	0.02	0.02	0.112	0.148
2009	0.51	0.074	0.4217	0.01	0.02	0.111	0.146
2010	0.52	0.08	0.4275	0.01	0.02	0.112	0.146
2011	0.54	0.071	0.4586	0.01	0.01	0.106	0.130
2012	0.53	0.082	0.4401	0.01	0.01	0.106	0.131
2013	0.54	0.09	0.4364	0.01	0.01	0.105	0.132
2014	0.57	0.088	0.4688	0.01	0	0.101	0.119

France (continued)

	Availability					Adaptability	
	Self sufficiency	Share of renewable in TPES	Share of nuclear in TPES	Oil self sufficiency	Gas self-sufficiency	Energy intensity	CO2 emission intensity
Max	0.570	0.090	0.469	0.050	0.470	0.167	0.440
Min	0.230	0.057	0.021	0.010	0.000	0.101	0.119
Mean	0.451	0.073	0.315	0.025	0.139	0.131	0.229
Median	0.510	0.075	0.405	0.020	0.100	0.134	0.198
STD	0.108	0.009	0.155	0.011	0.136	0.015	0.088

Hungary

z value	+	+	+	+	+	-	-		
Weight	15%	15%	15%	15%	15%	12.5%	12.5%		
Dimension	Availability					Adaptability			
Year	Self sufficiency	Share of renewable in TPES	Share of nuclear in TPES	Oil self sufficiency	Gas self-sufficiency	Energy intensity	CO2 emission intensity		HU Security Index
1973	1.769	-0.296	-1.522	0.306	2.109	0.818	1.402		0.077
1974	1.439	-0.346	-1.522	-0.145	2.068	0.746	1.366		-0.040
1975	0.943	-0.748	-1.522	-0.595	1.698	0.818	1.327		-0.302
1976	0.943	-0.648	-1.522	-0.370	1.575	1.032	1.358		-0.302
1977	0.778	-0.798	-1.522	-0.595	1.616	0.889	1.250		-0.346
1978	0.778	-0.949	-1.522	-0.595	1.657	1.604	1.708		-0.509
1979	0.448	-0.798	-1.522	-0.370	1.082	1.032	1.300		-0.466
1980	0.283	-0.849	-1.522	-0.145	0.753	1.068	1.274		-0.515
1981	0.283	-0.748	-1.522	0.080	0.629	0.853	1.108		-0.437
1982	0.613	-0.798	-1.522	0.531	0.712	0.675	1.011		-0.280
1983	0.778	-0.798	-1.149	0.756	0.629	0.532	0.806		-0.135
1984	0.778	-0.597	-0.977	0.756	0.712	0.603	0.803		-0.075
1985	0.943	-0.798	-0.585	0.531	0.835	0.818	0.778		-0.061
1986	0.778	-0.899	-0.482	0.756	0.547	0.710	0.650		-0.065
1987	0.943	-0.949	-0.077	0.531	0.547	0.675	0.545		-0.003
1988	0.778	-1.050	0.316	0.756	0.300	0.603	0.337		0.048
1989	0.613	-0.949	0.377	0.756	0.177	0.496	0.246		0.053
1990	0.283	-0.497	0.636	0.756	-0.111	0.460	0.025		0.100
1991	0.613	-0.346	0.564	1.207	-0.069	0.925	0.320		0.140
1992	0.943	-0.195	0.548	1.207	0.054	0.567	0.082		0.302
1993	0.613	-0.195	0.528	0.531	0.054	0.746	0.113		0.122
1994	0.613	-0.145	0.536	0.982	-0.069	0.389	-0.017		0.241
1995	0.778	-0.095	0.514	1.658	-0.193	0.532	-0.080		0.343
1996	0.283	-0.195	0.527	1.658	-0.439	0.675	-0.025		0.194
1997	0.283	-0.195	0.470	0.982	-0.439	0.353	-0.201		0.146
1998	-0.047	-0.145	0.473	0.531	-0.645	0.031	-0.300		0.059
1999	-0.377	-0.145	0.549	0.531	-0.809	-0.183	-0.360		0.030
2000	-0.542	-0.145	0.679	0.306	-0.809	-0.504	-0.621		0.064
2001	-0.873	-0.095	0.637	0.080	-0.933	-0.576	-0.640		-0.025
2002	-0.873	-0.095	0.649	0.531	-0.974	-0.755	-0.773		0.077
2003	-1.533	-0.044	0.242	0.531	-1.097	-0.862	-0.752		-0.083
2004	-1.698	0.006	0.470	0.306	-1.056	-1.076	-0.925		-0.046
2005	-1.863	0.358	0.700	-0.821	-1.097	-1.040	-1.025		-0.150
2006	-1.863	0.458	0.726	-1.271	-1.015	-1.219	-1.119		-0.152
2007	-1.863	0.760	0.652	-1.497	-1.097	-1.326	-1.184		-0.143
2008	-1.533	1.213	0.701	-1.271	-1.097	-1.433	-1.226		0.034
2009	-0.873	1.917	1.007	-1.271	-0.851	-1.398	-1.282		0.324
2010	-1.038	2.017	0.967	-1.497	-0.933	-1.291	-1.269		0.247
2011	-1.038	2.017	1.059	-1.722	-0.933	-1.469	-1.365		0.262
2012	-0.707	2.017	1.155	-1.271	-1.015	-1.648	-1.469		0.416
2013	-0.707	2.319	1.372	-1.722	-1.056	-1.898	-1.556		0.463
2014	-0.873	2.470	1.437	-2.398	-1.015	-1.969	-1.618		0.392

Hungary (continued)

raw data	+	+	+	+	+	-	-
Weight	15%	15%	15%	15%	15%	12.5%	12.5%
Dimension	Availability					Adaptability	
Year	Self sufficiency	Share of renewable in TPES	Share of nuclear in TPES	Oil self sufficiency	Gas self-sufficiency	Energy intensity	CO2 emission intensity
1973	0.6	0.03	0	0.25	0.97	0.138	0.555
1974	0.58	0.029	0	0.23	0.96	0.137	0.551
1975	0.55	0.021	0	0.21	0.87	0.138	0.546
1976	0.55	0.023	0	0.22	0.84	0.141	0.550
1977	0.54	0.02	0	0.21	0.85	0.138	0.536
1978	0.54	0.017	0	0.21	0.86	0.151	0.594
1979	0.52	0.02	0	0.22	0.72	0.14	0.542
1980	0.51	0.019	0	0.23	0.64	0.141	0.539
1981	0.51	0.021	0	0.24	0.61	0.135	0.518
1982	0.53	0.02	0	0.26	0.63	0.131	0.506
1983	0.54	0.02	0.114	0.27	0.61	0.127	0.480
1984	0.54	0.024	0.167	0.27	0.63	0.129	0.480
1985	0.55	0.02	0.287	0.26	0.66	0.131	0.477
1986	0.54	0.018	0.319	0.27	0.59	0.127	0.461
1987	0.55	0.017	0.443	0.26	0.59	0.126	0.448
1988	0.54	0.015	0.563	0.27	0.53	0.123	0.422
1989	0.53	0.017	0.582	0.27	0.5	0.122	0.410
1990	0.51	0.026	0.661	0.27	0.43	0.121	0.383
1991	0.53	0.029	0.639	0.29	0.44	0.129	0.420
1992	0.55	0.032	0.635	0.29	0.47	0.117	0.390
1993	0.53	0.032	0.628	0.26	0.47	0.117	0.394
1994	0.53	0.033	0.631	0.28	0.44	0.114	0.377
1995	0.54	0.034	0.624	0.31	0.41	0.113	0.369
1996	0.51	0.032	0.628	0.31	0.35	0.116	0.376
1997	0.51	0.032	0.611	0.28	0.35	0.108	0.354
1998	0.49	0.033	0.611	0.26	0.3	0.105	0.342
1999	0.47	0.033	0.635	0.26	0.26	0.101	0.334
2000	0.46	0.033	0.675	0.25	0.26	0.097	0.302
2001	0.44	0.034	0.662	0.24	0.23	0.097	0.299
2002	0.44	0.034	0.666	0.26	0.22	0.094	0.283
2003	0.4	0.035	0.541	0.26	0.19	0.093	0.285
2004	0.39	0.036	0.611	0.25	0.2	0.089	0.264
2005	0.38	0.043	0.681	0.2	0.19	0.092	0.251
2006	0.38	0.045	0.689	0.18	0.21	0.087	0.239
2007	0.38	0.051	0.666	0.17	0.19	0.083	0.231
2008	0.4	0.06	0.681	0.18	0.19	0.081	0.226
2009	0.44	0.074	0.775	0.18	0.25	0.083	0.219
2010	0.43	0.076	0.763	0.17	0.23	0.084	0.221
2011	0.43	0.076	0.791	0.16	0.23	0.081	0.208
2012	0.45	0.076	0.821	0.18	0.21	0.076	0.195
2013	0.45	0.082	0.887	0.16	0.2	0.075	0.185
2014	0.44	0.085	0.907	0.13	0.21	0.074	0.177

Hungary (continued)

	Availability					Adaptability	
	Self sufficiency	Share of renewable in TPES	Share of nuclear in TPES	Oil self sufficiency	Gas self-sufficiency	Energy intensity	CO2 emission intensity
Max	0.600	0.085	0.907	0.310	0.970	0.151	0.594
Min	0.380	0.015	0.000	0.130	0.190	0.074	0.177
Mean	0.493	0.036	0.467	0.236	0.457	0.112	0.379
Median	0.510	0.032	0.618	0.250	0.435	0.117	0.380
STD	0.061	0.020	0.306	0.044	0.243	0.023	0.125

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