UNITED NATIONS UNIVERSITY
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WIDER Working Paper 2016/21

European energy security

Challenges and green opportunities

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April 2016

In partnership with

JISEA
Joint Institute for
Strategic Energy Analysis

United Nations University World Institute for Development Economics Research
wider.unu.edu

Abstract: This research reviews relevant literature on the current state and effectiveness of developing renewable energy on energy security in general, and on energy security in the European Union in particular. The paper elaborates on primary energy import sources, possible alternatives, and how energy security is affected by the sources of supply. It also gives an analysis of the effects of the Ukrainian crisis, the isolation of Iran on diversification sources, and on European energy security. It examines European Union's energy policy, analyses the best motivation for a new energy policy direction within Europe, and suggests alternative solutions for enhanced energy supply security. The aim is to suggest suitable solutions for energy security in Europe through energy supply diversification. Supply diversification includes alternative energy corridors for reducing dependency on Russia as a supplier and enhancing the power generated by renewable energy sources under the European Union 2020 strategy.

Keywords: energy security, green energy, renewable energy, Ukraine crisis, Iran sanctions

Acknowledgements: The authors are grateful to Channing Arndt and three anonymous referees for their comments and suggestions on an earlier version of this paper.

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This study has been prepared within the UNU-WIDER project on 'The Political Economy of Clean Energy Transitions'.

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ISSN 1798-7237 ISBN 978-92-9256-064-5

Typescript prepared by Lesley Ellen.

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The Institute is funded through income from an endowment fund with additional contributions to its work programme from Denmark, Finland, Sweden, and the United Kingdom.

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1 Introduction

The world widely relies on energy which is crucial for driving desirable high levels of economic growth. However, energy resources are limited and those which can be explored economically exist only in specific regions. Additionally, threats to energy security, including political instability in crude oil producing countries, supply disruptions, competition over energy resources, terrorist attacks on supply infrastructures, as well as accidental events and natural disasters, are considered important parameters which affect global energy supply and security. Since the first oil shock in the 1970s, the issue of energy supply security has become a major objective around the world, in particular in industrialized countries. Dominant countries—in Europe and the Eurasia region—which are dependent on foreign oil and gas supply face problems in relation to energy security. The Middle East and Russia are the main sources of energy supply internationally, comprising more than a half of the global proven crude oil reserves. The free flow of oil to world markets in sufficient quantities, at low costs, and through secure channels from these sources forms a vital part of energy security.

Energy security can be considered as both international and national security issues that may lead to cross-national tensions. Europe is facings some challenges and also has possible opportunities to avoid or to overcome these challenges. The crisis in Ukraine, with its importance as an energy corridor for Europe, is a threat to energy security at a time when political tensions have increased between Ukraine and Russia. Iran could be considered as an alternative source of energy for the European market, but there is a longstanding dispute between Iran and the West involving economic sanctions. Iran is not only the holder of the largest natural gas reserves and the fourth largest crude oil reserves in the world (BP 2014), but it is also located in a geopolitical area.

The European Union (EU) is determined to diversify its energy supply in order to reduce its dependency on Russian supplies. In this regard, renewable energy technologies are an alternative for power generation and subsequent dependency reduction. A sizable investment has been made in the EU for developing renewable energies. The advanced technologies of Europe enable these countries to produce renewable energy more cost effectively and the power generated by these sources continues to increase. However, profitability of renewable energies depends on the prices in the depletable energies market. Thus, developing the renewable energy market is very sensitive to price fluctuations in primary energy sources. In this regard, integrating distributed renewable energy sources and smart grids within local marketplaces for trading renewable energy in small units can be a promising combination for enhancing renewable energy deployment. Considering Europe's intention to organize a single harmonized system, the member countries are required to apply suitable mechanisms to support renewable energy enhancement. Applying a proper financial support mechanism enables the EU to implement the Intended National Determined Contributions (INDCs), which is one of the important components of the process towards implementing the commitments made at the United Nations Climate Change Conference held in Paris in December 2015 (COP21).

In this research, we review the relevant literature on the current state and effectiveness of developing renewable energy on energy security. The review uses primary energy import sources, possible alternatives, and considers how energy security in Europe is affected by the sources. For this purpose, the Herfindahl-Hirschman Index (HHI) is calculated to measure the level of energy security for selected countries. We also examine EU energy policy, try to analyse the reasons why Europe should adopt a new energy policy direction, and we suggest alternative solutions for enhanced energy supply security. The aim is to suggest suitable solutions for energy security in Europe through energy supply diversification, including alternative energy corridors, to reduce dependency on Russian supplies and enhance the power generated by renewable energy sources

in order to meet energy targets based on the EU 2020 strategy[1] including greenhouse gas (GHG) emission reduction, renewable energy deployment, and energy efficiency enhancement. The information used for the study is derived mainly from official reports and is based on secondary data sources.

The rest of this study is organized as follows: Section 2 discusses the effects of renewable energy development on energy security. Section 3 deals with the challenges in the Middle East and the balance of energy demand and supply in Europe—the monopolized energy market—and the necessity to find new suppliers. This is followed by a discussion of import sources and possible alternatives for Europe in Section 4. Section 5 presents a policy framework aimed at enhancing energy security in Europe. The final section provides a conclusion.

2 The effects of renewable energy development on energy security

Ongoing concerns about energy security have been raised since the Arab oil embargo in 1973 when oil importing countries in Europe and elsewhere were faced with the effects of high oil prices and limited energy supplies. Although concerns about energy security started waning with low oil prices in the 1980s, oil prices increased again over the next decades. Considering the importance of energy for economic development and growth, industrialized countries focused on alternative policies to enhance alternative energy sources such as nuclear power and renewable energy. Over recent years, climate change and environmental protection have been at the core of energy policies together with energy security. Nuclear power and renewable energy sources have been suggested as alternative sources since the 1970s. However, since the Fukushima Daiichi nuclear disaster in Japan in 2011, energy policies in relation to nuclear power plants have been reshaped around the world. While, due to its large share of total electricity generated, nuclear power has a critical role for some countries like France, some other countries like Germany are determined to close all their nuclear power plants by 2022. At the same time, Finland has invested in new nuclear power plants.

Deese (1979) discusses the economic, political, and security aspects of energy. Energy security is achieved when stable sources of energy are available at affordable prices. It is possible to attain high energy security through internal (domestic) or external (imported) energy supplies. Russia has been the main source, providing 41 per cent of total European imports of energy in 2014 (BP 2015a). Germany has been importing 45 per cent of its natural gas demand from Russia. Considering the disputes that have occurred between Russia, Ukraine, and Western powers over recent years regarding gas transmission and political interventions, European countries are looking for sustainable sources of energy to diversify their energy supply sources. Policy makers have therefore been trying to enhance the deployment of renewable energy sources through different incentive policies such as feed-in-tariffs and renewable portfolio standard carbon tax.

2.1 Natural gas and the interplay with renewables and the environment

The literature about natural gas and the interplay with renewables, particularly related to temporal transitions, energy/environmental policies, and energy security, has been developing rapidly. Creutzig et al. (2014) view the energy transition in Europe as catching two European birds (mitigating climate change and energy security crisis) with one renewable stone. The

[1] Europe 2020 is a 10-year strategy proposed by the European Commission in March 2010 for advancement of the economy of the EU. It aims for smart, sustainable, inclusive growth with greater coordination of national and European policy (European Commission 2010).

analysis suggests that country-specific conditions and policy frameworks require member state policies to play a leading role in fostering coordination of regulatory frameworks to govern energy transition. The governance of natural gas transit in Europe is investigated by Bouzarovski et al. (2015). They develop a theoretical framework to explore the regulatory practices and spatial features of this unexplored infrastructural realm. This paper reveals emerging new socio-technical assemblage and institutional orders other than the traditional organizational arrangements.

The interaction of risks associated with natural gas and renewable resources for electricity is analysed by Esposito et al. (2015). They identify risks relating to development, construction of power plants and transmission systems, planning, costs, and policy decisions, and show how the risks can potentially be offset. Lee et al. (2012), in the case of the US, find natural gas and renewable energy technologies enjoy many complementarities arising from their similarities, but find that their dissimilarities provide the biggest opportunities for mutually beneficial collaboration. Mediavilla et al. (2013) refer to the physical limits and temporal conditions in the transition from an oil economy towards renewable energies. The temporal dynamics of energy transitions is studied by Sovacool (2016). The focus is on the speed at which transition can take place and causal complexity underlying the conceptions and definitions of energy transitions.

Fischhendler and Nathan (2014), in their study of energy security in Israel, find the concept of energy security open to manipulation and various interpretations by inter-ministerial committees. The security concept differs from environmental acceptability and interdependency, supply reliability, and geopolitical benefits. Verdeil et al. (2015) also discuss the challenge of the transition to development of urban natural gas in the Mediterranean Metropolis. The issue of accurately forecasting the availability of natural gas to ensure sustainable energy policy is emphasized by Darda et al. (2015). The use of alternative reserve estimates for South Asian natural gas shows where in the region the reserves allow for building a sustainable power reserve system for natural gas to meet increasing energy demand in the medium term. Ghezelbash et al. (2015) emphasize the use of high net present values of selected systems in the assessment of performance of natural gas expansion. Kahrl et al. (2013) analyse the changes necessary to increase the share of natural gas in China's electricity mix. The emphasis is on the cost-competitiveness, methods of compensation, government's technology policy, and reforms in the natural gas supply industry to make gas competitive as a baseload resource.

2.2 Renewable energy development

As mentioned earlier, renewable energy sources have been developed in order to enhance energy security and to reduce greenhouse gases (GHGs). European countries are at the forefront when it comes to improving efficiencies and using renewable energy. Also, tax policies have been applied by these countries in order to reduce liquid fossil fuel consumption. It is expected that liquid fuel consumption in the Organization of Economic Cooperation and Development (OECD) countries will be 14.0 million b/d (barrels per day) in 2040 which is 0.8 million b/d lower than the 2010 level (EIA 2014). The importance of developing renewable energy has been highlighted by climate change and energy security issues through the excessive consumption of fossil fuels, political instabilities in the Middle East, and uncertainty around supply disruptions due to political disputes in Ukraine. Germany is considered to be the forerunner when it comes to generating renewable energy, because it was able to raise the share of renewable energy sources in its fuel-mix to more than 10 per cent in 2014. Primary energy consumption in Germany was 311 Mtoe (million tonnes of oil equivalent) in 2014 and renewable energy sources contributed 31.7 Mtoe. The latter will increase to 36.3 Mtoe if hydroelectric power is included in the calculation.

Renewable energy has been developing rapidly in recent years. Reductions in costs due to economies of scale and use of advanced technologies have made it possible for countries to generate renewable energy more efficiently and cost effectively. Tables 1a and 1b compare power generation costs based on different sources of energy over the period 2000–15.

Table 1a: Power generation costs based on sources of energy (2000–15), US$ per megawatt hour

	2000	2010	2014	2015	2000–15 (%)
Gas (CCGT) US	62	58	52	47	-24
Hydro	52	70	67	66	25
Geothermal	48	84	77	72	50
Gas (CCGT) Europe	47	80	80	76	62
Coal US	57	81	80	80	40
Wind onshore	76	116	82	86	14
Gas (OCGT) US	117	110	96	91	-23
Coal (Europe)	77	109	92	92	19
Nuclear	74	96	100	102	37
Gas (OCGT) Europe	94	142	139	134	42
Solar PV	509	333	145	135	-74
Biomass	109	144	140	139	28
Coal w/CCS US	84	135	146	156	86
Coal w/CCS Europe	107	152	154	164	53
Wind offshore	NA	205	180	184	NA
Solar CSP	207	238	226	200	-4
Wave-tidal	NA	280	296	302	NA

Note: CCGT=combined cycle gas turbine, OCGT=open cycle gas turbine, CCS=carbon capture and storage, CSP=concentrated solar power, PV=photovoltaic, NA=not available, US=United States.

Source: Adapted from EI Energy Intelligence (2015).

As can be seen in Table 1a, Solar PV accounted for the largest reductions in costs during the last decade. Renewable technologies may not be compatible with conventional fuels due to unit costs, but they could be feasible if we were to consider associated externalities such as carbon emissions and social effect. Also, economies of scale are crucial for reducing unit costs. Bohi and Toman (1993) studied energy security by looking at externalities and policies. Table 1b shows that Solar PV is expected to be the least expensive power-generation technology by 2050. The unit cost for this technology reduced by 74 per cent during 2000–15 and it is forecast that this will reduce further by another 62 per cent over 2015–50. Therefore, Solar PV could be considered as an alternative source of energy in decent sunlight conditions, for example, in Central Europe.

Currently, nuclear power is being considered as an alternative to fossil fuels in European countries, but these countries are also coming under pressure to stop the operation of existing nuclear power plants. There has been a de facto moratorium on the construction of new nuclear power plants, with phase-out decisions having been announced by Sweden, Germany, Switzerland, Spain, Belgium, and the Netherlands (Asif and Muneer 2007).

Table 1b: Power generation cost outlook, based on source of energy (2015–50), US$ per megawatt hour

	2015	2020	2030	2050	2015–50 (%)
Solar PV	135	117	89	51	-62
Geothermal	72	71	69	66	-8
Hydro	66	66	66	66	1
Wind onshore	86	83	79	70	-18
Solar CSP	200	178	141	88	-56
Gas (CCGT) US	47	61	70	92	94
Nuclear	102	101	98	92	-9
Gas (CCGT) Europe	76	85	92	102	34
Coal US	80	92	101	114	43
Wind offshore	184	172	151	116	-37
Coal Europe	92	112	122	130	42
Biomass	139	138	137	133	-5
Coal w/CCS US	156	157	150	137	-13
Coal w/CCS Europe	164	175	167	149	-9
Wave-tidal	302	274	226	154	-49
Gas (OCGT) US	91	111	124	159	76
Gas (OCGT) Europe	134	147	157	174	31

Notes: CCGT=combined cycle gas turbine, OCGT=open cycle gas turbine, CCS=carbon capture and storage, CSP=concentrated solar power, PV=photovoltaic, US=United States.

Source: Adapted from EI Energy Intelligence (2015).

Additionally, high primary energy prices combined with energy support policies have been the main driver in enhancing renewable energy sources. Many OECD countries have enacted national policies to support sustainable development through clean technologies. These policies deal with a wide range of objectives such as energy security, market competition, and environmental protection. Economic feasibility is at the core of renewable energy development. Without this essential parameter, renewable energy technologies will not be able to compete with conventional fossil fuels. Financial support mechanisms are becoming important for deploying renewable energy sources. EU-28 countries are using a number of financial support policies including feed-in-tariffs, tax incentives, and tradable green certificates. However, the most important point that should be in focus is the sustainability of policy. Large investments are made based on government support mechanisms and these may be affected negatively if this financial support is discontinued or decreased due to economic recession or possible changes in policy-making. Table 2 shows the growth rates of wind and solar energy consumption as the main renewable energy sources, based on region, over the period 2010–14.

Table 2: Wind and solar energy consumption in 2010–14, in TeraWatt hour (TWh)

	Wind power			Solar power		
	2010	2014	Change, %	2010	2014	Change, %
North America	105.5	202.1	91.6	1.3	19.3	1384.6
South and Central America	3.5	17.7	405.7	a	1.1	>2000.0
Europe & Eurasia	152.6	261.6	71.4	23.2	99.7	329.7
Middle East	0.2	0.3	50.0	0.1	1.1	1000.0
Africa	2.2	6.1	177.3	0.3	2.1	600.0
Asia-Pacific	79.4	218.3	174.9	6.4	62.6	878.1
World	343.4	706.2	105.6	31.4	185.9	492.0

Note: 'a' indicates less than 0.05 level of significance.

Source: Authors' calculations based on BP Statistical Review of World Energy (BP 2015a).

Based on the figures presented in Table 2, we see a rapidly increasing trend (as high as a 3–4 digit growth rate) during 2010–14 for wind and solar energy consumption. In parallel with non-oil and gas producing countries, even countries located in the Middle East are determined to develop solar energy for environmental reasons. Among individual countries, the United States (US) had the highest consumption of wind energy (183.6 TWh), which was more than the total consumption in the top five consumer countries in Europe (171.1 TWh); the US also accounted

for 26 per cent of the total global consumption of wind power (BP 2015a). Europe had a lower growth rate than North America, but it ranked first in relation to total wind and solar energy consumption. In other words, developing renewable energy sources has already reached a high level in Europe.

Various installation facilities are required in order to utilize renewable energy deployment; these have also been implemented in many countries for power generation. As a result of differences in investment intensities, the share of electricity generated by renewable energy technologies varies by region and across countries.

3 Middle East challenges and energy balance in Europe

The Middle East is considered to be the main source of crude oil supply in the world. Almost 35 per cent of the total crude oil traded on the world market is supplied by Middle Eastern exporters. Russia and the Middle East are major exporters of natural gas and crude oil to Europe. Considering the potential for terrorist attacks and political instability in these regions, Europe requires alternative sources of energy supply. Other factors such as climate change and crude oil prices make it even more important to switch from fossil fuels to renewable energy sources. The Yom Kippur War (1973), the Iranian Revolution (1979), the Iran/Iraq War (1980), the First Persian Gulf War (1991), the Second Persian Gulf War (2003), the Arab Spring in Egypt, the Libyan and Syrian Civil Wars (2011), and the Yemen Civil War (2014), together with the Saudi Arabian invasion of Yemen (2015) have all contributed to continued political instability in the Middle East. Owen (2004) discusses oil supply insecurity: control versus damage costs. Sen and Babali (2006) focus on problems of and solutions to security concerns for oil supply in the Middle East.

In the future, natural gas will play a critical role in the global energy market due to its advantages relating to prices, availability, cleanness, and security. Currently, European countries greatly depend on Russia as a supplier of natural gas. After the Fukushima disaster, nuclear power has lost its priority in the energy portfolio of EU-28 countries and alternative clean energy resources are being seriously considered. However, the generation capacity of renewable energy sources is not enough to cover the gap created by shutting down nuclear power plants completely. If this trend aggregates with climbing demand in the natural gas sector, Europe will depend more on foreign energy resources and major producers. Therefore, in all probability, major natural gas exporters will be in a better and comparatively more important position in the European energy market. This development seems to determine the Middle East and the Caucasus as the two main strategic regions in the natural gas supply cycle of Europe. One can view the European preference for new partnerships as a result of recent challenges in North Africa with its proliferation of political changes. This struggle to shape a new framework for a common security policy reveals the EU's preference for a neighbourhood security policy which is directly related to energy as the main exporting commodity of the neighbouring Southern and Eastern regions.

In the past, the EU built an integrated single energy market to be used as an asset in relations with neighbouring supplying countries. Therefore, when we talk about supply diversification, not only different sources of energy but also different exporters and transit routes should be taken into account for the EU. Europe therefore needs to design a new energy policy based on regional integration in order to use it as leverage for making long-term and stable partnerships with major suppliers. This new policy should create an ability to develop concrete mechanisms to deal with emergency situations arising from changing attitudes on the supply side. Vivoda (2009) asks whether diversification of oil import sources and energy security is a key strategy or an

elusive objective. Nuttall and Manz (2008) discuss a new energy security paradigm for the twenty-first century.

Considering this perspective, Europe needs to try and have a close relationship with the Caucasus region to improve supply security and to establish an international partnership. The Caucasus has started an ongoing trend of capturing larger shares of the EU energy market, while export capacity is affected by increasing domestic demand. Furthermore, there are some constraints on exports because of limited investments, lack of transport infrastructure, lack of technology, and only a few available transit routes. Europe depends on Russian energy sources, and Qatar's exports cannot decrease Europe's energy vulnerability. Russia's position as a dominant supplier in the European energy market along with the EU's limited internal resources is forcing the EU to consider other suppliers in the Persian Gulf region. In this regard, Iran could serve as a candidate for changing the EU's energy portfolio. Iran, with its large resources, presents a new solution to the serious issues of security in supply and sustainable energy sources. This alternative seems promising, as the current dispute between Iran and the Western powers is in the process of being resolved following the recent agreement made in Vienna on 14 July 2015. However, Iran's isolation and the prevention of oil companies from investing in the oil and gas industry, together with the reduction of crude oil production in Iran, may hurt global energy security. In other words, the effect of sanctions which have been imposed on Iran will influence the world energy market both in the short and the long term. The negative impact of these sanctions, therefore, could extend from a national to a global level in the future.

3.1 Energy demand in Europe

EU domestic suppliers will have to rely more on foreign energy resources in order to respond to domestic demand if they cannot improve their energy efficiency, control energy intensity, and improve renewable energy usage in the residential and industrial sectors. Based on a report by Christie et al. (2012), from 2010–35 coal and oil demand should be reduced in the EU-28 by 86 and 65 per cent respectively. Consequently, electricity and gas demand are expected to increase by 23 and 25 per cent respectively. According to International Energy Outlook's (EIA 2014) reference case shown in Table 3, consumption of liquid fossil fuels in OECD Europe will either decline or remain unchanged over the period 2010–40 (EIA 2014) while the consumption of liquids by the non-OECD region will increase.

Table 3: World liquids consumption by region, reference case, (2009–40), in millions of barrels of oil per day, (mmbpd)

	History		Projections			Average annual
Region	2009	2010	2020	2030	2040	growth%
OECD						
Americas	23.1	23.5	24.3	23.6	23.5	0.0
Europe	15.0	14.8	14.1	14.0	14.0	-0.2
Asia	7.7	7.7	8.0	7.7	7.2	-0.2
Total OECD	45.8	46.0	46.4	45.3	44.7	-0.1
Total Non-OECD	38.7	40.7	51.2	62.1	74.7	2.0
Total World	84.5	86.8	97.6	107.4	119.4	1.1

Source: EIA (2014).

In recent years, world energy consumption was affected by the global recession of 2008–09. However, energy consumption levels recovered as a result of the economic recovery from the downturn cycle and rebound effects of lowered prices and income effects. World energy demand is expected to increase sharply in the reference case of IEO 2014 as a result of healthy economic growth and expanding populations in non-OECD countries. Considering that OECD members are more technologically advanced energy consumers, they will reduce consumption of liquid

fossil fuels through improving energy efficiencies, by applying incentive policies for renewable energy deployment, and by using tax policies for motor fuels, etc. Electricity produced by power plants around the world is expected to increase from 5,950 GW (gigawatt) in 2013 to 10,700 GW in 2040 (IEA 2014). Power generated by nuclear reactors will reduce in OECD (Americas and Europe), but it will increase in the Asia-Pacific region (BP 2015b). Table 4 shows the distribution of electricity generated by nuclear power plants regionally. It is forecast that the power generated in Europe and Eurasia will decrease from 266.1 Mtoe in 2015 to 255.2 Mtoe in 2035.

Table 4: World nuclear energy production, (2013–35), (Mtoe)

	History		Projections			
Region	2013	2015	2020	2025	2030	2035
North America	213.7	231.7	238.5	238.0	234.3	186.2
South and Central America	4.7	5.3	6.5	7.9	8.6	9.4
Europe and Eurasia	263.0	266.1	259.8	254.5	254.9	255.2
Middle East	0.9	1.0	1.2	3.4	4.8	7.2
Africa	3.1	3.1	3.1	3.1	4.4	6.3
Asia-Pacific	77.8	125.9	210.8	272.9	327.9	377.7
Total	563.2	633.2	719.9	779.8	835.0	841.9

Source: Authors' calculations based on BP Energy Outlook 2035 (BP 2015b).

Concerns about energy security and greenhouse gas emissions have induced general support for the development of new nuclear generating capacities. Although a large part of the electricity consumption in some European countries, such as France, comes from nuclear power, the 2011 Fukushima accident in Japan has had a long-term effect on nuclear power development. Some countries, such as Germany, faced anti-nuclear protests after the Fukushima disaster and its government announced a policy of shutting down all nuclear power plants by 2022. In parallel with phasing out nuclear power plants, several EU countries are also trying to develop renewable energy sources. Denmark is the forerunner among clean producers in Europe, as it was able to raise the share of renewable energy (excluding hydropower) to 24 per cent of its total primary energy consumption. The figure for Germany, Italy, Sweden, Spain, and Portugal is 10–15 per cent (BP 2015a). The share of renewable energy will increase to 67, 38, and 23 per cent for Norway, Sweden, and Finland respectively if we include hydropower plants. Scandinavian countries will be able to export a large surplus of power if they connect their power market to the European network. The diversity in the fuel-mix of primary energy consumption in some European countries is shownin Table 5 which gives the level of fuel-mix concentration of energy consumption in seven European countries for 2010 and 2014.

Table 5: Fuel-mix of primary energy consumption in seven European countries (%)

	Year	Oil	Natural gas	Coal	Nuclear	Hydro	Renewable
France	2010	33.04	16.72	4.79	38.39	5.67	1.35
	2014	32.38	13.60	3.79	41.52	5.98	2.74
Germany	2010	36.03	22.91	23.94	9.95	1.35	5.82
	2014	35.85	20.51	24.89	7.07	1.48	10.19
Italy	2010	42.50	39.71	7.97	-	6.51	3.26
	2014	38.01	34.32	9.07	-	8.66	9.94
The Netherlands	2010	49.75	39.16	7.89	0.09	-	2.20
	2014	48.83	35.64	11.10	1.11	-	3.21
Poland	2010	27.45	13.47	56.37	-	0.84	1.98
	2014	24.87	15.36	55.28	-	0.52	4.08
Spain	2010	49.77	20.71	5.54	9.29	6.41	8.28
	2014	44.74	17.82	9.02	9.77	6.69	12.03
UK	2010	35.25	40.41	14.92	6.74	0.38	2.34
	2014	36.88	31.93	15.70	7.66	0.69	7.03

Source: Authors' calculations, based on BP Statistical Review of World Energy (BP 2015a).

Unlike the Scandinavian countries, which rely mainly on hydropower, the EU-28 will be relying on natural gas resources rather than on clean energy in the future. This implies that these countries need to develop relations with the main suppliers and transit countries. Although part of Europe's energy demand could be covered by domestic suppliers in the east and north of the continent, the EU imported around 78 per cent of crude oil consumption for 2014 (BP 2015a). Despite Europe being at the forefront of renewable energy deployment in recent years, the figure shows that fossil fuels still remain the main source of primary energy consumption in the region.

3.2 Energy supply sources for Europe

According to the EIA (2013) reference case, it is expected that natural gas imports will increase over the projection period 2010–40 by an average annual rate of 1.6 per cent because of declining local production, particularly in the United Kingdom (UK) (EIA 2013). In contrast, natural gas production in Europe will decrease by an average annual rate of 0.2 per cent. A major part of the worldwide increasing inter-regional natural gas exports comes from non-OECD Europe and Eurasia, the Middle East, and African regions. The EU's dependence on energy imports will increase in the next decades as oil and gas fields in Europe are depleted. Some oil fields in the North Sea are at a stage of maturity. In this regard, major oil companies such as Shell have plans to decommission the Brent oil fields.

EU policymakers are trying to reduce their dependency on energy imports through enhancing renewable energy and developing energy efficiency and energy technologies. It is forecast that renewable energy production in Europe and Eurasia will increase to 330.7 Mtoe in 2035 compared to 115.5 Mtoe in 2013 (BP 2015b). However, this trend is declining for oil production, as estimates show that oil production levels will decrease to 803.3 Mtoe in 2035 compared to 834.8 Mtoe in 2013. Table 6 shows the estimated total primary energy supply (TPES) in Europe and Eurasia by 2035.

Table 6: TPES Europe and Eurasia (2013–35) (in Mtoe)

Primary energy supply	2013	2015	2020	2025	2030	2035
Oil	834.8	831.4	843.7	841.5	816.1	803.3
Natural gas	929.6	930.7	960.7	1,049.4	1,061.6	1,081.6
Coal	450.2	425.7	402.1	392.8	388.3	385.3
Nuclear	263.0	266.1	259.8	254.5	254.9	255.2
Hydro	201.3	200.1	206.0	212.3	218.8	225.1
Biofuel	11.0	10.4	13.6	15.6	15.7	15.2
Renewable	115.5	133.6	179.9	229.3	278.6	330.7
Total	2,805.4	2,798.0	2,865.8	2,995.4	3,034.0	3,096.4

Source: Authors' calculations based on BP Energy Outlook 2035 (BP 2015b).

Currently, natural gas is the preferred source of energy in the EU. Countries located in Eastern Europe, the Caucasus, Central Asia, the Persian Gulf, and Northern Africa have large proven resources of natural gas that require investments, infrastructure development, high technology, and safe transit routes to reach the global energy market. Europe accounts for 5.5 per cent of the total natural gas consumption as proven by reserves in Europe and Eurasia countries. It had 58.0 tcm (trillion cubic metres) at the end of 2014 (a total share of around 31 per cent), while total EU proven resources of natural gas were 3.2 tcm. Natural gas proven reserves in the Middle East and Africa were 79.8 and 14.2 tcm, respectively. Considering that they accounted for 50 per cent of the total world reserves, a large source of energy is located around the European energy market. Also, since most of these states relied on this gas for supply to industrial and residential consumers, they are keen on developing their own resources.

3.3 Energy policy in Europe

The location of existing oil reserves does not align with population concentration and energy use structures around the world. As an example, consumption in Asia-Pacific, Europe, and North America accounts for almost 77 per cent of the total world consumption, while they control only 19 per cent of the global oil reserves (BP 2015a). At the same time, the former Soviet Union, Middle East, South America, and Africa consume 26 per cent while they control 81 per cent of the world's oil reserves.

A majority of energy suppliers are located in politically unstable regions, such as the Middle East, Latin America, and Africa, which poses high potential risks due to political instability (in Iraq, Syria, Venezuela, and Nigeria). There was a longstanding dispute between Iran as a key supplier in the Middle East and Western powers, but this has been resolved recently. The changed relations could offer great potential for an alternative solution for the EU's supply diversification plans. Therefore, EU countries need to use a specific energy policy framework or energy diplomacy in order to take advantage of competition among suppliers including Iran.

Energy security can also be improved by replacing more vulnerable supplies with stable sources of supplies. More than 40 per cent of Europe's imported natural gas through pipelines comes from Russia (BP 2015a). The gas supply dependency of Ukraine and Belarus on Russia is 74 and 100 per cent respectively. Considering that Ukraine is the main transit route for Russia to export natural gas to Europe, the EU, as a third party, could suffer because of any supply disruptions caused by a Ukraine–Russia dispute (gas pricing, transit fee, or other political issues affecting the two countries' relations).

In light of the increasingly interdependent and rapidly changing global energy landscape, the EU is required to build an effective energy policy framework. Considering that the EU's consumption of a major part of crude oil and natural gas comes from imports, it not only needs to diversify its supply routes but also integrate its energy policy towards third countries. Supply disruptions could be bypassed through well-interconnected liquid markets. A fully integrated energy market ought to be used as an asset in relations with the EU's neighbours and external suppliers (EPP 2011). Therefore, we should not only take into account the different sources of energy but also different exporters and transit routes when we are talking about energy supply diversification for the EU region.

'Optimal policy can be achieved by pricing both energy security and greenhouse gas abatement and pursuing each technology to the point where its additional cost is equal to the marginal benefits achieved in both dimensions' (Brown and Huntington 2008). There are three key targets under the EU 2020 growth strategy that are supposed to be met by the year 2020: first, a 20 per cent cut in greenhouse gas emissions from the 1990 level; second, 20 per cent of energy to come from renewable energy sources; and third, a 20 per cent improvement in energy efficiency. The effects of renewable energy technologies, energy efficiencies, and market regulation on carbon emission reduction are very important for this purpose. Different energy policies may interact with each other. These interactive effects should be accounted for in policy-making.

The EU Parliament and the European Commissioner for Energy Union agreed that building energy diplomacy is an imperative. The EU needs to further integrate its internal energy market and use it as leverage in relations with third country suppliers (EPP 2011). It is important that the EU makes concrete plans for emergency situations in case of a problematic attitude on the part of a third country. Therefore, responsibility for security of supply, demand, and international cooperation for regional integration is required. In this situation, a platform should be provided for a constructive discussion on the long-term challenges that the EU market may face, and relations between energy supply, transit, and demand security need to be formed. It

should be noted that the adequacy of energy supply and its sustainability are not just related to external sources of supplies.

Indicators that are considered for supply diversification and energy security include import dependency, fuel-mix, and stocks of critical fuels (Bhattacharyya 2011). The percentage of dependency on fuel imports shows the potential of the risk. This dependency may not be the same for all fuel types. Some countries are self-sufficient in producing one fuel type but they have to import another one. A ratio of the fuel-mix can be used by countries in order to diversify sources of energy supply. The EU has developed renewable energy sources in recent years and the region has also changed the major source of motor fuels from gasoline to diesel. The Scandinavian region may have an adequate surplus of supply for exporting to neighbouring countries by 2020. According to Bhattacharyya, stocks of critical fuels could be considered as another indicator to measure supply security. This indicator shows the availability of national stocks of fuels and the number of days that they may cover at the current level of consumption if there is any supply disruption. Strategic Petroleum Reserves accommodated by OECD countries are the best example of this indicator.

3.4 The monopolized energy market and the necessity of including new suppliers

Undoubtedly, Russia is the largest supplier of natural gas for EU countries. Russia has the second largest natural gas proven reserves in the world and enjoys a monopoly in the European energy market, but we cannot ignore the other players in the market. Some countries such as Azerbaijan, Algeria, Nigeria, and Qatar have specific shares in gas supply to Europe. But in the future we must observe some variations in these supplies which may cause certain problems for EU countries. A similar situation may apply in the case of crude oil. The share of non-OPEC countries in the crude oil market, particularly in Europe, will decline over the next few decades and lead to calls for increasing OPEC's crude oil, of which the Persian Gulf contains the majority of the current proven reserves. Natural gas reserves have not been concentrated as much as crude oil, but Russia together with the Caspian Sea and the Middle Eastern regions is the owner of about half of the total natural gas reserves in the world.

Major consumers, including the EU, will be more dependent on the same regions for importing oil and gas. We should keep in mind that there is rapid growth in energy consumption in developing countries such as China and India; they are looking for sources of energy in these regions too. So finding a new source of energy and a sustainable supplier is very important not only for Europe, but also for major emerging economies like China and India. In other words, the Middle East is a kind of battlefield between Western and Eastern powers to win a greater share of oil and gas resources to obtain long-term influence over the sector. Therefore, the security of oil and gas supply to the EU in the long term depends on having access to producing areas such as Russia, Central Asia, the Persian Gulf, and Africa. This accessibility should be facilitated by indigenous generation or investments by international oil companies.

For a long time, spare capacity was concentrated in Saudi Arabia, but this reduced over time due to domestic demand and operating refineries. Lack of investments for building new capacity and the absence of technological support for current fields caused by political conflicts has led to reduced production in some major oil producing countries like Iran and Nigeria.

4. Import sources and possible alternatives for Europe

Comprising more than 40 per cent of the world's crude oil and natural gas proven reserves, the Middle East is the key region for energy supply. The free flow of oil to world markets from the

Persian Gulf region forms a vital part of major security issues. Iran, the holder of the largest natural gas reserves and the third largest crude oil reserves in the world after Venezuela and Saudi Arabia, is located in the most important geopolitical area in the world and it has great potential to be an alternative source of energy for Europe. Cooperation between Iran–Europe, Iran–US and Iran–Persian Gulf states could show the Middle East to be a stable region that could be important for both Europe and the US. DeRosa and Hufbauer (2008) investigate the consequences of the normalization of economic relations for Iran's economy and the US. Katzman (2012) discusses US concerns about and policy responses in relation to Iran. Europe would have access to an alternative source of energy and the US would save a large amount of military expenses if this happened. Political stability in the Middle East would allow for the US's estimated military expenses in the Persian Gulf to be reduced by about US$27–US$73 billion per year (in 2004 USD); that translates to US$0.03–US$0.15 per gallon (US$0.005–US$0.05 per litre) for all gasoline and diesel fuels used by motor vehicles (Delucchi and Murphy 2008).

Table 7 presents a security index for some countries over the period 1980 to 2012 in the European Union, including Germany, Spain, France, Italy, the Netherlands, Sweden, and the UK. Net energy imports have been used as an energy security index in this table. Net energy imports are calculated as a percentage of energy use (production is excluded).

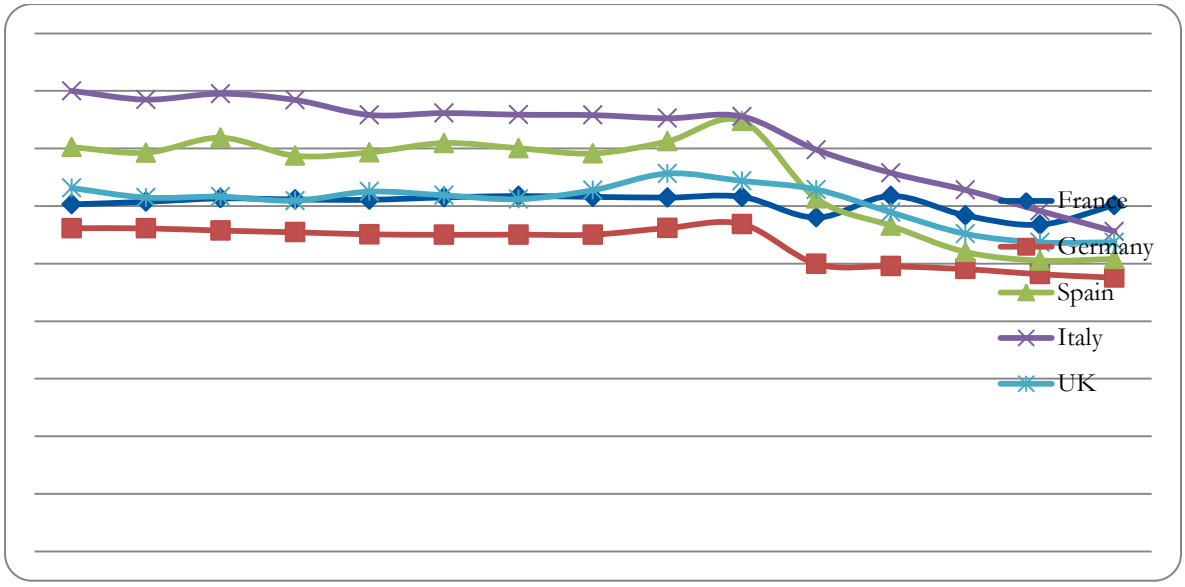
Table 7: Energy security index for some countries in the European Union

	1980	1990	2000	2010	2012
Germany	48.03	46.98	59.79	59.78	59.88
Denmark	95.02	41.03	-48.84	-20.68	-16.94
Spain	76.70	61.60	74.10	73.15	74.19
France	72.57	50.06	48.12	48.17	47.11
Italy	84.79	82.73	83.58	82.52	79.40
The Netherlands	-11.58	7.83	21.38	16.31	17.26
Sweden	60.16	37.11	35.82	34.72	28.53
Europe Union	44.88	42.21	43.90	51.25	

Source: World Bank (2015).

The Herfindahl-Hirschman Index (HHI) can be used to measure the level of energy security. However, this index has a disadvantage as it does not take political risks into consideration. The UK, Germany, Italy, and Spain had HHI above 2000, indicating that these countries were highly concentrated for power generation (Bhattacharyya 2011). We calculated the HHI of fuel-mix concentration for the selected countries for the period 2000–14. Figure 1 shows the index values. Consistent with Bhattacharyya's study, our calculations show clearly that these countries rely heavily on fossil fuels for power generation.

Figure 1: Fuel-mix concentration level using HHI (2000–14)



Source: Authors' calculations.

With the exception of France, we see a declining trend in the fuel-mix concentration since 2009. This shows the effect of the 2008–09 crisis on energy consumption. Policy makers tried to support alternative energy sources and enhance energy efficiency which led to decreasing levels of concentration. We find that Germany's energy policy was more stable than that of other sample countries. Also, Germany had the lowest HHI among the five selected countries, while Italy and Spain showed significant improvements in HHI measurements after 2009. However, the level of concentration in the countries chosen indicates that supportive policies should be the focus of policy makers for diversifying energy sources.

4.1 Import sources for Europe

Currently, Russia is considered to be the main source of energy for Europe. Pipelines are not only a means of transportation for natural gas and crude oil transmission, they also play a critical role related to geopolitics and energy security. The Russia–Ukraine dispute in 2009 over pricing, when Russia cut off gas supply to Ukraine and allowed increased flows to South Eastern Europe and to some parts of Central and Western Europe, is the best example of pipeline politics leading to an energy crisis in Europe. The importance of pipeline transmissions is also relevant in Central Asia and the Caucasus. Europe is looking for supplies from this region as part of its energy consumption and as an alternative solution for reducing its dependency on Russia. However, Russia has started constructing another pipeline for natural gas transmission to avoid transit countries. The main export pipelines used by Russia for supplying gas to Europe are:

A. Nord Stream: This is a new route for exporting natural gas to Europe. Germany, the UK, the Netherlands, France, Denmark, and other countries are considered as targets for supply through the Nord Stream pipeline. This pipeline will be used to cover growing demand in the European market over the coming decade. Nord Stream is an offshore natural gas pipeline in the Baltic Sea, and therefore, there is no transmission cost nor political risk in removing Russia from the picture.

B. Yamal–Europe: This pipeline runs across Russia, Belarus, Poland, and Germany. Yamal–Europe has increased the flexibility and reliability of Russian gas supply to Western Europe. The Jagal pipeline connects Germany's gas system to the Yamal–Europe pipeline.

C. Brotherhood: This is also known as the Urengoy–Pomary–Uzhgorod pipeline. The Brotherhood pipeline is the largest Russian pipeline to Europe. Previously, almost 80 per cent of Russian natural gas was exported to Europe through Ukraine. But this volume reduced to 50–60 per cent when the Nord Stream pipeline became operational in 2011.

In 2014, more than 30 per cent of energy trade movement through pipelines in Europe was supplied by Russia. Europe imported 365.70 bcm (billion cubic metres) of natural gas (320.8 pipeline, 44.9 Liquefied Natural Gas, LNG) in 2014 (BP 2015a). A major part of the LNG import demand in Belgium, France, Italy, Spain, and the UK is supplied by Qatar and Algeria. The other suppliers (outside Europe) are Nigeria and Trinidad and Tobago. About 3 per cent of European LNG consumption is covered by other European suppliers.

Given current tensions between Russia, Ukraine, and Turkey, there is increasing concern about potential disruptions to the security of energy supply to EU consumers in the long-term; pipeline connections running from the East to the West should be given special priority in order to mitigate these (Lise et al. 2008). Iran could be considered as a potential source in this regard. Security and the diversification required for EU energy supply highlight the significance of an energy corridor bridging the large natural gas reserves of the Caspian region, including those in Iran, with the EU market (Mavrakis et al. 2006). The EU has failed to create coherent energy security and energy foreign policy since the Russian–Ukrainian gas conflict in January 2006. Supply diversification through the aforementioned countries and implementing an energy policy of decreasing their overall gas demand will enable EU countries to reduce Russia's gas exports (Umbach 2010). The implementation of the Joint Comprehensive Plan of Action regarding Iran's nuclear programme was agreed in Vienna on 14 July 2015 between Iran and Western powers (effective on 16 January 2016). This agreement could facilitate possible changes in making a bridge between Iran's natural gas sources and major consumers in Europe.

4.2 Renewable energy technologies as alternative sources

The critical role of alternative energy sources comes together with climate change issues associated with higher consumption of fossil fuels. Energy security, economic impacts, and reduction in carbon dioxide emissions are considered as main drivers for enhancing renewable energy technologies. We can refer to any form of energy other than conventional sources of energy when we use the term 'alternative energy source' (including hydropower). In recent years the focus has been on renewable energy sources (Abolhosseini et al. 2014).

There are two concepts of energy technologies when clean technologies are considered: energy supply technologies which refer to alternative sources of renewable energy such as wind and solar power, and energy efficiency technologies which refer to technologies which are used to enhance energy efficiency such as combined heat and power, virtual power plant, and smart meters. It should be noted that transforming the energy sector and replacing conventional energy with renewable energy is evolutionary and is associated with technological changes and forming markets.

At an individual country level, Germany has the highest rate of economic growth together with the highest level of installed capacity of renewable energy sources, while we see low levels of economic growth and installed renewable energy capacities in Luxembourg, Hungary, Slovakia, and Estonia; these are also associated with the lowest levels of carbon emissions (Moutinho et al. 2015). Natural gas is able to bridge the transition period required for renewable energy technologies to facilitate larger energy deployment in order to make it feasible from an economic point of view. It is forecast that natural gas consumption in Europe will be 650 billion cubic

metres of natural gas (bcma) in 2020 and 780 bcma in 2030, while conventional gas production will decline to 230 bcma in 2020 and 140 bcma in 2030 (Weijermars et al. 2011).

Some scholars believe that transition progress for renewable energy sources such as wind and solar will happen after 2020; even the growth rate of consumption will increase rapidly during the next decade. Also, renewable energy markets are not formed easily due to cost disadvantages and subsidized fossil fuels (Jacobsson and Bergek 2004). Some countries such as Indonesia took advantage of falling oil prices during 2014–15 to reduce subsidies paid for fossil fuels, but still a large amount of subsidies are paid by oil rich countries. Because of the negative and irreversible externalities associated with conventional energy production, what is required is enhancing renewable energy supply technologies. These renewable technologies may be incompatible in view of economic feasibility compared with conventional fuels in view of unit production costs, but they are compatible if we consider their associated positive externalities such as environmental and social effects.

As mentioned earlier, cost reduction due to economies of scale and use of advanced technologies allow countries to generate renewable energy more efficiently and more cost effectively. Data from Platts Renewable Power Tracker (Platts 2015) shows that wind and solar power in Europe's five biggest power markets increased by around 8 GW in the first half of 2015; German wind and UK solar recorded the highest gains. Rapid growth in renewable energy has been possible in recent decades because of technological advances, increasing fossil fuel prices, and continued financial support by the state. For example, Germany's state-owned lender, KfW Group, announced in September 2011 that it will provide more than €100 billion (US$137 billion) over 2012–16 to facilitate the country's transition from nuclear power generation to renewable energy sources (Nicola 2011). This was supposed to boost loans and guarantees for solar plants and wind farms and set up low-interest lending programmes for building efficiency, regional power-grid growth, energy-storage projects, and clean fossil fuel-fired generators.

Economic policies can be used as incentives for enhancing production and use of renewable energy sources. Also, charging taxes on emission generation or fossil fuel consumption can be used as a supportive policy to promote the deployment of renewable energy. There are three types of supportive mechanisms that are widely used by states to promote renewable energy technologies: feed-in-tariffs (FIT), tax incentives, and renewable portfolio standard (RPS). Both FIT and RPS mechanisms have been applied by the EU to develop renewable energy technologies and it therefore has experience with both of these mechanisms. FIT policy has led to the rapid expansion of power generated by renewable energy sources and it has been employed more than the RPS mechanism (Rickerson and Grace 2007). Although the RPS mechanism has also been used widely across the US, the FIT policy is more attractive for policy makers due to its success in the EU, particularly in Germany.

A comparison of these policies indicates that FIT is an appropriate policy for developing renewable energy sources when a low level of risk for investors is required. However, the RPS mechanism works well when the government wants to use a market view policy. Europe intends to organize a single harmonized FIT system though this is impossible because of different policies across the countries in the EU. The RPS system has not been implemented in Europe because the FIT system has been used by most EU countries. Hence, FIT policies are suitable for encouraging development of renewable energy sources, while the RPS mechanism should be applied to renewable energy sources promoted to a certain level (Abolhosseini and Heshmati 2014).

Considering the outlook for the renewable energy market, what is required is a marketplace where small volumes of power generated can be traded. If such a marketplace does not exist

then enhancing renewable energy will be limited to individual households to cover their own demands.

> Power generation by renewable energy sources can also benefit from integration of technologies. Distributed power generation, which will be the basis of renewable energy production, encourages the production of renewable energy resources and, accordingly, decreases transmission losses, increases energy saving and enhances energy efficiency. Therefore, integrating distributing and renewable energy sources and smart grids within local marketplaces for trading renewable energy in small units can be a promising combination for developing renewable energy sources across the EU. (Heshmati and Abolhosseini 2014).

The EU is considered to be at the forefront of renewable energy enhancement and the 2020 strategy sets three critical targets for it to meet by 2020. This includes GHGs reduction, renewable energy deployment, and energy efficiency improvement. These targets could be achieved by developing renewable energy sources, technological change, and market regulation on carbon emissions. An estimated model (Heshmati et al. 2015) shows that the role of governmental policy-making is more important than economic growth. Heshmati et al. (2015) examined three hypotheses to compare the effect of renewable energy production technology, energy efficiency, and market regulation over time and across the selected countries in the EU. The effect of renewable energy generation, technological innovation, and environmental tax has been assessed and could be used by policy makers to evaluate the implication of new commitments under the EU 2020 and new INDC, as well as national policy frameworks. According to their finding, environmental tax had a negative and strong effect on carbon emission by itself, but the positive elasticity indicated that its negative effects become positive because of the high income and revenue recycling effects of tax policy. We should be aware that elasticities vary across the EU due to different demography, geography, economic structure, and policies of member states.

5. A new European policy framework

Energy security has moved up the EU's priority list. A high import dependency is not considered a problem in itself but it becomes an issue when supply is interrupted. Energy policy and management of international relations enable consumer countries to effectively secure primary energy supply. In spite of Europe's struggle for energy saving and improving the share of renewable energy in its energy basket, the region remains highly dependent on imports, especially of natural gas. The EU's collaboration has to extend to the Persian Gulf, East Mediterranean, and the Caucasus area because Europe plays a critical role in the supply side of energy markets. Limited natural gas resources in North Africa may lead to an increased focus on Azerbaijan, Turkmenistan, Iraq, Qatar, and Iran as substitute sources. Due to existing infrastructure problems, limited investments in gas fields, and underdeveloped transit routes in these countries, Europe has to share the costs and benefits with the owners of energy resources.

A common energy policy applied by EU member countries enables them to have a well-interconnected market in order to avoid possible supply disruptions. These countries can create a competitive market for suppliers through international collaborations with all market players. There are also economies of scale in building necessary infrastructures. Considering certain targets for reducing carbon emissions which have been defined by different scenarios, it is crucial for the EU to choose an optimal and proper direction for enhancing energy efficiency. The share prices of major manufacturers of solar panels in China and wind turbines in Denmark have decreased due to a sharp decrease in crude oil prices. This suggests that clean energy policies are

influenced more by economic conditions than by environmental concerns. A decoupling of the two will be crucial for the expansion and stability of renewable energy markets.

In this research we aimed to define a policy framework for the EU's energy security. Considering the small share of power currently generated by renewable energy sources, it is necessary for EU countries to design an applicable green pathway in order to achieve energy supply security (Heshmati 2014). In order to improve energy efficiency and power generation by renewable energy sources, a high-level commitment, investment resources, and efficient management are required for the development and implementation of policies and programmes (Gellings 2009). There are some barriers related to market creation, technical issues, public acceptance, compatibility between current operating systems, and new technology implemented in the renewable energy market that should be removed in order to facilitate the market creation process.

The Middle East and the Caucasus are two main strategic regions for the supply of natural gas to Europe. For renewable energy to be enhanced, a marketplace for green energy needs to be designed in order to promote market liquidity. Developing renewable energy has relied on public support and economic incentive programmes, but this has been affected by the economic crisis. A proper marketplace for trading the power generated by distributing renewable energy sources installed by households, combined with support policies for enhancing energy efficiency will lead to promoting market liquidity (see Heshmati and Abolhosseini 2014; Heshmati et al. 2015).

A multidimensional policy approach is required for achieving sustainable energy security in Europe. Important dimensions of this policy include improved security, lowered dependency, increased share of clean and renewable energy, diversified energy sources, and common energy policies. As such, it is necessary to create a balanced security situation incorporating all potential market partners through international cooperation. For this to happen, a proper policy design, effective policy-making for internal efficiency, and diplomacy in external energy are required so as to be able to take advantage of international cooperation.

6. Summary and conclusion

The world widely relies on energy, which is crucial for driving economic growth. However, energy resources are limited and they exist only in specific regions. Furthermore, threats to energy security, including political instability in crude oil and gas producing countries, supply disruptions, competition in energy resources, terrorist attacks on supply infrastructures, as well as accidental events and natural disasters, are considered important parameters which affect global energy security. Since the first oil shock in the 1970s, these issues have become major concerns around the world. Dominant countries in Europe and the Eurasia region which are dependent on foreign oil and gas supplies face problems of energy security. Comprising more than a half of the global proven crude oil reserves, the Middle East and Russia are the main sources of energy supply internationally.

The free flow of oil to world markets from these sources is a vital part of energy safety issues. Energy security can be considered as both international and national security issues that may lead to cross-national tensions. Europe is faced with some challenges and also has possible opportunities to overcome these challenges. The Ukrainian crisis and its importance as an energy corridor for Europe is a threat to energy security when political tensions increase between Ukraine and Russia. Iran could have been considered as an alternative source of energy supply for Europe, but there has been a longstanding disagreement between Iran and the West involving economic sanctions.

The nuclear deal between Iran and Western powers in July 2015 (effective on 16 January 2016) may facilitate possible changes that could build a bridge between Iran's natural gas sources and major consumers in Europe. Iran is not only the holder of the largest natural gas reserves and the fourth largest crude oil reserves in the world, but it is also located in a geopolitical area. The European Union is diversifying its energy supply in order to reduce its dependency on Russia. In this regard, renewable energy technologies are an alternative means of power generation. The EU has made sizable investments and the use of advanced technologies enables the countries to produce renewable energy more cost effectively. The power generated by these sources also continues to increase. This is consistent with sustainable development goals.

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