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Abstract: This report presents the main research activities developed in Task 1.4, focusing on the macroregional geopolitics of energy security and on the largest mega-projects in the renewable energy field. It encompasses potential geopolitical tensions concerning energy in a global scenario, with particular attention to relevant topics, such as the availability of stable and sustainable energy sources, the global competition for energy sources, the main trends towards the exhaustion of fossil fuels. All these elements are today crucial in global geopolitics, and many scholars have suggested that we are entering in a 'new' energy world order, in which a county's energy surplus (or deficit) strongly contributes to determine national position in the global world-system.

Disclaimer

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Abbreviations

AC	Alternating Current
ACER	Agency for the Cooperation of Energy Regulators
CSP	Concentrated Solar Power
EEA	European Environment Agency
ENTSO-E	European Network of Transmission System Operators for Electricity
EU	European Union
EUMENA	European Union-Middle East-North Africa region
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GW	Gigawatt
HVDC	High Voltage Direct Current
IEM	Integration of Energy Markets
MASEN	Moroccan Solar Agency
MENA	Middle East-North Africa region
MW	Megawatt
NSCOGI	The North Sea Countries' Offshore Grid Initiative
NSOG	North Sea Offshore Grid
OPEC	Organisation of the Petroleum Exporting Countries
TWh	Terrawatt-hour

Introduction

Energy plays today a crucial role in international affairs, arguably much more than in the past (Klare, 2008a; Bradshaw, 2009; Favennec, 2011). International relations with energy suppliers and issues of energy security are central nodes of geopolitical tensions and political agendas of countries all over the world (Goodstein, 2004; Roberts, 2004), and European Union is not an exception (Youngs, 2009; Umbach, 2010; Bosse, 2011).

This deliverable is about the geopolitics of energy security. It originates from the results and the analysis of trends defined in the previous Deliverable 1.3. It is articulated in four main parts.

The first section is about problems concerning energy in a global scenario: it proposes an evaluation of geopolitical tensions between different areas in the world. New energy corridors, physical infrastructures and an exploration of potential regional and macro-regional conflicts (e.g. Caspian question, access to African oil, Middle East conflicts, etc) are analysed. The information, perspectives and key nodes for EU energy security are combined and represented through qualitative mapping and visual representations. This task will be performed by working on a geographical synthetic image of key areas for EU energy security, strategic spatial development zones, key corridors and functional-energetic macro-regions from the perspective of the EU.

The second part analyses renewable energy (and related) mega-projects and their influence on energy security and fostering new geopolitical relationships. Two studies of renewable energy mega-projects visions are presented (DESERTEC and the North Sea Offshore Grid) and mini-case studies are conducted on pilot projects under development and associated with the visions (Ouarzazate CSP and Kriegers Flak).

The third part is about the realisation of reduction targets assigned by 20/20/20 package and the National Renewable Energy Action Plans; it offers, also, a general review concerning national environmental and energy policies in Europe and their impacts and effects on social and economic everyday life.

The forth part conceptualises the links between energy security and low-carbon policies and it introduces a methodological framework to assess their interactions. This section outlines the modelling tools used for the assessment and it elaborates on the input assumptions guiding the scenario analysis.

Box. 1 What do we mean by macroregional geopolitics?

The expression 'macroregional geopolitics' may sound unfamiliar or ambiguous to those who are not scholars in the fields of geopolitics, strategic studies and international relations. Firstly, the concept of "region" is generally used in geography in order to designate: (a) an area or zone of indeterminate size on the surface of the Earth, whose diverse elements form a functional association; (b) a part of a system of regions covering the globe; or (c) a feature of the Earth, as in economic region (see Gregory et al., 2009). As many geographical concepts, it is possible to detect and to analyse regions at different geographical scales, and the concept of region is not just used with reference to official, administrative regions, such as for Lombardia, Baden-Wurttemberg and Scotland. For instance, it is possible to consider a region as a small port area within a NUTS 3[1] region (e.g. the port area of Genoa may include an area that is smaller than the province of Genoa), a larger industrial cluster crossing various NUTS 2 regions (as the mechanic industrial region of Piedmont-Lombardy, to provide another Italian example, or the Randstad, Rhine-Ruhr and Flemish diamond area, that may be considered as a single urban region: see Dieleman and Faludi, 1998), or even groups of nations as in the case of economic and commercial areas as NAFTA or MERCOSUR (Börzel, 2012). The prefix 'macro' is often used in order to reduce ambiguity and to emphasise a 'vast' dimension, with all the ambiguities connected to the different possibilities to intend 'vastness'. Here, the macro-regional scale is intended basically as a supra-national/continental dimension.

Secondly, the concept of geopolitics is as well ambiguous and qualitative (Gregory et al, 2009). According to Klaus Dodds (2007), geopolitics "is preoccupied with borders, resources, flows, territories" and "can provide a pathway for critical analysis and understanding – albeit a controversial one" (p. 3). Geopolitics, in today scientific debates, is understood as a broad umbrella term used to indicate analysis of the ways in which a broad range of imaginative geographies actively shape politics, conflicts, social actions and ideologies (see Agnew, 2003). Furthermore, the concept of geopolitics is intrinsically multi-scalar: it is possible to analyse the everyday political geographies of intra-urban violent conflicts (Graham, 2004) as well as the global effects of geographical metaphors as the 'axis of evil', used to describe and to legitimate military interventions in the aftermaths of 9/11 (Dodds, 2007).

In conclusion, this report refers to 'macroregional geopolitics' as the practice of analysing actually existing or potential energy conflicts, spatial relations and functional interactions based on the logics of energy production, consumption or supply that Europe (or relevant parts of Europe) is developing or may develop in the future with external territories, as Russia, the Caspian area, the Northern Africa region. Obviously, the analysis of EU's energy relations implies the consideration of a large space and a global perspective. European energy relations, in fact, spread above a large part of Asia and Africa, and - as it will be discussed – to a minor degree even the Americas.

[1] NUTS - meaning Nomenclature of Territorial Units for Statistics - is a statistical classification of geographical subnational regions provided by European Union. See http://epp.eurostat.ec.europa.eu/portal/page/portal/nuts_nomenclature/introduction

1. Energy security in a geopolitical perspective[2]

1.1 Energy in an international scenario

The availability of secure energy sources is today essential for the proper functioning of the economy (Klare, 2008a). According to recent estimates by the EIA (Energy Information Administration, 2013), in the next three decades energy consumption is expected to increase by 56% globally, driven by the economic growth of emerging economies. Globally, energy consumption is expected to rise from the current level of 524 quadrillion British thermal units (Btu) per year in 2010, to 820 quadrillion Btu in 2040.

Competition for energy is extreme today (Peters, 2004; Klare, 2008b). In the aftermaths of the Second World War, core industrial countries such as the United States, UK and Japan accounted for a large share of global energy consumption. Today, a number of 'new' emerging countries are driving further increases in the demand for energy sources (Klare, 2008a). According to the EU-funded POLINARES project[3], new actors such as China, India and Brazil now play an important role on the international stage both as engines of demand and also leading producers of minerals and energy resources. Russia and other countries, which emerged from the break-up of the Soviet Union, are also significant forces in the oil, gas and mineral markets. However, a pivotal role is played by China (Cornelius and Story, 2007). In 1990, China accounted for 8% of global energy consumption, while USA accounted for 24% and Europe for 20%. With the growth of Chinese economy, the situation has changed radically: in 2010, China surpassed USA becoming the most important country in terms of energy consumption (2.469 Mtoe Gross Inland energy use by China, eq. to = 19,3% of World consumption; EIA, 2013). It is easy to figure that China will find more and more difficult, in the future, to get further energy supplies. Chinese policy makers will probably try to raise both local energy production and control over external energy sources (Li Zhi Dong, 2003).

Most of the energy used in the world is still provided by fossil fuels (oil, coal and natural gas): oil is the predominant source (33% of total energy consumption), followed by coal (27%) and natural gas (24%). Renewable sources, with an average annual growth of 1,8% since 1990, currently provide about 13% of global energy consumption. Nuclear energy provides about 6% (EIA, 2013).

In this framework, it is, infact, necessary to emphasise collective fears about a potential future exhaustion of main fuels, and particularly oil. A growing number of facts and figures suggest that the 'easy oil' era will be replaced by a 'difficult oil' era (Roberts, 2004). The marginal cost of oil production is, in fact, expected to increase: every new oil barrel added to global reserve will be more difficult and more costly than the previous one, according to scholars. In fact, every new barrel will be extracted deeper in the Ocean, in less accessible places, and in dangerous spaces, for example

[2] This Chapter has been developed by POLITO.

[3] POLINARES - *The changing oil value chain: Implications for security of supply* (www.polinares.eu) is an EU-funded research project exploring global challenges in the competition for natural resources and proposing new approaches to collaborative solutions.

because of possible wars (Roberts, 2004; Jojarth, 2008) Similar scenarios will most probably characterize all other energy sources, such as carbon, natural gas, uranium (Goldthau and Witte, 2010). Moreover, it should be stressed that the world is changing from a regime characterised by liberal market principles to one in which state capitalism is more prevalent than in the 1990s. It is widely recognised that the world is currently in transition from a political and economic regime in which liberal market values were prevalent, even if not dominant, to one in which State Capitalist values appear to be gaining more adherents. A consequence may be that energy and mineral prices will be volatile, that markets will be fragmented, or that partial supply interruptions will occur for some actors, even though there will be no absolute shortage of resources. This transition is occurring at the same time as demand for energy and mineral resources is rising. The result is a greater degree of unpredictability and volatility in international commodity markets[4].

In addition, despite large investments for the development of new technologies for oil production (and other fuels), the possibility of compensating both the expected decreases of production in existing extraction sites and the expected increases in demands, is pretty uncertain (Deffeyes, 2001)[5]. On the one hand, R&D activities aim at producing new fuels that may replace the ones running towards exhaustion, on the other hand, it is a common opinion that so far, no State has invested enough money to ensure (with meaningful confidence) that alternative sources will be available within a short time and in meaningful amounts (Klare, 2008a). As mentioned, policy makers and business managers will keep on building strategies based on the idea that fossil fuels will still be the main energy sources for the planet for several decades. In the words of Energy Information Administration (EIA, 2013), it is expected that in 2030 fossil fuels will provide about 87% of the world's energy needs. According to these scenarios, most countries will still rely on traditional fuels, with a consequent increase in the competition for the control of unexploited energy reserves (Klare, 2001; Bradshaw, 2009). As stated by the POLINARES project, the increasing interdependence of the world's nations in the context of energy and minerals cause tensions and conflicts that may undermine future global peace and economic development.

1.2 Towards a new energy world order

Many scholars currently think that, with the issue of energy security becoming more and more crucial, concepts as "power" and "influence" in the international system will change their meaning (see for example Favennec, 2011). In this sense, scientific debates use the expression 'new energy world order' (Klare, 2008a, p. 7).

In the 'old' energy world order, each country occupies a place in a hypothetical hierarchy of States according to its endowment in terms of nuclear missiles, warships and soldiers. Super-powerful States were characterized by impressive destructive

[4] http://www.polinares.eu/docs/policy/polinares_policy_brief_no4.pdf. European policy brief. POLINARES - Accessing Oil, Gas and Minerals in a Changing World

[5] But we must also consider that in relation to the lights of shale gas and oil extracted the situation is not so clear; thanks to new discoveries and to the techno-revolution, opinions expressed in the past years change very quickly (Bradshaw, 2009).

power, and countries as USA and USSR were assumed as the 'heartland' of the world, with a direct influence on weaker countries (Cohen, 1991).

With the 'new' energy world order, the position of a country in the global ranking seems to be increasingly determined by the possession or control of vast oil and natural gas reserves, or by the capability to mobilize money and relations in order to acquire energy resources from the outside. In this sense, energy surplus or deficit has significant and complex geopolitical and economic implications[6]. The importance of this topic is also reflected in the field of social research: POLINARES project, for example, examines the global challenges faced with respect to access to oil, gas and mineral resources over the next 30 years and proposes solutions for the various policy actors, including the EU, by combining theoretical and empirical analyses from a wide range of disciplines as political science, economics, geology, engineering, technology, law and security studies. In other words, the need for multidisciplinary and strategic analysis in this field is evident. Countries with energy deficit will be progressively forced to pay higher and higher prices for imported fuels. Also, countries with energy deficits will probably compete with each other in order to secure supplies, i.e. to acquire energy sources from countries characterized by energy surplus. At the same time, energy exporting countries will gain more and more from growths in the cost of energy. This phenomenon may be grasped by thinking that, in 2008, oil-exporting countries have gained something like 970 billion dollars from the export of oil, a figure that is three times higher than the one of 2002 (Klare, 2008a). Dynamics like these have just made the fortune of countries like Russia. In fact, since 2000 Russia has experienced a rapid growth in the exportation of oil and natural gas. Similarly, a number of financial centres in the Middle East, as Dubai and Abu Dhabi, have grown up because of the rise in the prices of fuels (see Acuto, 2010).

Thinking to this "new energy world", POLINARES project stresses the "differences" between democratic countries, such as the EU ones and state capitalist governments, such as China. The first, with liberal market economies, may wish to see State Capitalist governments adopt certain criteria and principles in their policy approaches to encourage cooperation in the exploitation of natural resources with a mismatch between this set of criteria and principles as put forward by such countries on the one hand, and the values and priorities of State Capitalist governments on the other hand. This mismatch creates tension in political and economic relations[7].

In this global energy order, both energy-exporting and energy-importing countries develop strategies in order to improve their position with respect to actual or potential competitors (Helm, 2002; Peters, 2004). This is evident when looking at the construction of networks and formal/informal agreements between exporting countries (as the possible 'natural gas Opec', based on the well-known experience of Opec), institutions and organizations grouping energy-importing countries (such as the International Energy Agency in the case of oil), and hybrid forms of regionalization

[6] Military power still remains crucial, but its relative importance in geopolitics is decreasing when compared to energy. Saudi Arabia, for example, is characterized by a 'weak' army, but the country occupies a central role in international affairs because of its vast oil reserves. Similarly, countries such as Azerbaijan, Kazakhstan, Angola and Sudan have begun to gain influence, despite their limited size (Klare, 2008a).

[7] http://www.polinares.eu/docs/policy/polinares_policy_brief_no4.pdf.

gathering both exporting and importing countries (such as the strategic alliance between China and Russia in order to limit the American influence in Asian energy affairs). Although it is too early to predict the overall impact of these agreements, many scholars believe in an ongoing, radical realignment of political powers in order to secure the exploitation of energy resources (Klare, 2004; Bradshaw, 2009; Bosse, 2011).

A clear sign of this reorganization may be found in the ongoing nationalization of energy companies and energy resources in many countries. Until recently, most of the world's oil reserves were controlled by large Western private companies (like Exxon Mobil, Chevron, British Petroleum, Royal Dutch Shell, Total SA etc.). Today, national oil companies control more than 80% of the known oil reserves. Giant players like Saudi Aramco (Saudi Arabia), National Iranian Oil Company (Iran), Petroleos de Venezuela SA (Venezuela), Gazprom (Russia) play a crucial strategic role in economic and geopolitical terms. In all these cases, the companies are wholly or largely owned by local governments (Klare, 2008a).

Of course, energy operators in the private sector still play a significant role, as testified by their colossal profits in recent years, but strategic decisions are more and more in the hands of national governments (Behr, 2010). To describe the increasing role of governments in the national energy policy, the expression "resource nationalism" is often used. Resource nationalism refers to the management of energy flows according to the interests of States. To put it differently, States acquire a major role in terms of property and/or control of energy resources, energy trade, energy distribution, energy infrastructures, etc.

The most striking example of the tendency towards resource nationalism is probably the one Vladimir Putin, who led Kremlin towards national control of oil and gas recourses and who transformed Gazprom, the Russian national enterprise with a monopolistic position in the field of natural gas, in one of the richest and most powerful energy companies of the world (Stern, 2005; Champion, 2006). Also the case of Japan, a country characterized by a huge energy deficit, testifies the tendency towards resource nationalism. In fact, Japan supports national energy companies in the seek for secure oil supplies overseas (Hisane, 2006). Also European countries, as France and Italy, have promoted the development of strategic connection with energy-exporting countries, particularly in Africa, where it is possible to take advantage of socio-cultural and economic networks with former colonies (Klare, 2008a).

Resource nationalism is so diffused that it may be conceptualized as a phenomenon echoing the old 'arms race'. Control over oil, natural gas and other energy resources is considered crucial, and in this sense geopolitical relations are evolving according to the logics of energy security (Behr, 2010). The global inter-national political atlas is changing under the pressure of the quest for energy resources (Bradshaw, 2009; Favennec, 2011; Goldthau and Witte, 2010).

1.3 Oil in the international order

1.3.1 Oil in the world

Despite global energy policies are aiming at reducing oil consumption and promoting the differentiation of energy sources (EIA, 2013), oil is still the main energy source in the world (33% of the total energy consumption in 2012). In Europe, as mentioned in Deliverable 1.3, oil is the main fuel, accounting for 35% of energy consumption (compared to 24% of natural gas) (source: BP, 2013).

In the 1950s, with the economic boom of Western countries, about 2,000 billion barrels of crude oil have been produced (source: BP, 2013). New explorations and the constant discovery of new deposits allowed, with time, impressive leaps in terms of oil production (10 million barrels per day in 1950, 25 million in 1962, 50 million in 1971, 75 million at the end of the last century and 86 million in 2012, source: EIA, 2010; BP, 2013). Particularly, between 1950 and 1970 several giant reserves were discovered in the northern area of Alaska, in the area of the North Sea between the United Kingdom and Norway, and in the Gulf of Guinea in Africa. But in the last decades of the century there has been a slowdown in the discovery of new fields, and since the early 70s, in coincidence with the 1973 energy crisis, concerns about the limits of oil stocks – being a scarce and exhaustible resource – begun to rise. Since then, the communities of experts have begun to question the capability of the energy industry to ensure increases in oil production (see, above all, the famous and controversial The Limits to Growth, 1972).

Given current oil reserves in the world (about 1,668 billion barrels in 2012) and current production and consumption rates, the average residual life of oil reserves is estimated to be about fifty years (source: BP, 2013).

Many scholars think that, with similar figures, the “peak” of the extraction is quickly approaching (Curis, 2009; Hall and Day, 2009). Other scholars believe, instead, that the peak of oil production has already been reached and that we are right now experiencing a decline in production (Ago and Saw, 2005). In synthesis, the different opinions testify to the fact that the optimism that prevailed at the beginning of the last century is vanishing[8].

Oil is an energy source characterized by high territoriality: it is inextricably linked to the places where crude oil is extracted and where transport infrastructures are located. Extraction sites are geographically concentrated in areas which are not rarely distant from places of consumption, and for this reason oil has to be moved over long distances through different countries. The management of oil security, therefore, involves a number of countries and places, including extraction, transit and consumption sites.

[8] Most experts believe that the production has/will reach rather a plateau than a peak. For a review on these issues cf. Al-Husseini (2006). The focus on the geological origin and the date of peak oil distracts the attention from the core determinants and the economic consequences of the end of cheap oil. The date of peak oil is, in fact, in priority a matter of flows that depend on the rate of extraction and this rate is driven by economic and technological factors Roberts, 2004.

According to British Petroleum (BP, 2013), over 50% of the oil reserves in the world are currently located in the Middle East. The largest shares of reserves are located in Saudi Arabia (15,9%), Iran (9,4%), Iraq (9%), Kuwait (6,1%) and the United Arab Emirates (5,9%). Outside of the Middle East only Venezuela (17,8%), Canada (10,4%) and Russia (5.2%) posse relevant reserves (source: BP, 2013).

Country	Thousand million barrels	Share of total %	R/P ratio
Venezuela	297,6	17,8	>100
Saudi Arabia	265,9	15,9	63
Canada	173,9	10,4	>100
Iran	157	9,4	>100
Iraq	150	9	>100
Kuwait	101,5	6,1	88,7
United Arab Emirates	97,8	5,9	79,1
Russian Federation	87,2	5,2	22,4
Lybia	48	2,9	86,9
Nigeria	37,2	2,2	42,1
World	1.668,9	100	52,9

* R/P: remaining life (in terms of years) of these reserves

Tab. 1 - Major countries in terms of oil reserves, 2012

Source: BP, 2013

It is worth mentioning that some countries are apparently distant from their productive peak. Particularly, this is the case of Canada, Venezuela, Iran, Iraq, whose oil reserves are expected to have a residual life of more than 100 years. It is therefore evident their pivotal strategic role in forthcoming international scenarios (Klare, 2008a).

1.3.2 European oil suppliers

Europe is characterized by high needs of oil: the external demand in 2012 has been of 639 million tons (EC, 2013), and oil imports come from a large number of countries. At the same time, European oil production is pretty low, that is about 185 million tons in 2012 (source: EC, 2013). From many perspectives, Europe may be considered a ‘single’ market, characterized for example by common environmental laws (cf. Deliverable 1.3), but European countries are characterized by relations with different external suppliers and by different oil transport systems.

The European Union mainly acquires oil from five areas: the North Sea (particularly Norway), Russia, the Caspian area (Kazakhstan and Azerbaijan), Middle East (Saudi Arabia, Iran, Iraq) and North Africa (Libya and Nigeria). Geographical proximity is therefore crucial in the European oil supply scenario, but it has to be mentioned that about 12,8% of European imports come from two distant areas, that are Venezuela and West Africa (EC, 2013).

Country	%
Russia	34,5
Norway	13,8
Libya	10,2
Saudi Arabia	5,9
Iran	5,7
Kazakhstan	5,5

Nigeria	4,2
Azerbaijan	4,2
Iraq	3,3
Others (Venezuela and West Africa)	12,8

Tab. 2 – Major European oil suppliers, 2012
Source: EC, 2013

Offshore deposits in the North Sea belong to Norway, the UK and Denmark. Oil extracted from the North Sea is for two-thirds destined to Europe, and for one-third to North America. Crude oil refined in Norway, UK and Denmark is brought to Europe via undersea pipelines or ships. Supplies from the North Sea are considered highly secure, because of the stability of the European market and because of the good relations between European countries (Correlje and Van der Linde, 2006); but actually oil reserves in the North Sea are scarce (15 billion barrels). With an average oil production of about 4.5 million barrels per day, the estimated residual life of oil in the North Sea is of 10 years (EC, 2013).

Every year, Europe imports about 150 million tons of oil from the Middle East. Oil imports from this area used to be higher in the past, but with time – as a consequence of the various oil shocks experienced during the years – European countries have diversified oil suppliers, increasing imports from North Sea, the Caspian area and Russia.

Europe imports about 100 million tons of oil every year from North Africa, particularly from Libya and Algeria. European relations with these two countries were somehow tense in the past, especially in the aftermaths of the colonial era, but relations are now considered good, and therefore oil supplies are considered secure, despite the fact that the effects of the Arab Spring have yet to be fully understood (Correlje and Van der Linde , 2006; Dabashi, 2012).

Oil from Middle East and from North of Africa arrives in Europe mainly through pipelines running through the coasts of Syria, Lebanon, Israel, Egypt, Libya, Tunisia, Algeria and Morocco. From Morocco, oil is transported by ship, as there aren't pipelines crossing the Mediterranean. Current infrastructural projects refer to:

- two undersea pipelines that will connect Turkey to Syria and Egypt;
- three pipelines that will connect Italy to Libya, Tunisia and Algeria;
- two pipelines that are expected to connect Algeria to France and Spain;
- one pipeline connecting Morocco with Spain and Portugal.

Russia and countries of the Caspian area provide about 330 million tons of oil every year. Given current estimated reserves of about 120 billion barrels, production is expected to be assured for at least 30 years. Europe is the main importer for this area, followed by China and United States (each one importing about 20 million tons of oil every year according to BP Statistical Review of World Energy, 2013). It has to be mentioned that trade relations between Russia and Europe developed after the collapse of Soviet Union. In Soviet Union the extractive and the energy industries used to be highly integrated between Russia and the other countries of the area (Soviet zone of influence). But with the economic crises that characterized Soviet transition towards liberal market economy, Russia promoted direct exportations towards Europe, bypassing the Soviet zone of influence (Champion, 2006). This trend has determined the rise of Russian energy industry but also geopolitical tensions between former Soviet countries, as it is particularly evident in the case of natural gas (see section 4) (Stern, 2005; Aalto, 2008).

Oil from Russia and Caucasian area gets in Europe through various corridors, and particularly:

- The Druzhba Pipeline (also known as the 'friendship pipeline' and 'Comecon pipeline') is one of the longest in the world, running through Russia, Ukraine, Hungary, Poland and Germany, with an approximate length of 4.000 kilometres. Originally, it was intended to provide Russian oil to satellite Soviet zone of influence. Today, it mainly allows the movement of Russian and Kazan oil towards Europe. Crude oil comes mainly from Western Siberia. In fact, the pipeline starts from Almetyevsk in Tatarstan, where it collects oil from western Siberia, the Urals, and the Caspian Sea. It runs to Mozyr in southern Belarus, where it splits into a northern and southern branch. The northern branch crosses the remainder of Belarus across Poland to Schwedt in Germany. It supplies refineries in Płock and in Schwedt. The northern branch is also connected by the Płock-Gdansk pipeline with the Naftoport terminal in Gdansk, which is used for oil re-exports. In Schwedt the Druzhba pipeline is connected with the MVL pipeline to Rostock and Spergau. The southern branch runs south through Ukraine. In Brody the Druzhba pipeline is connected with the Odessa-Brody pipeline, which is currently used to ship oil from the Druzhba pipeline to the Black Sea. In Uzhgorod the pipeline splits into lines to Slovakia (Druzhba-1) and to Hungary (Druzhba-2)[9].

- The Baltic Pipeline System, a Russian oil transport system operated by the oil pipeline company Transneft. The Baltic Pipeline System transports oil from the Timan-Pechora region, West Siberia and Urals-Volga regions to Primorsk oil terminal at the eastern part of the Gulf of Finland. The pipeline has been completed in 2001 and reached full design capacity in 2006.

- The Sever pipeline (also known as Kstovo–Yaroslavl–Kirishi–Primorsk pipeline) is an oil product pipeline in North-West Russia inaugurated in 2008. It transports diesel fuel EN-590. The pipeline is owned and operated by Transnefteproduct, a subsidiary of Transneft. The 1,056 kilometres long pipeline runs from Kstovo through Yaroslavl and Kirishi to Primorsk, Leningrad Oblast. It uses the same technical corridor with the Yaroslavl-Kirishi and Kirishi-Primorsk oil pipelines of the Baltic Pipeline System.

As mentioned, during Soviet Union, Caucasian states used to maintain direct connections with Russia. During the Soviet era, Moscow controlled Caspian energy reserves and the pipeline networks were constructed so as to link all the energy-rich

[9] The line through Slovakia is divided once again near Bratislava: one branch leading in a northwest direction to the Czech Republic and the other to Hungary. The Druzhba-1 pipeline branches off toward Hungary in Slovakia, crosses the Hungarian border at Drégelypalánk and leads to Százhalombatta.

countries to Russia. Although Russian hegemony in the area is still visible, Caucasian states have partly opened their markets to direct commercial relations with the European Union. The Soviet Union's demise, in fact, opened the region to external actors allowing foreign companies to invest in exploiting energy reserves and constructing alternative pipeline routes to transport gas and oil from the region to the international markets. As mentioned, Caspian oil reserves are low when compared to those in the Middle East; what makes Caspian energy resources so significant is that they offer Western buyers the opportunity to diversify energy imports away from the near monopolistic energy supplies of the Middle East and Russia. Currently, strategic corridors in the Caucasian area are:

- The BTC pipeline running from Baku (Azerbaijan) via Tbilisi (Georgia) to Ceyhan (Turkey). This is the main oil export pipeline.
- The Baku to Novorossiisk (Russia) pipeline and the Baku to Supsa (Georgia) pipeline. Both these pipelines were constructed for Azerbaijani oil production and have a small capacity.

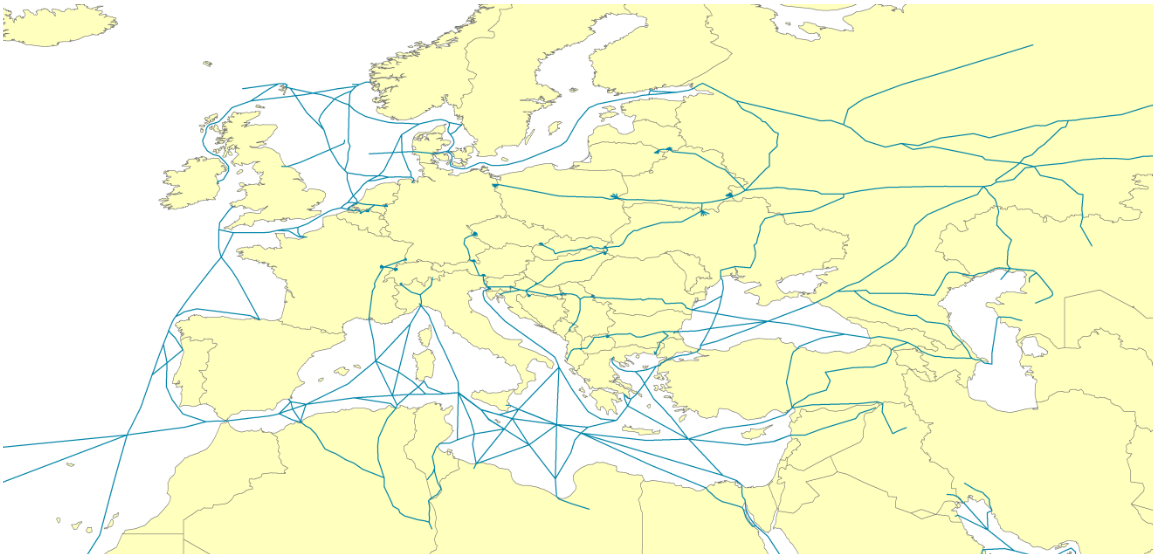


Fig. 1 - Main oil corridors in Europe
Source: R. Gerboni, D. Grosso, L. Schranz - REACCESS EU Project outcomes elaboration, 2014

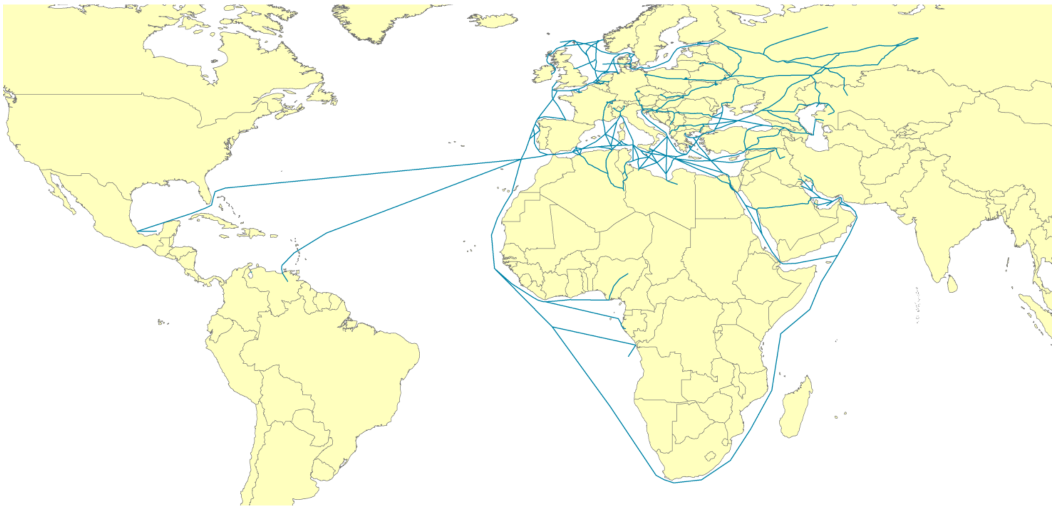


Fig. 2 - Main oil corridors in the world to/ from Europe
Source: R. Gerboni, D. Grosso, L. Schranz - REACCESS EU Project outcomes elaboration, 2014

From a geopolitical point of view, oil (and gas) corridors in the area are highly controversial. Russia considers them as political projects challenging Russian security, and Russian political and economic interests. Since Putin's presidency, Russia has emphasized a greater strategic interest in maintaining its influence in the "near abroad" (Badalyan, Kusznir, 2011). Clearly, redirecting Caspian energy exports away from the Russian transit system challenged not only Russia's dominant role as a key channel for Caspian energy supplies to Europe but also its traditional strategic interests in the Caucasus.

1.4 The role of natural gas in the world and in Europe

1.4.1 Natural gas in the world

Natural gas consumption quickly rose during the last decades: currently, global consumption surpasses 3.000 billion m3 per year, that is, 24% of global energy sources (EIA, 2013). Demand for natural gas is expected to increase in the future, and current reserves – about 180.000 billion m3 – will assure global supplies for about 60 years (BP, 2013).

Natural gas is today a crucial element of the energy mix. Natural gas is employed all over the world for the production of electricity, heating, as a raw material in many industries, and as fuel in the transport sector. The high energy efficiency of natural gas, together with the discussed fears for oil depletion, promotes the use of natural gas in many countries (Victor et al., 2006; Selley, 2013)[10]. The distribution of natural gas extraction sites is even more geographically concentrated than in the case of oil: a limited number of countries control most of the reserves.

[10] The diffusion of natural gas as an energy source took place many years after oil. The geopolitics of natural gas is therefore a rather recent phenomenon, which has become relevant just in the latest two decades (Economides and Wood, 2009).

Country	Trillion cubic metres	Share of total %	R/P ratio
Iran	33,6	18	>100
Russian Federation	32,9	17,6	56
Qatar	25,1	13,4	>100
Turkmenistan	17,5	9,3	>100
USA	8,5	4,5	12,5
Saudi Arabia	8,2	4,4	80,1
United Arab Emirates	6,1	3,3	>100
Venezuela	5,6	3	>100
Nigeria	5,2	2,8	>100
Algeria	4,5	2,4	55,3
Australia	3,8	2	76,6
World	187,3	100	55,7

* R/P: estimate life expectancy of reserves in years

Tab. 3 - Major countries for natural gas reserves, 2012

Source: BP, 2013

The countries, Iran, Russia and Qatar, control about half of world reserves, while other eight countries (Turkmenistan, USA, Saudi Arabia, United Arab Emirates, Venezuela, Nigeria, Algeria and Australia), as a whole, control a further 21%. With the exceptions of Venezuela, USA and Australia (controlling together 9,5% of world reserves) all these countries are located in Africa, in the Persian Gulf area and in the former Soviet Union (BP, 2013).

Natural gas presents tight linkages with territorial proximity, even more than oil. Natural gas is too voluminous to be moved by other means than pipelines. As it will be discussed later, the main challenge with natural gas corridors is to maintain relatively constant flows of supplies (Victor et al., 2006; Aalto, 2008). In the case of countries non connected through pipelines – for example because separated by oceans – the only possibility is to import natural gas in liquid form (LNG, liquefied natural gas), involving complex and expensive processes of gasification and cooling (Klare, 2008a).

1.4.2 European natural gas suppliers

Consumption of natural gas in the European Union accounted for 24% in the total energy mix in 2012, a figure fully in line with global trends. Specifically, European Union consumed 520 billion m3, with an increase of 7,2% with respect to 2011 (EC, 2013)[11]. Also in the case of natural gas, Europe strongly depends from external supplies: with the exceptions of Netherlands and Denmark, all the other countries are net importers (EC, 2013).

Europe imports every year more than 330 billion m3 of natural gas via pipelines and 50 billion m3 in liquid form. About 75% of imported natural gas comes from three countries: Russia, Norway and Algeria. More than 80% of natural gas exported from

[11] According to the Department of Energy United States (DOE), consumption of natural gas in Europe will rise of more than 43% between 2005 and 2030, i.e. from 18.8 to 26.9 trillion cubic feet, while in Asian emerging countries it will rise by 222%, i.e. from 8.5 to 27.4 trillion cubic feet. A relevant increase (about 46%) is also expected for former Soviet Union countries. Totally, global consumption of natural gas is expected to rise of 64% in the next 25 years (DOE, 2010).

Russia and Algeria is directed to Europe, as the majority of natural gas coming from Norway.

Country	%
Russia	31,8
Norway	28,2
Algeria	14,4
Qatar	8,6
Nigeria	3,6
Libya	2,8
Trinidad and Tobago	1,5
Egypt	1,3
Turkey	0,2
Others	7,7

Tab. 4 - Major European natural gas suppliers, 2010

Natural gas arrives in Europe through three different paths:

- From North Africa (Algeria and Libya) through four pipelines: Transmed (connecting Algeria and Italy through Tunisia), Greenstream (connecting Libya and Italy); Maghreb (connecting Algeria with Spain via Morocco) and Medgas (connecting Algeria with Spanish coasts);

- From Northern Europe through pipelines from the Northern sea (Langeled Gas Pipeline) connecting Norway, United Kingdom and Netherlands. Central Europe is also bypassed by pipelines Tenp and Transitgas, carrying natural gas from Netherlands and from the Northern sea in Switzerland and Italy;

- From Russia through a number of routes. Nord Stream pipeline, with a total length of 1.224 kms and a carrying capacity of about 27,5 billions of m3 per year (to be amplified in the future) connects Russia and Germany through the Baltic sea, bypassing Ukraine. Yamal runs from Russia to Germany through Byelorussia and Poland, with a total length of 4.200 kms. Tas runs from Russia to Austria, Slovenia and Italy. Finally, Blue Stream carries natural gas to Turkey via Black sea. Two more pipelines transport natural gas in Turkey from Central Asia: the corridor between Iran and Turkey, and the Baku-Tblisi-Erzurum pipeline.

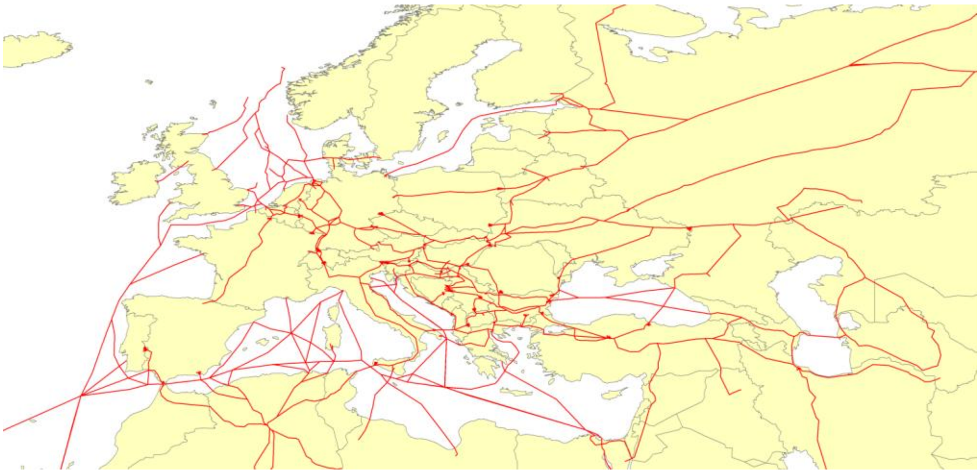


Fig. 3 - Main gas corridors in Europe

Source: R. Gerboni, D. Grosso, L. Schranz - REACCESS EU Project outcomes elaboration, 2014

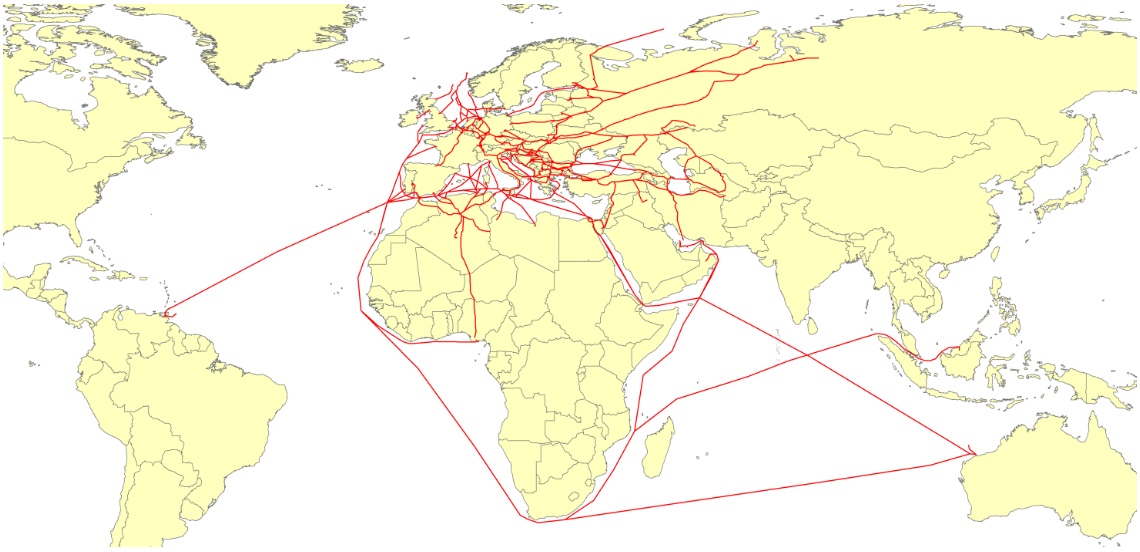


Fig. 4 - Main gas corridors in the world to/ from Europe
Source: R. Gerboni, D. Grosso, L. Schranz - REACCESS EU Project outcomes elaboration, 2014

Recently, European Union is promoting the differentiation of natural gas suppliers in order to reduce energy dependency from Russia. International relations with Russia are, in fact, rather complex, differently from other external suppliers which are considered 'reliable partners' and which agreed with European Union well-defined economic and contractual frameworks (Youngs, 2009)[12]. In the case of Russia, with Vladimir Putin's leadership (since 1999), the countries hegemony in the control of natural gas has increased. Gazprom, in fact, is acquiring control of more and more transport infrastructures (Volkov, 2004; Hurst, 2010)[13].

In Europe, Russia is often considered as an 'unreliable' natural gas supplier, particularly because of Russian 'economic menaces' concerning gas exports. On the one hand, European countries are trying to promote alternative ways to acquire natural gas, particularly by developing routes directed to countries other than Russia. On the other hand, Russia has tried to exclude Ukraine and Byelorussia from the construction of two new sections of North Stream (ended in 2011) and South Stream[14].

[12] With this aim, European Union has approved a rule (n. 994/2010, European Parliament and Council, 20 October 2010) containing measures in order to guarantee security in the supply of natural gas. A general framework states that security in supplies is a common responsibility of enterprises, European countries and the European Commission. The rule introduces mechanisms for transparency and for dealing for possible emergencies of regional, National and continental level.

[13] Currently Gazprom possesses shares of 9 foreign companies providing gas transport. The most important one is the Austrian company managing the Vienna hub, providing Russian gas to Italy, Germany, Switzerland and Hungary.

[14] In the past, contrasts between the two countries (with reference to prices for natural gas) pushed Russia to reduce, and in some cases to stop, the provision of natural gas, with relevant consequences also for European countries. Specifically, as discussed previously (cfr. d 1.3) this happened in the winter of 2005-06 in order to stop the effects of Ukrainian 'Orange revolution'. Many analogous events emphasise the Russian hegemony in the area (see Stern, 2005; Champion, 2006; Correlje and Van der Linde, 2006; Aalto, 2008; Umbach, 2010).

North Stream and South Stream may be interpreted as explicit projects aimed at enhancing Russian monopolistic position in the provision on natural gas for Europe (Champion, 2006). With the construction of North Stream, Gazprom will distribute natural gas directly in Germany, Netherlands and in other European countries without interferences from Ukraine. Similarly, South Stream (which runs from Russia to Burgas, in Bulgaria, and then to Austria, Italy, Greece, Hungary and Serbia) has decreased the economic feasibility of Nabucco, a pipeline financed by European Union and USA which is expected to run side by side with South Stream, providing natural gas from Azerbaigian, Iran and Turkmenistan, and not from Russia[15].

1.5 Coal in the world and in Europe

In the early 1900s coal supplied about 95% of primary energy. Even if the use of oil and gas reduced drastically the share of coal, it remains (with 27% of the total) the second major source (after oil) of primary energy.

According to IEA, coal production has more than doubled since 1980 and coal could replace oil to become the most important source of energy within next years (IEA, 2013). Thanks to the enormous reserves of coal and thanks to the increasing demand for energy, the use of coal could increase in the future, ensuring security of supply with reduced geopolitical risks. Coal and lignite are, in fact, widely available: proven reserves are sufficient for the next 109 years at current rates of production (source: BP, 2013). Coal is also widely distributed around the world with particularly large reserves in the USA (27,6%), Russia (18,2%) and China (13,3%). Big reserves are also held by India, Australia, South Africa, Kazakhstan, and Ukraine (Figure 5)[16].

[15] Nabucco pipeline started the so-call ‘pipelines war’. Nabucco should have started from Erzurum, in Turkey (nearby Armenia), running through Ankara, Istanbul, Sofia, bypassing Romania, Ungary and then arriving in the Vienna hub. The realization of this project has never started by now, and now the problem of Gazprom’s ownership of the Vienna hub makes things still more difficult (Kardas, 2011).

[16] The fact that coal is thought to be so plentiful has led many energy experts to view it not only as a primary fuel for use in generating heat and electricity, but also as a feedstock for chemical conversion into synthetic liquids and gas, generally termed “coal-toliquids” and “syngas,” respectively. This kind of use of coal could cause a huge increase in coal production for these alternative energy applications (Klare, 2008a).

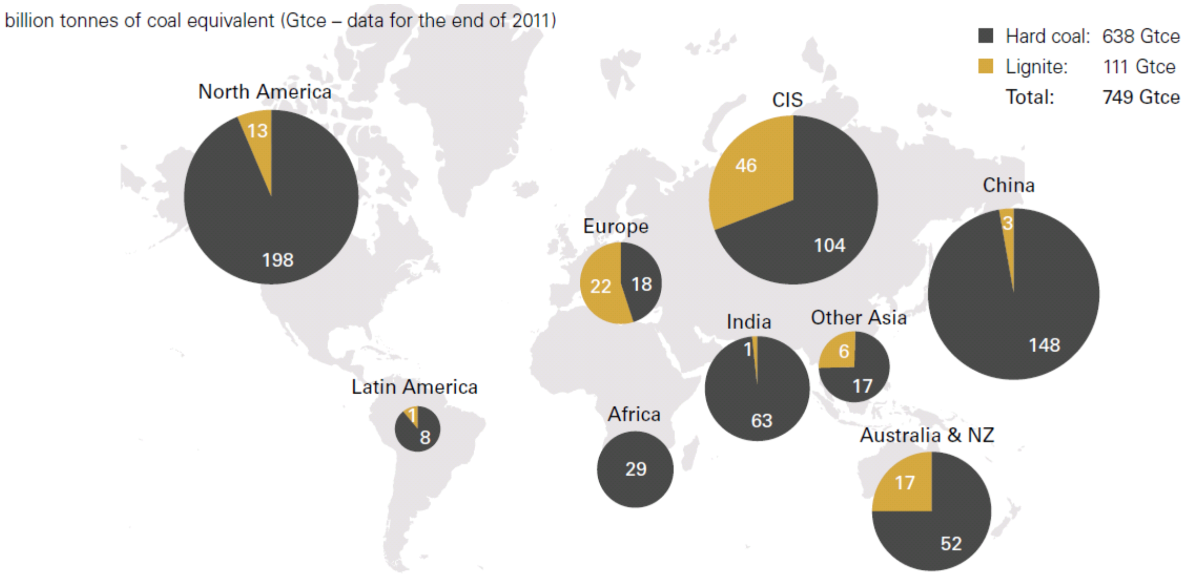


Fig. 5 - Global hard coal and lignite reserves
Source: BGR Energy Systems Limited, 2013

World coal production reached 7.8 billion tonnes in 2012: 6.9 billion tonnes of hard coal and 0.9 billion tonnes of lignite. In turn, the production of hard coal comprised 5.9 billion tonnes of steam coal and 1.0 billon tonnes of coking coal. China, with 3.650 million tonnes, is the biggest producer of coal in the world (47,5% share of total), followed by USA (922 million tonnes, 13,4%), India (605 million tonnes, 7,4%) (fig. 6).

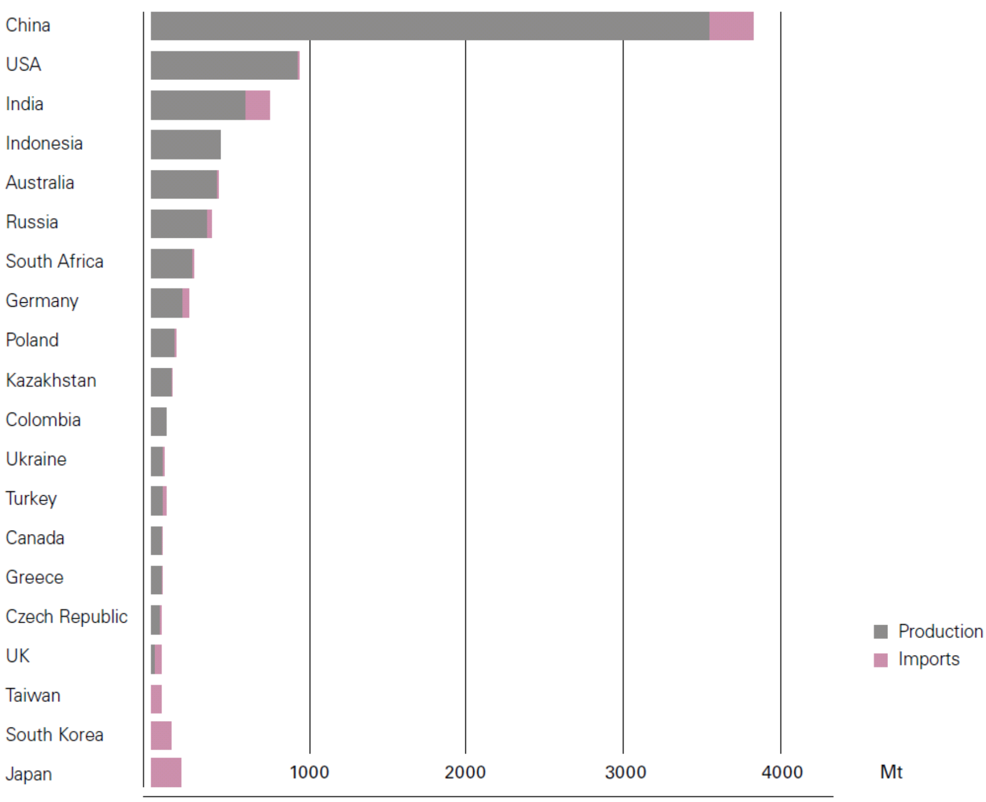


Fig. 6 - Major coal producing and importing countries, 2012
Source: BGR Energy Systems Limited, 2013

In the coming years, coal demand is expected to remain relatively stable in Russia and Japan and to grow in the United States, India, and China; China, in particular, is expected to consume ever increasing quantities as it struggles to keep up with rising demand for electrical power. As many as a thousand new coal-fired power plants are expected to come on line in China over the next twenty-five years. India, too, is expected to build many more coal-fired plants in order to satisfy its growing need for electricity. For most of these countries, a pronounced reliance on coal can be explained by its presumed abundance and relatively low cost.

Important exporting countries for hard coal are Indonesia, Australia, Russia, the United States, Colombia and South Africa, who together accounted for around 87% of all coal exports in 2012. The top coal importing countries are China, Japan, India, South Korea, Taiwan, Germany, the UK, Russia, Turkey, Italy and Spain, together accounting for 80% of coal trade.

Trends in coal use differ by region. In OECD countries, coal consumption declined slightly since 2000; in the EU it decreased of about 14%. In contrast, coal demand in developing countries has increased dramatically. Growth in non–OECD countries from 2000 to 2012 amounted to 2.3 Gtce, (+126%). The main driver was China, where coal consumption increased from 1.0 Gtce in 2000 to 2.8 Gtce in 2012. Thus, China has accounted for 83% of the growth in world coal consumption; India accounted for 12%.

The EU produces about 250 million tonnes; nevertheless, at 433 million tonnes, the EU remains the world's largest lignite producer by a wide margin.

On an energy basis, the European Union is the world's fourth largest consumer of coal after China, the United States and India.

In the EU, hard coal production has declined from Europe's mature production centres whilst volumes of imported coal have grown significantly.

Major coal consuming countries in the region are Germany, Poland, the UK, the Czech Republic, Italy, France, Greece, Spain, the Netherlands, Bulgaria and Romania. In 2012, Germany was the largest coal importer in the EU, followed by the UK, Italy, Spain, France, the Netherlands and Poland.

In 2012, 17% of all coal exports were destined for EU member states. Leading exporters to the EU are Russia (26,1%), Colombia (23,9%), the United States (18,1%), Australia (8,9%), South Africa (8%) and Indonesia (5,2%) (Figure 7).

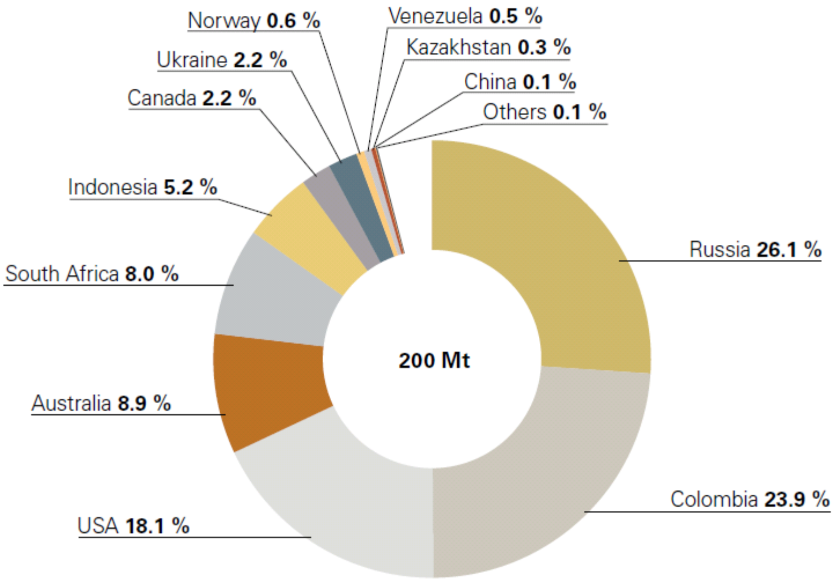


Fig. 7 - Coal imports into the EU by source country, 2011
Source: DG Energy, 2013

Imported hard coal makes a significant contribution to the EU's security of energy supply and offers a competitive fuel which can be easily and safely transported and stocked. Coal offers a much higher level of supply security: the reserves and resources of coal and lignite that are most significant, together they account for 94% of the EU's remaining potential.

Hard coal, both produced and imported, is much less expensive than imported oil or gas and the majority of EU member states enjoy the benefits of coal.

Nowadays environmental impacts associated with coal are fairly understood. Inevitably, coal mining interferes with the environment; however, today, ecological impacts are increasingly well addressed during mine planning, operation and landscape restoration. The maritime transport of coal is safer than before and it can be easily stocked in large quantities. Emissions from coal use, such as sulphur dioxide, NOX and dust, can be almost eliminated by commercially available pollution control equipment.

In the EU, most coal fired power plants are now equipped with highly efficient flue gas desulphurisation. For some years, the environmental debate has focused on global climate protection. The strategy to reduce CO2 emissions from coal use begins with more efficient state of the art power plants, assumes the further development of power plant technology to reach higher efficiencies, and leads ultimately to power plants fitted with CO2 capture and storage. Installations with CO2 capture should be commercially available by 2020, reducing CO2 emissions from coal - fired plants by around 90 %. Central to the wide use of this technology is an investment friendly legal framework and public support for a CO2 transport and storage infrastructure.

Box 2. Geopolitical threats in the post Cold-war era

Talking about political risks, we have to assume in the first place, that *war* is a word that – paradoxically enough – has proven to be less and less able to cover all the ways armed force is used. This is clearly evidenced by the researchers' penchant for coupling *war* with ever new attributes – privatized, informal, degenerate, post-modern, low-intensity, or, more simply new (Kaldor, 1999). In the second place, *state* is a term that, inevitably, has become less and less able to describe the actors in every kind of conflict, whether civil or international. In fact, private actors as mafias, terrorist networks, and military corporations are competing with the state in the use of violence. These are groups that have become significantly more organized and more and more international. Their appearance on the world stage has distorted or invalidated the framework of hypotheses that we had begun to give a certain credit to. The first of these hypotheses is the allegedly universal character of the state as a legal entity. It seemed as if this form of political organization had no rivals. There seemed to be no piece of the earth which does not belong to a state. This fact evoked the image of a world that had already been stabilized or that had in any case completed a necessary and decisive phase in its stabilization. There were other factors that seemed to reinforce our sense of stability. There was the slow but steady increase in the number of democratic regimes that came into being after the fall of the Berlin wall in 1989. There was the much-heralded end of conflicts between opposing ideologies. There was the globalization of the economy. In addition, the idea had sunken in that these same states had been tending to opt more and more tenaciously for the peaceful instruments of the law, something exemplified by tighter and tighter networks of international organizations. All these factors seemed to confirm that very shortly violence would be restricted to the remaining areas of the planet, where war would give way to the mildest actions of international policing.

Certainly the repeated incursions of violence into our daily lives, even in the privileged west, has been sorely testing the faith of even the most optimistic. There are many authors who interpret this turn of events as the return to the state of nature, to the pre-political condition of war of everybody against everybody. They think of this as something that is not happening only in the international arena, where, in any case, anarchy was the rule rather than the exception. According to them, the very premises of civil co-existence have come to be questioned, particularly those of the *pactum subiectionis* on which the ruler's claim to hold the legitimate monopoly on the use of force is based (Kaplan, 2000). It is no accident that the political-science lexicon has been enriched by words like *failed states* and *rogue states*, and that even relevant authors theorized the decline of the authority of states (Strange, 1996).

This is to say that the violence of today is a violence that is more and more "civil". It is not civil in the traditional meaning of an intestine, civil war, but in the literal meaning of a violence that is produced directly by actors in civil society – that is, in the private sphere or in the sphere of economic relationships. This is a type of violence that is less and less political because it is no longer managed by the protagonists of the public sphere or of the sphere of political relationships.

The fall of the Berlin wall, the sudden opening of immense new markets, and the rhetoric of globalization had all come together to lay bare the will of politics to step aside to make room for the economy, which is held to be able to regulate itself according the free market. Mafias, terrorist networks, and multinational corporations are the main new types of brands of a renewed private industry of violence. Mafias incessantly reproduce the original violent accumulation of resources on local levels. They then invest their profits on the global market. Here they play a role that is fundamental for capitalist economies – that of long-distant merchants who can make merchandise (mostly illegal) and money circulate (Armao, 2003). Terrorists help feed the security market by selling marginalized groups the illusion of future access to the political arena. In exchange, they obtain an immediate sacrifice from them. Military corporations produce their own revenue by selling the services of their own soldiers for their customers. This happens, for example, every time the defense of the interests of a multinational corporation leads to practices of real exploitation of natural resources. Obviously, there are differences among these actors that mainly result in their not competing with one another in the long run. Mafiosi and mercenaries tend to use violence more instrumentally than terrorists, who often opt to target their use of violence to more typically subversive ends, sometimes domestically, sometimes internationally. Nevertheless, there are many analogies among these three organizations, particularly their compartmentalized structure – by clan, cell, or combat unit. Thus there are frequent incidents of overlapping. For example, there are mafia clans that practice subversive terrorist acts or terrorist groups that finance themselves through trafficking in narcotics.

The private industry of violence can count on a series of competitive advantages over the public management of force entrusted to states. These advantages tend to reinforce each other, fueling a mechanism that is surely efficient from their point of view. The first competitive advantage is the almost unlimited availability of their financial resources. These are practically tax-free because they evade almost every power of control by national and international authorities. This makes it easier for them to buy arms and recruit men able to use them. The second advantage is the partially or totally covert nature of their organization. Therefore they can operate outside the law, hiding the identities of their own members. Their secrecy put them in a position of unquestionable strategic superiority in reference to the use of force against whoever is trying to oppose their activities openly and legally. Mafiosi, terrorists, and mercenaries who want to hit some enemies – whether they are helpless citizens or representatives of institutions – can take advantage of their own invisibility in order to exploit the element of surprise to the fullest. In contrast, the potential victims may never know when and where they will be hit. They may also deploy impressive and costly security apparatus without ever ending up fully guaranteeing their safety.

The third and greatest advantage is that each of these actors is positioned so as to be able to control the market of violence on the demand side as well as on the supply side. Though working in different sectors, all of them sell “protection” as a good, a product. Mafiosi present themselves to extortion victims as the guardians of the safety of their persons and possessions, upon payment. Terrorists claim to defend the masses, yet obtain in exchange tributes in the form of money or eventually in the form of something natural – the human lives of their suicide attackers. Mercenaries offer themselves as professionals in the service of any cause as long as they are adequately compensated. At the same time, all of them help generate and feed the insecurity that is at the origin of the demand for protection. Mafia clans are also the authors of extortion. Terrorist groups jeopardize civil coexistence by bringing out the contradictions in societies and then exposing their own communities to the risks of reprisals. Mercenary units can endlessly reproduce the conflicts they were called in to settle by skillfully switching sides. None of these actors makes an irrational use of violence. On the contrary, all have proven over time that they know how to forward the interests of their own groups, adapting a kind of logic that is wholly “economic”.

1.6 European energy geopolitics: key regions

This paragraph analyzes strategic areas for EU energy supply. These strategic areas, indeed, possess meaningful reserves – oil and/or natural gas – which are crucial in world geopolitics. As already seen in POLINARES project, a problem or a resource facing one party has the potential to affect other parties, however distant. Specific proposals will be made as to how the EU can participate in the formulation and implementation of a more equilibrate geopolitic framework. The strategic areas are the Persian Gulf, the Caspian Sea area, and North-western Africa. Of course, other areas may play a major role in world energy geopolitics, but in the logics of this report, the discourse focuses on those areas which play a main role according to an European perspective. For this reason, areas like the North Pole, Canada and Venezuela will just be briefly mentioned in the following pages.

1.6.1 The Persian Gulf

The Persian Gulf area includes the coasts of Oman, United Arab Emirates, Saudi Arabia, Qatar, Bahrain, Kuwait, Iraq, Iran. According to British Petroleum, in 2012 the Persian Gulf possessed about 800 billion barrels of oil in proven reserves. Put it differently, this relatively small geographical area possess almost half of the world oil reserves (BP, 2013). As discussed in section 4, oil reserves are concentrated mainly in Saudi Arabia, Iran, Iraq, Kuwait and the United Arab Emirates; Iran and Qatar also possess huge reserves of natural gas. As known, some areas of the Persian Gulf are characterized by great instability because of wars, ethnic-religious conflicts, several disputes, such as those concerning Iran's nuclear program (Merrill, 2007; Barnes and Jaffe, 2006). With the exception of Iran and Iraq, the Countries of the area are grouped in the Cooperation Council for the Arab States of the Gulf (CCASG).

Europe imports a respectable share of oil from the Gulf (approximately 15% of the oil that Europe needs; EC, 2013), but the main external country with a major political influence in the area is USA. The USA military and economic presence in the region is so consolidated that the Gulf has been ironically described as an "American lake" (fig. 8) and it is not a coincidence that the USA tend to interpret any operation carried out in the area as a potential national or world threat (Klare, 2008a). Energy reserves in the Persian Gulf are so large that several other countries – Russia, China, India and Japan in particular – are trying to expand their influence (Barnes and Jaffe, 2006) [17].

[17] President Putin, for example, is interested in the Gulf with the aim of increasing Russian energy hegemony and to exercise even greater geopolitical influence in the world. Moscow encouraged national energy companies to strengthen connections with national companies in the Gulf, and authorized a substantial increase in the export of Russian weapons to the region (Stern, 2005).

Fig. 8 - Major USA Bases in the Persian Gulf Area
Source: Klare, 2008a.

Signs of resistance and opposition to American influence over the area are visible; it is worth mentioning the position of Abdullah, the Saudi King, in March 2007, who considered illegal the USA military occupation of Iraq. The Saudi King affirmed that Arab countries would have to cooperate, all together, to solve the region's problems and to avoid that Americans will determine their fate.

There is no doubt that growing economic relations with China, Japan, Russia and other countries are in line with the words of the Saudi King and with the attempt to erode the role of the Americans in the Gulf; this process of diversification will intensify, probably, in the future (Goldthau and Witte, 2010).

1.6.2 The Caspian sea

In the last two decades, the Caspian Sea basin has increased its importance as supplier of oil and natural gas for the world markets: this area, with large untapped oil fields, has been defined as the new "Great Game" (Gokay, 2006) because of the international competition for the control of its strategic resources.

At the time of the Soviet Union only two independent states, the Soviet Union and Iran, faced the Caspian Sea basin. Today there are three new ones: Azerbaijan, Kazakhstan and Turkmenistan. Kazakhstan and Azerbaijan possess large reserves of oil, Turkmenistan is characterized by large natural gas reserves.

	Oil	**Natural gas**
Country	**Thousand million barrels**	**Trillion cubic metres**
Azerbaijan	7	0,9
Kazakhstan	30	1,3
Turkmenistan	0,6	17,5
Russian Federation	87,2	32,9
Iran	157	33,6

Tab. 5 - Caspian sea basin, oil and gas reserves, 2012

According the United States Department of Energy (DOE, 2010), this area will have an increase in oil production of about 171% between 2005 and 2030 (from 2.1 to 5,7 million barrels per day). In addition, Turkmenistan is the fourth largest gas exporter in the world (after Iran, Russia and Qatar) and it has about 17,5 trillion cubic meters of gas reserves (BP, 2013)[18].

Before the collapse of the Soviet Union, Central Asian and Caucasian states were strictly controlled by Russia: oil and gas were always consumed within the borders of the USSR, and foreign companies were not allowed to operate in this area. Most of the decisions concerning oil platforms, refineries and pipelines were taken by Soviet planners (Gokay, 2001). This scenario changed in the aftermaths of the formation of the independent states of the Caspian Basin, in 1991: these countries, generally lacking technical and financial capacities to fully exploit their oil and gas reserves, started to cooperate with Western companies in order to break free from Russian control. They allowed foreign companies to extract national oil and gas obtaining, in a few years, foreign direct investments for billions of dollars (Sukhanov, 2005)[19] (see tab. 6).

[18] It is estimated that the greatest untapped reserve of oil and gas in the world could be in the area including Kazakhstan, Azerbaijan and Turkmenistan. The sizes of reserves are characterized by high uncertainty, but global interest in this area is growing (Gokay, 2001).

[19] The first oil company to exploit this opportunity has been Chevron, which in 1993 signed a multibillion agreement with the government of Kazakhstan in order to extract oil in Tengiz (the second largest oil field in the country). Since then, many other companies from Italy, France, UK, Norway, China and Japan acquired the rights to the exploitation of local reserves.

Country	Project	Company	Home country of the company
Azerbaijan	Azeri, Chirag, and Deepwater Guneshli (Azerbaijan International Operating Company, AIOC)	BP	UK
		Chevron	USA
		Impex	Japan
		SOCAR	Azerbaijan
		Statoil	Norway
		Exxon Mobil	USA
		TPAO	Turkey
		Devon Energy	USA
		Itochu	Japan
		Amerada Hess	USA
Azerbaijan	Shah Deniz	BP	UK
		Statoil	Norway
		SOCAR	Azerbaijan
		LukAgip	Russia/Italy
		Total	France
		OIEC	Iran
Kazakhstan	Karachaganak (Karachaganak Integrated Organization, KIO)	Eni	Italy
		BG Group	UK
		Chevron	USA
		Lukoil	Russia
Kazakhstan	Kashagan (Agip Kashagan North caspian Operating Company, Agip, KCO)	Eni	Italy
		Total	France
		Exxon Mobil	USA
		Royal Dutch Shell	UK/Holland
		ConocoPhillips	USA
		KazMunaiGaz	Kazakhstan
		Inpex	Japan
Kazakhstan	Tengiz	Chevron	USA
		Exxon Mobil	USA
		KazMunaiGaz	Kazakhstan
		LukArco	Russia/UK

Tab. 6 - International participation in major oil and natural gas projects in Azerbaijan and Kazakhstan
Source: Klare, 2008a.

The hydrocarbons of the Caspian Sea basin are crucial for many geopolitical actors. Russia traditionally controlled the Caspian Sea basin since the beginning of the nineteenth century. Currently, United States, Europe and China consider the Caspian Basin an attractive alternative to the Persian Gulf (Gokay , 2006).

Most of the existing pipelines in the region have been built by the Soviets during the Cold War years. In recent years, USA promoted the construction of alternative export routes bypassing the Russian territory; for example, USA, Azerbaijan and Georgia in 2006 completed the Baku-Tbilisi-Ceyhan oil pipeline, which runs from Baku (Azerbaijan) to Ceyhan (Turkey) avoiding the Bosporus.

The European Commission hopes that the Caspian basin will help to reduce European dependence on Russia. European companies have a substantial presence in some of the largest reserves of the area (for example, Eni and British Gas hold a significant amount of reserves in Karachaganak; Eni, Total, Royal Dutch Shell and Inpex play a key role in the consortium managing Kashagane's fields). European companies are also interested in the construction of pipelines carrying Caspian oil to Europe without passing through the Russia Federation: several European consortia participated in designing corridors, as in the cases of the Nabucco project (cf. section 5), or White Stream project, which should transport natural gas from Turkmenistan to Central Europe, running through Ukraine.

It has to be considered that the pipeline strategy is crucial for Putin, too. In the last decades, Russia has been fast in realizing new corridors in former USSR countries, like in the case of the Caspian pipeline (Caspian Pipeline Consortium) linking, since 2001, Tangiz (Kazakhstan) to Novorossiisk (Russia). Russia, by the means of Gazprom and other national companies, signed agreements with main Caspian energy producers and with transit countries in order to manage energy exports directed to Europe (Gokay, 2006)[20].

1.6.3 Africa

Africa is characterized by abundance of raw materials in a deeply divided continent, with often politically weak countries which are exposed to international exploitation (Watts, 2008). Africa posses some of the largest unexploited oil and gas deposits of the world, as well as extensive reserves of bauxite, cobalt, chromium, copper, platinum, titanium and uranium, mines of gold and diamonds. Because of the world's increasing thirst for energy, Africa is the battleground for a fierce competition between a large number of transnational corporations and countries (Carmody and Owusu, 2007).

Some experts argue that African oil will be one of the cornerstones of the energy issue in the coming decades (Ferguson, 2006). International interest for energy resources in Africa is so high that some scholars speak about a new "scramble for Africa" (Lee, 2006).

With about 10 million barrels per day in 2012, African produces about 10% of global oil production (BP, 2013). According to BP, Africa possesses about 126 billion barrels of oil in proven reserves, nearly 10% of the world's total (BP, 2013). Thanks to the discovery of new deposits and the intensive exploitation of existing ones, Africa is the continent with highest growth in oil production, while Africa is also the continent with the lowest level of oil consumption (3.5% of world consumption in 2012).

Most of oil and gas reserves are concentrated in few countries: Libya, Nigeria, Angola, Algeria and Egypt control together about 115 billion barrels of oil, more than 87% of African proven reserves.

	Oil	Natural gas
Country	Thousand million barrels	Trillion cubic metres

[20] In this competition the stakes are high. Caspian oil is 'non-OPEC oil'. Caspian oil therefore may reduce OPEC's capability to keep fuel prices high (Shaffer, 2001).

Algeria	12,2	4,5
Angola	12,7	0,3
Lybia	48	1,5
Nigeria	37,2	5,2
Chad	1,5	0,2
Congo-Brazzaville	1,6	0,9
Egypt	4,3	2
Equator Guinea	1,7	0,4
Gabon	2	0,2
Sudan	1,5	0,8
Other Africa	3,7	1,3
World	1.668,9	187,3

Tab. 7 - Caspian sea basin, oil and gas reserves, 2012
Source: BP, 2013

Oil production in Africa is concentrated in the Mediterranean coast (particularly in Algeria and Libya) and, in the last decades, also in the Gulf of Guinea. The oil extracted in this region is considered of excellent quality and the majority of the new fields are located off-shore. Oil extracted off-shore is characterized by lower transport costs. It is also easier to guarantee the security of off-shore sites because they are isolated by political events of the mainland (Fergusson, 2006; see box 2).
From a geopolitical point of view, Africa is considered by USA an ideal energy supplier, and African oil represents about 25% of U.S. imports (Carmody and Owusu, 2007).

During the last decade also China's dependence on African oil has increased: in 2012, China imported 46 million tons of oil from African countries; in 2006, Angola became the main supplier of China's foreign oil (see box 2), surpassing Saudi Arabia (Carmody and Owusu, 2007). Chinese national companies, like CNOOC, CNPC and Sinopec, purchased rights for the exploration and exploitation of oil and gas in Angola, Nigeria, Sudan, Gabon, Congo Brazzaville, Equatorial Guinea, Mauritania, Niger, Kenya, Algeria, Libya and Somalia[21].

European countries are key players in the exploitation of African resources because of geographical proximity, because of old connections dating back to colonial times, and because of the desire to diversify energy suppliers, i.e. to weaken the role of Russia as main energy supplier (Dicken, 2007). The French transnational corporation Total produces oil in seven African countries: Algeria, Angola, Cameroon, Congo-Brazzaville, Gabon, Libya and Nigeria. Total is also the main foreign corporation investing in Congo-Brazzaville and Gabon. Differently, British transnational corporation operate specifically in former colonies. British Petroleum, for example, has invested in Algeria (in alliance with Sonatrach), in Libya (in alliance with the local company National Oil

[21] The growing dynamism of China in Africa is not only due to the quest for secure energy sources, but also to the seek for new exporting areas for Chinese products, and to the seek for new profitable investment areas where to destiny Chinese economic trade surplus. It has to be mentioned that during the 70s and the 80s the government of People Republic of China supported (economically, politically and even directly in terms of military resources) many revolutionary African armies. This allowed the development of functional relations with many current African leaders, with evident positive political outcomes. Consider, for example, the current relations between China and Robert Mugabe's government in Zimbabwe and, above all, the institution of the China-Africa Cooperation Forum in 2000. China still economically supports many African governments with favourable interest taxes, without the typical conditionalities concerning human rights and economic liberalization required by International agencies as IMF (Watts, 2008).

Company) and in Angola (particularly in activities of off-shore extraction). Royal Dutch Shell in 2005 has extracted about 1,1 million barrels per day, right before the closure of many extraction sites as a consequence of riots and disorders in the delta of river Niger[22]. Italian transnational corporation ENI (formerly a State-owned enterprise, currently privatized) has invested in Algeria, Angola, Congo-Brazzaville, Egypt, Libya and Nigeria.

Many less-known European transnational corporation are operating in Africa since decades, in strict connection with local elites and local policy-makers. The meaningful profits exploited by foreign corporations, together with the lack of positive spillovers for African economies, have been at the centre of a number of critical analysis (Dicken P. (2007). European corporations are willing to maintain their hegemonic positions in the continent in the future, but during the last decade their role in the extractive industry has been reduced because of the growing role of giant American energy corporations and because of the investments from China and India. Overall, the global competition for the control of African energy resources underlines a number of global problems concerning global energy governance and, in general, the uneven, ongoing processes of economic globalization (Fergusson, 2006; Dicken, 2007).

1.7 Building spatial representations

The aim of this section is to summarize the regional scenarios analyzed in the previous section by assembling a synthetic geographical representations of European energy geopolitics. It has to be emphasised that the word ‘scenarios’ is used here with reference to qualitative assemblages of information, perspectives and raw data, and not to quantitative scenarios. The production of representations and scenarios is a typical task of disciplines as geography and spatial planning. Representations are devices for interpreting reality, for communicating messages, for thinking about alternatives and for building politics. Political choices are not rarely based on symbolic representations of space, such as spatial metaphors or visual metaphors (Barnes and Duncan, 1992).

It has to be mentioned that every spatial representation is embedded in subjective choices, concerning for example the use of conventional symbols, colours and scales (Harley, 1989; Starling, 1998). In this sense, geographical representations have to be evaluated not just in terms of accuracy, but above all in terms of usefulness: are geographical representations useful for the circulation of knowledge and the building of innovative ideas? Are geographical representations useful for the raise of political consensus? How communicative are they? (Taylor et al., 1995; Vanolo, 2010).

The kind of representations proposed in this section are explicitly suggestive and communicative, by taking advantage of the use of chorems (Reimer, 2010). Chorematic diagrams (for example with the shapes of circles, squares, arrows) are dynamic symbols introduced in maps in order to summarize information and to show relevant (supposed or actual) spatial dynamics (see the classic work of Reynaud, 1981;

[22] Shell, the main foreign oil company in the country, has been the target of attacks from many Nigerian groups, accusing Shell of exploiting the county without providing any local improvement. (Watts, 2008).

see also Paklone, 2011). Probably the most known examples are the maps and scenarios proposed by French institution DATAR (see for example Datar, 2000) or, going back in time, the famous 'blue banana' proposed by French geographer Brunet (1989). Today, visual scenarios based on qualitative hypothesis are widely used in planning activities all over Europe (Dühr, 2003 and 2007; see also CRPM, 2002). The aim of these representations is to invent an alphabet, in order to represent and, in case, to try to manage spatial dynamics. Fig. 9 is a first attempt to build a geographical representation of European's view of world geopolitics.

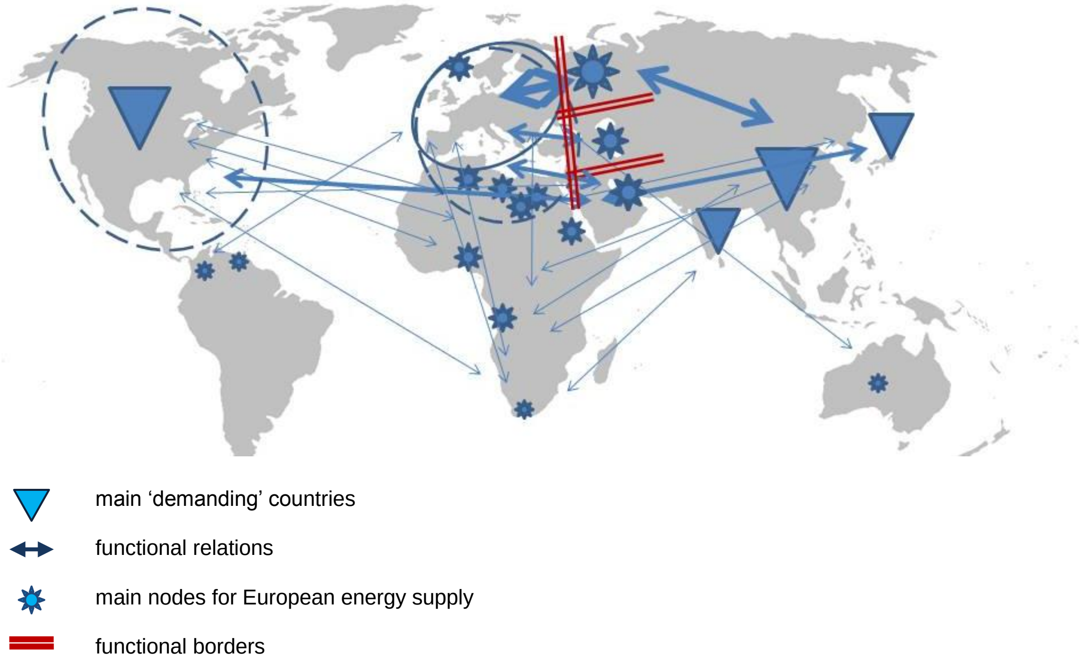


Fig. 9 - A spatial scenario European energy security

In the picture, the stars represent the main nodes for European energy supply, while the triangles are the main 'demanding' countries. As discussed in the previous sections, the main strategic areas are Russia, the Caspian area and the Persian gulf area. While the Caspian and the Persian areas may be conceptualized as spaces characterized by a certain internal coherence (the Caspian countries willing to emancipate from Russian hegemony; the OPEC countries may be considered as a sociological 'collective actor'), as well as the evident case of Russia, this is definitely not the case of Africa. Africa is in fact characterized by a high degree of internal fragmentation; put it differently, a number of countries have developed individual relations with Europe or with single European countries, as well as with USA and/or China. Africa is a contested space, at the centre of strategic fluxes and investments from all over the world. From a quantitative point of view, energy flows are currently not as important as those involving Russia, the Caspian area and the Persian gulf area, but flows are important because geopolitical scenarios are still open, and it is not yet so clear if and how Europe, USA, China or other rising powers (as India) will secure their energy supplies from Africa.

In the African space, only the northern part of the continent is strongly connected to Europe in terms of safe energy flows (larger European chorem, with dotted line). The Mediterranean area has long-time energy relations with Southern Europe, and these relations are basically considered safe. In a similar way, gas and oil provisions from the Northern sea are basically fully safe (and this is the reason because the Northern sea star-symbol has been put inside the European chorem), but rather marginal from a quantitative point of view.

As well known, the Persian gulf area (and similarly, on a smaller scale, also the Caspian area) is a global energy supplier, and for this reason meaningful connections link Persian gulf with major global energy importers, as USA, Europe, China and India.

As fully discussed in the previous section, the key node for European energy security is Russia. Russia is the biggest 'star' in the qualitative representation of fig. 9, because Russia is de facto the main European energy supplier. At the same time, 'border effects', that means (in this case) conflictual connections, characterize the relations with Russia, as well as between Russia and the countries of the Caspian area (double-red lines, in the figure). Russia is, in fact, in a kind of monopolistic position with respect to Europe, and at the same time Russia has sorts of 'imperialistic' attitudes towards its southern neighbourhoods. A key element for the energy security in Europe is to diversify as much as possible energy supply, while of course building stable and friendly relations with Russia.

Fig. 10 is a representational exercise dealing with a 'maximum diversification' scenario. It refers to the quite optimistic idea that Europe, in the future, will diversify as much as possible the geography of energy suppliers.

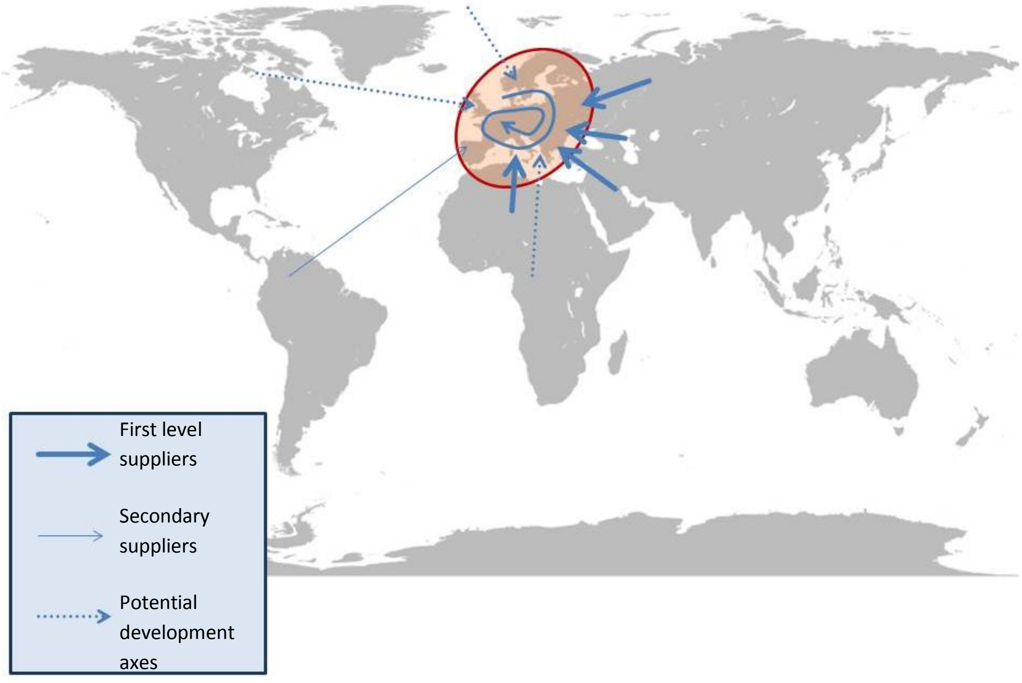


Fig. 10 - Maximum diversification scenario

The figure proposes three different types of arrows. The thicker arrows are 'first level suppliers'. These are the geographical relations that will be pivotal for European energy supply. In the hypothetical scenario of Fig. 10, Russia will still be a major supplier, but a number of other areas will share a similar role. Particularly, the Caspian area and the Persian basin area will export oil and gas side by side with Russia (but independently from Russia). Of course, such an option will be possible if the ongoing ‘pipeline war’, discussed in previous sections, will end with a major role of European companies in the control of transport corridors. Finally, Africa will be a major oil exporting area for Europe.

Secondary suppliers are geographical space that will play a minor role in oil provision. Of course, a minor role may be as well important in a diversification logic. The only area represented in Fig. 10 as a secondary supplier is central America: currently, as already seen, Venezuela is a European oil supplier; it is not likely that its role will increase in the future, but it is a player in global energy geopolitics.

Finally, potential development axis refers to connections that are currently not relevant, but that may become crucial in the future. Put it differently, potential development axis may represent European challenges in the future. The connection with Canada is for example represented. Canada is right now a minor oil supplier for Europe, but its role may increase in the future if new technologies will help the exploitation of local giant reserves of bituminous sands[23]. Secondly, the Western Arctic reserves will probably become in the future a key geopolitical area because of the major oil reserves probably located in the area; it is estimated that about one quarter of world unexplored oil reserves are there. Finally, a key potential development axis connects Europe with sub-Saharan territories in Africa; a key area is, of course, the Guinea gulf, that is right now a contested space for the control over oil extraction.

Of course, Europe energy self-reliance, that means increasing internal energy production and energy efficiency are pivotal in this scenario. The more Europe will become self-reliant, the more Europe will be resilient and resistant to energy crises and fluctuations in energy markets, reducing at the same time the need for the diversification of external suppliers. Currently, the self-reliance scenario seems to be impossible, but internal production and energy efficiency have to be considered as virtuous processes: if self-reliance is (actually) impossible, it doesn’t mean that it is not necessary to try to walk that path.

It is interesting to try to compare and overlap these two scenarios with the four alternative images of the ‘future world’ provided by the previously mentioned POLINARES research. Differently from the qualitative images proposed in the previous pages, POLINARES provides four alternative images of the world in 2040 which have been developed on the basis of the possible state of world economic system (dominantly market vs. dominantly strategic or corporatist) and the world political system (dominantly multilateral institutional structures vs. dominantly national institutional structures) (see image 11):

• Quadrant #1 refers to a ‘Bretton Woods 3.0’ scenario, referring to a world where the major powers have converged on a new set of rule-based multilateral norms which

[23] According to the World Energy Council, natural bitumen is reported in 598 deposits in 23 countries, with the largest deposits in Canada, Kazakhstan, and Russia. Discovered original oil in place is 2,511.326 billion barrels and total original oil in place is estimated 3,328.598 billion barrels. Natural bitumen reserves are estimated at 249.67 billion barrels globally, of which 176.8 billion barrels are in Canada, 42.009 billion barrels in Kazakhstan and 28.38 billion barrels in Russia (WCE, 2012).

emphasize the role of markets and where balance of payments equilibrium (trade and financial flows) is central to managing rebalancing in an orderly fashion.

• Quadrant #2 describes a world where China has become the largest economic power, and has slowly replaced the US as the main player, and a more managed world is introduced. The norms and rules which underpin multilateral collaboration reflect those of China and its allies, and thus involve greater state participation in trade and investment.

• In quadrant#3, the world has aligned itself in various competing blocks, where trade, investment, and financial markets are governed by rules of the group rather than by a global system. Governments and national companies are very strong.

• Quadrant #4 refers to a 'fracture' scenario: the world is struggling with the serious erosion of the rule of international law, underinvestment, the weakness of the nation state in some parts of the world and the complete integration of the state and economy in others. Large private conglomerates compete with state companies for scarce resources and markets.

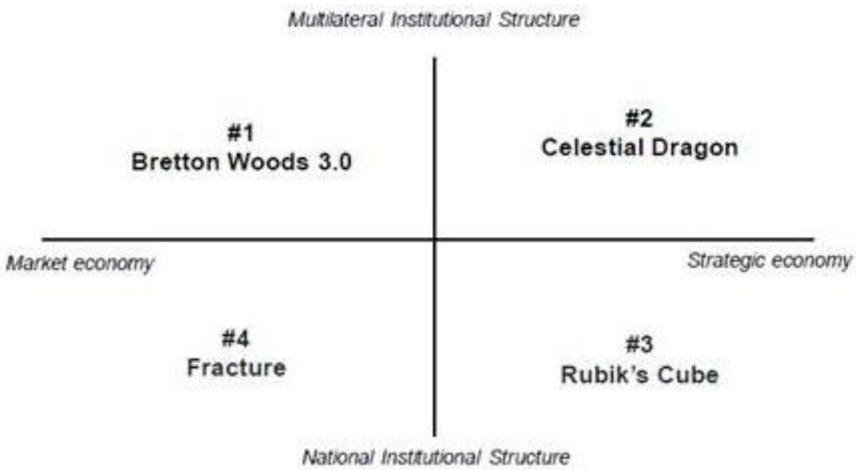


Fig. 11 – The four Future World Images
Source: www.polinares.eu

Of course, these four images are just provocative and stimulating scenarios for the world to be, and these images have not to be interpreted as 'predictions', but rather as potential trends. In the logics of this work, it is interesting to reflect on the potential consequences of these trends in the field of energy security. Image #1 surely represents the "success case" for the neoliberal principles put forward by the EU, the US and other OECD nations, and international markets will be operating with a relatively high degree of effectiveness. In such a framework, the issue of energy security will keep on being crucial, as it is today. But in Image #2, political risk rises and competition for resources with China will be a main theme, and therefore the issue of energy security will be quite more problematic than today.

In the other two images, the hierarchy of states, firms and other organisations or groups is more pronounced. In other words, the distinction between rule setters and rule followers is greater, creating a situation where tension and conflict arise easily. Moreover, these two images fail to provide the generally accepted mechanisms to defuse conflicts peacefully. This will for sure produce consequences in the fierce competition for energy sources, especially in the case of a highly-dependent Europe. Particularly, in Image #3, the world becomes much more regionally organized, and the importance of alliances for access to energy resources is crucial. In Image #4, many risks will be internalized along the value chain within corporations. In such a scenario, corporations will play a key role in the control and provision of energy sources.

1.8 Concluding remarks

The aim of this chapter has been to build a geographical analysis of political relations, paths, risks and possibilities related to European energy security. In other words, this report may be considered as a geopolitical analysis of energy security for Europe. In order to explore this topic, the geographies of oil and natural gas supplies have been analysed, and current bottlenecks, potential dangers and possible lines of development have been discussed.

The main conclusions have been summarized in the geographical representations presented in section 1.7. These graphical representations emphasise two well known pivotal directions that Europe strongly needs to follow.

First and foremost, it is crucial to reduce energy dependency, that means increasing internal energy production and energy efficiency (cf. Deliverable 1.3 about main European Union policies). Technology is the most obvious mean for achieving this goal, and in this sense the role of R&D is confirmed as a cornerstone element[24]. European Union is certainly pushing R&D in many ways – consider for example the recent emphasis on smart city programs – and this report emphasises how a decrease in the need of oil and natural gas may free Europe from a number of complex and evolving geopolitical struggles. It has to be mentioned that the controversial possibility of increasing nuclear energy production in Europe may be considered as an alternative path to foster self-reliance in the energy field as clean coal technologies implementation will be a self-reliance alternative too.

Secondly, reducing Russian hegemonic position for European energy supply is a hot topic. A geographical diversification of energy imports is needed in order to make European energy supply safer, more reliable and probably also more competitive and resilient.

Thirdly, as emphasised in the POLINARES project, it should be useful to adopt, for EU, a constructive approach through a policy framework around elements of the enlightened self-interest of those governments displaying features of State Capitalism, such as China. In the case of some countries which are part of a transition from the Liberal Capitalist to the State Capitalist regime, and only so far display limited State Capitalist tendencies it may even be feasible to arrest those tendencies by pro-actively pursuing mutual interests on a country-to-country basis. This would imply, for example, a higher than hitherto level of joint investment, accelerated adoption of common technical, legal, commercial and market standards, and a concentration on truly open trade based on mutual understanding and advantage, rather than on a culture of

[24] Also consumer's behaviors are very decisive: energy efficiency without incentives on the demand side can result in rebound effects that overcome the positive effects of energy savings.

complaint and counter-complaint. The pursuit of mutual self-interest should result in more secure or more dependable access to oil, gas and minerals[25].

Finally, it has to be mentioned that this report focused on the external geopolitical dimension of energy security, particularly by focusing on the problem of energy provision, and therefore the report has not considered a number of topics that have been analysed in Deliverable 1.3, as the need for developing an internal integrated energy market and the relations between energy production and climate change. These perspectives may be considered anyway as alternative and important takes on the European energy question, and in this sense D 1.3 and Deliverable 1.4 have to be considered as complementary interpretative frameworks for the development of an integrate understanding of the problem of European energy security.

[25] http://www.polinares.eu/docs/policy/polinares_policy_brief_no4.pdf

2. Energy security and geopolitical impacts of renewable energy mega-projects[26]

The following chapter analyses renewable energy (and related) mega-projects and their influence on energy security and fostering new geopolitical relationships. Two studies of renewable energy mega-project visions are presented - **DESERTEC** and the **North Sea Offshore Grid** - and mini-case studies are conducted on pilot projects. These under development projects are of geographic or other relevance to the visions - **Noor CSP** and **Kriegers Flak**. The driving question assessed is *whether large-scale renewables projects foster energy security*. Key findings can be summarised:

- Renewable energy mega-projects and mega-visions can have widely divergent impacts on energy security, depending on the current energy mix, energy governance, and the definition of *energy security*.
- The case studies point to the central question in the debate on energy system design: *how should the system be optimised?* In terms of local supply, a resilient mix, the lowest-cost option, or based on environmental concerns? As there is no 'right' answer to the question, the issue needs to be dealt with at the political level.
- A decarbonised, energy secure future based on mega-projects will shift geopolitical dependences to new hands of economic and political power and to new delivery infrastructure, with major cultural and societal repercussions locally and abroad.

Renewable energy projects have proven social, economic, and political feasibility through demonstration projects in their technological infancy. As public support for renewables has increased up and transmission operators have integrated renewables into energy mixes, the project scale of renewables has also increased. While 5.2 MW was considered a very large installation in the 1980s,[27] today's record installations under development will have capacities over 2.4 GW, such as the Westlands solar park in the Californian San Jaoquin Valley (Hernandez et al., 2014).

Economies of scale and governmental incentives have driven the progression toward "mega-projects". As the global renewables industry has matured, project installation sizes, have also increased. In the United States, new wind farms doubled in average capacity between 2004-2005 and 2007, and quadrupled between 1998-1999 and 2007 (Wiser and Bolinger 2008). The same story has unfolded in Europe, where in 2010, the average capacity of offshore wind farms doubled from 2009, from 72 MW to 155 MW (International Renewable Energy Agency, 2012). While the funding regimes have prevented a similar development in photovoltaics, the increasing role of new capacity in the Sun Belt is expected to shift the market from mostly roof-top to utility-scale installations (EPIA, 2013).

This evolution to larger installations and mega-projects represents an opposite extreme in the deployment of renewable energy supply compared to decentralised and

[26] This chapter has been developed by ECOLOGIC.
[27] The 5.2 MW solar plant in California was the world record holder for over a decade (Wenger et al. 1991).

community-driven projects.[28] That is, mega-projects are planned by large consortia with long lead times and require massive coordination, capital, permitting, and organisation.

This distinction between mega-projects and community-driven projects is important to draw in the context of understanding the political, economical, and behavioural traits of a low-carbon transition. The prevailing paradigm of energy consumption assumes that energy should be instantaneously available to any consumer. The rationale for renewable energy (and energy infrastructure) mega-projects (as discussed further below), often is to meet not only aggregated *energy* needs (annual consumption) but also *capacity* needs (instantaneous balancing). If a paradigm shift among consumers occurs and unrestricted instantaneous access becomes less important, the focus of power planning could change and the arguments behind some mega-projects and the infrastructural redundancies could deflate. Differences in socio-cultural priorities must also be considered when discussing the optimisation of the energy system and renewable energy mega-projects: while some countries seem willing to live with a certain amount of power outages, others aim for 100% grid reliability.

The impacts of renewable energy mega-projects are not limited to the area of energy generation and consumption: Mega-projects have the potential to create new geopolitical alliances and relationships, often unexpected.

Furthermore, the underlying energy policies can create a playing field for new business models and possibly renewable energy mega-projects to unfold: For example, European demand for biomass across Member States has supported a biomass pellet export industry in the United States from unused timber. Nearly 40 million metric tonnes of biomass pellets are expected to be used for co-firing in thermal plants in Europe by 2020. Coal plant emissions standards in Europe (Dorminey, 2012), have driven the new transatlantic pellet market.

The impacts of the biomass example are perhaps more direct and contained than impacts from large renewable energy mega-projects, which may shift energy security or geopolitical alliances in much more dispersed and dramatic ways. The main reasons being that the transatlantic pellet market is oriented around trade between two economic partners of similar size and structure – the EU and the US – and is neither pivotal for the supplier (US) nor the importer (EU).

Box 3. Energy security topics

There is a difference between *energy security* and *electricity security*. Primary energy can be converted directly into energy services (such as when a vehicle combusts fuel to travel on a road) or into energy carriers such as electricity, which can also be converted into services (Sweeney 2000).

Eurostat tracks net imports of *primary energy* (coal, natural gas, petroleum, uranium, etc), for example, through the indicators “nrg100a” and “tsdcc310.” The former of which

[28] This chapter relates strongly to the “Report on integrated analysis of local anticipatory experiences” (Caiati, et al., 2013) (http://www.milesecure2050.eu/documents/public-deliverables/en/milesecure-2050-report-on-integrated-analysis-of-local-anticipatory-experiences-d2-1tu-berlin), which presents benefits and successes of bottom-up energy projects. This chapter demonstrates rationales for and conflicts from top-down renewable energy planning.

presents an import and export balance (in tonnes of oil equivalent) while the latter shows the fraction of imports divided by total inland energy consumption (Eurostat 2012b). **The balance of imports and exports is the common metric for energy security today.**

Primary energy is traded across borders through oil tankers and pipelines, among other mechanisms. Electricity can also be moved internationally through grid interconnections, depending on regulatory frameworks.

The topic of *energy security* is broader than *electricity security*, and so even the most dramatic renewable energy megaprojects that redefine the electricity import and export balance in a country may not necessarily strongly influence its overall energy security. (see the case study below).[29]

Energy security can also be defined along metrics other than quantity of primary energy imported.[30] For example, maximising security of supply may require pursuing new energy resources domestically, perhaps negatively impacting the reliability of the infrastructure to deliver that energy. Grid resiliency (minimal blackouts), therefore, can also be considered a form of *electricity security* often not covered by the usual energy security metrics. In other chapters of this report, other definitions of energy security are proposed. In this chapter, however, *energy security* is referred to in its common definition of import and export balance, although where relevant, other components of energy security are also mentioned.

Visions and case studies

The following subchapters examine mega-project visions that have the potential to reshape existing geopolitical equilibria, with regards to governance, energy security, and energy economics. Each vision review will also include a case study of a major project under development. Both the vision and case study will follow the same assessment steps:

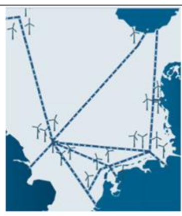
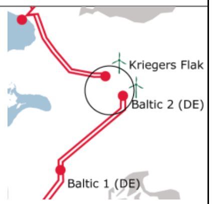
1. Background and Energy Policies,
2. Energy Security Implications, and
3. Geopolitical Effects

The distinction drawn between *vision* and *mega-project* is that visions are longer-term strategies that require many renewable energy projects and may not be realised as envisioned. *Mega-projects* are large-scale projects well under development today, and in these cases, associated with a broader vision.

[29] With increasing electrification of the transport and heating sectors through 2050, which is a component of supranational and other energy transition plans, electricity demand may replace petroleum and/or natural gas consumption from transport and heating sectors (European Commission, 2011; Delucchi and Jacobson, 2010). On a long time horizon, therefore, *electricity security* may become a larger component of traditionally defined *energy security*.

[30] While outside the scope of this report, the discussion on energy security would be enriched by evaluating or changing the metric of success. Is 0% energy imports truly better than 10%? What are the ancillary benefits provided by importing energy? Does the power grid most reliably deliver power to customers in the 0% or 10% import scenario?

The visions and projects were selected based on available information on renewable energy mega-projects in Europe or affecting Europe.

	Visions		Projects	
	DESERTEC	North Seas Offshore Grid	Noor CSP	Kriegers Flak
				
	desertec.org	http://www.benelux.int /NSCOGI/	acwapower.com	energinet.dk
Location	EUMENA area	North Sea	Morocco	Baltic Sea
Project Type	Major **transmission** interconnections and combination of **wind/ solar** development	**Transmission/capacity infrastructure** to enhance delivery of **wind** energy, develop electricity market	**Concentrating Solar Power** (parabolic trough)	Two **offshore wind** farms and new **offshore grid**/capacity exchange
Total Estimated Cost	~ €400 bn	~ €53 bn	~ €1 bn	~ €900 m
Estimated Project Completion Date	~ 2050	~ 2030	2021	2018
Generation Capacity	~ 2,630 GW	~ 55 GW	500 MW	600 MW, 288 MW
Footprint	3,025 km^2 - 15,600km^2	30,000 km (perimeter)	35 km^2	44 km^2, 27 km^2
Project Developers	DESERTEC Foundation	North Seas Countries' Offshore Grid Initiative	Moroccan Solar Agency, ACWA Power Ouarzazate	Energinet,dk, 50Hertz, EnBW
Key governments	Germany, Morocco, Saudi Arabia, France, Italy	Norway, U.K., France, Germany, the Netherlands, Denmark	Morocco, France, Germany	Denmark, Germany (formerly Sweden)

Tab. 8 - Overview and characteristics of renewable energy mega-project visions and case studies

Sources: Zickfeld and Wieland, 2012; The DESERTEC Foundation, 2007; Energinet.dk, 2013; European Commission, 2013b; Danish Energy Agency, 2013; Benelux, 2012; Steinmetz 2011; ACWA Power, 2013; The World Bank, 2011; Rignall 2012; EnBW AG, 2014; Schinke, 2014

2.1 DESERTEC Vision

2.1.1 Background and Energy Policies

The DESERTEC Foundation consists of a consortium of 19 energy-related companies (15 of which are European), promoting a cross-continental renewable energy and energy infrastructure project with a total investment need upwards of €400 bn. Seeking to capitalize on the immense solar and wind resources (on and offshore) in the North Africa region, a realised DESERTEC vision could theoretically provide up to 90% of projected 2050 continental European electricity demand with renewables (19% of total electricity demand would be sourced from Middle East and North Africa, the remainder generated domestically in Europe) (Zickfeld and Wieland 2012).

The concept of a "Mediterranean Transmission Line Ring" dates back to Egyptian minister, Maher Abaza's 1987 proposal, which morphed and evolved over time, eventually laying the foundation for the DESERTEC initiative launched in 2003 (El Nokrashy, 2005). The DESERTEC strategy involves interconnecting the electricity grids of Europe, the Middle East and North Africa (EUMENA) through mostly new High Voltage Direct Current (HVDC) transmission lines, many of which are planned to traverse the Mediterranean Sea (see Fig. 12 below). The interconnections among the continental grids are currently not designed to instantaneously move massive volumes of electricity long distances (German Aerospace Centre, 2006). Coordinating the EUMENA grids into a single, unified market could enable European consumers to benefit in real time from the Saharan resources, and lower electricity costs across the board. This argument is based on the assumption that there will be lower direct costs of renewable energy in the MENA region (i.e., better solar and wind resources) and total system infrastructural synergies (i.e., accessing energy from a disparate location reduces the need for local "peaking" plants, and avoids situations where excess renewable generation is dumped) (Zickfeld and Wieland, 2012). Full DESERTEC project implementation will also involve "locally-available energy sources," including renewables or sometimes local natural gas in Europe, in order to align the delivery of power with changing consumer demand (The DESERTEC Foundation, 2007).[31]

[31] DESERTEC's cost-optimised simulation of a combined EUMENA grid demonstrates that 91% of 2050 EUMENA demand can be met with DESERTEC goals and existing renewable energy targets. 9% of electricity needs would be met by natural gas. For more information: http://www.dii-eumena.com/fileadmin/Daten/Downloads/Desert%20Power%202050/dp2050_study_web.pdf

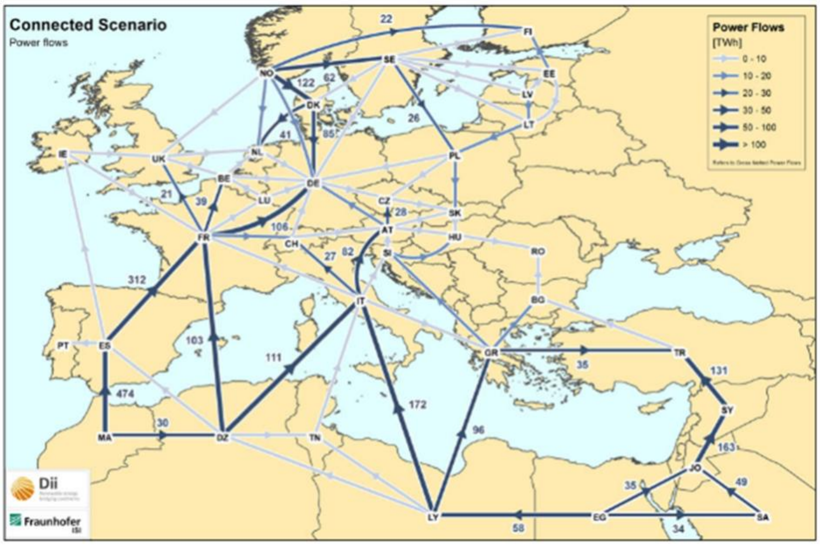


Fig. 12 - Connected DESERTEC 2050 scenario power flows.
Source: Zickfeld and Wieland 2012

In recent years, the initiative has honed in on developing pilot projects to prove the value and feasibility of their proposed desert outlay. As partners with Saudi Arabia, the DESERTEC Foundation is supporting a 54 GW solar-oriented renewable energy plan (Levitan 2013).

For the purposes of this review, the focus of the assessment will be on the MENA region. Due to the hypothetical nature of the DESERTEC proposal, actual impacts may differ from the ones mentioned below.

Energy Policy Backdrop

MENA investment in renewable energy is growing. In 2013, a total of 106 renewable energy projects under development have expanded non-hydroelectric renewable energy capacity in the region by 7.5 GW, or an increase of almost 4.5 fold. The total of all combined MENA country targets would result in 107 GW of capacity by 2030 if fully implemented. Since 2007, when only five MENA countries held renewable energy targets, renewable energy strategies and targets have spread to all 21 MENA countries. Saudi Arabia leads in ambition with a 54 GW target by 2032. 18 of the 21 countries have renewable energy policies in place such as feed in tariffs for renewables (seven MENA countries), net metering (seven countries), and capital subsidies or production credits for renewables (11 countries) (Bryden, Riahi, and Zissler, 2013).[32] The Middle East and North African regions are seeking to increase the share of renewable energy through policy, and hope to benefit in terms of energy diversity and in some cases security of supply.[33] The DESERTEC vision complements (or perhaps has influenced) these political priorities.

[32] Where "net metering" refers to a customer deducting excess renewable energy generated from his/her monthly bill; "capital subsidies" refers to upfront payments or discounts for renewable energy investors, and "production credits" are tax exemptions associated with amount of energy generated over time.
[33] Many, but not all MENA countries hold significant reserves of fossil fuels, especially oil and gas.

Current Geopolitics

Recent geopolitics between Europe and MENA build on the Barcelona Declaration of 1995 (“Barcelona Process”), which aims at promoting peace and stability, economic free trade and cooperation, and socio-cultural “health” and participation in the Mediterranean region. The subsequent agreements between the EU and MENA countries included, for the first time, explicit mentions of the environment in Mediterranean policy. In 2008, the Union for the Mediterranean partnership was absorbed into the Barcelona Process, and announced the prioritisation of projects with a regional dimension (Lesser, 2009). Specific projects under the DESERTEC vision (and the Ouarzazate Concentrated Solar Power plant detailed below) would follow this “Barcelona Process: Union for the Mediterranean.” There are fora in place to facilitate EUMENA geopolitical cooperation and economic investment.

Box 4. Local political and implementation challenges with DESERTEC renewables projects

One complex situation, that is perhaps indicative of the national and international political challenges of European financial interests returning to Africa, may develop in Northwest Africa. Western Sahara, formerly a Spanish colony, is a disputed territory southwest of Morocco that was annexed by Morocco in two separate steps from 1976 to 1979 after Mauritania withdrew from the region (United States Central Intelligence Agency, 2014). As shown in Fig. 13, Western Sahara has some of the best wind energy resources in Northwest Africa. Since the UN hosts a peacekeeping operation in Western Sahara and the political situation is still far from resolved (United States Central Intelligence Agency, 2014), the procurement of financing for renewable energy projects in the region may prove to be difficult.

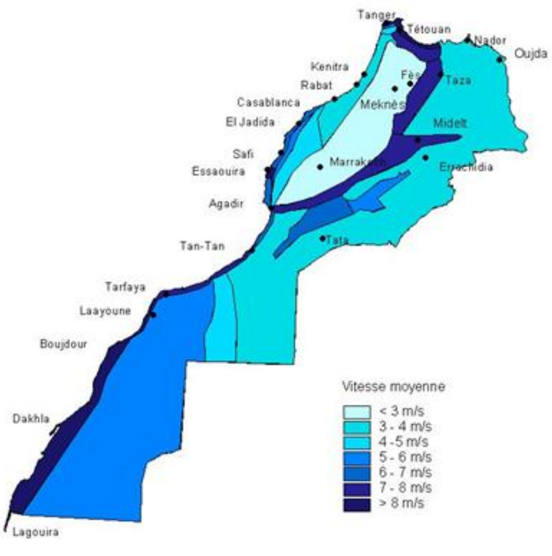


Fig. 13 - Wind resource potential on and offshore in Morocco and Western Sahara
Source: Moroccan Investment Development Agency 2014

The state of Western Sahara affairs demonstrates that even with ambitious European plans, the local political and cultural challenges cannot be underestimated in renewable energy project development. Participatory political and social instruments must be wielded early on in project deployment, in addition to the more traditional technical and economic instruments such as pilot renewable energy projects or new energy development companies. Approaches may include public-private partnerships or involving the public and businesses early on in the regional planning processes or joint-ventures.

As Box mentions, socio-political stability in the MENA region is of great relevance to the proposed DESERTEC strategy. The most significant recent socio-political movement of geopolitical importance is the Arab Spring, which began in late 2010 and affected Arab societies broadly. The energy sector (the largest economic sector in nearly all Arab countries) is still heavily dependent on oil revenues, and Arab nations have not diversified their economies away from oil since the Arab Spring. The OPEC operational approach has changed due to price volatility and supply disruptions in Libya, Egypt, Yemen, and Syria during the Arab Spring. OPEC producers have significantly increased prices to ensure a steady footing position in an increasingly unsteady region. Supply-related disruptions caused by political events, therefore, have a large impact on the economic prosperity and political stability in the region (Bahgat 2012).

But the major impacts of the Arab Spring, as a series of political revolutions that upended many of the long-standing Arab governments, were political in nature. Many commentators note the central economic motivations within the national movements, including widespread dissatisfaction with unemployment and limited opportunities (Malik and Awadallah, 2011). In the aftermath of the Arab Spring, the DESERTEC initiative has raised questions about the sustainable local implementation of large renewables projects, specifically regarding economic equity, codetermination, and lack of stakeholder engagement (German Aerospace Centre, 2014; Kwasniewski, 2013). A major concern among civil society observers so far is the question, '*from where the additional water (necessary for modern CSP plants) will come?'* in this semi-arid region. Workshops such as the World Social Forum have been held to tackle these questions (Schinke and Klawitter 2013), but in a fragile socio-political region after the Arab Spring, the DESERTEC concept will need to prove local socioeconomic benefits to all stakeholders on top of the projected aggregated financial, environmental, and energy security benefits, which would be reaped mostly by Europeans.

The Arab Spring also recalibrated European-MENA relations. The major EU responses, through Joint Communications, financial instruments, and a revision of the European Neighbourhood Policy, sought to encourage institution building in the MENA region, facilitate democratic governance, spur economic growth, and define migration flows to and border security with Europe. New medium- and long-term market access policies have been introduced (Wouters and Duquet, 2013), and thus, the EU has considered new liberalised trade and investment policies with its neighbouring nations in light of the recent economic crisis and Arab Spring revolutions Lesser et al., 2012).

Box 5. "Energy imperialism" of DESERTEC Initiative

Perhaps the most controversial element of the DESERTEC project is related to the historical geopolitical and exploitative relationships between European powers and the people of Africa. Critics of the DESERTEC initiative argue that it stands as a new form of energy imperialism.[34] Others suggest that if providing electricity to Africans is the

[34] Many opinion pieces and reports in academia, observer organizations, and the media have questioned this topic of European energy imperialism or "power grab," such as the New York Times, The Independent, and research at the University of Texas. For more information: http://www.nytimes.com/2009/06/22/business/energy-environment/22iht-green22.html?pagewanted=all&_r=0, http://www.independent.co.uk/news/world/africa/the-big-question-should-africa-be-generating-much-of-europes-power-1776802.html, http://soa.utexas.edu/sustainabledesign/docs/marks.pdf

goal, smaller-scale renewable projects could better deliver the electrical service and financial benefits to communities (International Energy Agency,2011). Some organisations employ approaches such as capacity building and policy design support at the local level to "unlock" clean energy development (United States Agency for International Development, 2013). Indeed, major investment projects in Africa, energy-related or not, will continue to stir tension based on the question of who will benefit most and why.

2.1.2 Energy Security Implications

A key outcome of DESERTEC implementation that has been modelled by proponents is that a net 1,064 TWh per year could be exported from the MENA regions to Europe, which corresponds to approximately 46% of MENA annual electricity consumption and 19% of annual European consumption. Also according to the model, the Maghreb and Libyan regions in northern Africa would become "super producers," exporting significant amounts of electricity (hundreds of TWh) through seven sub-Mediterranean transmission corridors. These "super producing" regions would have an assured security of supply. The majority of the Middle Eastern countries, i.e., Egypt and Syria, expected to boom in population leading up to 2050, would serve in the DESERTEC system as "balancers," producing roughly the amount of electricity that is consumed over the course of the year and importing and exporting energy when necessary (120 TWh exporter and 25 TWh importer, respectively). Finally, one MENA country, Turkey, would become a net-importer, depending on other EUMENA production (158 TWh annual imports) (Zickfeld and Wieland, 2012).

From a European perspective, the role of the integrated MENA-sourced electricity supply in the model is to "fill the gaps" in demand, while the bulk of demand is still met by new, European renewable energy. Energy "self-supply," as measured by the fraction of fuels used for electricity originating within the boundaries of a country, is modelled to increase in Europe and MENA by 2050 with DESERTEC (Zickfeld and Wieland, 2012). In an inherently import-oriented DESERTEC vision, a key explanation for why overall European electricity self-supply in 2050 would increase is that **local renewables would be deployed at the expense of thermal plants**, such as coal- and natural gas-fired plants (coal, natural gas, and petroleum are generally imported today). The underlying projections on electricity demand are critical in the modelling assumptions, since a low-carbon transformation may involve shifting heat and transport services to the electricity sector. And distinguishing again between energy and electricity, it is difficult to predict and assess how fossil fuel consumption and imports outside of the electricity sector, and therefore under the entire umbrella of "*energy security*," will change. It is possible and in fact likely that a significant volume of fossil fuel imports would still come into the EU with a centralised desert power approach, as long as the energy regime in transport and heating does not change fundamentally.

The primary investors on DESERTEC projects are European. If only 19% of consumed European electricity would be sourced from MENA under an idealised DESERTEC realisation (and funded nearly 100% by European interests), this conjures the question: *'to what extent is "filling the gaps" with renewables worth the investment (for Europeans)?'* Or in other words: *is the investment in DESERTEC the preferred approach to optimising the energy system?*

The fundamental tension underlying the DESERTEC debate is the question of which objectives are most weighted in the long-term energy system design: minimising environmental damage, the least-cost option, or optimising for (one of the many definitions of) energy security.

DESERTEC may also alter the international economic balances of MENA states, potentially shifting international trade balances and the structure of national economies. A particularly pointed example of this would be Saudi Arabia, a nation currently dependent on the petroleum extraction and export industry. With DESERTEC cooperation, Saudi Arabia could transition to a major renewable energy producer (Levitan 2013) and reap economic benefits in the energy sector; the same sector that will see the petroleum subsector output decline through 2050. That is, the DESERTEC vision anticipates Europeans reducing their dependence on foreign oil and gas and increasing dependency on imported electricity. The Saudi economy therefore may be poised to remain an energy supply powerhouse, yet with a new focal form of energy.

It is important to note, however, the undesirable economic trajectory that may be offered to some countries in the DESERTEC vision: if an economy changes from net-importer to net-exporter, it is usually not met with internal resistance. However a DESERTEC plan that calls for countries to shift from exporting to importing energy may provoke geopolitical tension within the consortium before the implementation of DESERTEC.

2.1.3 Geopolitical Effects

Box 6. Migrational and geopolitical aspects of energy projects

Historically, the emergence of new energy resources has encouraged opportunity-driven migration and therefore has implications on local culture. As merely one example in the Persian Gulf, British oil interests in Iraq led to a post-World War I presence and influence, where "oil acted as a social and political agent" in the development of the Iraqi government and even urbanisation (Reisz, 2013).

A realisation of DESERTEC would change key geopolitical relationships, by ending a current European dependence on Russian natural gas and the transporting pipeline infrastructure that lies between. The modelled DESERTEC 2050 plan includes consumption of some natural gas, but the resource would overall be consumed at much lower rates than currently and sourced more locally on the proposed EUMENA grid (Zickfeld and Wieland 2012).[35] The European Commission describes Gazprom, the Russian producer and supplier of natural gas as holding a "dominant market position in upstream gas supply markets in Central and Eastern European Member States" (European Commission 2012).[36] Energy and infrastructure development partnerships between Europe and MENA would create a new interdependence (see Geopolitical Effectsbelow for an example).

[35] One weakness in the modeled scenario is that there is no technological or explanation made for how some countries such as Luxembourg, that provides under 10% of self supply today from natural gas would have access to 60% self supply from natural gas in 2050.

[36] It is estimated that Russia provides 30-35% of European oil and gas (Zickfeld and Wieland 2012).

The DESERTEC project raises a key question about dependence. With a movement away from fossil fuels in transport, heat, and electricity, will Europe be placing itself in a dependent position to new countries and a different energy? Instead of relying on oil extraction from one country and gas exports from another, will European countries now rely on electricity facilities in one country and transmission lines through another?

2.1.4 Noor Concentrated Solar Power Case Study

Even though the Noor Concentrated Solar Power (CSP) plant in Ouarzazate is not an officially financed DESERTEC project and it will not deliver power to Europe upon completion, the project could be considered a part of the broader DESERTEC vision (Friedman 2011; Wille 2013). The plant may be the first step in building up North African renewables. Ultimately this electricity could be shared with Europe via new transmission infrastructure.

Background and Energy Policies

Morocco benefits internationally from its strategic geographic location and resource access. Like other Mediterranean MENA countries, Morocco can take advantage of the economic cooperation opportunities with Europe through the Barcelona Process: Union for the Mediterranean mechanism (outlined in 2.1.1). And above and beyond, Morocco has already gained from flexing its strategic position in the energy future and cooperating with European interests, which can be exemplified by preferential "advanced status" (in terms of trade, cooperation, political dialogue),[37] which was awarded to Morocco by the EU in 2008 (King of Morocco 2012; Rignall 2012). The EU has offered the "the prospect of deeper economic integration to Morocco," and currently Morocco is recipient of major European development aid (ranked 18th in the world, formerly in the top 10) (European Commission 2013a). With European funding agencies such as the German GIZ supporting the project, the Noor plant represents Euro-Moroccan energy cooperation and will likely entail closer economic ties.

The Moroccan Solar Agency (MASEN) has received funding from a blend of development agencies and energy interests to develop the first phase (160MW) of a 500MW CSP plant in Ouarzazate, Morocco, through a public private partnership (The World Bank 2011). The Noor site sees very high solar insolation, 20% better than the best site in Southern Spain, for example, and is located near transmission and water infrastructure (see Fig. 14 below) (Almaouja - Le magazine du renouveau des territoires au Maroc 2012). Parabolic mirror trough CSP technology will be developed on 35 square-kilometres of communally owned tribal lands, currently without significant urban infrastructure (The World Bank, 2011; Rignall, 2012; Schinke, 2014).

Morocco seeks to develop enough domestic renewable energy capacity, including large solar and wind projects to meet 42% of annual electricity needs by 2020. The target stems from the goal of reducing energy imports (United States Energy Information Agency 2013b), which currently total 96% of energy consumed (Ministère de l'Energie des Mines de l' Eau et de l' Environnement 2012). The government has

[37] Further information about this available online: http://ec.europa.eu/europeaid/where/neighbourhood/country-cooperation/morocco/morocco_en.htm

focussed on creating new institutions, developing public-private-partnership cooperation on projects, and research, development, and deployment (RD&D) in facilitating these renewable energy goals (International Energy Agency and International Renewable Energy Agency 2013). With most of these policies taking effect within the last five years, Morocco can do much more to develop its domestic renewable energy industry in the near future.

As briefly discussed in Box 4. Local political and implementation challenges with DESERTEC renewables projects”), social and political conditions in Morocco pose challenges for foreign investors and have also created a somewhat contentious reputation for Morroco. Most relevant in the context of renewable energy projects perhaps is the reported governmental corruption (United States Department of State 2013), and the relationship between the King and the Moroccan business world (The Guardian, 2010). The King, in effect, still has control over large sections of the economy, thanks to the phosphate industry and other key holdings (Khakee, 2010). In light of these sociopolitical governance issues, Morocco has room to improve its international reputation, which might encourage and attract outside investments.

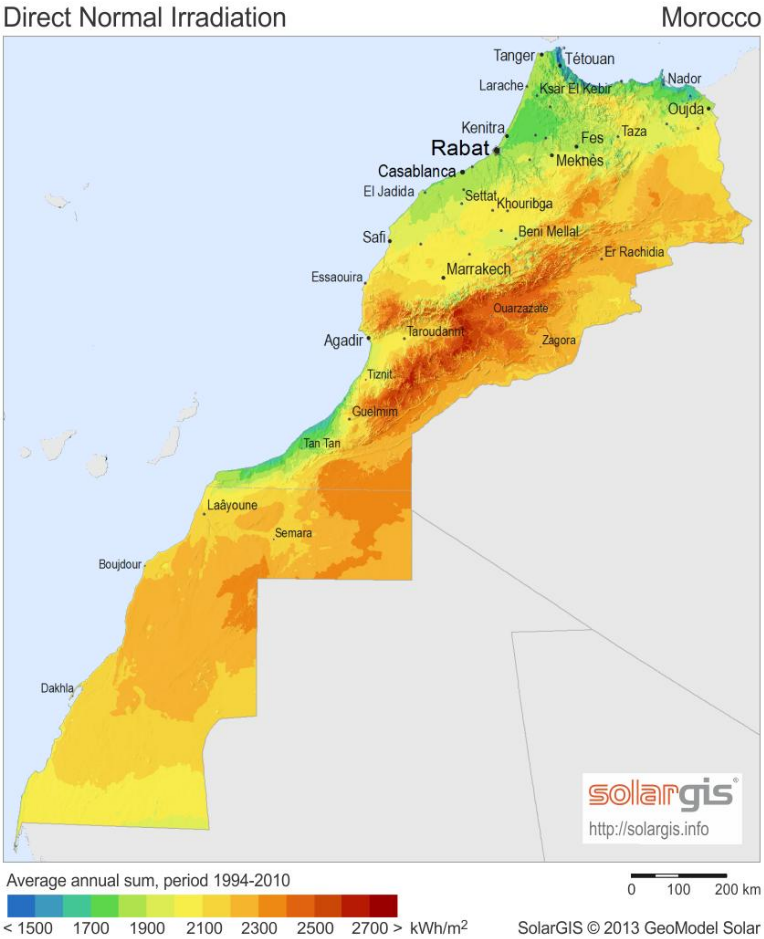


Fig. 14 - Solar CSP resource potential in Morocco and Western Sahara.
Source: IEA Energy Technology Network 2014

Energy Security Implications

Along with the renewable energy installations required of DESERTEC, the Noor project would provide significant regionally-sourced electricity, and thus the CSP plant poses an opportunity to benefit Morocco in terms of domestic energy access. Morocco will still import energy, but the amount of electricity sourced from the currently dominant coal-fired plants will be reduced.

Box 7. National sociopolitical implications of Noor CSP plant

As the first major solar development in Morocco, the Noor CSP plant also faces challenges with regard to the collective land on which the project is being developed. MASEN and ACWA Power invited local stakeholders to participate in the preliminary project processes. And with the funds from the land acquisition, a variety of community development measures have been introduced, such as building a road and youth complex, improving irrigation and drainage canals, or enhancing educational opportunities (Schinke 2014, Almaouja - Le magazine du renouveau des territoires au Maroc 2012). But discontent has locally developed in response to a negotiated land sale price and due to a misalignment between the high expectations of local economic benefits and the real job creation that resulted. This discontent manifested itself in protests and forced the stoppage of construction on the Noor project for 19 days (Schinke 2014).

Particularly in the aftermath of the Arab Spring, addressing socioeconomic inequality in the MENA region has become central to community acceptance. While MASEN and ACWA made clear efforts to involve the public in this pilot project, the developers can improve in their dissemination of transparent information – about their role in the project, and how the project will financially affect the local population – to the community in subsequent project stages (Schinke, 2014).

As a first nationally coordinated major renewable energy project with societal acceptance challenges (and opportunities) the Noor project may also cause rangeland fragmentation and other agricultural impacts on local shrublands where land use has been stressed in recent years (Baumann, 2009; Rignall, 2012). Overall, the operational environmental impacts may include: very high water consumption in the cooling process (the water availability problem may worsen in the mid-term due to climate change), potential toxic fluid leaks, visual pollution, and soil compaction changes. The construction phase may also bring intense impacts in terms of toxicity and land use change (The World Bank, 2013).

Effectively managing social acceptance will be critical to the success of the Noor project, and perhaps more notably, predictive of how future large-scale renewables projects in Morocco may be received. Germanwatch argues that, "transparent information and a fair and comprehensive dialogue with North African civil [society] is of utmost importance," in shaping the public view on renewable energy projects (Schinke, 2013). In addition to the responsibility falling on the project developers, some responsibility will fall on the government. Internal institutional reform within Morocco can lubricate international economic partnerships and strengthen the credibility of the Moroccan government as it pursues further project opportunities with investors (Lesser et al., 2012). The political and social instruments, therefore, will take centre stage in shaping the evolving energy politics in Morocco.

Geopolitical Effects

The Noor CSP plant represents broader geopolitical positioning repercussions in Morocco. Morocco's current industrial economic strength lies in the phosphate industry, which meets about 27% of world demand (Newman 2012). A successful Noor project, seen as the first domino to fall in the DESERTEC vision (Rignall 2012), could lead to a series of projects that ultimately might shift Morocco's international trade balance and its place in the global economy as a specific mineral exporter to a major energy supplier.[38]

The locally supported and technologically effective implementation of the Noor CSP plant can have local political impacts and potentially hoist a new flag of economic

[38] The position of the renewable energy industry in comparison to the phosphate industry depends on how the worldwide economy continues to consume phosphate. Although the USGS has noted that the phosphates industry has been growing (Newman 2012), critics argue that the local environmental impacts of using phosphates in industrial farming are severe and the practice is unsustainable. For more on this topic, see section 5 of the European Commission's Joint Research Centre's Policy Report, *Will there be enough plant nutrients to feed a world of 9 billion in 2050?* http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/25770/1/npk%20final%20report%20_%20publication%20be%20pdf.pdf

opportunities in Western MENA region. If the financial benefits to the local population are sufficiently high, this might have repercussions beyond Ouarzazate: possibly influencing developments in Western Sahara or even accelerating project implementation in other MENA countries. Importantly, the project could play a key influencing role in terms of social acceptance of renewables projects in the MENA world, especially of the socio-economic benefits align with the expectations (Schinke 2014).

On the other hand, significant flows of money from abroad can cause severe disruptions of the local economy, as can be observed in Nigeria or Sudan (Bobai 2012). The sudden influx of foreign direct investment can lead to positive and negative effects in the host country (Forte and Moura, 2013). The net impact depends on the pre-existing framework conditions in the host country.

Looking to the full DESERTEC vision, another possible impact of more renewables exports is through the currency exchange rate. However, the direction of the impact depends on the currency in the trade. Still, the risk of currency appreciation or depreciation is looming.

2.1.5 Assessment

It is likely that European companies would financially benefit from developing sections of DESERTEC in the MENA regions, but the actual energy security benefits, total costs, and environmental benefits are currently still uncertain.

The Noor CSP project brings up the important conflict among balancing or prioritising these three competing interests when designing an energy system. Furthermore, a combination of geopolitical uncertainty in the region and the currently limited European supranational incentives for energy infrastructure also reveal that such a DESERTEC outlay as proposed seems unrealistic to be executed in the current framework.

Box 8. Likelihood of necessary capital infrastructure investments in mega-projects

How realistic are renewable mega-projects, in terms of capital investment needs? Low interest rates currently suggest that capital-intensive infrastructure investments can be attractive to investors seeking long-term, predictable returns, as long as interest rates remain comparatively low (Kaminker and Stewart, 2012). The investment environment, therefore, is supportive for private infrastructure investment. On the other hand, current public austerity measures limit the ability of governments to co-finance large energy infrastructures.

The Noor project in Morocco offers the opportunity for the nation to prove that it can become a renewable energy supply hub for North Africans before it can become one for Europeans. But in order to attract investment beyond these early projects and earn local support of renewables, the government should concentrate on its governance weaknesses and domestic social issues. This can be accomplished by increasing political transparency, formalising new processes for civilian involvement on energy projects (and learning from current experiences), and continuing to fund and support domestic renewable energy research and developers.

Overall, current research on the impacts of renewables mega-projects focusses mostly on energy-related aspects and should also take in consideration the broader socioeconomic, environmental and geopolitical implications. Lessons can be learned from past experience with energy development in developing countries.

The move towards the implementation of DESERTEC should be seen as an opportunity to also go beyond energy security and aim for energy responsibility: Europe needs to assume full responsibility of its energy consumption and consider the entire value chain (i.e. social and environmental impacts), when proposing new energy exploration and generation strategies.

2.2 The North Sea Offshore Grid

2.2.1 Background and Energy Policies

The prospect of offshore wind energy development near European population centres has caught supranational and international attention, as an opportunity to decarbonise the economy and attain the European Commission's Energy Infrastructure Package goals of "[affordable] integration of energy markets (IEM), [sustainable] integration of renewable energy sources and [a security] of energy supply" (Benelux, 2012). The European Commission has therefore recognised the potential North Sea offshore grid as a "priority corridor" for the key energy infrastructure projects that comprise of the "projects of common interest" (PCI). PCIs will see expedited permitting and regulatory treatment, as well as potential access to funds (European Commission, 2013c). Kriegers Flak, the case study presented in 2.2.4 below, can be considered testing waters for the success of a North Sea offshore grid.

The push for an electric grid in the North Sea has been symbolic for the idea of a "supergrid" to connect Europe to remote renewable energy sources through sprawling high voltage direct current (HVDC) networks (Piria and Zavolas, 2013). Similar to the DESERTEC strategy, the promotion of a supergrid with offshore wind energy in the North Sea represents an extreme vision of centralised renewable energy generation providing massive amounts of power to consumption centres at great distances.

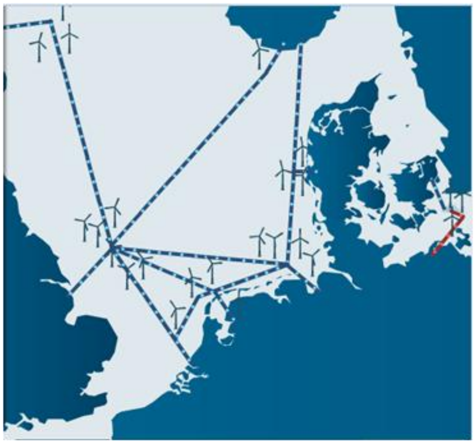


Fig. 15 - Potential North Sea offshore grid with Kriegers Flak project (in red) in Baltic Sea superimposed.
Source: Energinet.dk 2013

Organisations and gatherings have appeared to further pursue a North Sea offshore grid,[39] demonstrating the degree to which an offshore renewable energy superhub has become a central geopolitical discussion.

In emphasising its commitment to a North Sea grid, the European Commission, along with the European Network of Transmission System Operators for Electricity (ENTSO-E) and the Agency for the Cooperation of Energy Regulators (ACER) facilitated the formation of the North Seas Countries' Offshore Grid Initiative (NSCOGI) to evaluate grid implementation, potential markets/regulation, and permissions/planning. NSCOGI additionally is tasked with optimising the offshore renewable sources and infrastructure investments in terms of cost-effectiveness and efficiency (European Network of Transmission System Operators for Electricity, 2013).

Of relevance today are the geopolitical relationships among northern and central European governments with key oil and gas suppliers, and their national governments. It is estimated that Russian energy suppliers, for example, provide up to 35% of European petroleum and natural gas (Zickfeld and Wieland, 2012). This interdependency has recently been reinforced by major gas infrastructure development projects supported by the European Commission in the Baltic and eastern regions to diversify and increase supply and bolster the European internal natural gas market (European Commission, 2009)[40].

Natural gas pipeline projects remain prominent on the European Commission's PCI list (European Commission, 2013c).[41] These projects require major funding, support a large industry, and are promoted by governments who host such companies or have major proven natural gas resources. According to the EEA and Eurostat, over 27% of final electricity consumption in the EU is from natural gas generation (EEA 2013), and 38% of total natural gas consumption is used by the electricity sector (Eurostat 2012a), showing that natural gas is at least a partial substitute for electricity supply. Fossil fuel and pipeline infrastructure industries, in addition to certain governments that host these industries, thus stand to oppose European efforts for offshore renewables grid integration or other electricity grid infrastructure development projects aiming at an integration of higher shares of renewables, since these would be opposed to their long-term business interests.

On the other hand, natural gas is not only competing with renewables but is also complementary to renewable electricity production in the sense that gas-fired power plants are considered suited for stabilising the grid at short notice in case of lower supply of renewable energy from intermittent wind and solar (Lee, Zinaman, and Logan 2012). Moreover, gas is also competing with coal in the power sector. Gas currently has the advantage in terms of lower emissions and dispatch flexibility, while coal is

[39] For example, Friends of the Supergrid (http://www.friendsofthesupergrid.eu/), the Northern European Energy Dialogue (led by Denmark), and an annual conference called SUPERGRID (http://www.fosg-event.eu/)

[40] Probably, in the lights of recent EC announcement after Ukraine's conflict this plans should be changed.

[41] Many of the priority corridors designated are exclusively focused on the transport or delivery of eastern gas and petroleum, such as the "Southern Gas Corridor," "Gas East," "Gas Baltic Energy Market Interconnection Plan," and "Oil Supply Connections in Central Eastern Europe" corridors.

generally a cheaper primary resource. The competitive setting among these different resources depends not only on energy supply and demand in Europe, but also on global energy demand and supply and globally interconnected energy markets, such as for oil or coal. Therefore, considerations of the costs and benefits of the NSCOG need to take the broader context into account.

2.2.2 Energy Security Implications

One of the benefits of an offshore grid is to reduce the delivery inefficiencies of the national European grid systems. In the first NSCOGI study, a reference scenario was developed in which the NSCOGI countries' electricity sectors are modelled[42] to deliver an extra 110 TWh to the region in 2030, or 5% *over* the region's anticipated demand (based on existing national energy strategies). These systemic inefficiencies could be avoided with the new meshed North Sea network design, which would save millions of Euros annually (Benelux 2012),[43] but could also fundamentally change the national sourcing of electricity to depend greatly on interconnectivity.

The North Sea Offshore Grid (NSOG) will benefit electricity "balancing." There will be a higher diversity of electricity sources. Instead of the United Kingdom, for example, building unilaterally large wind installations in the middle of the North Sea and running cables back to land to access the power, with an offshore grid, these planned wind farms can link to Norway and share capacity when necessary or efficient.

The NSOG physical infrastructure likely **will not change overall energy import and export dynamics** in Member States unless national energy strategies in the ten NSCOGI countries are updated. That is, if a large number of new renewable installations (beyond those currently under development in the North Sea) came online, the NSOG could have a greater impact on electricity balances in the NSCOGI countries. An interconnected NSOG network could influence these electricity trade balances, and therefore, *electricity security*, but the first NSCOGI study does not expect these changes to be large (Benelux, 2012). Thus, these changes in electricity sector will likely not affect overall primary energy import and export behaviour at the European Union-level.

Instead of a wind development strategy, the NSOG is an infrastructure strategy designed to meet the needs of planned energy generators and create opportunities for new ones. One possible outcome is that a physical offshore grid in place might financially and politically encourage changes in national strategies to support more offshore wind. The infrastructure itself will not be enough of a motivating factor to expand the installation of renewables in Europe – such incentives would need to come from a political level.

Since the NSOG would not influence energy imports and exports at the EU-level, the "balancing" component of the NSOG would be the most important *energy security* argument in favour of the project. It is also important to note that national *electricity*

[42] Key assumptions in the NSOG study include political cooperation, sufficient physical infrastructure is developed, and relevant transmission operators can effectively coordinate the new, sprawling power flows.

[43] The model accounted for the existing power plant fleet and expected plant retirements. For more information, see: http://www.benelux.int/NSCOGI/NSCOGI_WG1_OffshoreGridReport.pdf

security may not improve (according to traditional metrics) in all relevant countries, but this would be a result of the many new interconnections and interdependencies.

2.2.3 Geopolitical Effects

Box 9. Maritime considerations of an offshore grid

One impact of a massive build up of offshore wind in the North Sea to realise the "supergrid" vision will be increasing environmental pressure on the marine environment and economic pressure on maritime activities. Ongoing installations of offshore wind facilities are coinciding with heightened demand for European territorial waters, leading to growing competition among maritime interests such as resource extraction, renewable energy, shipping, and fishing (European Wind Energy Association, 2011; Meiner and Rekker, 2013). A poorly designed maze of wind farms in the North Sea could reduce the efficiency of shipping routes to European ports, causing unintended socioeconomic consequences with regard to fishing grounds, fish prices, and availability of shipped goods. Integrated and coordinated "Maritime Spatial Planning" could ensure balanced economic and environmental interests on European waters.

Fig. 16 - Wind developments compete for space with other maritime uses, such as fishing and shipping.
Image: Siemens

One hope for the vision is that the European nations within and bordering the NSCOGI region will benefit from lower electricity prices, which hinges on an effectively designed European integrated energy market.

The goal of integrating offshore resources within Europe, (in essence what Kriegers Flak and the potential North Seas grid would accomplish), has coincided with a push for resource sharing, cross-border coordination, and a European internal energy market. An integrated market seems economically attractive: in a report prepared for the European Commission's Directorate General of Energy, it was found that integration through market coupling could yield benefits from €2.5 bn to €4 bn per year (Newberry et al. 2013). Notably, follow up research estimated that cross-border coordination could save Europe up to €416 bn between 2020 and 2030 (European Climate Foundation 2011).

Such market design would require significant physical connections between existing grids[44] and logistical coordination. In some ways, the benefits of the planned offshore wind projects associated with a North Seas grid depend on the physical infrastructure, which must be in place for an internal energy market. It is therefore important that the regulatory framework and market rules for such an internal market are developed alongside and in coordination with a North Seas grid.

2.2.4 Kriegers Flak Case Study

Kriegers Flak, while located in the Baltic Sea, could become a stepping stone to realise similar projects in the North Sea.

Background and Energy Policies

Kriegers Flak is a collaborative offshore wind energy and transmission venture under development in the Baltic Sea between German and Danish Transmission System Operators, 50Hertz and Energinet.dk (and formerly Svenska Kraftnät of Sweden[45]). Kriegers Flak will be the first project to both connect offshore renewables through a grid connection and exchange electricity capacity across borders. With this dual functionality of transmission and capacity exchange (called a “combined grid solution”) Kriegers Flak will become the first offshore power grid (E-Bridge 2010; 50Hertz Offshore GmbH 2010; Energinet.dk 2013). Two separate wind farms at the Kriegers Flak location will be installed by 2018, “Baltic 2” (288 MW) led by German developers EnBW and the “Kriegers Flak Offshore Wind Farm” (600 MW) (Danish Energy Agency, 2013; Energinet.dk, 2013).

The project will be implemented by stringing alternating current (AC) cables from northern Germany to Baltic 2 (the German wind installation at Kriegers Flak), while AC cables will also connect Baltic 2 to the Danish Kriegers Flak wind farm. Power will be converted from AC to DC at an offshore converter station, before a DC cable brings the electricity to Denmark (Energinet.dk, 2013)

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[44] With a lack of or incomplete market liberalisation, integrating more low-carbon electricity resources can cause transmission congestion (Volk 2013). For example, the German demand for electricity coming from the Polish grid into Bavaria applies stress to the Polish network infrastructure. Real-time market-based activities, influenced by the spot prices of renewables flowing into the Polish grid from offshore wind in the north, contribute to this congestion (Grünig et al. 2013). Building out sufficient infrastructure for a European internal energy market could address some network congestion. In the Germany-Poland example, this would have positive political ramifications, as well.

[45] “Internal assessments” revealed that Svenska Kraftnät does not expect offshore wind development in the near future at Kriegers Flak (50Hertz Offshore GmbH 2010). Since a comparatively large share of interconnection costs would be borne by Svenska Kraftnät, and the regulatory framework in Sweden currently prevents allocating these costs to developers that would benefit from the interconnection (Granheim 2012), Svenska Kraftnät had incentives to drop out of the project.

Fig. 17 - Kriegers Flak offshore interconnection diagram.
Source: Energinet.dk 2013

Both Denmark and Germany pursue significant renewable energy integration strategies. The Danish parliament passed the Energy Agreement 2012−2020, which established policies to reach Denmark's long-term target of 100% renewable energy by 2050 and the intermediate goals of 35% renewables (in final energy consumption), including 50% wind power in electricity consumption, by 2020 (Danish Energy Agency 2012; Eberle et al. 2014).

Like Denmark, Germany follows ambitious climate and energy policy targets, known as the *Energiewende*, or 'energy transition.' The national targets for renewable energy include an 18% share of gross final energy consumption by 2020 (60% by 2050) and a 35% share of gross electricity consumption by 2020 (80% by 2050) (BMU and BMWi, 2010; Grünig et al., 2013; Velten et al., 2014). A combination of regulations, fiscal incentives, research funding, and other economic instruments are deployed in both countries to realise these targets.[46]

Energy Security Implications

A net importer of energy overall, Germany today is a net exporter of electricity, however, having sent a surplus of 22.8 TWh to its neighbours in 2012, thanks to its significant generating capacity (Grünig et al., 2013). Denmark is currently the only net exporter of energy in the EU-28 (Eurostat, 2012b).

Both Denmark and Germany have active renewable energy expansion and some degree of power infrastructure support policies in place (Grünig et al. 2013; Kristensen 2013). Neither country will significantly reduce foreign energy dependence with a complete Kriegers Flak project.[47] In the short term, without a fully integrated European electricity market to connect the Kriegers Flak electricity generation, Kriegers Flak may

[46] For more information, the International Energy Agency Global Renewable Energy Joint Policies and Measures Database (Denmark: http://www.iea.org/policiesandmeasures/renewableenergy/?country=Denmark; Germany: http://www.iea.org/policiesandmeasures/renewableenergy/?country=Germany)

[47] With the electrification of the transport and/or heating sectors, the electricity demand could replace petroleum and/or natural gas consumption, both fuels that are imported to Germany (United States Energy Information Agency 2013a). So it is possible that on a longer time horizon, Kriegers Flak may reduce foreign energy dependence for Germany.

even create grid management challenges. Connecting the grids of two countries that will face the same intermittency obstacles of a similar wind resource may not as such improve the resilience and reliability of the electricity grid in Denmark and Germany.

In the long-term, however, the benefits of a Kriegers Flak project emerge for the regions surrounding Germany and Denmark. Instead of economic (job opportunities, manufacturing, etc) and political benefits, which would be more immediate in Germany and Denmark, surrounding nations would gain under a fully liberalised European electricity market. Assuming Kriegers Flak and planned wind farms in the North Sea come online with an integrated market and appropriate physical infrastructure, there will be a greater supply of lower variable cost electricity to surrounding European nations. With a move towards increasing energy connectivity, therefore, Europe more broadly stands to gain from a successful Kriegers Flak project.

Geopolitical Effects

The investment in different energy infrastructure in Europe is relevant in the context of Kriegers Flak, as well. In the best case, a successful Kriegers Flak may catalyse public and private efforts for a North Sea Offshore Grid, which, if successful, may attract investments which otherwise would have gone into less sustainable forms of investments such as Eastern gas pipeline projects.

Kriegers Flak could send a signal to main providers of fossil fuels, showing that Europe intends to break away from oil, coal and gas. Such a signal could influence the perception of energy dependency in Europe and could, thus, increase political authority of Europe in the field of energy.

2.2.5 Assessment

The North Sea Offshore Grid plan could dramatically change electricity availability and the fundamental relationships among European states and between EU and non-EU interests. Implementation can be most effective if planning is coordinated with the creation of market rules and the regulatory frameworks for an integrated European electricity market.

Kriegers Flak itself will not be a game changer in the European energy transition, in net import or export terms. But it can have a role proving the viability of the North Seas Offshore Grid plan.

2.3 Concluding remarks

The outlined renewable energy visions and mega-projects vary significantly in terms of size, cost, location, and technology, and also with regard to geopolitical and energy security impacts. If successfully implemented with multinational coordination, significant transmission infrastructure, and potentially new market delivery mechanisms, the DESERTEC and NSOG visions may reshape economic and broader political relations. Ultimately, renewable energy megaprojects represent one extreme vision of attaining a decarbonised society: centralised renewable energy generation facilities that send electricity to consumers over great distances through new transmission lines.

Renewable Energy Mega-project Overviews	***Energy Security Results of Mega-projects***
DESERTEC is a long-term renewables and grid interconnection initiative in the EUMENA region with the goal of providing both local and long-distance renewable energy at locations with prime natural resources. Many geopolitical challenges stand before realisation of the vision, including: improving intergovernmental cooperation, developing the financing roadmap, appropriately responding to local cultural needs, and physically building the necessary infrastructure.	***With a widely connected network, DESERTEC can improve local energy security reliability. It is unclear whether an implemented DESERTEC vision can improve European energy security across the board.***
In Morocco, the Noor Concentrated Solar Power plant leads the way as the first major solar project in the region with significant European funding. The CSP plant exemplifies how Morocco's position internationally (politically and economically) has both benefitted from and raised doubts about such a megaproject. The plant also poses questions about acceptance of renewable energy projects in MENA.	***The Noor Concentrated Solar Power plant will improve the balance of energy imports and exports in Morocco, since the solar electricity will replace coal-fired generation.***
The North Sea Offshore Grid would increase northern European transmission connectivity and open up new offshore wind development potential. NSOG is poised to develop hand-in-hand with a more integrated European electricity market, which is a major priority at the European Commission and among Member States.	***The North Sea Offshore Grid will benefit electricity "balance-ing" but likely will not significantly change energy security unless national energy strategies change.***
The Kriegers Flak offshore wind farm and grid project in the Baltic Sea is an early project that may indicate the feasibility of and provide early lessons for the NSOG. The offshore capacity exchange will be the first of its kind in the world.	***The Kriegers Flak project is not positioned to reduce energy dependence in Germany or Denmark, but may offer some balancing flexibility to transmission operators.***

Decarbonising and moving to a more energy secure future in the EU, and beyond, will require the incorporation of significant new renewable energy generation capacity. Industrial-scale renewable energy installations are one option with appeal to many stakeholders. However, many of the political, economic, and social impacts of large projects are difficult to predict, as the impacts from small installations cannot simply be up-scaled. New transmission lines and culturally sensitive outreach programmes are merely two tangible examples of the complexities that must be considered. Furthermore the broader economic implications of massive foreign direct investment also demand assessment.

Decentralised renewable energy projects offer potentially less predictable hourly supply to consumers, but tend to have an advantage over mega-projects in securing public support and acceptance. A more decentralised approach would diffuse the national sourcing of energy and, thus, also reduce the risk associated with energy dependence.

If the argument for an energy secure future is based on reducing the negative or undesired qualities of the current geopolitical energy dependence, it is important to consider the types of geopolitical dependences that will also exist in a renewables mega-project future. Instead of depending on large tankers to provide oil from certain parts of the world, a renewables mega-project future would create a dependence on transmission infrastructure. And instead of purchasing energy from the hands of certain governments and corporations, a renewables mega-project future would send this capital and power into few new hands. Renewable energy mega-projects, therefore, will shift the current geopolitical dependence to the proposed superhubs of generation, but may not necessarily reduce the degree of dependence.

Finally, renewable energy mega-projects highlight the central tension in long-term energy planning. *On what basis should we optimise the system*: the most predictable and local supply, an interconnected and resilient mix, the lowest-cost option, or the least environmentally harmful? The study of mega-projects also sparks questions about the current paradigm of energy consumption. *What are societal priorities with regard to energy? Can we accept certain likelihoods of power failure?*

The cultural, societal, and ethical nature of these questions cannot be representatively answered by researchers. They require a political and societal dialogue and process, and the use of models can provide some imputs to this dialogue (cf. section 4).

3. The realisation of GHG reduction targets assigned by 20/20/20 package and the National Renewable Energy Action Plans (NREAP)[48]

The analysis concerns years 2005-2012 and comprises of the following parts[49]:

- GHG emission level in 28 EU countries with distinction between direct emission from the burning of fossil fuels plus industrial production within country area (territorial-based production emissions) and the emissions associated with the consumption of goods and services (consumption-based emission)
- Changes in the relation between the renewable energy production and the gross final energy consumption by each country;
- Differences between the targets assigned by NREAP and the projections made by RES industry organisations in each country.

Data for the analysis were obtained from the following sources:

- Eurostat http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database
- European Renewable Energy Council (EREC 2011)
- Global carbon budget, http://www.globalcarbonproject.org/carbonbudget

The statistical picture of the emissions reduction achievements by each country has been supplemented by some data concerning social and economic condition which may influence the realisation of the climate policy. The average values were determined for four regions defined in the Deliverable 2.1[50].

- Central Europe
- Eastern Europe
- Mediterranean
- Northern Europe

3.1 Long term (1990-2011) changes in GHG emission level from EU countries

The main goal of the Global Carbon Budget organisation is to classify data concerning dynamic of the carbon cycle in the global scale. The organisation tracks changes in

[48] This chapter has been developed by EnergSys.

[49] The aim of this third part is having a comparative analysis concerning regional and national environmental/energy policies in Europe and their impacts and effects on social and economic everyday life.

[50] Deliverable 2.1 *Report on integrated analysis of local anticipatory experiences in energy transition in Europe*
- Central Europe (Austria, Belgium, Germany, Netherlands and Switzerland);
- Eastern Europe (Croatia, Hungary, Poland and Slovenia);
- Mediterranean (France, Spain, Portugal and Italy);
- Northern Europe (Denmark, Finland, Ireland, Norway, Sweden, United Kingdom).

carbon concentration in atmosphere, the anthropogenic emission level (fuel burning, industry production, changes in land-use) and the natural emission and absorption processes. Data concerning the anthropogenic emission distinguish the emission origin country. Thanks to the use of a special model analysis it is possible to distinguish territorial based production emissions and the emissions induced by the country trade balance. The difference between the standard territorial-based emission and consumption-based emission is the net transfer (exports minus imports) of emissions from the production of internationally traded products and services.

Fig.17 illustrates GHG emission level for 28 EU states within a period of 1990-2012[51] . Data concern emission from the EU area and consumption-based emission which shows production/territorial-based emissions minus emissions embodied in exports plus the emissions embodied in imports.

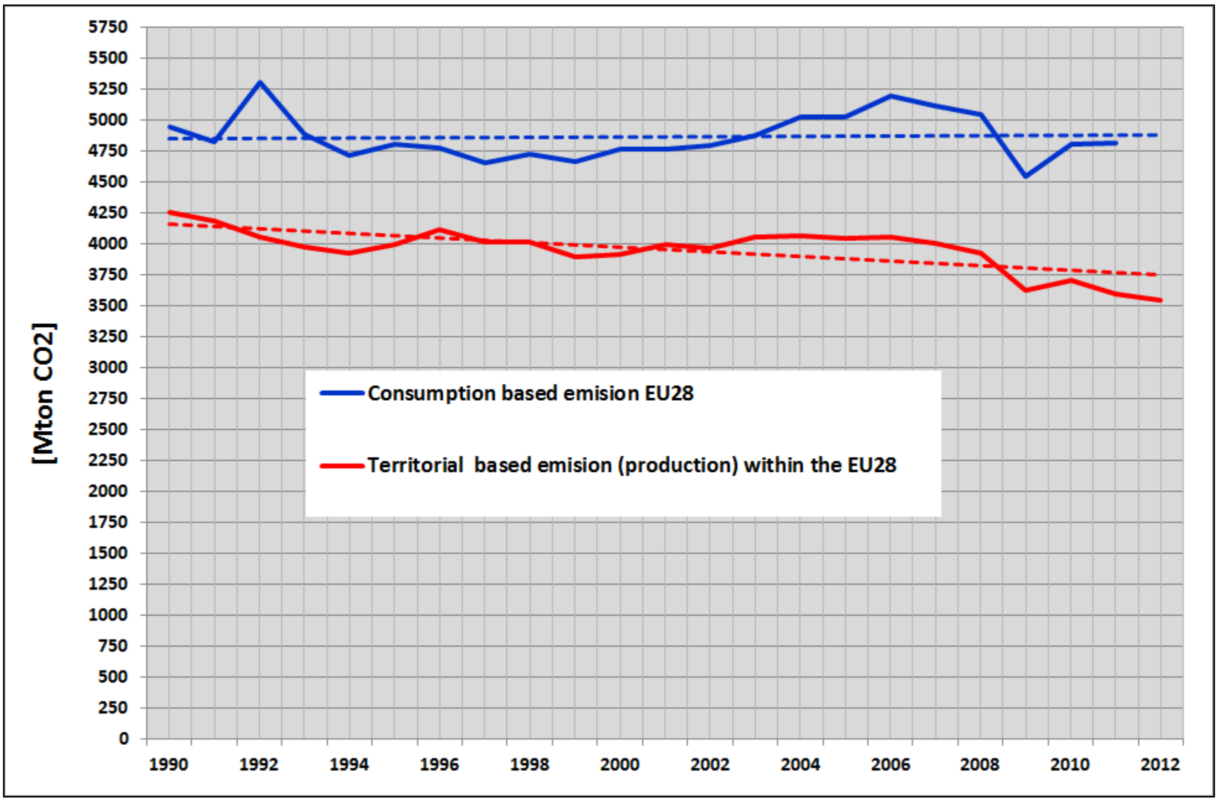


Fig. 18 - Comparison of the level of CO2 emission "consumed" by EU28 states and directly generated during 1990-2012

Source: EnergSys based on data from The Global Carbon Budget 1959 – 2011, 2012

One can see that territorial-based emissions within this area decreased about 15% in years 1990 - 2012. Two main groups of factors influenced this situation. Firstly, fall of the energy intensive, based on outdated technology post-soviet industry in the early 90s combined with the last global financial crisis had a significant influence on the territorial-based emission decrease. The second group of factors include commitments made by the European countries in Kyoto and the implementation of the European Climate Policy. The significant decrease of territorial-based emission by 15% does not give a clear picture of the actual decrease. It has been recorded that the reduction of

[51] Publication doesn't contain the consumption-based GHG emission data for 2012.

direct emission form the territory of the European Union has been compensated by so called “import of emission” by the trade exchange of the EU as whole. It means that in the global sense the emission has not been decreased. The scale of the net “import” of GHG emission is shown on the Fig. 18.

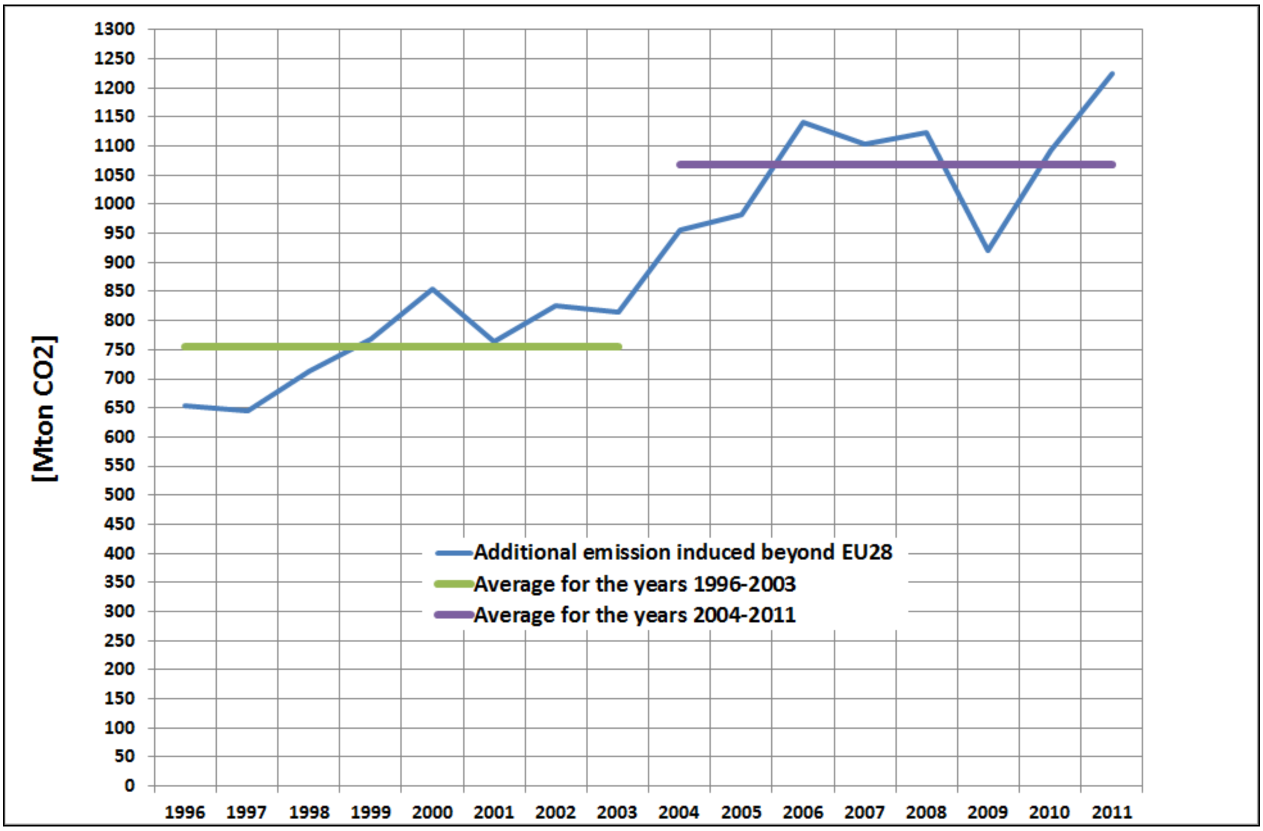


Fig. 19 - Additional CO2 emission induced beyond the EU28 countries during 1997-2011
Source: EnergSys based on data from The Global Carbon Budget 1959 – 2011, 2012

In average the increase of CO2 imported emission by the EU28 countries in years 2004-2011 increased by 300 Mtons in comparison to the average from years 1996-2003. But the observed long-term stabilisation of the emission level can be still regarded as a small success in the reduction efforts.

3.2 Renewable Energy Action Plans (NREAPs)

The Directive 2009/28/EC requires the EU Member States to create special programmes supporting the development of renewable energy sources to facilitate meeting the 20/20/20 package objectives. These programmes include certain partial, measurable targets, established for tracking the progress of the policy realisation. The partial targets are following:

- Relation of the energy supplied by the renewable sources to the gross final energy consumption (RES/energy)
- Relation of the electricity supplied by the renewable sources to the gross national electricity consumption (RES/electricity)

Obtaining the targets is possible by both increase of the energy produced from RES and decrease of the overall energy (electricity) consumption.

3.2.1 Relation of the energy supplied by renewable sources to the gross final energy consumption (RES/energy)

	2005	2012	National Binding Target established by the 2009/28/EC Directive	National targets in its NREAPs	Country RES Industry forecast
European Union (27 countries)	8.5	14.1	20.0	-	-
Belgium	2.3	6.8	13.0	13.0	14.5
Bulgaria	9.2	16.3	16.0	18.8	20.8
Czech Republic	6.1	11.2	13.0	13.5	13.7
Denmark	16.0	26	30.0	30.5	30.5
Germany	6.0	12.4	18.0	19.8	26.7
Estonia	17.5	25.2	25.0	25.0	25.0
Ireland	2.8	7.2	16.0	16.0	16.0
Greece	7.2	15.1	18.0	20.2	25.2
Spain	8.4	14.3	20.0	22.7	28.3
France	9.5	13.4	23.0	23.3	23.6
Italy	5.1	13.5	17.0	16.2	19.1
Cyprus	2.6	6.8	13.0	13.0	14.5
Latvia	32.3	35.8	40.0	40.0	46.4
Lithuania	17.0	21.7	23.0	24.2	31.7
Luxembourg	1.4	3.1	11.0	8.9	10.4
Hungary	4.5	9.6	13.0	14.7	18.3
Malta	0.0	1.4	10.0	10.2	16.6
Netherlands	2.1	4.5	14.0	14.5	16.8
Austria	23.8	32.1	34.0	34.2	46.4
Poland	7.0	11	15.0	15.5	18.4
Portugal	19.8	24.6	31.0	31.0	35.3
Romania	17.6	22.9	24.0	24.0	24.0
Slovenia	16.0	20.2	25.0	25.3	34.1
Slovakia	6.6	10.4	14.0	15.3	26.0
Finland	28.6	34.3	38.0	38.0	42.3
Sweden	40.4	51	49.0	50.2	57.1
United Kingdom	1.4	4.2	15.0	15.0	17.0

Tab. 9 - Realizations in 2012 and the targets for relation "RES/ energy" in percentage points

Source: EnergSys based on data from Eurostat and EREC 2011

The level of fulfilment of the commitments concerning RES/energy by the EU countries can be shown in two ways:

1) As obtained additional percentage of "RES/energy" related to the reference level – assumed for the ratio of "RES/energy" noted in 2005 (Fig. 19)

2) As additional percentage points required to meet the targets for 2020 concerning the ratio "RES/energy" (the Distance to the NREAP – 2020 objectives) - presented on the Fig. 20.

Fig. 19 shows also the additional percentage of "RES/energy" to be obtained in 2020 (related to the level from 2005). In average for all the EU countries the required improvement is at the level of just above 10%. The smallest commitment was made by Romania (6.4% points) and the largest by Denmark (14.5% points).

Concerning the fulfilment of the objectives, Sweden was an absolute leader by 2012. The country increased its relation of "RES/energy" by over 10% points, exceeding the target for 2020. The next were the following countries: Denmark, Italy, Austria, Greece, Estonia and Bulgaria which improved the relations by over 7%. On the other hand there were countries far from reaching the assumed commitments. Malta, Luxemburg, the Netherlands, and the United Kingdom hardly made any progress in increasing the relation "RES/energy" with progress not exceeding 3% points.

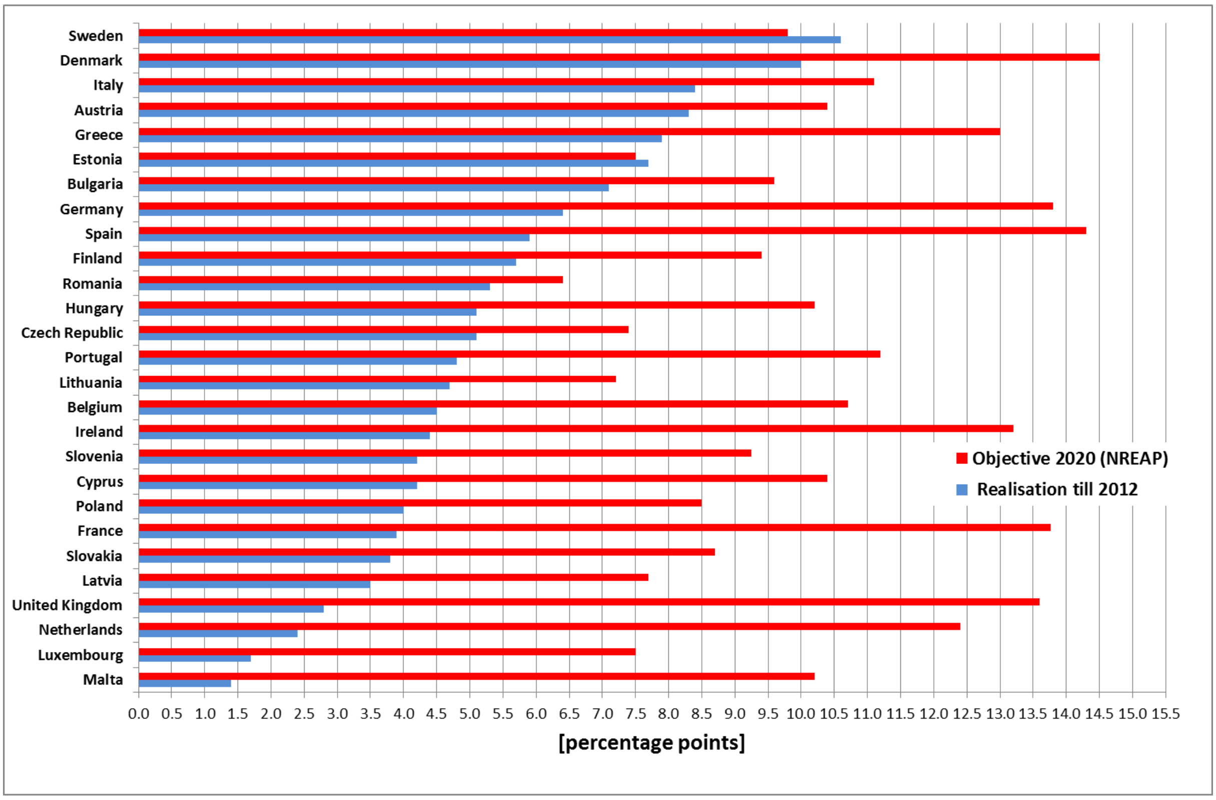


Fig. 20 - Pledges and realization in 2012 NREAP target as concerns relation "RES/ Energy" by European countries

Source: EnergSys based on data from Eurostat and EREC 2011

Fig. 20 shows the level of fulfilment of the commitments in a different perspective – as the distance left to meet NREAP – 2020 objectives. This perspective ranks the EU countries in different order. Sweden and Estonia, who has already exceed the required improvement, stay at the positions of leaders, but only 6 other countries have less than 3% points to the achieve the targets: Romania, Austria, Czech Republic, Lithuania, Bulgaria and Italy. The next 4 countries: Ireland, Malta, Spain and Germany should increase the "RES/energy" relation by more than 7.0% points. Last in the ranking are France, United Kingdom and Netherlands which need to improve the relation by more than 9% points.

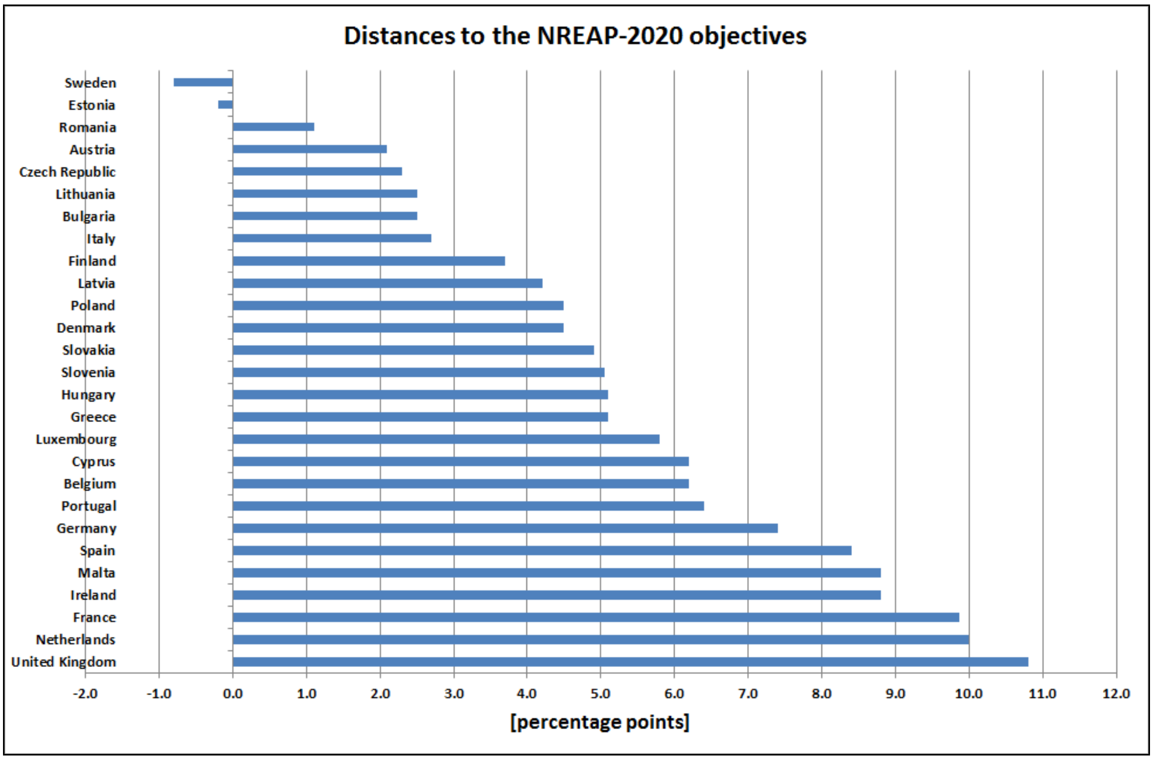


Fig. 21 - Distances in 2012 to fulfil in 2020 NREAP targets as concerns relation "RES/energy" by European countries
Source: EnergSys based on data from Eurostat and EREC 2011

The targets declared by the different governments in their NREAPs are not always identical with those set in the Annex 1 of the 2009/28/EC Directive. Only 9 Member States repeated it exactly. Two countries – Italy and Luxemburg – set less ambitious goals, 16 declared higher improvements than required by the Directive, out of which 3 – Bulgaria, Spain and Greece – increased the 2020 target by more than 2% points. The declared targets are presented on the Fig. 21.

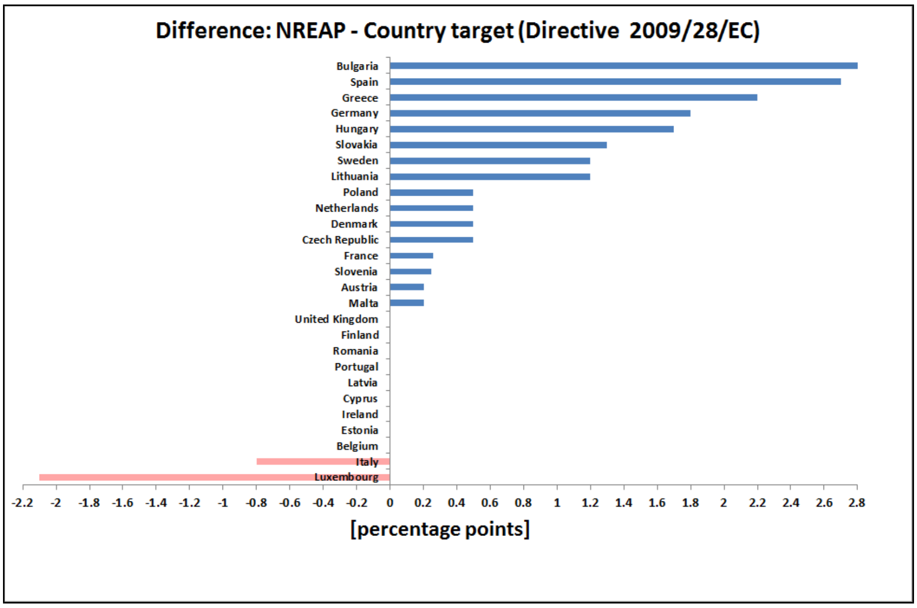


Fig. 22 - Modification "RES/Energy" target by European countries in its NREAPs
Source: EnergSys based on data from EREC 2011

3.2.2 Relation of RES electricity produced to the gross national electricity consumption (RES/electricity)

Country	2005	2012	National targets in its NREAPs	Country RES Industry forecast
European Union (27 countries)	**13.6**	**23.5**	**34.3**	
Belgium	2.3	11.1	20.9	26.6
Bulgaria	11.8	17.0	20.6	40.5
Czech Republic	4.5	11.6	14.0	16.0
Denmark	26.3	38.7	54.5	-
Germany	10.0	23.6	38.6	47.0
Estonia	1.3	15.8	17.6	-
Ireland	6.7	19.6	42.5	75.8
Greece	10.0	17.3	39.8	48.2
Spain	14.3	33.5	40.2	53.6
France	11.0	16.6	28.5	27.7
Italy	13.7	27.6	26.4	39.5
Cyprus	0.0	4.9	16.0	16.1
Latvia	48.4	44.9	59.8	59.2
Lithuania	3.9	10.9	21.3	30.9
Luxembourg	2.9	4.6	11.8	20.4
Hungary	4.5	6.1	10.9	19.0
Malta	0.0	1.1	13.8	19.1
Netherlands	6.3	10.5	37.0	39.6
Austria	58.8	65.5	70.6	93.0
Poland	2.6	10.7	19.1	25.8
Portugal	15.5	47.6	55.2	71.9
Romania	35.8	33.6	42.6	-
Slovenia	24.2	31.4	39.3	45.5
Slovakia	16.6	20.1	24.0	32.0
Finland	26.8	29.5	32.9	34.5
Sweden	53.8	60.0	62.9	76.0
United Kingdom	4.2	10.8	31.0	40.3

Tab. 10- Realisations in 2012 and the targets for relation "RES/ electricity" (percentage)
Source: EnergSys based on data from Eurostat and EREC 2011

Regarding the relation "RES/electricity" until 2012 Portugal was at the leading position by increasing the relation by 32% points. Next was Spain, obtaining an improvement at the level of 18% points. The increase at the level near or above 10% was obtained in Ireland, Denmark, Estonia, Germany and Italy. The change in the relation of "RES/electricity" in years 2005 and 2012 and the targets for 2020 are presented on the Fig. 22.

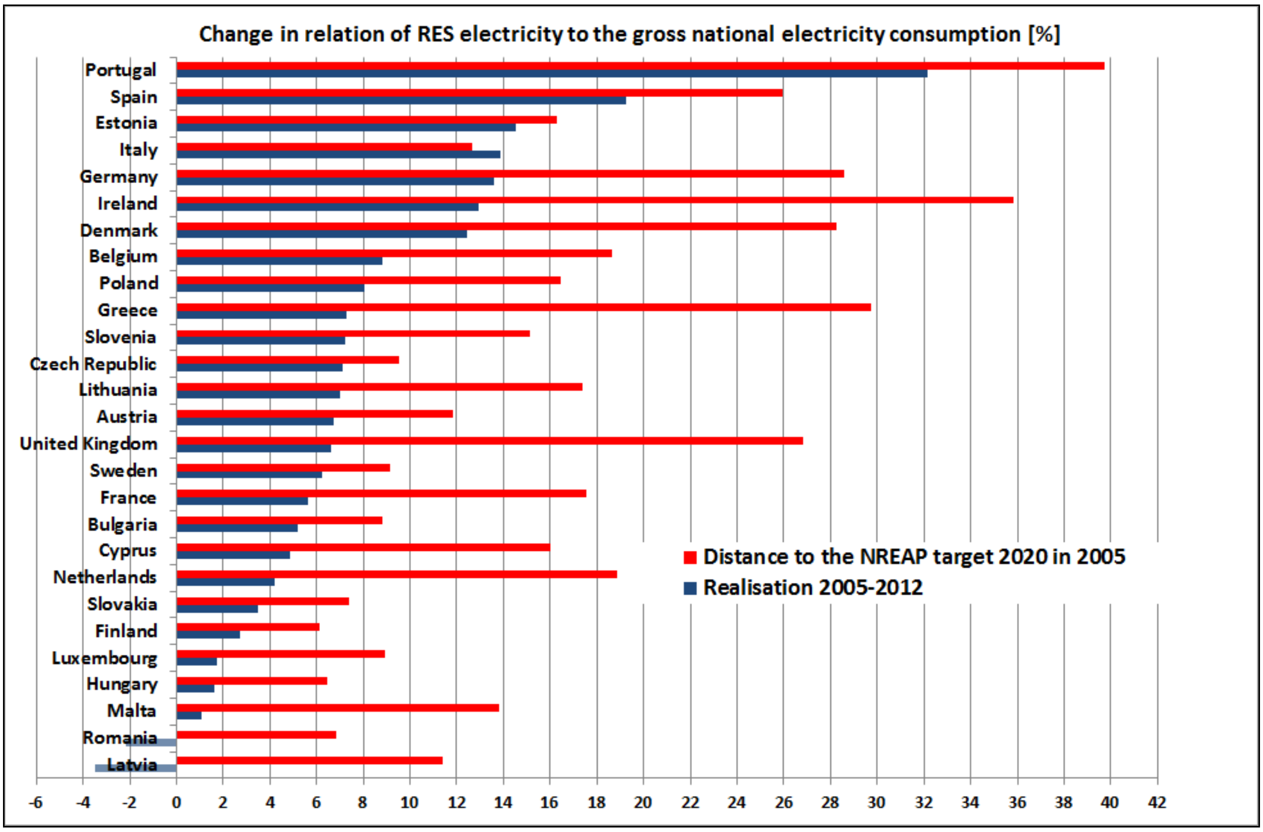


Fig. 23 - Pledges and realization NREAP target as concerns relation "RES/electricity" by European countries

Source: EnergSys based on data from Eurostat and EREC 2011

Romania and Latvia, which had in 2005 relatively high index of the relation "RES/electricity" had decreased it by 2012. The other countries: Estonia, Czech Republic, Sweden, Finland and Bulgaria are very closed to meeting the targets set for 2020. Italy already exceeded the level required for 2020.

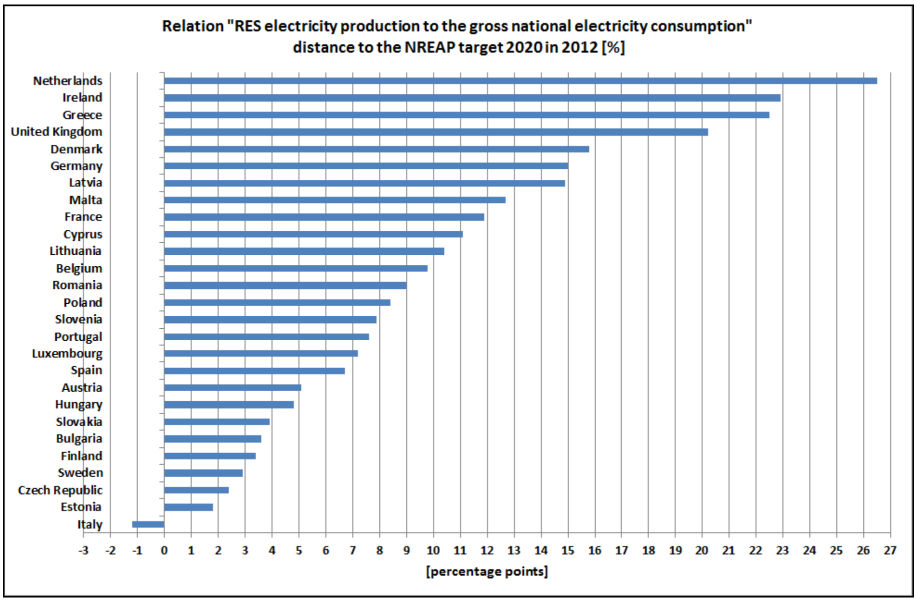


Fig. 24 - Distance in 2012 to the NREAP target as concerns relation "RES/electricity" by European countries

Source: EnergSys based on data from Eurostat and EREC 2011

The other countries will have huge problems with achieving the required level of the relation “RES/electricity” For Netherlands, Ireland, Greece and United Kingdom it seems to be rather unlikely. Concerning the obtained by 2012, relatively low improvements, it seems to also highly unlikely for Cyprus, Malta, Luxembourg, Slovakia and France Apart from the countries that already obtained significant improvements (Denmark, Germany, Belgium), the other are still far from the assumed targets.

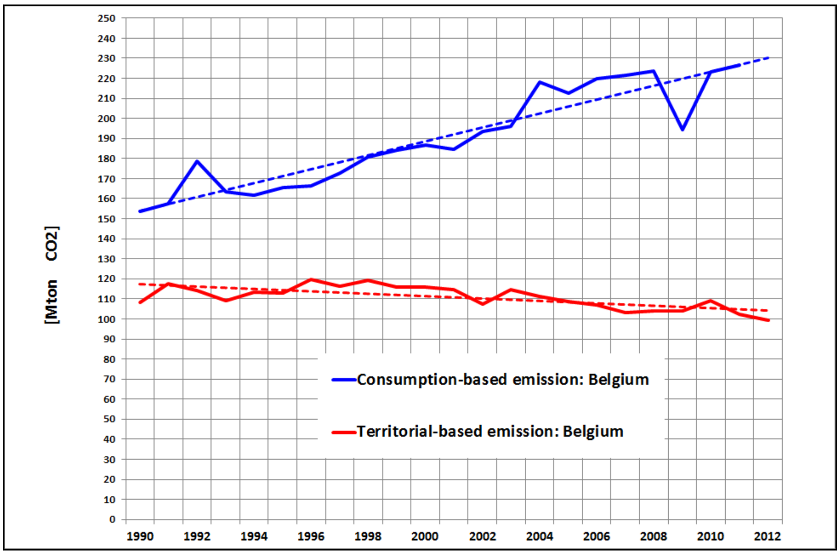
3.2.3 Conditioning factors of GHG reduction (2005-2012)

Belgium

Ranked fourth in terms of energy consumption per capita and seventh in terms of GHG emissions per capita in 2012. Additionally, the level of consumption-based GHG emissions was more than twice higher than the level of the territorial-based one (exceeded by 122%). Compared to the 2005 there was observed increased number of habitants (by 6.2%) and growth of the GDP (by 7,8%). Energy consumption decreased by 4.5% but territorial-based GHG emissions decreased more (by 8,6%). In contrary consumption-based emissions increased by 6.7% (till 2011).

The government and RES industry plans regarding the role of renewable energy sources are not far from each other and NREAP doesn't increase the binding targets for Belgium established by the 2009/28/EC directive. Till 2012 Belgium was characterised by relatively medium realisation of the "RES/Energy" and "RES/Electricity" targets.

Despite of slow GDP development, the employment grown but unemployment rate increased in comparison to the year 2005.



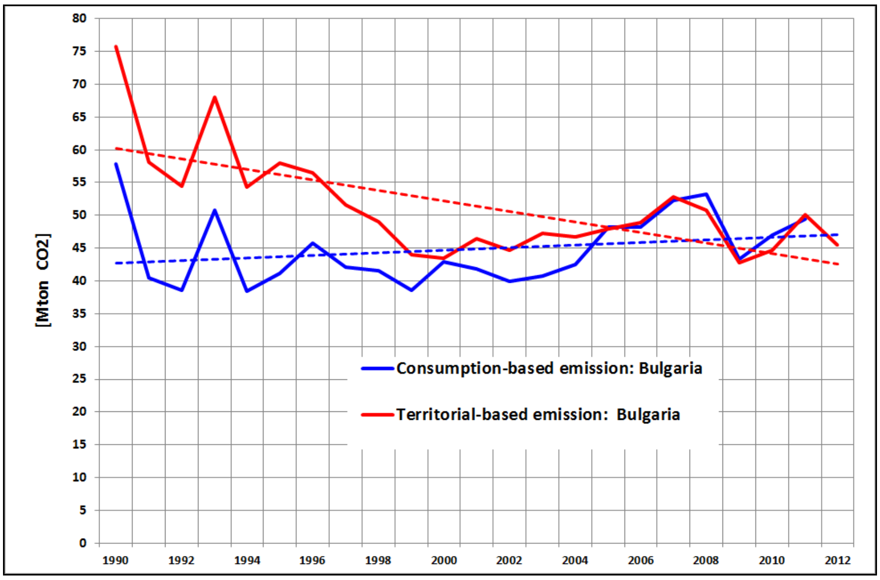
Belgium	2005	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	303	321	324	315	322	328	327	*107.8%*
Gross inland energy consumption [PJ]	2469	2387	2496	2433	2575	2499	2358	*95.5%*
Population [mln]	10.4	10.6	10.7	10.8	10.8	11.0	11.1	*106.2%*
Energy consumption per capita [GJ/person]	236.4	225.5	234.0	226.3	237.5	227.2	212.6	*89.9%*
Territorial-based emission CO2 [Mt]	108.5	103.2	103.9	104.2	108.9	102.3	99.2	*91.4%*
Consumption-based emission CO2 [Mt]	212.4	221.7	223.8	194.3	223.0	226.6		*106.7%*
Emission per capita [t CO2/person]	10.39	9.75	9.74	9.69	10.05	9.30	8.94	*86.1%*
Emission per GDP [kg CO2/€]	0.358	0.322	0.321	0.331	0.338	0.312	0.303	*84.8%*
Employment [mln]	4.24	4.38	4.45	4.42	4.49	4.51	4.52	*106.8%*
Unemployment rate [%]	8.5	7.5	7.0	7.9	8.3	9.3	10.3	*+1,8%*
NREAP targets	2005	2007	2008	2009	2010	2011	2012	2020
„RES/Energy" [%]	2.30	2.60	3.00	3.60	4.00	4.10	6.80	13.0
„RES /Electricity" [%]	2.26	3.65	4.62	6.08	6.79	9.04	11.10	20.9

Bulgaria

Ranked twentieth in terms of energy consumption per capita and seventieth in terms of GHG emissions per capita in 2012th. Consumption-based GHG emissions are almost equal to the territorial-based ones (smaller by 1%). Compared to the 2005, there was observed decrease in number of habitants (by 5.6%) and GDP increase by 17.3%. Energy consumption dropped about nearly10% but territorial-based GHG emissions decreased only by 5%. On the contrary consumption-based GHG emissions increased by 2.3% (till 2011).

The government and RES industry plans regarding the role of renewable energy sources energy sources are far from each other as the "RES/Electricity" target and close as the "RES/Energy" one. Bulgarian NREAP increases the binding targets established by the 2009/28/EC directive by 2.8 points. Till 2012[th] Bulgaria was characterised by fluctuation in realisation of the "RES/Electricity" target despite really good realisation of the "RES/Energy" goal (actually exceed the 2020 target). The achievement of the both targets is very likely.

Despite of relatively not bad GDP development, employment decreased and unemployment rate increased in comparison to to the 2005.



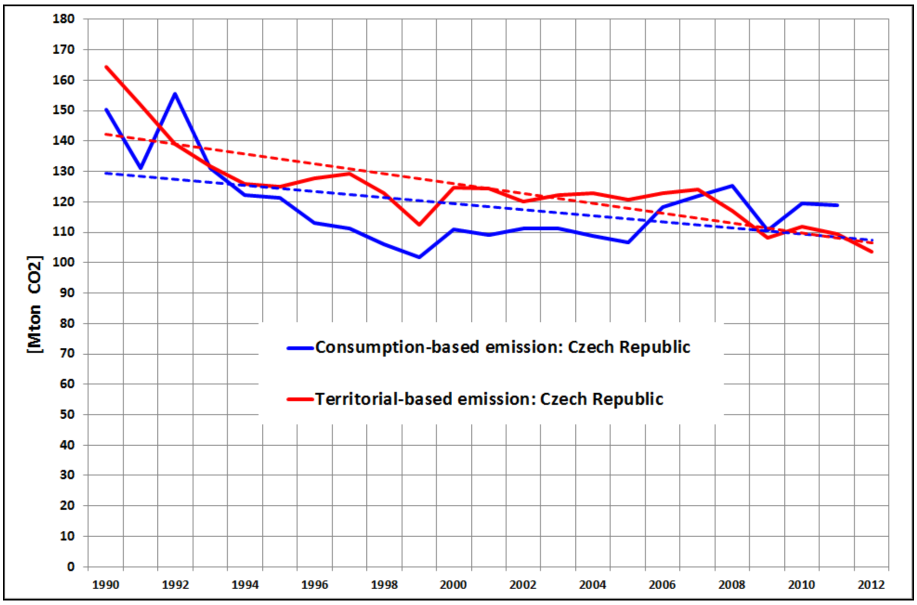
Bulgaria	2005	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	23	26	28	26	27	27	27	*117.3%*
Gross inland energy consumption [PJ]	841	850	842	737	751	807	763	*90.8%*
Population [mln]	7.8	7.7	7.6	7.6	7.6	7.4	7.3	*94.4%*
Energy consumption per capita [GJ/person]	108.3	110.7	110.2	96.8	99.3	109.5	104.2	*96.2%*
Territorial-based emissions CO2 [Mt]	47.9	52.8	50.8	42.8	44.7	50.1	45.5	*95.0%*
Consumption-based emissions CO2 [Mt]	48.3	52.2	53.3	43.3	47.1	49.4		*102.3%*
Emissions per capita [t CO2/person]	6.17	6.88	6.65	5.63	5.91	6.79	6.21	*100.6%*
Emissions per GDP [kg CO2/€]	2.060	2.003	1.814	1.617	1.681	1.850	1.669	*81.0%*
Employment [mln]	2.98	3.25	3.36	3.25	3.05	2.97	2.93	*98.4%*
Unemployment rate [%]	10.1	6.9	5.6	6.8	10.3	11.3	12.3	*+2.2%*
NREAP targets	2005	2007	2008	2009	2010	2011	2012	2020
„RES/Energy" [%]	9.20	9.00	9.50	11.70	13.40	13.80	16.30	16.00
„RES /Electricity" [%]	11.80	7.52	7.42	9.81	15.15	9.80	17.00	20.60

Czech Republic

Ranked seventh in terms of energy consumption per capita and fourth in terms of GHG emissions per capita in 2012. Consumption-based GHG emission is a little bit higher than the territorial-based one (exceeded by 9%). Compared to the 2005 there was observed increased number of habitants (by 2.8%) and growth of the GDP by 15%. Energy consumption dropped by 8.1% and territorial-based GHG emissions by 4.1%. On the contrary consumption-based GHG emissions increased by 11.1% (till 2011)

The government and RES industry plans regarding the role of renewable energy sources are not far from each other. Czech NREAP increases the binding targets established by the 2009/28/EC directive only by 0.6 points. Till 2012 Czech Republic was characterised by relatively good realisation of the RES targets and the achievement of the both is very likely .

With relatively not bad GDP development, employment increased by 2.6% and unemployment rate decreased slightly in comparison to the year 2005.



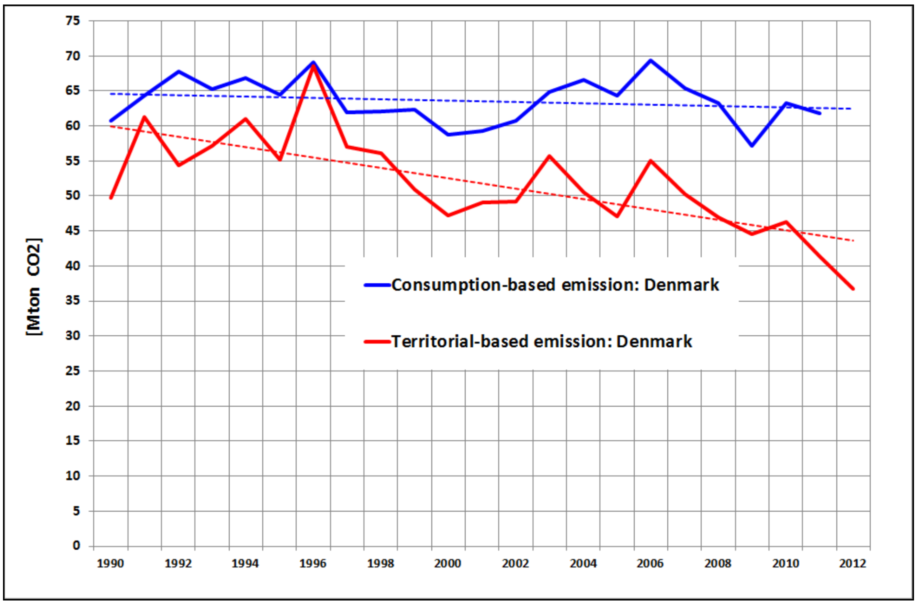
Czech Republic	2005	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	104.6	118.4	122.1	116.6	119.4	121.6	120.4	*115.0%*
Gross inland energy consumption [PJ]	1895.6	1937.8	1895.1	1775.8	1875.1	1813.6	1791.3	*94.5%*
Population [mln]	10.2	10.3	10.4	10.5	10.5	10.5	10.5	*102.8%*
Energy consumption per capita [GJ/person]	185.5	188.4	182.6	169.6	178.5	172.9	170.5	*91.9%*
Territorial-based emissions CO2 [Mt]	120.7	123.9	117.0	108.1	111.7	109.5	103.7	*85.9%*
Consumption-based emissions CO2 [Mt]	106.8	121.8	125.3	110.6	119.5	119.0		*111.4%*
Emissions per capita [t CO2/person]	11.8	12.0	11.3	10.3	10.6	10.4	9.9	*83.6%*
Emissions per GDP [kg CO2/€]	1.154	1.047	0.959	0.927	0.936	0.900	0.862	*74.7%*
Employment [mln]	4.8	4.9	5.0	4.9	4.9	4.9	4.9	*102.6%*
Unemployment rate [%]	7.9	5.3	4.4	6.7	7.3	6.7	7.0	*-0.9%*
NREAP targets	2005	2007	2008	2009	2010	2011	2012	2020
„RES/Energy” [%]	6.1	7.3	7.2	7.8	8.4	9.4	11.2	13.0
„RES /Electricity” [%]	4.5	4.7	5.2	6.8	8.3	10.3	11.6	14.0

Denmark

Ranked twelfth in terms of energy consumption per capita and fifteenth in terms of GHG emissions per capita in 2012. Consumption-based GHG emission exceeded the level of the territorial-based one by 49%. Compared to the 2005 there was observed increased number of habitants (by 3.1%) and GDP stay almost on the 2005 level (increase by 0.6%). Energy consumption decreased by 8.2% but territorial-based GHG emissions decreased much more (by 22.1%) and consumption-based emissions only by 6.4% (till 2011).

The government and RES industry plans regarding the role of renewable energy sources are not far from each other and NREAP increases the binding targets for Denmark established by the 2009/28/EC directive by 0.5% point. Till 2012 Denmark was characterised by very good realisation of the "RES" targets but in the case the "RES/Electricity" the goal is really ambitious and its achievement is still problematic.

Together with slow GDP development, the employment dropped by 2.3% and unemployment rate increased in comparison to the year 2005.



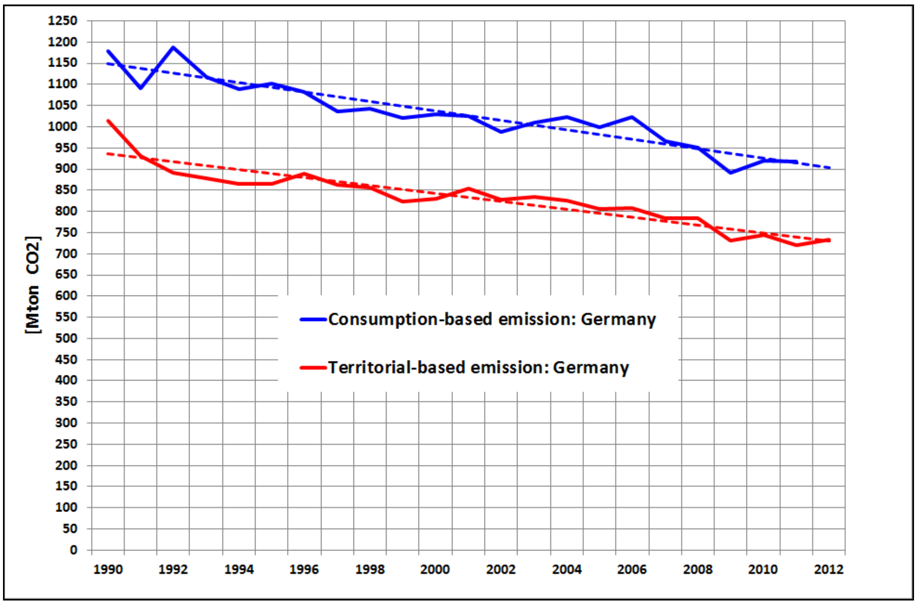
Denmark	2005	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	207.4	217.8	216.1	203.8	207.1	209.4	208.6	*100.6%*
Gross inland energy consumption [PJ]	827.3	865.8	845.7	806.1	849.3	795.2	759.5	*91.8%*
Population [mln]	5.4	5.4	5.5	5.5	5.5	5.6	5.6	*103.1%*
Energy consumption per capita [GJ/person]	152.9	159.0	154.4	146.3	153.5	143.0	136.1	*89.0%*
Territorial-based emissions CO2 [Mt]	47.1	50.2	47.0	44.5	46.3	41.4	36.7	*77.9%*
Consumption-based emissions CO2 [Mt]	64.4	65.4	63.3	57.2	63.3	61.9		*96.1%*
Emissions per capita [t CO2/person]	8.7	9.2	8.6	8.1	8.4	7.4	6.6	*75.6%*
Emissions per GDP [kg CO2/€]	0.227	0.231	0.217	0.218	0.224	0.198	0.176	*77.5%*
Employment [mln]	2.8	2.8	2.9	2.8	2.7	2.7	2.7	*97.7%*
Unemployment rate [%]	4.8	3.8	3.4	6.0	7.5	7.6	7.5	*+2.7%*
NREAP targets	2005	2007	2008	2009	2010	2011	2012	2020
„RES/Energy" [%]	16.0	17.8	18.6	20.0	22.0	23.1	26.0	30.0
„RES /Electricity" [%]	26.3	27.0	26.7	27.5	33.1	38.8	38.7	54.5

Germany

Ranked tenth in terms of energy consumption per capita and sixth in terms of GHG emissions per capita in 2012. Consumption-based GHG emissions exceeded the level of the territorial-based one by 28%. Compared to the 2005 there was observed decreased number of habitants (by 0.8%) and GDP increased by 11.1%. Energy consumption decreased by 7.7% but territorial-based GHG emissions decreased more than 9% and consumption-based emissions by more than 8% (till 2011).

The government and RES industry plans regarding the role of renewable energy sources are relatively far from each other and NREAP increase the binding targets for Germany established by the 2009/28/EC directive by 1.8 point. Till 2011[th] Germany was characterised by very good realisation of the "RES" targets but like in the case of Denmark the both goals are ambitious and its achievement can be problematic.

GDP growth was not to high, W employment increased by 10.2% and unemployment rate decreased significantly in comparison to the year 2005.



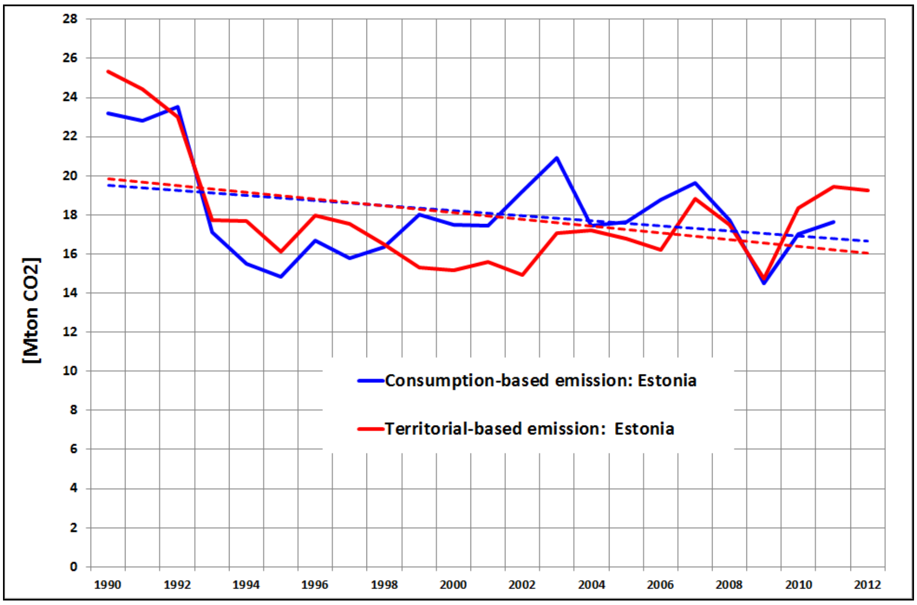
Germany	2005	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	2224	2382	2408	2284	2376	2455	2472	*111.1%*
Gross inland energy consumption [PJ]	14486	14226	14355	13668	14072	13243	13375	*92.3%*
Population [mln]	83	82	82	82	82	82	82	*99.2%*
Energy consumption per capita [GJ/person]	176	173	175	167	172	162	163	*93.1%*
Territorial-based emissions CO2 [Mt]	807	784	783	732	745	719	732	*90.8%*
Consumption-based emissions CO2 [Mt]	999	965	951	892	919	918		*91.9%*
Emissions per capita [t CO2/person]	9.78	9.52	9.53	8.93	9.11	8.80	8.95	*91.5%*
Emissions per GDP [kg CO2/€]	0.363	0.329	0.325	0.321	0.314	0.293	0.296	*81.7%*
Employment [mln]	36.36	37.99	38.54	38.47	38.74	39.74	40.08	*110.2%*
Unemployment rate [%]	11.3	8.7	7.5	7.8	7.1	5.9	5.5	*-5.8%*
NREAP targets	2005	2007	2008	2009	2010	2011	2012	2020
„RES/Energy" [%]	5.2	7.1	7.3	8.0	10.7	12.3	12.4	18.0
„RES /Electricity" [%]	10.0	14.1	14.6	16.2	16.9	20.4	23.6	38.6

Estonia

Ranked sixth in terms of energy consumption per capita and in terms of regarding the GHG emissions per capita in 2012. Consumption-based GHG emissions is slightly lower than the territorial-based one (by 9%). Compared to the 2005 decreased number of habitants (by 0.6%) and GDP increased by 13.8%. Energy consumption increased by 10.2% and territorial-based GHG emissions increased more (by 14.7%). But consumption-based emissions decreased by 0.2% (till 2011).

The government and RES industry plans regarding the role of renewable energy sources are exactly the same. Estonian NREAP copied the binding targets established by the 2009/28/EC directive. Till 2011 Estonia was characterised by very good realisation of the "RES" targets ("RES/Energy" target was actually achieved in 2011) and its achievement is very likely.

With not so high GDP development, employment increased by near 3% but the unemployment rate increased in comparison to the year 2005.



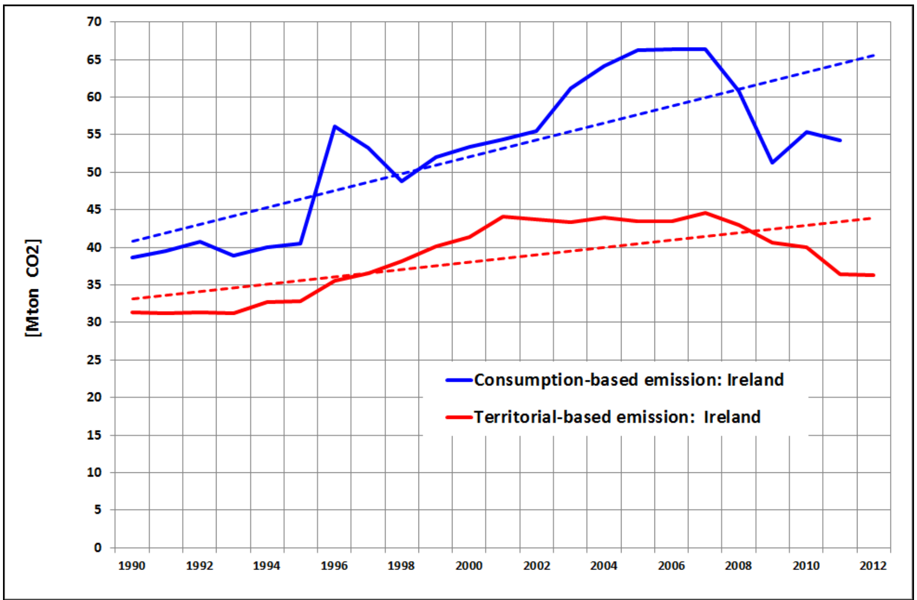
Estonia	2005	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	11.2	13.2	12.7	10.9	11.2	12.2	12.7	*113.8%*
Gross inland energy consumption [PJ]	233	254	246	222	256	258	257	*110.2%*
Population [mln]	1.348	1.342	1.341	1.340	1.340	1.340	1.340	*99.4%*
Energy consumption per capita [GJ/person]	172.8	189.4	183.7	165.8	191.0	192.5	191.5	*110.8%*
Territorial-based emissions CO2 [Mt]	16.8	18.8	17.5	14.7	18.3	19.5	19.2	*114.7%*
Consumption-based emissions CO2 [Mt]	17.6	19.6	17.7	14.5	17.0	17.6		*99.8%*
Emissions per capita [t CO2/person]	12.45	14.04	13.04	11.00	13.68	14.52	14.36	*115.3%*
Emissions per GDP [kg CO2/€]	1.501	1.424	1.379	1.353	1.641	1.589	1.512	*100.8%*
Employment [mln]	0.61	0.66	0.66	0.60	0.57	0.61	0.62	*102.8%*
Unemployment rate [%]	7.9	4.6	5.5	13.8	16.9	12.5	10.2	*+2.3%*
NREAP targets	2005	2007	2008	2009	2010	2011	2012	2020
„RES/Energy" [%]	17.50	17.10	18.90	23.00	24.60	25.90	25.20	25.00
„RES /Electricity" [%]	1.29	1.48	2.04	6.11	10.75	12.64	15.80	17.60

Ireland

Ranked fifteenth in terms of energy consumption per capita and tenth in terms of GHG emissions per capita in 2012. Consumption-based GHG emissions exceeded the level of the territorial-based one by 51%. Compared to the 2005 there was observed, increased number of habitants (by 11.5%) and GDP increased by 2.7%. Energy consumption decreased by 8.4% and territorial-based GHG emissions decreased more (by 16.7%). consumption-based emissions decreased even more (by 18% till 2011).

The government and RES industry plans regarding the role of renewable energy sources energy sources are exactly the same regarding the “RES/Energy” target and extremely different regarding the “RES/Electricity” one. Irish NREAP copied the binding targets established by the 2009/28/EC directive. Till 2012 Ireland was characterised by relatively good realisation of both RES targets but in the case of Ireland both goals seemed to be too ambitious and its achievement can be problematic.

With very weak GDP development employment dropped by 5.9% and unemployment rate increased tremendously in comparison to the year 2005.



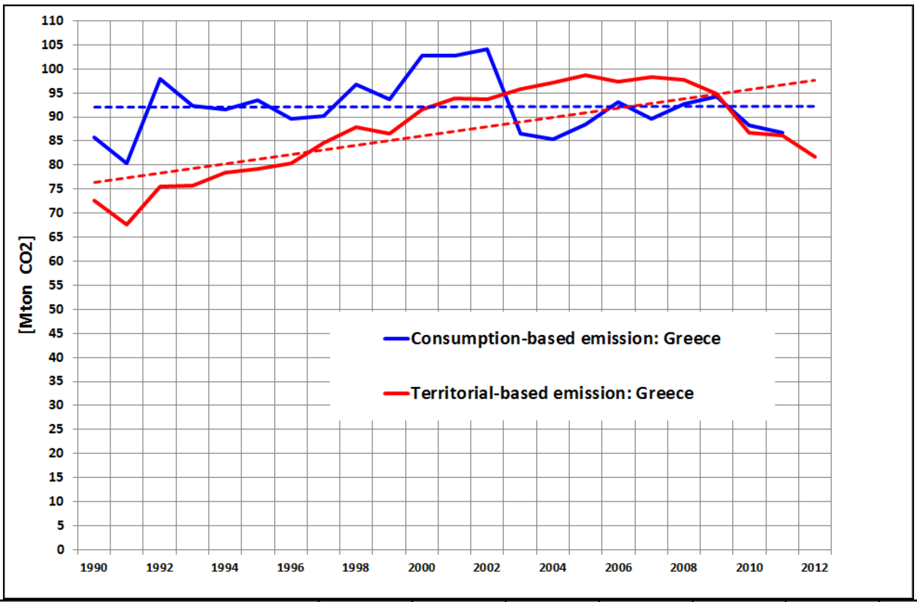
Ireland	2005	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	163	180	177	165	163	167	167	*102.7%*
Gross inland energy consumption [PJ]	633	668	661	616	628	580	580	*91.6%*
Population [mln]	4.1	4.3	4.4	4.5	4.5	4.6	4.6	*111.5%*
Energy consumption per capita [GJ/person]	153.9	155.0	150.2	138.5	140.5	126.9	126.5	*82.2%*
Territorial-based emissions CO2 [Mt]	43.5	44.6	43.0	40.6	40.0	36.4	36.3	*83.3%*
Consumption-based emissions CO2 [Mt]	66.2	66.4	60.8	51.3	55.3	54.3		*82.0%*
Emissions per capita [t CO2/person]	10.59	10.34	9.77	9.13	8.95	7.97	7.91	*74.7%*
Emissions per GDP [kg CO2/€]	0.267	0.247	0.244	0.246	0.245	0.218	0.217	*81.1%*
Employment [mln]	1.95	2.12	2.10	1.96	1.88	1.85	1.84	*94.1%*
Unemployment rate [%]	4.4	4.7	6.4	12.0	13.9	14.7	14.7	*+10.3%*
NREAP targets	2005	2007	2008	2009	2010	2011	2012	2020
„RES/Energy” [%]	2.80	3.40	3.60	4.50	5.60	6.70	7.20	16.00
„RES /Electricity” [%]	6.69	9.46	11.69	14.13	12.83	19.40	19.60	42.50

Greece

Ranked twenty first in terms of energy consumption per capita and thirteenth in terms of GHG emission per capita in 2012. Consumption-based GHG emissions similar to the territorial-based. Compared to the 2005 there was observed increased number of habitants (by 1.9%) and GDP decreased by 12.7%. Energy consumption decreased by 15.9 % and territorial-based GHG emissions decreased more (by 17.2%). Much less decreased consumption-based emissions (by 1.9% till 2011).

The government and RES industry plans regarding the role of renewable energy sources are far from each other. Greek NREAP increased the binding target established by the 2009/28/EC directive by 2.2% points. Till 2011 Greece was characterised by relatively not bad realisation of the “RES/Energy” and “RES/Electricity” targets. In the case of Greece the RES/electricity goal seemed to be too ambitious and it achievement seems to be impossible, especially regarding the crisis.

With GDP decrease employment dropped by 13.9% and unemployment rate increased tremendously in comparison to the year 2005.



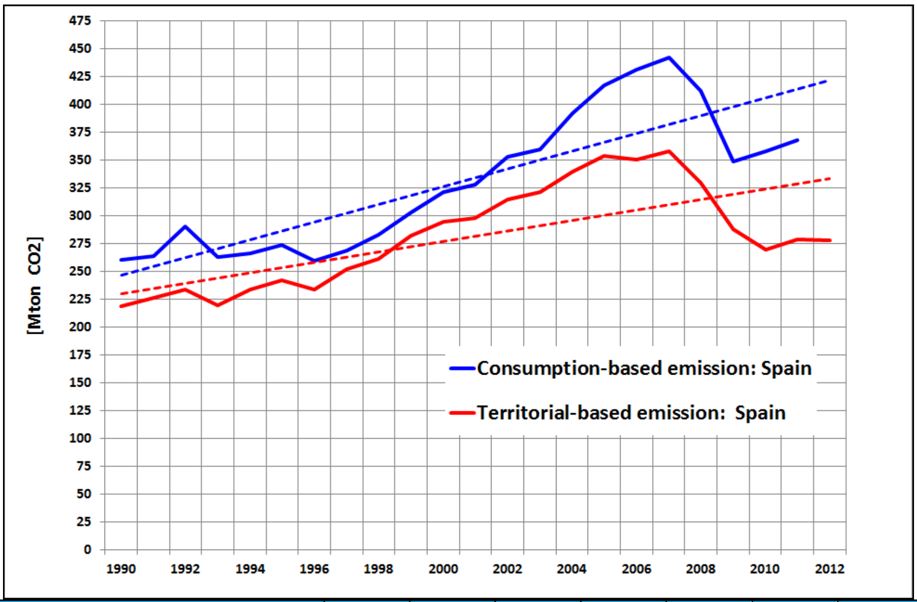
Greece	2005	2006	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	193	204	211	210	204	194	180	169	*87.3%*
Gross inland energy consumption [PJ]	1314	1322	1323	1333	1285	1208	1169	1132	*86.1%*
Population [mln]	11.1	11.1	11.2	11.2	11.3	11.3	11.3	11.3	*101.9%*
Energy consumption per capita [GJ/person]	118.6	118.8	118.5	118.9	114.1	106.8	103.4	100.3	*84.6%*
Territorial-based emissions CO2 [Mt]	98.7	97.3	98.2	97.8	94.9	86.7	86.1	81.7	*82.8%*
Consumption-based emissions CO2 [Mt]	88.4	93.1	89.7	92.6	94.3	88.2	86.7		*98.1%*
Emissions per capita [t CO2/person]	8.90	8.74	8.79	8.72	8.43	7.67	7.61	7.24	*81.3%*
Emissions per GDP [kg CO2/€]	0.511	0.478	0.466	0.465	0.466	0.447	0.478	0.485	*94.9%*
Employment [mln]	4.37	4.45	4.51	4.56	4.51	4.39	4.09	3.76	*86.1%*
Unemployment rate [%]	9.9	8.9	8.3	7.7	9.5	12.6	17.7	24.3	*+14.4%*
NREAP targets	2005	2006	2007	2008	2009	2010	2011	2012	2020
„RES/Energy” [%]	7.20	7.20	8.00	8.00	8.10	9.20	11.60	15.10	18.00
„RES /Electricity” [%]	10.04	11.82	6.77	8.29	12.45	16.68	12.99	17.30	39.80

Spain

Ranked seventeenth in terms of energy consumption per capita and twentieth in terms of GHG emissions per capita in 2012. Consumption-based GHG emissions exceeded the level of the territorial-based by 32%. Compared to the 2005 there was observed increased number of habitants (by 7.3%) and GDP increased by 2.6%. Energy consumption decreased by 11.8 % and territorial-based GHG emissions decreased more (by 21.5%). Smaller decrease of consumption-based emission (by 11.8% till 2011).

The government and RES industry plans regarding the role of renewable energy sources are far from each other. Spanish NREAP increased the binding target established by the 2009/28/EC directive by 2.7 point. Till 2011 Spain was characterised by very good realisation of the "RES/Energy" target and as good "RES/Electricity" one. Nevertheless in the case of Spain the "RES" targets seem to be too ambitious and it achievement regarding the crisis seems to be problematic.

With very weak GDP development, employment dropped by 8.9% and unemployment rate increased tremendously compared to the year 2005th exceeding 25%.



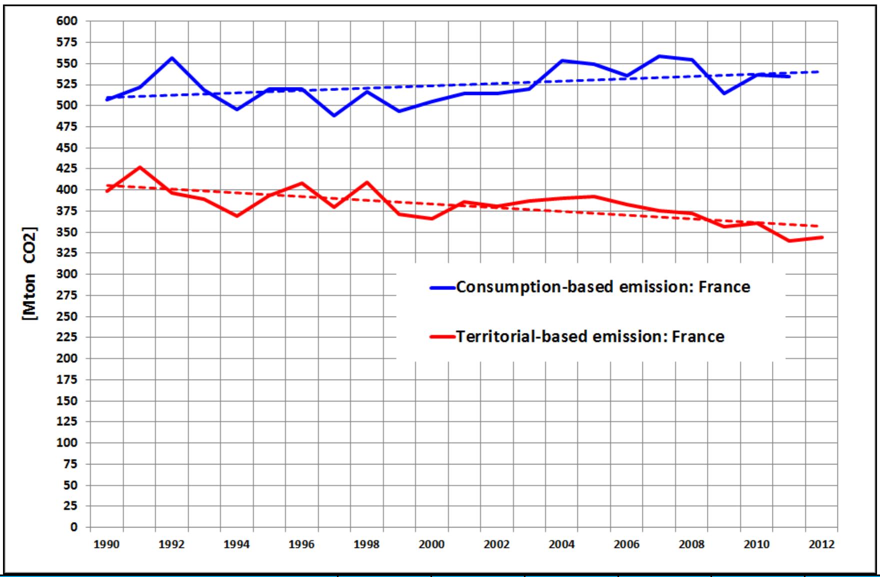
Spain	2005	2006	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	909	946	979	988	950	948	949	933	*102.6%*
Gross inland energy consumption [PJ]	6045	6055	6130	5942	5461	5442	5382	5330	*88.2%*
Population [mln]	43.0	43.8	44.5	45.3	45.8	46.0	46.2	46.2	*107.3%*
Energy consumption per capita [GJ/person]	140.5	138.4	137.8	131.2	119.2	118.3	116.6	115.4	*82.1%*
Territorial-based emissions CO2 [Mt]	353.4	350.0	358.2	329.3	288.2	269.7	278.7	277.5	*78.5%*
Consumption-based emissions CO2 [Mt]	417.3	431.0	442.1	412.3	348.4	358.1	368.1		*88.2%*
Emissions per capita [t CO2/person]	8.21	8.00	8.05	7.27	6.29	5.86	6.04	6.01	*73.1%*
Emissions per GDP [kg CO2/€]	0.389	0.370	0.366	0.333	0.303	0.284	0.294	0.297	*76.5%*
Employment [mln]	18.97	19.75	20.36	20.26	18.89	18.46	18.10	17.28	*91.1%*
Unemployment rate [%]	9.2	8.5	8.3	11.3	18.0	20.1	21.7	25.0	*+15.8%*
NREAP targets	2005	2006	2007	2008	2009	2010	2011	2012	2020
„RES/Energy" [%]	8.20	9.00	9.30	10.10	11.80	13.80	15.10	14.30	20.00
„RES /Electricity" [%]	14.26	17.58	19.45	20.58	25.83	33.06	30.18	33.50	40.20

France

Ranked ninth in terms of energy consumption per capita and twenty first in terms of GHG emissions per capita in 2012. Consumption-based GHG emissions exceeded the level of the territorial-based by 57%. Compared to the 2005 there was observed increased number of habitants (by 4.1%) and GDP increased by 5.3%. Energy consumption decreased by 6.6 % and territorial-based GHG emissions decreased more (by 22.4%). Much smaller decrease of consumption-based emissions (by 2.7% till 2011).

The government and RES industry plans regarding the role of renewable energy sources are very close but what is strange French NREAP is a little bit more ambitious than RES industry plans and increased the binding target established by the 2009/28/EC directive by 0.3% points. Till 2012 France was characterised by relatively extremely poor realisation of the both “RES” targets. Taking this into account in the case of France achievement the “RES” targets seems to be problematic.

With very weak GDP development employment increase by 3.4% and unemployment rate increased only slightly compared to the year 2005.



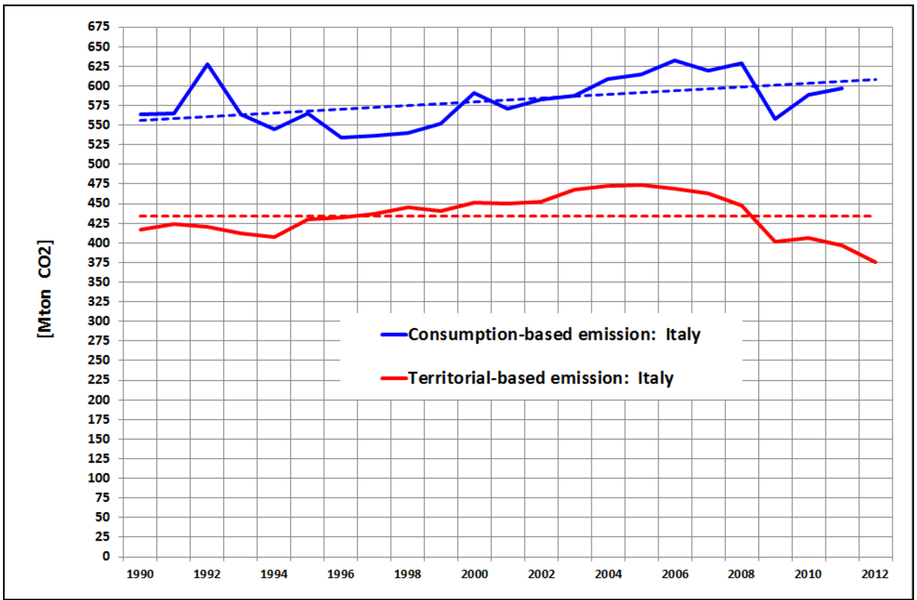
France	2005	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	1718	1801	1799	1743	1773	1809	1809	*105.3%*
Gross inland energy consumption [PJ]	11582	11314	11380	10880	11198	10857	10818	*93.4%*
Population [mln]	62.8	63.6	64.0	64.4	64.7	65.0	65.3	*104.1%*
Energy consumption per capita [GJ/person]	184.5	177.8	177.8	169.1	173.2	167.1	165.6	*89.8%*
Territorial-based emissions CO2 [Mt]	392.0	375.8	372.5	356.9	361.2	339.3	343.6	*87.6%*
Consumption-based emissions CO2 [Mt]	548.8	558.2	554.2	514.0	536.9	534.1		*97.3%*
Emissions per capita [t CO2/person]	6.25	5.91	5.82	5.55	5.59	5.22	5.26	*84.2%*
Emissions per GDP [kg CO2/€]	0.228	0.209	0.207	0.205	0.204	0.188	0.190	*83.2%*
Employment [mln]	24.95	25.55	25.89	25.64	25.69	25.78	25.80	*103.4%*
Unemployment rate [%]	9.3	8.4	7.8	9.5	9.7	9.6	10.2	*+0.5%*
NREAP targets	2005	2007	2008	2009	2010	2011	2012	2020
„RES/Energy” [%]	9.20	9.30	9.90	10.80	11.40	11.50	13.40	23.00
„RES /Electricity” [%]	10.98	12.96	14.07	13.62	14.45	12.84	16.60	28.50

Italy

Ranked eighteenth in terms of energy consumption per capita and nineteenth in terms of GHG emissions per capita in 2012. Consumption-based GHG emissions exceed the level of the territorial-based one by 51%. Compared to the 2005 there was observed increased number of habitants (by 4%) and GDP decreased by 3.3%. Energy consumption decreased by 13.5% and territorial-based GHG emissions decreased more (by 20.7%). Much less decreased consumption-based emissions (by 2.8% till 2011).

The government and RES industry plans regarding the role of renewable energy sources are far from each other. Italian NREAP is even a little bit less ambitious than the binding target established by the 2009/28/EC directive (by 0.8 % points). Till 2012 Italy was characterised by very good realisation of the both "RES" targets. Actually Italy exceeded the 2020 target for the "RES/Electricity" relation and is not far from achieving the "RES/Energy" one.

Despite of the drop in GDP development, employment increased by 1.5% but unemployment rate also increased compared to the year 2005.



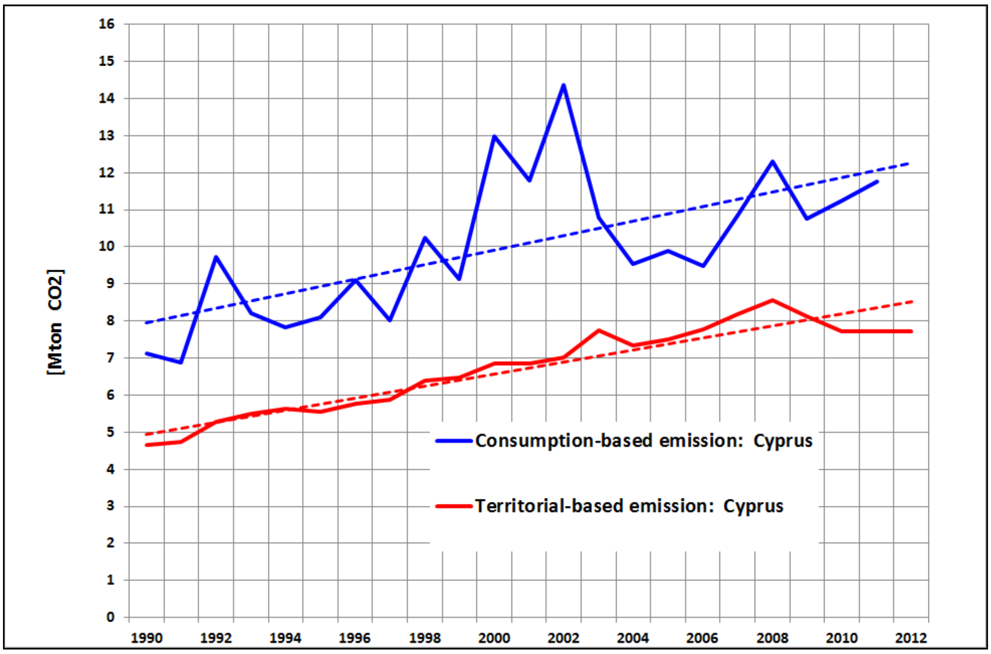
Italy	2005	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	1436	1493	1475	1394	1418	1425	1389	*96.7%*
Gross inland energy consumption [PJ]	7893	7752	7605	7116	7349	7241	6827	*86.5%*
Population [mln]	58.5	59.1	59.6	60.0	60.3	60.6	60.8	*104.0%*
Energy consumption per capita [GJ/person]	135.0	131.1	127.6	118.5	121.8	119.4	112.2	*83.1%*
Territorial-based emission CO2 [Mt]	473.3	462.6	447.1	401.6	406.3	396.4	375.4	*79.3%*
Consumption-based emission CO2 [Mt]	614.2	619.4	628.9	558.3	588.9	596.9		*97.2%*
Emission per capita [t CO2/person]	8.10	7.82	7.50	6.69	6.73	6.54	6.17	*76.2%*
Emission per GDP [kg CO2/€]	0.330	0.310	0.303	0.288	0.286	0.278	0.270	*82.0%*
Employment [mln]	22.56	23.22	23.40	23.03	22.87	22.97	22.90	*101.5%*
Unemployment rate [%]	7.7	6.1	6.7	7.8	8.4	8.4	10.7	*+3%*
NREAP targets	2005	2007	2008	2009	2010	2011	2012	2020
„RES/Energy" [%]	5.00	5.40	6.30	7.60	9.80	11.50	13.50	17.00
„RES /Electricity" [%]	13.73	13.25	16.19	20.54	22.23	23.64	27.60	26.40

Cyprus

Ranked sixteenth in terms of energy consumption per capita and fifth in terms of GHG emission per capita in 2012th. Consumption-based GHG emission exceeded the level of the territorial-based one by 52%. Compared to the 2005 there was observed increased number of habitants (by 15.1%) and growth of the GDP by 10.5%. Energy consumption decreased slightly by 0.3% but territorial-based GHG emission increased by 2.9% and the consumption-based one much more (by 18.9% till 2011th).

The government and RES industry plans regarding the role of renewable energy sources are very close to each other. Cyprian NREAP obligations are equal to the binding target established by the 2009/28/EC directive. Till 2011 Cyprus was characterised by poor realisation of both "RES" targets. Additionally in the case of Cyprus both "RES" targets are really ambitious and their achievement seems to be problematic.

With increase of the GDP, employment increased by 11.7% but unemployment rate also increased compared to the year 2005.



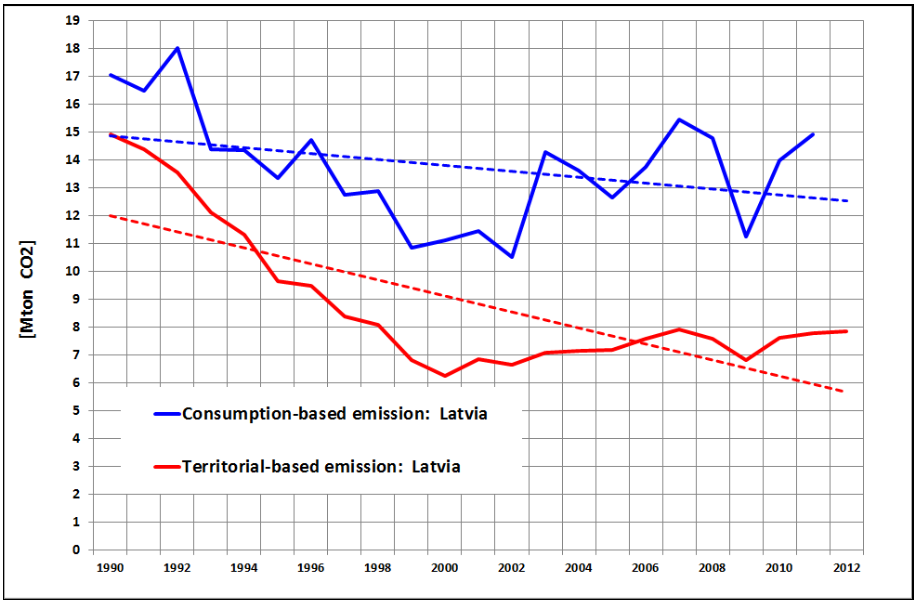
Cyprus	2005	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	14	15	15	15	15	15	15	*110.5%*
Gross inland energy consumption [PJ]	105	114	120	117	114	112	105	*99.7%*
Population [mln]	0.7	0.8	0.8	0.8	0.8	0.8	0.9	*115.1%*
Energy consumption per capita [GJ/person]	140.7	146.9	152.2	147.1	138.6	133.2	121.9	*86.6%*
Territorial-based emission CO2 [Mt]	7.5	8.2	8.6	8.1	7.7	7.7	7.7	*102.9%*
Consumption-based emission CO2 [Mt]	9.9	10.8	12.3	10.7	11.2	11.7		*118.9%*
Emission per capita [t CO2/person]	10.01	10.52	10.84	10.21	9.41	9.20	8.96	*89.4%*
Emission per GDP [kg CO2/€]	0.552	0.551	0.555	0.538	0.503	0.502	0.514	*93.2%*
Employment [mln]	0.35	0.38	0.38	0.38	0.40	0.40	0.39	*111.7%*
Unemployment rate [%]	5.3	3.9	3.7	5.4	6.3	7.9	11.9	*+6.6%*
NREAP targets	2005	2007	2008	2009	2010	2011	2012	2020
„RES/Energy" [%]	2.60	3.40	3.70	4.20	4.60	5.40	6.80	13.00
„RES /Electricity" [%]	0.01	0.06	0.27	0.07	0.70	2.53	4.90	16.00

Latvia

Ranked twenty forth in terms of energy consumption per capita and twenty sixth in terms of GHG emissions per capita in 2012. Consumption-based GHG emission was almost twice higher than the territorial-based one (exceed by 91%). Compared to the year 2005 there was observed decreased number of habitants (by 11.5%) and growth the GDP by 13.1%. Energy consumption increased by 1.2% and the territorial-based GHG emission increased also (by 9.5%). But consumption-based emission increased even more (by 17.8% till 2011).

The government and RES industry plans regarding the role of renewable energy sources energy sources are exactly the same. Lettish NREAP copies the binding targets established by the 2009/28/EC directive. Till 2012 Latvia was characterised by very poor realisation of the "RES" targets (actually the relation "RES/Electricity" was smaller in 2012 than in 2005) so the achievement of the targets is highly unlikely.

With poor GDP development, employment dramatically dropped by 15.3% and unemployment rate increased significantly compared to the year 2005.



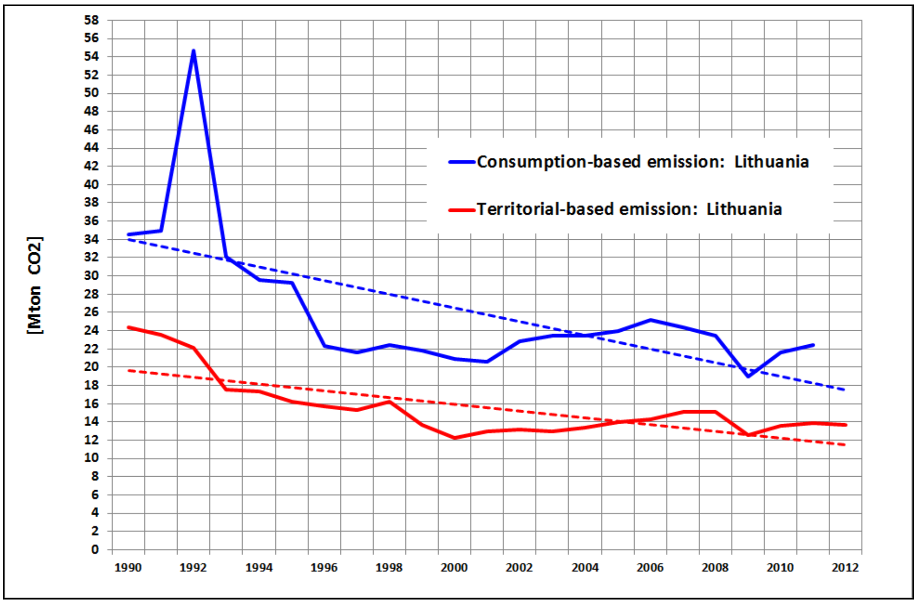
Latvia	2005	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	13	16	15	13	12	13	15	*113.1%*
Gross inland energy consumption [PJ]	188	199	192	181	190	178	190	*101.2%*
Population [mln]	2.3	2.3	2.3	2.3	2.2	2.1	2.0	*88.5%*
Energy consumption per capita [GJ/person]	81.4	87.4	84.7	80.1	84.5	85.6	93.0	*114.3%*
Territorial-based emission CO2 [Mt]	7.2	7.9	7.6	6.8	7.6	7.8	7.9	*109.5%*
Consumption-based emission CO2 [Mt]	12.7	15.4	14.8	11.2	14.0	14.9		*117.8%*
Emission per capita [t CO2/person]	3.11	3.47	3.34	3.02	3.39	3.76	3.85	*123.7%*
Emission per GDP [kg CO2/€]	0.555	0.502	0.495	0.540	0.611	0.594	0.538	*96.9%*
Employment [mln]	1.03	1.12	1.12	0.98	0.94	0.86	0.88	*84.7%*
Unemployment rate [%]	9.6	6.5	8.0	18.2	19.8	16.2	15.0	*+5.4%*
NREAP targets	2005	2007	2008	2009	2010	2011	2012	2020
„RES/Energy" [%]	32.20	29.60	29.80	34.20	32.50	33.10	35.80	40.00
„RES /Electricity" [%]	48.40	36.39	41.21	49.23	48.47	41.93	44.90	59.80

Lithuania

Ranked twenty third in terms of energy consumption per capita and twenty fifth in terms of GHG emissions per capita in 2012. Consumption-based GHG emission exceeded the level of the territorial-based one by 61%. Compared to the 2005 there was observed decreased number of habitants (by 12.2%) and growth of the GDP by 15.9%. Energy consumption decreased by 19.3% but the territorial-based GHG emission decreased only by 2.6% and the consumption-based one decreased by 6.4% (till 2011).

The government and RES industry plans regarding the role of renewable energy sources are far from each other. Lithuanian NREAP exceeds the binding targets established by the 2009/28/EC directive by 1.2%. Till 2012 Lithuania was characterised by not bad realisation of the "RES" targets and the realisation the "RES/Energy" one is possible. The progress in increasing "RES/electricity" relation is still negligible.

With poor GDP development, employment dramatically dropped by 13.3% and unemployment rate increased significantly compared to the year 2005.



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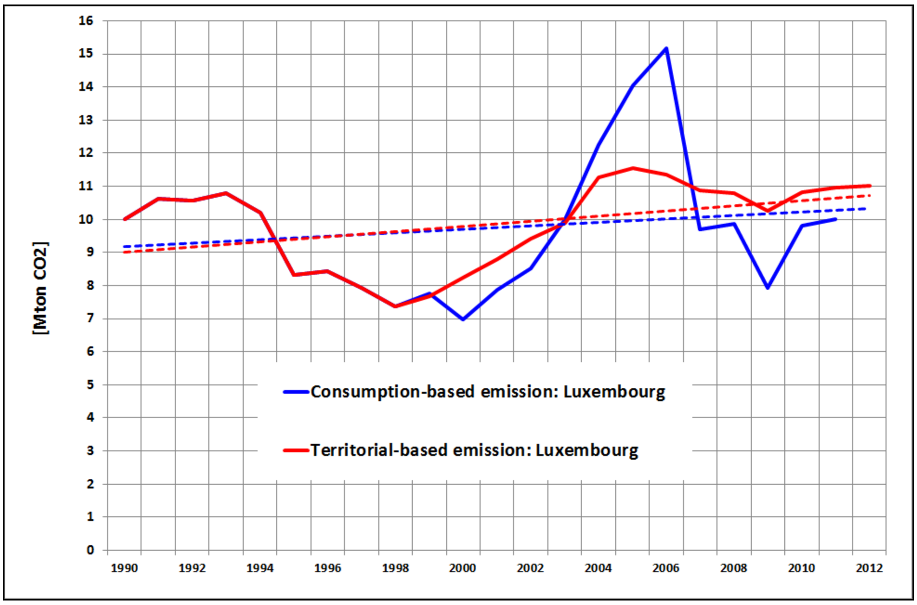
Lithuania	2005	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	21	25	26	22	22	23	24	*115.9%*
Gross inland energy consumption [PJ]	367	390	392	357	288	296	297	*80.7%*
Population [mln]	3.4	3.4	3.4	3.3	3.3	3.1	3.0	*87.8%*
Energy consumption per capita [GJ/person]	107.2	115.2	116.4	106.7	86.4	96.9	98.6	*92.0%*
Territorial-based emission CO2 [Mt]	14.0	15.1	15.1	12.6	13.6	13.9	13.6	*97.4%*
Consumption-based emission CO2 [Mt]	23.9	24.3	23.5	19.0	21.6	22.4		*93.6%*
Emission per capita [t CO2/person]	4.08	4.47	4.49	3.75	4.07	4.55	4.53	*111.0%*
Emission per GDP [kg CO2/€]	0.667	0.610	0.592	0.578	0.614	0.592	0.561	*84.1%*
Employment [mln]	1.47	1.53	1.52	1.42	1.25	1.25	1.28	*86.6%*
Unemployment rate [%]	8.0	3.8	5.3	13.6	18.0	15.4	13.4	*+5.4%*
NREAP targets	2005	2007	2008	2009	2010	2011	2012	2020
„RES/Energy" [%]	16.90	15.70	16.90	19.00	19.80	20.30	21.70	23.00
„RES /Electricity" [%]	3.89	4.60	4.65	5.50	7.76	9.63	10.90	21.30

Luxembourg

Luxembourg was an absolute leader regarding the energy consumption per capita and the GHG emission per capita in 2012. The level of the consumption-based GHG emission is lower than the level of the territorial-based one by 9%. Compared to the 2005 there was observed increased number of habitants (by 13.8%) and GDP growth by 10%. Energy consumption decreased by 7.5% and the territorial-based GHG emission decreased less (by 4.5%). The consumption-based emission decreased much more (by 29.8% till 2011[th]).

The government and RES industry plans regarding the role of renewable energy sources are relatively not far from each other. Luxembourgian NREAP is less ambitious than the binding target established by the 2009/28/EC directive (by 2.1 % points). Till 2011 Luxembourg was characterised by really poor realisation of the "RES" targets and regarding this the realisation of both goals seemed to be unlikely.

Despite poor GDP development, employment significantly increased by 22% and unemployment rate increased slightly in comparison to the year 2005

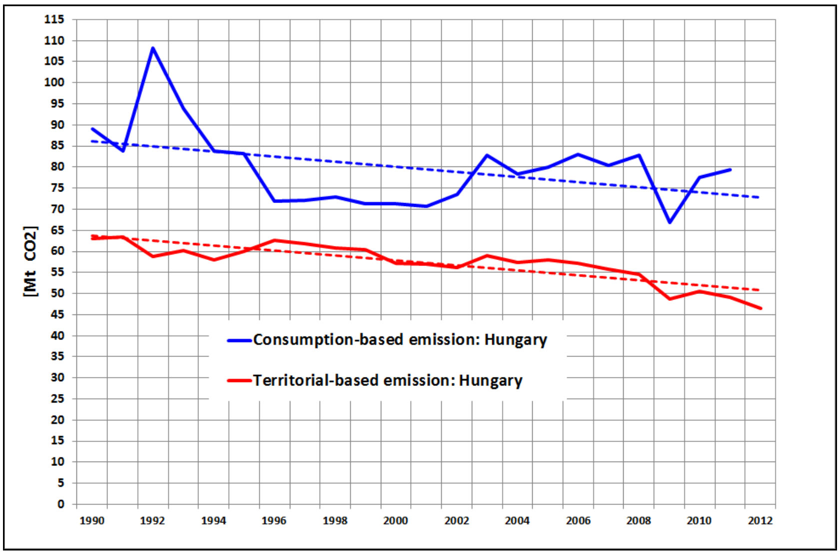


Luxembourg	2005	2006	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	30	32	34	34	32	33	33	33	*110.0%*
Gross inland energy consumption [PJ]	202	198	195	195	183	195	192	186	*92.5%*
Population [mln]	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	*113.8%*
Energy consumption per capita [GJ/person]	436.9	422.5	408.8	402.2	371.6	388.3	375.1	355.3	*81.3%*
Territorial-based emission CO2 [Mt]	11.5	11.4	10.9	10.8	10.2	10.8	11.0	11.0	*95.5%*
Consumption-based emission CO2 [Mt]	14.0	15.2	9.7	9.9	7.9	9.8	10.0		*71.2%*
Emission per capita [t CO2/person]	25.03	24.21	22.82	22.30	20.77	21.57	21.44	21.00	*83.9%*
Emission per GDP [kg CO2/€]	0.381	0.358	0.321	0.321	0.323	0.331	0.329	0.331	*86.8%*
Employment [mln]	0.19	0.20	0.20	0.20	0.22	0.22	0.22	0.24	*122.0%*
Unemployment rate [%]	4.6	4.6	4.2	4.9	5.1	4.6	4.8	5.1	*+0.5%*
NREAP targets	2005	2006	2007	2008	2009	2010	2011	2012	2020
„RES/Energy" [%]	1.40	1.50	1.70	1.80	1.90	2.90	2.90	3.10	11.00
„RES /Electricity" [%]	2.85	3.12	3.33	3.58	3.66	3.09	2.95	4.60	11.80

Hungary

Ranked twenty second in terms of energy consumption per capita and twenty fourth in terms of GHG emissions per capita in 2012. Consumption-based GHG emission exceed the level of the territorial-based one by 62%. Compared to the 2005 there was observed decreased number of habitants (by 1.4%) and GDP decrease by 1.3%. Energy consumption decreased by 14.9% and the territorial-based GHG emission decreased even more (by 19.7%). On the contrary consumption-based emission decreased much less than consumption of energy (by 0.7% till 2011).

The government and RES industry plans regarding the role of renewable energy sources are far from each other. Hungarian NREAP exceeds the binding targets established by the 2009/28/EC directive by 1.7%. Till 2011 Hungary was characterised by not so bad realisation of the "RES/Energy" target and rather less impressive realisation of the "RES/Electricity" one. Regarding not so huge remaining challenge the both goals are achievable, but concerning a poor state of Hungarian economy the success can be problematic. With very poor GDP development, employment slightly dropped by 0.6% and unemployment rate increased in comparison to the year 2005.



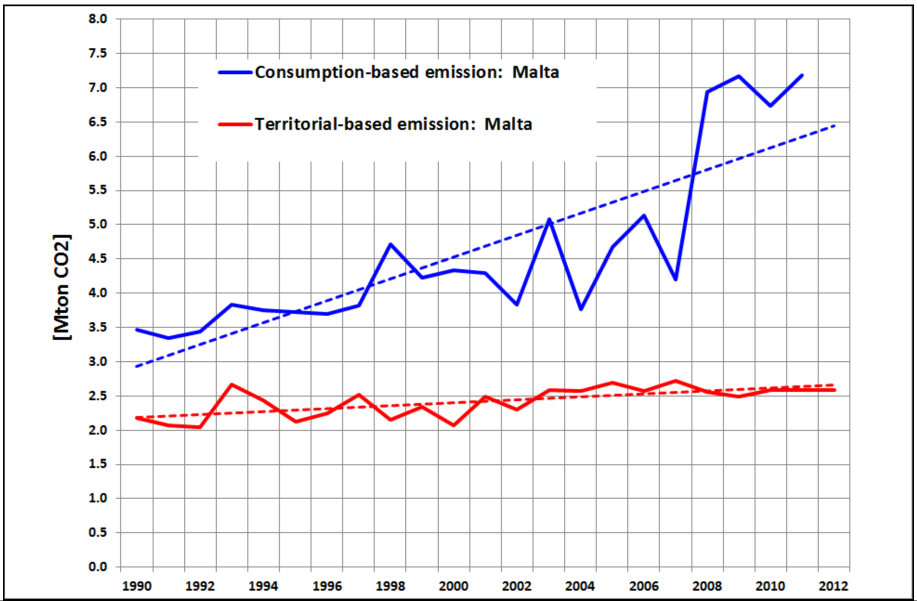
Hungary	2005	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	89	92	93	87	88	89	88	*98.7%*
Gross inland energy consumption [PJ]	1160	1128	1122	1062	1088	1056	987	*85.1%*
Population [mln]	10.1	10.1	10.0	10.0	10.0	10.0	10.0	*98.6%*
Energy consumption per capita [GJ/person]	114.9	112.1	111.7	105.8	108.6	105.8	99.1	*86.3%*
Territorial-based emission CO2 [Mt]	57.9	55.9	54.7	48.7	50.6	49.1	46.5	*80.3%*
Consumption-based emission CO2 [Mt]	80.0	80.3	82.7	66.8	77.5	79.4		*99.3%*
Emission per capita [t CO2/person]	5.74	5.55	5.44	4.85	5.05	4.92	4.67	*81.4%*
Emission per GDP [kg CO2/€]	0.652	0.605	0.587	0.560	0.576	0.551	0.530	*81.3%*
Employment [mln]	3.90	3.93	3.88	3.78	3.78	3.81	3.88	*99.4%*
Unemployment rate [%]	7.2	7.4	7.8	10.0	11.2	10.9	10.9	*+3.7%*
NREAP targets	2005	2007	2008	2009	2010	2011	2012	2020
„RES/Energy" [%]	4.50	5.70	5.60	7.00	7.60	8.10	9.60	13.00
„RES /Electricity" [%]	4.45	4.29	5.36	6.99	7.09	6.35	6.10	10.90

Malta

Ranked twenty fifth in terms of energy consumption per capita and eighteenth in terms of GHG emission per capita in 2012. Consumption-based GHG emission is almost three times higher than the territorial-based one (exceeded by 177%). Compared to the 2005 there was observed increased number of habitants (by 3.7%) and GDP growth by 14.8%. Energy consumption decreased by 6.2 % but territorial-based GHG emission increased by 53.8% (till 2011).

The government and RES industry plans regarding the role of renewable energy sources are not so close to each other. Maltese NREAP exceeds the binding target established by the 2009/28/EC directive only by 0.2% point. Till 2012 Malta was characterised by the worst realisation of the both "RES" targets. Additionally in the case of Malta the both "RES" targets are not small so their achievement seems to be unlikely.

With increase of the GDP, employment increase by 16.2% and unemployment rate decreased compare to the year 2005.

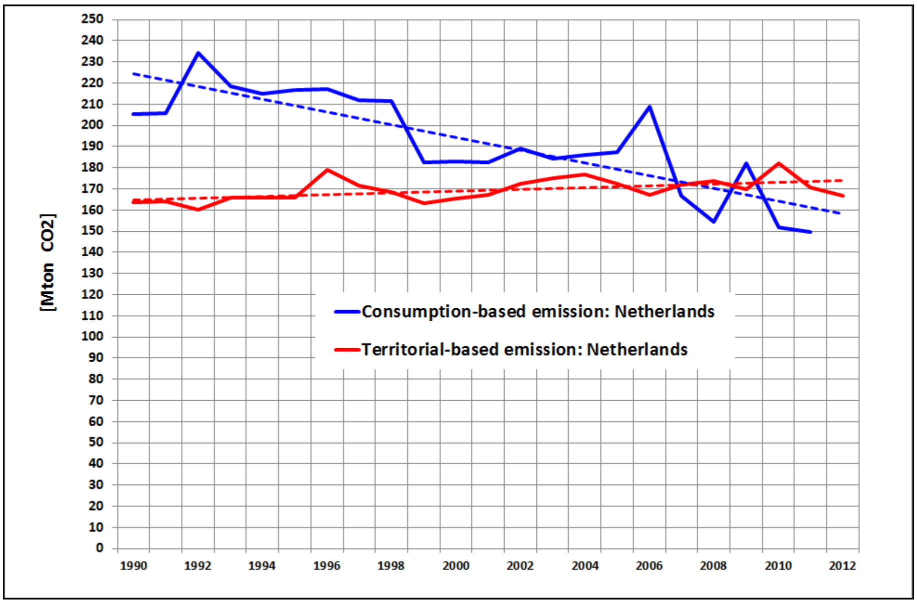


Malta	2005	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	5	5	5	5	6	6	6	*114.8%*
Gross inland energy consumption [PJ]	41	40	40	35	40	47	38	*93.8%*
Population [mln]	0.4	0.4	0.4	0.4	0.4	0.4	0.4	*103.7%*
Energy consumption per capita [GJ/person]	100.7	99.2	98.4	85.4	96.1	113.5	91.1	*90.5%*
Territorial-based emission CO2 [Mt]	2.7	2.7	2.6	2.5	2.6	2.6	2.6	*95.9%*
Consumption-based emission CO2 [Mt]	4.7	4.2	6.9	7.2	6.7	7.2		*153.8%*
Emission per capita [t CO2/person]	6.70	6.68	6.24	6.04	6.25	6.23	6.20	*92.5%*
Emission per GDP [kg CO2/€]	0.547	0.518	0.468	0.470	0.468	0.461	0.457	*83.6%*
Employment [mln]	0.15	0.16	0.16	0.16	0.16	0.17	0.17	*116.2%*
Unemployment rate [%]	7.3	6.5	6.0	6.9	6.9	6.5	6.4	*-0.9*
NREAP targets	2005	2007	2008	2009	2010	2011	2012	2020
„RES/Energy" [%]	0.00	0.00	0.00	0.00	0.20	0.40	1.40	10.00
„RES /Electricity" [%]	0.00	0.00	0.00	0.00	0.00	0.00	1.10	13.80

Netherlands

Ranked fifth in terms of energy consumption per capita and third in terms of GHG emissions per capita in 2012. The level of consumption-based GHG emission is lower than the level of the territorial-based one by 12%. Compared to the 2005 there was observed increased number of habitants (by 2.6%) and GDP growth by 6.6%. Energy consumption decreased only by 0.7% but the territorial-based GHG emission a little bit more (by 3.3%). According to the Global Carbon Budget data consumption-based emission decreased by 20.2% (till 2011).

The government and RES industry plans regarding the role of renewable energy sources renewable energy sources are relatively not far from each other as the Dutch NREAP increased the binding targets for Netherlands established by the 2009/28/EC directive by 0.5 % point. Till 2011 the Netherlands were characterised by really bad realisation of the both "RES" targets. But regarding the distance remaining in the case of the Netherlands the achievement of both targets is very unlikely. With not so high GDP development, the employment increased by 3.9% and unemployment rate stayed unchanged compared to the year 2005.



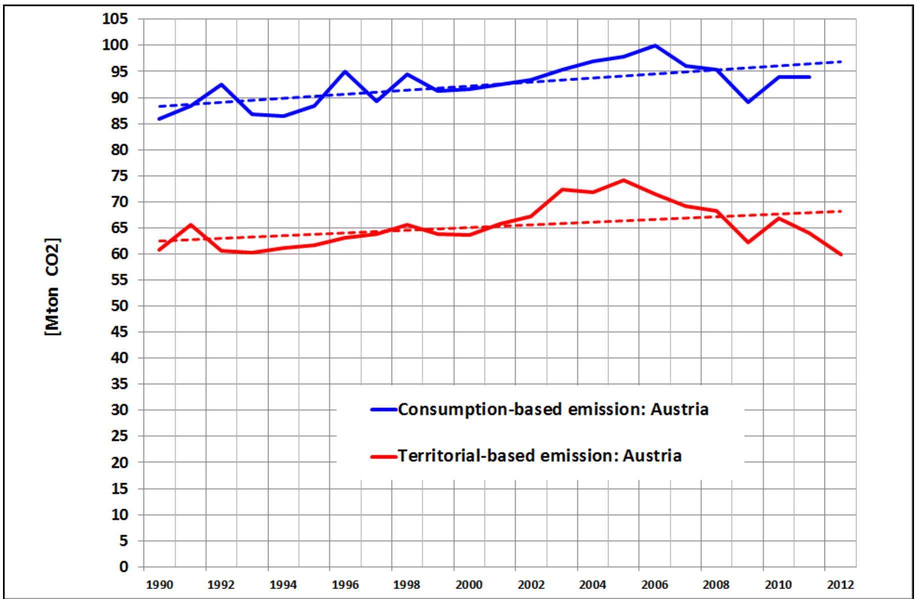
Netherlands	2005	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	513	552	562	541	549	554	548	*106.6%*
Gross inland energy consumption [PJ]	3455	3597	3514	3417	3644	3404	3432	*99.3%*
Population [mln]	16.3	16.4	16.4	16.5	16.6	16.7	16.7	*102.6%*
Energy consumption per capita [GJ/person]	211.9	219.9	214.2	207.3	219.8	204.4	205.2	*96.8%*
Territorial-based emission CO2 [Mt]	172.2	171.8	173.8	169.6	182.1	170.5	166.5	*96.7%*
Consumption-based emission CO2 [Mt]	187.2	166.9	154.5	181.9	151.6	149.4		*79.8%*
Emission per capita [t CO2/person]	10.56	10.50	10.60	10.29	10.98	10.24	9.95	*94.3%*
Emission per GDP [kg CO2/€]	0.335	0.311	0.310	0.314	0.331	0.308	0.304	*90.7%*
Employment [mln]	8.11	8.46	8.59	8.60	8.37	8.37	8.42	*103.9%*
Unemployment rate [%]	5.3	3.6	3.1	3.7	4.5	4.4	5.3	-
NREAP targets	2005	2007	2008	2009	2010	2011	2012	2020
"RES/Energy Consumption" [%]	2.10	2.40	2.70	3.30	3.30	4.30	4.50	14.00
"RES electricity/Electricity Consumption" [%]	6.28	6.18	7.72	9.15	9.26	10.09	10.50	37.00

Austria

Ranked eighth in terms of energy consumption per capita and fourteenth in terms of GHG emissions per capita in 2012. Consumption-based GHG emissions exceeded the level of the territorial-based one by 47%. Compared to the 2005, there was observed increased number of habitants (by 2.9%) and growth of the GDP by 10.7%. Energy consumption decreased by 2.2% and the territorial-based GHG emission decreased much more (by 19.4%). Much less decrease of consumption-based emission (by 4.1% till 2011).

The government and RES industry plans regarding the role of renewable energy sources are really far from each other. Austrian NREAP is only a little bit more ambitious than the binding target established by the 2009/28/EC directive (by 0.2 % point). Till 2012 Austria was characterised by very good realisation of the "RES/Energy" target and fluctuations in results for the "RES/Electricity" goal in the 2005-2012 period. Taking into account that in 2012 this target was almost fulfilled it is very likely that Austria will achieve both goals before 2020.

With not so high GDP development, employment increased by 9.4% and unemployment rate decreased compared to the year 2005.



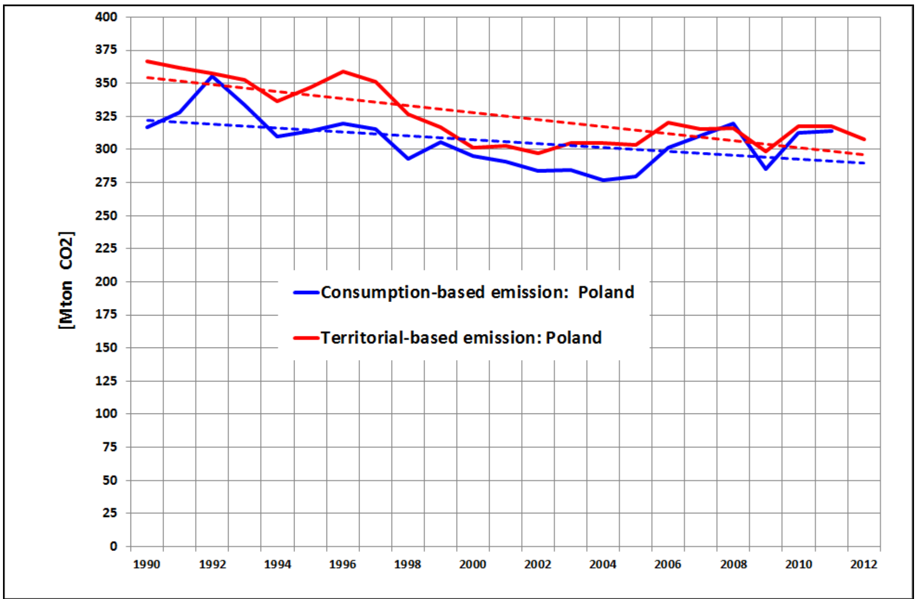
Austria	2005	2006	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	245	254	264	267	257	262	269	272	*110.7%*
Gross inland energy consumption [PJ]	1440	1446	1430	1437	1368	1466	1421	1409	*97.8%*
Population [mln]	8.2	8.3	8.3	8.3	8.4	8.4	8.4	8.4	*102.9%*
Energy consumption per capita [GJ/person]	175.6	175.2	172.6	172.8	163.8	175.1	169.1	166.9	*95.0%*
Territorial-based emission CO2 [Mt]	74.2	71.6	69.1	68.3	62.3	66.9	64.0	59.8	*80.6%*
Consumption-based emission CO2 [Mt]	97.9	100.0	96.0	95.3	89.2	94.0	93.9		*95.9%*
Emission per capita [t CO2/person]	9.05	8.67	8.35	8.21	7.45	7.99	7.61	7.08	*78.3%*
Emission per GDP [kg CO2/€]	0.303	0.281	0.262	0.255	0.242	0.256	0.238	0.220	*72.8%*
Employment [mln]	3.82	3.93	4.03	4.09	4.08	4.10	4.14	4.18	*109.4%*
Unemployment rate [%]	5.2	4.8	4.4	3.8	4.8	4.4	4.2	4.3	*-0.9*
NREAP targets	2005	2006	2007	2008	2009	2010	2011	2012	2020
„RES/Energy" [%]	23.70	24.40	26.10	26.90	28.40	30.40	30.90	32.10	34.00
„RES /Electricity" [%]	58.79	57.45	60.72	62.30	67.69	61.41	55.23	65.50	70.60

Poland

Ranked nineteenth in terms of energy consumption per capita and ninth in terms of GHG emissions per capita in 2012. One of five European states with net GHG emission "export": the territorial-based exceeded the level of consumption-based one by 1.0%. Compared to the 2005 there was observed increased number of habitants (by 1%) and GDP growth by 34.1%. Energy consumption increased by 5.3% and the territorial-based GHG emission increased much less (by 1.3%). The consumption-based emission increased much more (by 12.3% till 2011).

The government and RES industry plans regarding the role of renewable energy sources are relatively not so far from each other. Polish NREAP is only a little bit more ambitious than the binding target established by the 2009/28/EC directive (by 0.5 % point). Till 2011 Poland was characterised by not bad realisation of both "RES" targets and it is possible that both of them will be achieved.

With relatively high GDP development, employment increased by 10.5% and unemployment rate decreased significantly compared to the year 2005.



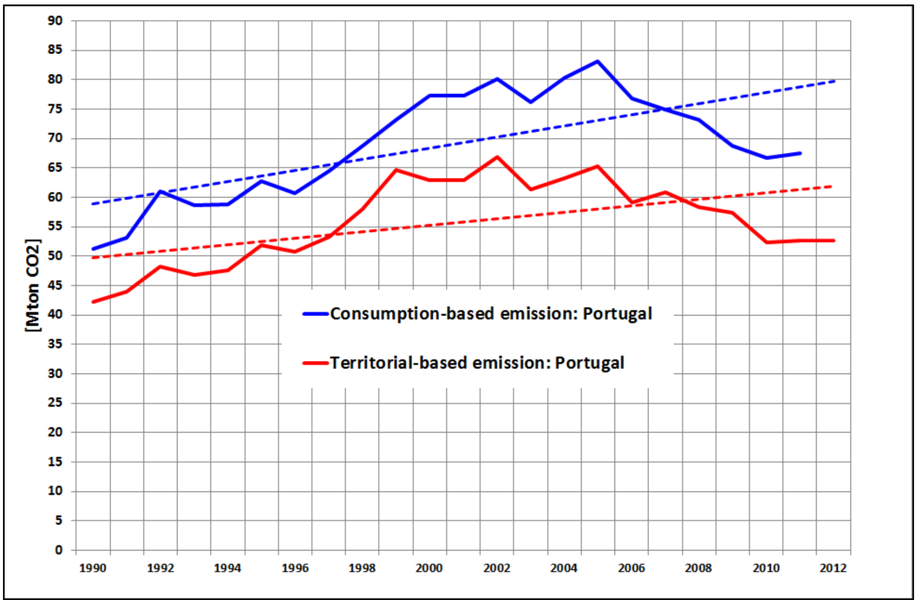
Poland	2005	2006	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	244	260	277	291	296	308	322	328	*134.1%*
Gross inland energy consumption [PJ]	3897	4099	4080	4145	3991	4261	4278	4102	*105.3%*
Population [mln]	38.2	38.2	38.1	38.1	38.1	38.2	38.5	38.5	*101.0%*
Energy consumption per capita [GJ/person]	102.1	107.4	107.0	108.8	104.6	111.6	111.0	106.4	*104.3%*
Territorial-based emission CO2 [Mt]	303.6	320.0	315.6	316.1	298.8	317.2	317.6	307.6	*101.3%*
Consumption-based emission CO2 [Mt]	279.8	301.4	310.5	319.9	285.2	312.5	314.2		*112.3%*
Emission per capita [t CO2/person]	7.95	8.39	8.28	8.29	7.83	8.31	8.24	7.98	*100.4%*
Emission per GDP [kg CO2/€]	1.242	1.232	1.138	1.084	1.009	1.031	0.987	0.938	*75.5%*
Employment [mln]	14.12	14.59	15.24	15.80	15.87	15.47	15.56	15.59	*110.5%*
Unemployment rate [%]	17.9	13.9	9.6	7.1	8.1	9.7	9.7	10.1	*-7.8*
NREAP targets	2005	2006	2007	2008	2009	2010	2011	2012	2020
„RES/Energy" [%]	6.90	6.90	6.80	7.20	7.80	9.30	10.40	11.00	15.00
„RES /Electricity" [%]	2.64	2.85	3.53	4.27	5.80	6.97	8.30	10.70	19.10

Portugal

Ranked twenty sixth in terms of energy consumption per capita and twenty second in terms of GHG emissions per capita in 2012. Consumption-based GHG emission exceeded the level of the territorial-based one by 28%. Compared to the 2005 there was observed increased number of habitants (by 0.1%) and GDP growth by 1.8%. Energy consumption decreased by 19% and territorial-based GHG emission decreased by 19.3%. Similarly, there was decrease of consumption-based emission (by 18.9% till 2011[th]).

The government and RES industry plans regarding the role of renewable energy sources renewable energy sources are far from each other. Portuguese NREAP copies the binding target established by the 2009/28/EC directive. Till 2011 Portugal was characterised by excellent realisation of the "RES/Energy" target and even better realisation the "RES/Electricity" one. Due to these achievements in the case of Portugal the "RES" goals could be fulfilled despite the weakened economy.

With very weak GDP development, employment dropped by 9.5% and unemployment rate increased significantly compared to the year 2005 exceeding 15.9%.



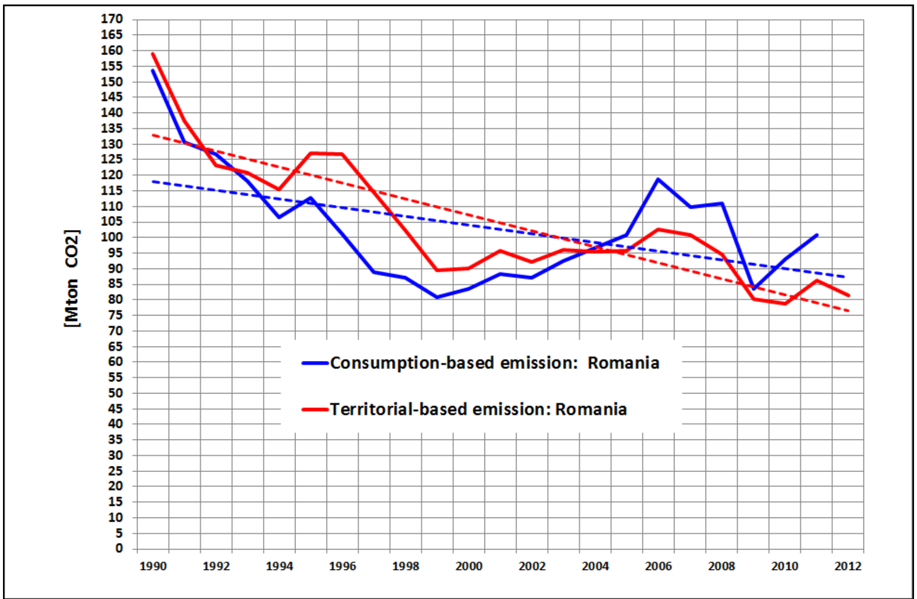
Portugal	2005	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	154	160	160	156	159	157	152	*98.2%*
Gross inland energy consumption [PJ]	1147	1100	1055	1044	1020	1001	930	*81.0%*
Population [mln]	10.5	10.6	10.6	10.6	10.6	10.6	10.5	*100.1%*
Energy consumption per capita [GJ/person]	109.0	103.8	99.4	98.2	95.9	94.6	88.2	*80.9%*
Territorial-based emission CO2 [Mt]	65.3	60.9	58.4	57.4	52.4	52.7	52.7	*80.7%*
Consumption-based emission CO2 [Mt]	83.1	74.9	73.2	68.7	66.8	67.4		*81.1%*
Emission per capita [t CO2/person]	6.20	5.74	5.50	5.40	4.92	4.98	5.00	*80.6%*
Emission per GDP [kg CO2/€]	0.423	0.380	0.364	0.369	0.330	0.336	0.348	*82.1%*
Employment [mln]	5.12	5.17	5.20	5.05	4.98	4.84	4.63	*90.5%*
Unemployment rate [%]	8.6	8.9	8.5	10.6	12.0	12.9	15.9	*+ 7.3*
NREAP targets	2005	2007	2008	2009	2010	2011	2012	2020
„RES/Energy" [%]	19.80	21.30	22.30	23.40	22.70	24.90	24.60	31.00
„RES /Electricity" [%]	15.47	29.63	26.42	33.27	49.99	43.62	47.60	55.20

Romania

The very last state regarding the energy consumption per capita and regarding the GHG emissions per capita in 2012. Consumption-based GHG emission exceed the level of the territorial-based one by 17%. Compared to the 2005 there was observed decreased number of habitants (by 1.4%) and GDP growth by 17%. Energy consumption decreased by 10.1% and territorial-based GHG emission decreased more (by 14.9%). The consumption-based emission in 2011th was the same as in 2005.

The government and RES industry plans regarding the role of renewable energy sources renewable energy sources are very close to each other. Romanian NREAP copies the binding target established by the 2009/28/EC directive. Till 2012 Romania was characterised by relatively good realisation of the "RES/Energy" target and fluctuations in results for the "RES/Electricity" goal in the 2005-2012th period. It is very likely that Romania will achieve only one target – concerning "RES/Energy" relation.

With weak GDP development employment increased by 1.6% and unemployment rate decreased slightly compared to the year 2005.



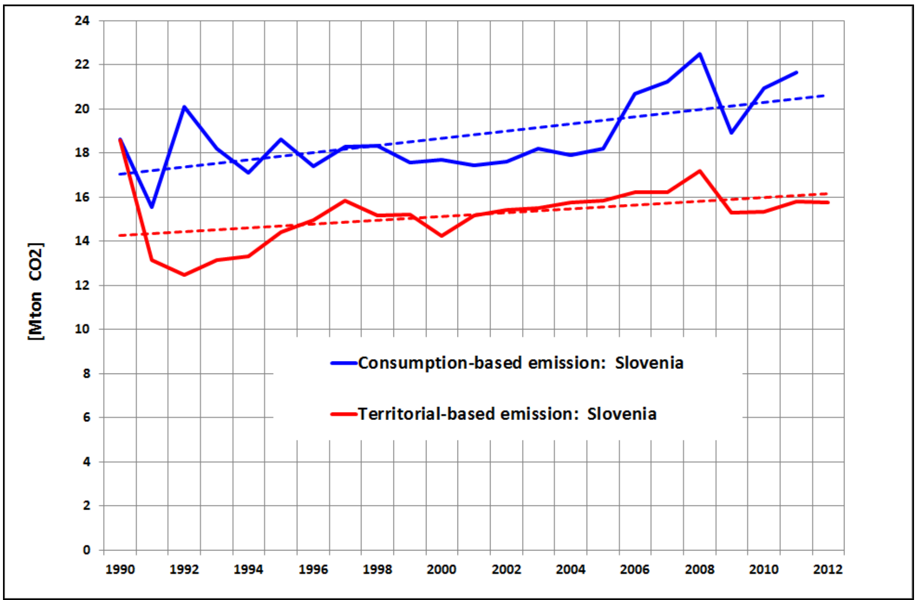
Romania	2005	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	80	92	98	92	91	93	93	*117.0%*
Gross inland energy consumption [PJ]	1647	1699	1695	1487	1493	1522	1481	*89.9%*
Population [mln]	21.7	21.6	21.5	21.5	21.5	21.4	21.4	*98.6%*
Energy consumption per capita [GJ/person]	76.1	78.8	78.8	69.1	69.6	71.1	69.3	*91.2%*
Territorial-based emission CO2 [Mt]	95.7	101.0	94.6	80.3	78.7	86.1	81.4	*85.1%*
Consumption-based emission CO2 [Mt]	100.8	109.6	111.0	83.5	93.2	100.8		*100.0%*
Emission per capita [t CO2/person]	4.42	4.68	4.40	3.74	3.67	4.02	3.81	*86.3%*
Emission per GDP [kg CO2/€]	1.199	1.103	0.963	0.875	0.868	0.929	0.873	*72.8%*
Employment [mln]	9.11	9.35	9.37	9.24	9.24	9.14	9.26	*101.6%*
Unemployment rate [%]	7.2	6.4	5.8	6.9	7.3	7.4	7.0	*-0.2*
NREAP targets	2005	2007	2008	2009	2010	2011	2012	2020
„RES/Energy" [%]	17.60	18.20	20.10	22.20	22.90	21.40	22.90	24.00
„RES /Electricity" [%]	35.77	26.86	28.37	27.91	34.18	27.05	33.60	42.60

Slovenia

Ranked eleventh in terms of energy consumption per capita and in terms of GHG emissions per capita in 2012. Consumption-based GHG emission exceed the level of the territorial-based one by 37%. Compared to the 2005 there was observed increased number of habitants (by 2.9%) and GDP growth by 7.1%. Energy consumption decreased by 4.1% and territorial-based GHG emission decreased less (by 0.7%). On the contrary the consumption-based emission increased by 18.9% (till 2011[th]).

The government and RES industry plans regarding the role of renewable energy sources are far from each other. Slovenian NREAP increases the binding target established by the 2009/28/EC directive by 0.3 points. Till 2012 Slovenia was characterised by relatively slow realisation of the "RES/Electricity" target and not bad realisation if the "RES/Energy" one. Taking this into account in case of Slovenia achievement the "RES/Electricity" goal seems to be rather problematic.

With weak GDP development, employment decreased by 2.7% and unemployment rate increased compare to the year 2005.



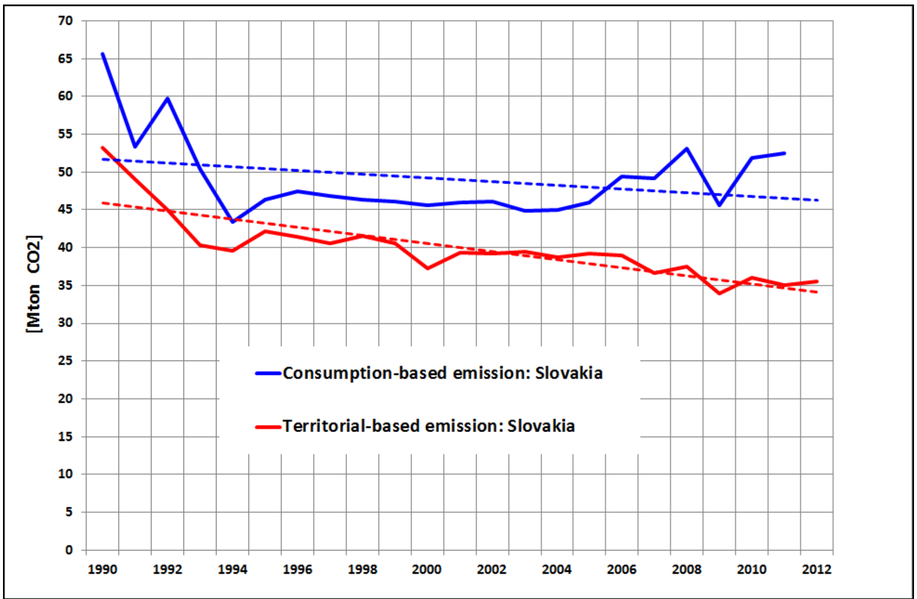
Slovenia	2005	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	29	33	34	31	31	32	31	*107.1%*
Gross inland energy consumption [PJ]	306	307	325	298	303	304	293	*95.9%*
Population [mln]	2.0	2.0	2.0	2.0	2.0	2.1	2.1	*102.9%*
Energy consumption per capita [GJ/person]	153.0	152.8	161.6	146.6	148.2	148.4	142.7	*93.2%*
Territorial-based emission CO2 [Mt]	15.9	16.2	17.2	15.3	15.3	15.8	15.8	*99.3%*
Consumption-based emission CO2 [Mt]	18.2	21.2	22.5	18.9	20.9	21.7		*118.9%*
Emission per capita [t CO2/person]	7.94	8.06	8.55	7.53	7.49	7.71	7.67	*96.5%*
Emission per GDP [kg CO2/€]	0.552	0.498	0.511	0.494	0.489	0.501	0.512	*92.7%*
Employment [mln]	0.95	0.99	1.00	0.98	0.97	0.94	0.92	*97.3%*
Unemployment rate [%]	6.5	4.9	4.4	5.9	7.3	8.2	8.9	*+ 2.4*
NREAP targets	2005	2007	2008	2009	2010	2011	2012	2020
„RES/Energy" [%]	16.00	15.40	14.60	18.40	19.60	18.80	20.20	25.00
„RES /Electricity" [%]	24.17	22.13	29.11	36.76	33.13	26.20	31.40	39.30

Slovakia

Ranked fourteenth state in terms of energy consumption per capita and sixteenth in terms of GHG emissions per capita in 2012. Consumption-based GHG emission exceeded the level of the territorial-based one by 50%. Compared to the 2005 there was observed increased number of habitants (by 0.4%) and GDP growth by 32.3%. Energy consumption decreased by 12.5% and territorial-based GHG emission decreased less (by 9.3%). On the contrary the consumption-based emission increased by 14.1% (till 2011).

The government and RES industry plans regarding the role of renewable energy sources are far from each other. Slovak NREAP increases the binding target established by the 2009/28/EC directive by 1.3 points. Till 2012 Slovenia was characterised by relatively slow realisation of the "RES/Energy" target and similar realisation the "RES/Electricity" one. Thus in the case of Slovakia the "RES" targets are not too high and are likely to be achieved.

With GDP development, employment increased by 5.1% and unemployment rate decreased compare to the year 2005.



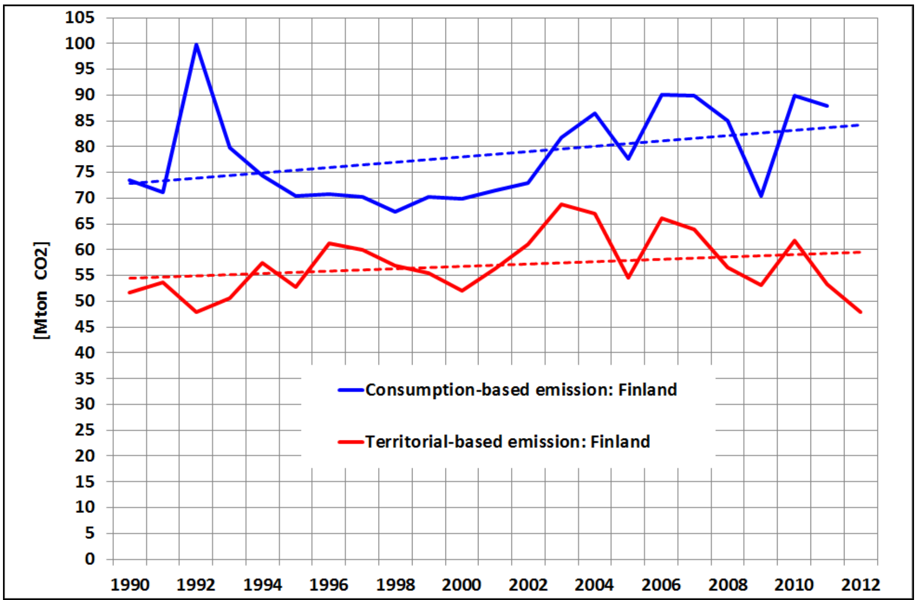
Slovakia	2005	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	38	46	49	46	48	50	51	*132.3%*
Gross inland energy consumption [PJ]	799	749	771	704	749	729	699	*87.5%*
Population [mln]	5.4	5.4	5.4	5.4	5.4	5.4	5.4	*100.4%*
Energy consumption per capita [GJ/person]	148.5	139.0	142.7	130.0	138.1	135.3	129.4	*87.2%*
Territorial-based emission CO2 [Mt]	39.2	36.6	37.6	33.9	36.1	35.0	35.5	*90.7%*
Consumption-based emission CO2 [Mt]	46.0	49.2	53.1	45.6	51.9	52.4		*114.1%*
Emission per capita [t CO2/person]	7.27	6.79	6.95	6.26	6.65	6.50	6.57	*90.4%*
Emission per GDP [kg CO2/€]	1.018	0.794	0.771	0.732	0.746	0.702	0.698	*68.6%*
Employment [mln]	2.22	2.36	2.43	2.37	2.32	2.32	2.33	*105.1%*
Unemployment rate [%]	16.4	11.2	9.6	12.1	14.5	13.7	14.0	*-2.4*
NREAP targets	2005	2007	2008	2009	2010	2011	2012	2020
„RES/Energy" [%]	6.50	7.60	7.50	8.90	8.50	9.70	10.40	14.00
„RES /Electricity" [%]	16.59	16.57	15.48	17.88	20.51	17.01	20.10	24.00

Finland

Ranked second in terms of energy consumption per capita and eighth in terms of GHG emissions per capita in 2012th. Consumption-based GHG emission exceeded the level of the territorial-based one by 65%. Compared to the 2005 there was observed increased number of habitants (by 3.1%) and GDP growth by 6.2%. Energy consumption decreased by 2.8% and territorial-based GHG emission decreased more (by 12.4%). The consumption-based emission increased significantly (by 13.1% till 2011).

The government and RES industry plans regarding the role of renewable energy sources are not so far from each other. Finish NREAP copies the binding target established by the 2009/28/EC directive. Till 2012 Finland was characterised by relatively slow realisation of the "RES/Energy" target and similar realisation of the "RES/Electricity" one. Thus in the case of Finland the "RES" targets are not too high it is likely that will be achieved.

Despite of weak GDP development employment increased by 3.4% and unemployment rate decreased compared to the year 2005.



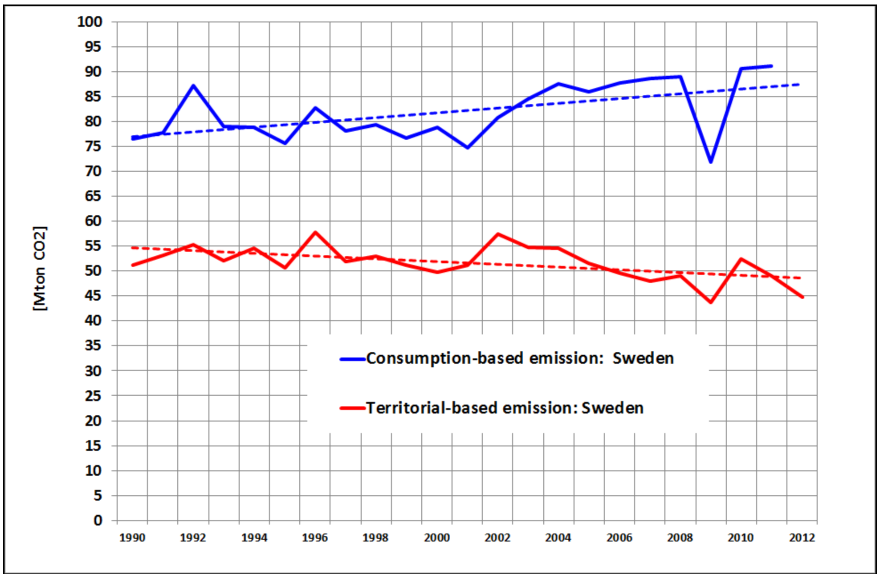
Finland	2005	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	157	173	174	159	164	169	167	*106.2%*
Gross inland energy consumption [PJ]	1468	1584	1521	1438	1567	1497	1427	*97.2%*
Population [mln]	5.2	5.3	5.3	5.3	5.4	5.4	5.4	*103.1%*
Energy consumption per capita [GJ/person]	280.4	300.2	287.0	270.0	292.8	278.4	264.2	*94.2%*
Territorial-based emission CO2 [Mt]	54.6	64.0	56.6	53.2	61.8	53.3	47.9	*87.6%*
Consumption-based emission CO2 [Mt]	77.7	89.9	85.1	70.3	89.9	87.8		*113.1%*
Emission per capita [t CO2/person]	10.43	12.12	10.68	9.98	11.56	9.91	8.86	*84.9%*
Emission per GDP [kg CO2/€]	0.347	0.369	0.326	0.335	0.377	0.316	0.286	*82.5%*
Employment [mln]	2.40	2.49	2.53	2.46	2.45	2.47	2.48	*103.4%*
Unemployment rate [%]	8.4	6.9	6.4	8.2	8.4	7.8	7.7	*-0.7*
NREAP targets	2005	2007	2008	2009	2010	2011	2012	2020
"RES/Energy Consumption" [%]	28.60	29.40	30.50	29.90	31.00	31.80	34.30	38.00
"RES electricity/Electricity Consumption" [%]	26.78	25.92	30.78	25.77	26.52	27.65	29.50	32.90

Sweden

Ranked third in terms of energy consumption per capita and twentieth in terms of GHG emissions per capita in 2012. Consumption-based GHG emission exceeded the level of the territorial-based one by 86%. Compared to the 2005 there was observed increased number of habitants (by 5.2%) and GDP growth by 12.6%. Energy consumption decreased by 3.8% and territorial-based GHG emission decreased significantly (by 13%). On the contrary the consumption-based emission increased by 6.1% till 2011.

The government and RES industry plans regarding the role of renewable energy sources are far from each other. Swedish NREAP increases the binding target established by the 2009/28/EC directive by 1.2% points. Till 2011 Sweden was characterised by relatively good realisation of the "RES/Energy" target and not much worse realisation the "RES/Electricity" one. Thus in the case of Sweden the "RES" targets are not too high it is very likely that will be achieved (actually RES/Electricity goal was already fulfilled in 2012th) .

Despite weak GDP development, employment increased by 7.1% but an the unemployment rate increased slightly.



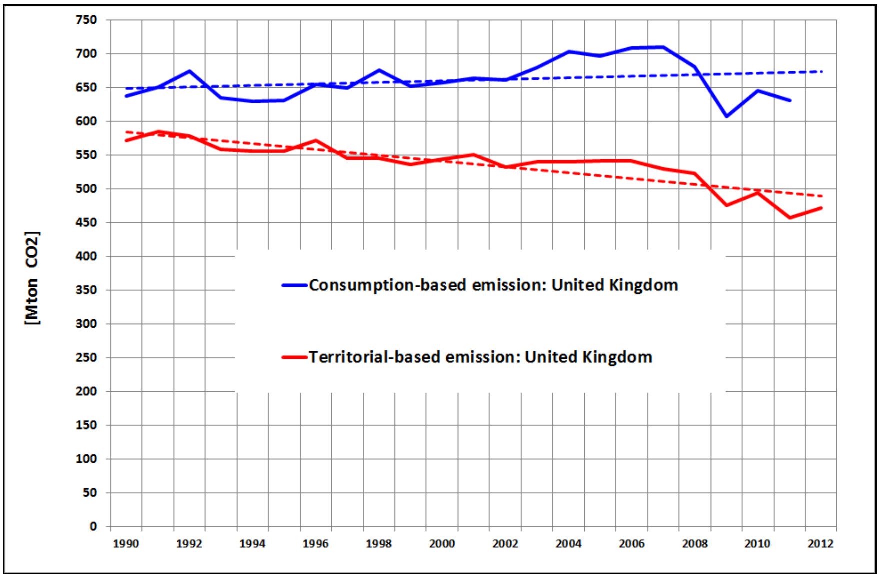
Sweden	2005	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	298	321	320	303	323	333	336	*112.6%*
Gross inland energy consumption [PJ]	2166	2104	2093	1915	2157	2073	2085	*96.2%*
Population [mln]	9.0	9.1	9.2	9.3	9.3	9.4	9.5	*105.2%*
Energy consumption per capita [GJ/person]	240.4	230.9	227.9	206.9	230.9	220.2	219.8	*91.5%*
Territorial-based emission CO2 [Mt]	51.6	48.1	49.1	43.7	52.5	49.1	44.9	*87.0%*
Consumption-based emission CO2 [Mt]	85.9	88.6	88.9	71.9	90.7	91.2		*106.1%*
Emission per capita [t CO2/person]	5.72	5.27	5.35	4.73	5.62	5.21	4.73	*82.7%*
Emission per GDP [kg CO2/€]	0.173	0.149	0.154	0.144	0.162	0.147	0.133	*77.3%*
Employment [mln]	4.35	4.54	4.59	4.50	4.52	4.63	4.66	*107.1%*
Unemployment rate [%]	7.7	6.1	6.2	8.3	8.6	7.8	8.0	*+ 0.3*
NREAP targets	2005	2007	2008	2009	2010	2011	2012	2020
„RES/Energy" [%]	39.90	43.00	43.90	46.50	47.90	46.80	51.00	49.00
„RES /Electricity" [%]	53.78	51.54	54.98	56.44	54.48	58.72	60.00	62.90

United Kingdom

Ranked thirteenth in terms of energy consumption per capita and twelve in terms of GHG emissions per capita in 2012. Consumption-based GHG emission exceeded the level of the territorial-based one by 38%. Compared to the 2005 there was observed increased number of habitants (by 5.4%) and GDP growth by 2.9%. Energy consumption decreased by 13.5% and similar territorial-based GHG emission (by 13.1%). Slightly less decrease of the consumption-based emission (by 9.5% till 2011th).

The government and RES industry plans regarding the role of renewable energy sources are far from each other. British NREAP copies the binding target established by the 2009/28/EC directive. Till 2012 the United Kingdom was characterised by relatively very poor realisation of the "RES/Energy" target and better realisation the "RES/Electricity" one. Regarding really ambitious targets combined with poor realisation in the case of the United Kingdom makes meeting the "RES" targets unlikely to be achieved.

With weak GDP development, employment increased only by 2.7% and the unemployment rate increased significantly compared to the year 2005.



United Kingdom	2005	2007	2008	2009	2010	2011	2012	2012/2005
GDP (mld €)	1867	1984	1969	1867	1898	1919	1922	*102.9%*
Gross inland energy consumption [PJ]	9793	9308	9181	8665	8885	8322	8470	*86.5%*
Population [mln]	60.0	60.8	61.2	61.6	62.0	62.5	63.3	*105.4%*
Energy consumption per capita [GJ/person]	163.1	153.1	150.0	140.7	143.2	133.1	133.9	*82.1%*
Territorial-based emission CO2 [Mt]	541.9	528.9	522.4	475.1	493.5	457.2	471.1	*86.9%*
Consumption-based emission CO2 [Mt]	696.5	709.8	681.2	607.6	645.8	630.7		*90.5%*
Emission per capita [t CO2/person]	9.03	8.70	8.54	7.71	7.96	7.31	7.45	*82.5%*
Emission per GDP [kg CO2/€]	0.290	0.267	0.265	0.254	0.260	0.238	0.245	*84.5%*
Employment [mln]	28.67	29.12	29.36	28.92	28.94	29.08	29.43	*102.7%*
Unemployment rate [%]	4.8	5.3	5.6	7.6	7.8	8.0	7.9	*+ 3.1*
NREAP targets	2005	2007	2008	2009	2010	2011	2012	2020
„RES/Energy" [%]	1.30	1.60	1.90	2.30	3.30	3.80	4.20	15.00
„RES /Electricity" [%]	4.16	4.88	5.40	6.63	6.71	9.20	10.80	31.00

3.2.4 Social and economic conditions influencing the realisation of the climate policy

The data from Eurostat database were used to expand the scope of regions distinguished by WP2 team. The inter-region differences have been presented, based on the statistical data, for the following countries:

- Central Europe (Austria, Belgium, Germany, Netherlands and Switzerland);
- Eastern Europe (Bulgaria, Czech Republic, Estonia, Latvia, Lithuania, Hungary, Poland, Romania, and Slovenia);
- Mediterranean[52] (France, Spain, Portugal Greece and Italy);
- Northern Europe (Denmark, Finland, Ireland, Norway, Sweden and United Kingdom).

The data set for Eastern Europe region does not include data for Croatia, but the additional data for Czech Republic, Estonia, Latvia, Lithuania and Romania were used. The Mediterranean region includes additionally Greece. The numerical values concerning certain factors for the regions were calculated as weighted average. The populations of the countries were used as the weights.

The first group of the calculated factors concerns the differences in the living conditions among the regions. The results are presented on Fig. 24 and in Tab. 11. The next group concerns the differences in societies mobility practises and habits. The results are presented on Fig. 25 and in Tab. 12. The last factors were taken from the perception survey, conducted in 2009 in European cities and published by Eurostat. For the purposes of this work, the respondents answers concerning their opinion on fight again the climate change and primary used mean of transport to get to work or training place were used. To calculate the weighted averages for the regions, the populations of the following cities were used:

- Central Europe (Brussels, Berlin, Amsterdam, Vienna)
- Eastern Europe (Sophia, Tallinn, Vilnius, Budapest, Warsaw, Ljubljana, Bucharest, Zagreb)
- Mediterranean (Athens, Madrid, Paris, Roma)
- Northern Europe (Copenhagen, Dublin, Helsinki, Stockholm, London)

The results are presented on the Fig. 26 and in the Tab.13.

[52] In following tables word *Mediterranean* is replaced by *South EU*

Living conditions

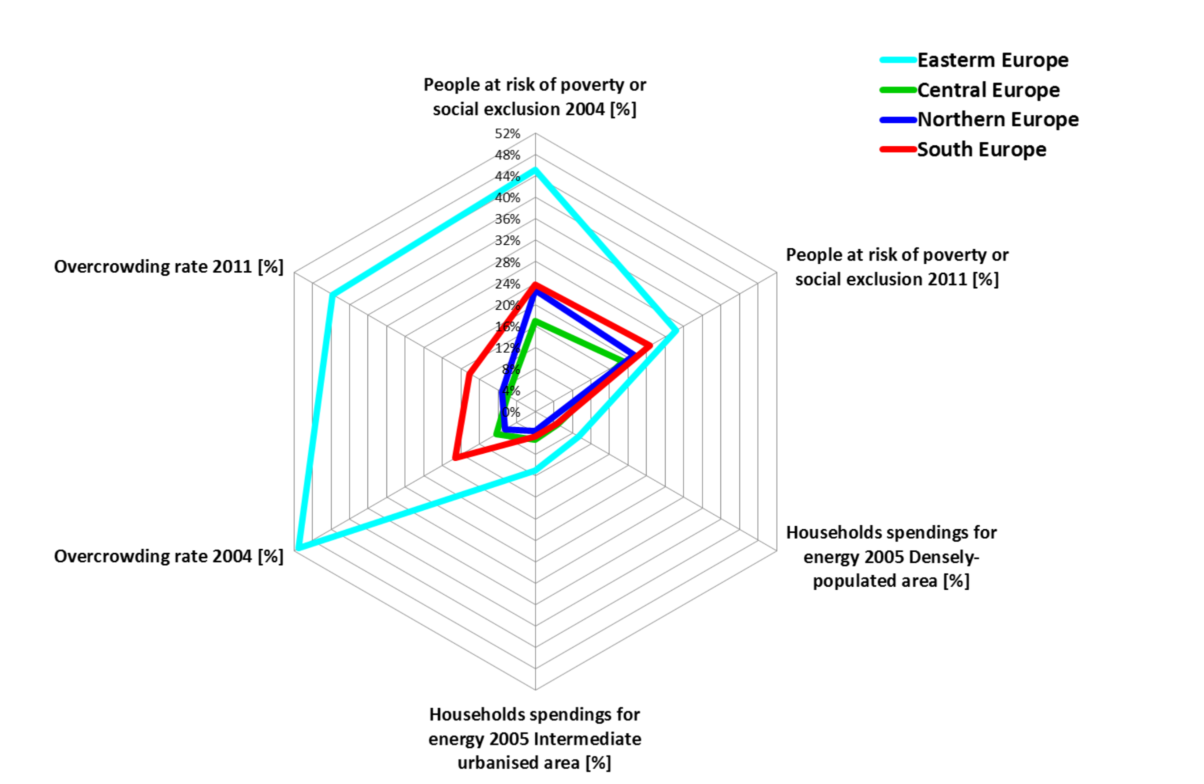


Fig. 25 - The differences among regions in scale of poverty and social conditions in 2004 and 2011

Population of the Eastern Europe region lives in much worse conditions than the rest of Europe. According to the Eurostat data description, the indicator defining people at risk of poverty or social exclusion is determine in the following way:

"The indicator sums up the number of persons who are at risk of poverty, severely materially deprived or living in households with very low work intensity. Persons present in several sub-indicators are counted only once. Persons at risk of poverty have an equivalised disposable income below 60% of the national median equivalised disposable income after social transfers. Material deprivation covers indicators relating to economic strain and durables. Persons are considered living in households with very low work intensity if they are aged 0-59 and the working age members in the household worked less than 20% of their potential during the past year.[53]"

Despite the progress made in years 2004-2011, in 2011 the percentage of people being at risk of poverty of social exclusion was still exceeding 30%. Regarding the number of dwellings, which at the moment is not sufficient for people living in the region, the improvement is slower than in case of living of poverty. Concerning share of spending for energy in households budget, in average it reached 10% (what is assumed as definition of living in fuel poverty). In Northern Europe share of spending for energy in budget is 3 times smaller and in Central and South regions 2 times

[53] Source: http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/en/t2020_50_esmsip.htm

smaller. This is caused by lower incomes in Eastern Europe, regardless smaller in absolute values, spending for energy than in the other regions.

Remaining three regions (North, Central and South Europe) do not differ significantly one from each other. Poverty margin is a little bit smaller in Central Europe and overcrowding rate is higher in South Europe. All the numbers are presented in Tab. 11.

	Eastern Europe	Central Europe	Northern Europe	South Europe
People at risk of poverty or social exclusion 2004 [%]	45.2%	17.0%	22.6%	23.7%
People at risk of poverty or social exclusion 2011 [%]	30.3%	18.8%	21.2%	24.7%
Households spending for energy 2005 Densely-populated area [%]	9.3%	4.8%	3.1%	4.6%
Households spending for energy 2005 Intermediate urbanised area [%]	11.0%	5.3%	3.6%	4.6%
Overcrowding rate 2004 [%]	51.0%	8.4%	6.6%	17.3%
Overcrowding rate 2011 [%]	43.6%	5.9%	7.2%	14.2%

Tab. 11 - The differences among regions in scale of poverty and social conditions in 2004 and 2011
Source: EnergSys based on data from Eurostat

Mobility customs

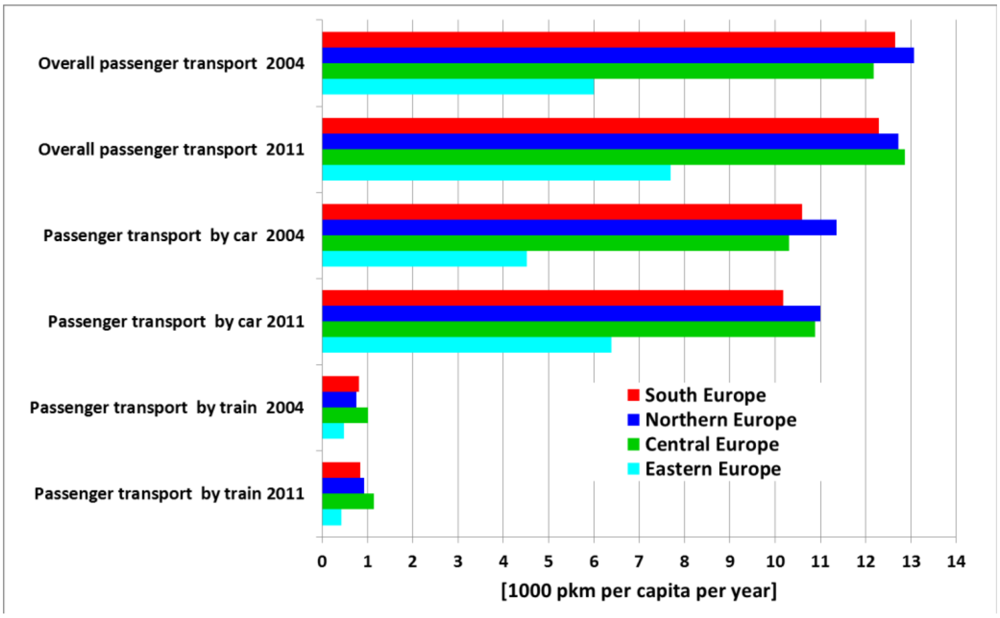


Fig. 26 - The differences among regions in overall mobility and in car use in 2004 and 2011
Source: EnergSys based on data from Eurostat

Eastern Europe region also clearly substantially deviates from the other regions concerning mobility habits and car use. East Europe citizens generally travel less frequently than the citizens of the other regions, but the difference is decreasing. Overall mobility increased in 2004-2011 in Eastern Europe by 28% and the use of cars increased by 41%. On the contrary to the other regions, there was observed decrease in the use of trains.

The overall mobility within the three other regions stayed almost unchanged. In Central Europe during 2004-2011 the overall mobility increased by 5.6% and in the Northern and South regions decreased by 2-3%. Even though the train use increased in these three regions, the role of train as a mean of transport is still marginal.

1000 pkm/y per capita	Eastern Europe	Central Europe	Northern Europe	South Europe
Passenger transport by train 2011	0.43	1.15	0.92	0.84
Passenger transport by train 2004	0.48	1.01	0.75	0.81
Passenger transport by car 2011	6.38	10.89	11.00	10.18
Passenger transport by car 2004	4.52	10.31	11.36	10.59
Overall passenger transport 2011	7.69	12.86	12.72	12.29
Overall passenger transport 2004	6.00	12.18	13.06	12.65
Change in the overall mobility 2011/2004	*128.3%*	*105.6%*	*97.4%*	*97.1%*
Change in the passenger car use 2011/2004	*141.2%*	*105.6%*	*96.8%*	*96.2%*
Change in the passenger train transport 2011/2004	*88.8%*	*113.1%*	*123.4%*	*103.4%*

Tab. 12 - The differences against regions in overall mobility and in car use in 2004 and 2011

Source: EnergSys based on data from Eurostat

Global climate awareness

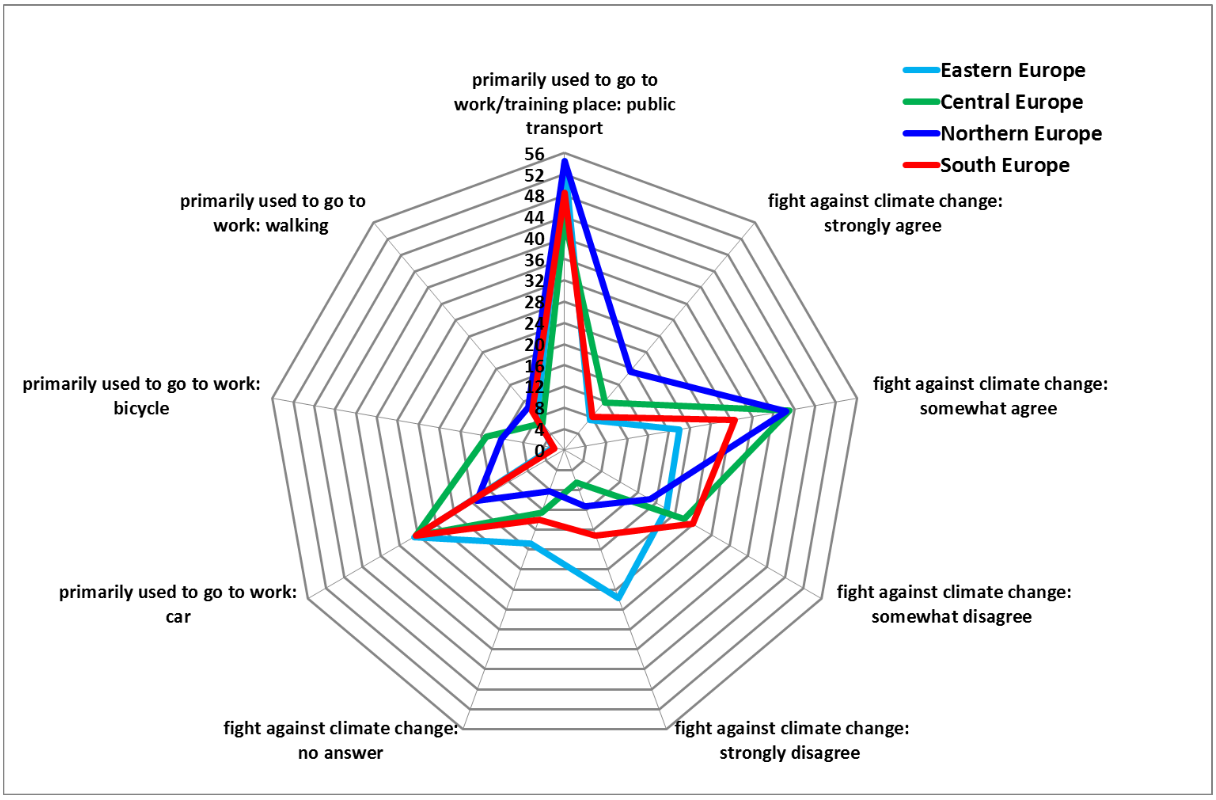


Fig. 27 - The differences among regions in awareness of climate change and in the means of transport choice in the cities

Source: EnergSys based on Eurostat data

Much more diversified are the results concerning the climate awareness and transport choice, declared in the perception survey conducted by Eurostat in 2009. The percentage of people who strongly agree with the fight against climate change is the highest in the Northern Europe (almost 20% of respondents). Much less determined to fight against the climate change are citizens of Mediterranean and Eastern regions (only 7-8% of respondents). The results concerning the percentage of citizens that agree somewhat to fight against climate change are similar between the regions. In Northern and Central regions the shares exceeded 40%, in Mediterranean 30% and 22% in the Eastern region. Eastern Europe has the highest share of highly determined opponents to the climate change fight (29.6%), while Central region the lowest (only 6.5%).

The neutral attitude to climate change problem is the most frequent in Eastern region (18,8%) and the less frequent in the Northern one (8,3%). The Mediterranean and the Central regions are characterised by similar rate of the respondents doubting in the sense of the climate change fight (26-28%). The lowest percentage of people doubting in the sense of the climate change fight live in Eastern and Northern regions.

Public transport is a main mean of transport used to get to work or training place in all regions, but only in Eastern and Northern regions was declared by more than 50% or respondents. Car is a second main mean of transport in all regions, used by more than 30% of respondents, apart from the Northern region, where only 19% of respondents declared it. There is visible discrepancy concerning the use of bicycles in Eastern and Mediterranean regions, where they are rarely used and the Central and North Europe where there are rather popular.

	Eastern Europe	Central Europe	Northern Europe	South Europe
fight against climate change: strongly agree	7.3%	11.8%	19.4%	8.2%
fight against climate change: somewhat agree	22.0%	43.1%	42.5%	32.6%
fight against climate change: somewhat disagree	22.2%	26.1%	18.7%	27.9%
fight against climate change: strongly disagree	29.6%	6.5%	11.3%	17.2%
fight against climate change: no answer	18.8%	12.6%	8.3%	14.0%
primarily used to go to work: public transport	54.6%	43.5%	54.4%	48.6%
primarily used to go to work: car	32.8%	32.4%	19.1%	32.3%
primarily used to go to work: bicycle	2.3%	15.0%	12.2%	2.0%
primarily used to go to work: walking	8.2%	6.6%	10.6%	9.6%

Tab. 13 - The differences among regions in awareness of climate change and in the means of transport choice in the cities
Source: EnergSys based on Eurostat data

Eastern Europe

Eastern Europe is characterised by the highest share of energy spending in households' budget and also the highest number of determined opponents against taking action on climate change. Together with not determined by doubting people the climate policy is neglected by more than 50% of the society. The region is also characterised by very poor dwelling conditions and the highest percentage of people being at risk of poverty of social exclusion. Concerning transport, there was observed decreased use of rail transport and increased use of cars. There was also observed the highest, within the 4 regions, use of public transport to get to work or training place, similarly the use cars for these purposes was higher than in the other regions. The bicycles are rather not popular.

Northern Europe

Northern Europe is characterised by the lowest share of energy spending in households' budget and also the highest number of determined supporters of taking climate change actions. Together with not determined by supporting people the climate policy is backed by more than 50% of the society. The region is also characterised by good dwelling conditions and near to European average percentage of people being at risk of poverty of social exclusion. Concerning transport, there was observed decreased use of cars and increased use of rail transport. There was also observed the lowest within the 4 regions, use of cars to get to work or training place. The public transport and bicycles are rather popular.

Central Europe

The Central Europe region is characterised by the lowest percentage of opponents against taking action on climate change. More than 50% of the society supports the climate policy. The region is also characterised by good dwelling conditions and the lowest, within the four regions, percentage of people being at risk of poverty of social exclusion. The energy spending share in households' budget is relatively low in average. The tendencies in mobility habits have changed rather negatively. There was observed increased use of cars, which in 2011 were used by almost the same percentage of society as in the Northern region. Even though the use of bicycles to get to work or training place was the highest within the regions, the use of public transport was the lowest.

Mediterranean

The Mediterranean region is characterised by low percentage of determined climate change actions supporters. Less than 50% of the society supports the climate policy. The region is also characterised by not bad dwelling conditions and near to European average percentage of people being at risk of poverty of social exclusion. The energy spending share in households' budget is relatively low in average. The tendencies in mobility habits have changed rather positively. There was observed decreased use of cars and increased use of trains. In cities the use of bicycles to get to work or training place is the lowest within the 4 regions. The use of public transport is only not significantly higher than in Central Europe.

4. Climate change and energy security objectives[54]

4.1 Introduction

The 5th assessment report of the Intergovernmental Panel on Climate Change (Change 2013) has confirmed that the warming of the climate system is unequivocal, that it is "extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century", and that "limiting climate change will require substantial and sustained reductions of greenhouse gas emissions." Global surface temperature change for the end of the 21st century is likely to exceed 2°C for RCP6.0 and RCP8.5[55] (Change 2013). As a global temperature increase within the limit of 2°C mark is widely considered to be the dividing line between warming which the system can cope with and that which is dangerous, a radical change of the global energy system is necessary. Indeed, "limiting the warming caused by anthropogenic CO2 emissions alone with a probability of >66% to less than 2°C since the period 1861–1880 will require cumulative CO2 emissions from all anthropogenic sources to stay between 0 and about 1000 GtC, since that period. At current rates of greenhouse-gas emissions, the latter threshold would be reached before 2040; it is estimated that the world has already emitted about 500 GtC by 2011.

Energy security is a great challenge for Europe. Section 3 has highlighted the challenges of the implementation of the EU2020 targets for each EU country. Moreover, all attempts so far to build an international climate change agreement that covers all countries have failed. Besides their wide macro-economic ramifications, governmental initiatives aimed at the reduction of GHG emissions can affect other energy policy objectives and hence bring about additional costs within the energy system (Change 2013). While there may exist obvious synergies between different policy objectives related to sustainability, security and competitiveness, there are also potential trade-offs. Indeed, the radical changes envisaged by low carbon policies are now causing new challenges for the future energy security of supply both in the short and medium term, particularly for electricity markets. On one hand, the increased penetration of Variable Energy Resources (VER) adds a set of specific operating challenges which makes it difficult to guarantee the stability of the power system. On the other hand, many power markets are unable to value the benefits of flexible resources. Indeed, in energy systems with a growing share of renewable electricity generation, more traditional thermal plant operators are finding it increasingly difficult to recover their fixed costs, due to the combination of persistently low market prices brought about by renewable plants (with virtually zero marginal costs) setting market clearing prices, and of the much lower load factors of thermal plants (Haas et al., 2013).

The role of natural gas as a bridging fuel to a low carbon energy system has recently been explored in a number of publications (Brown, Krupnick, and Walls 2009; Levi 2013; IEA 2011). Here, we focus on how the presence or absence of additional quantities of natural gas – in particular from unconventional sources – can affect the security of an

[54] This chapter has been developed by JRC.
[55] Representative Concentration Pathways (RCPs) are four greenhouse gas concentration (not emissions) trajectories adopted by the IPCC for its fifth Assessment Report (AR5).

energy system as it transitions towards a low-carbon pathway. The purpose is further developing the debate about the role of natural gas as a bridging fuel by specifically investigating its ability to strengthen the system's adaptation to climate change policies. The role of unconventional gas in relieving the pressure on the system from progressively tightened conditions brought about by carbon emission limits will be explored by observing differences in the stability, flexibility, adequacy, resilience and robustness of the system under optimistic versus conservative assumptions about the availability of unconventional gas.

The structure of this chapter is as follows. Section I will conceptualise the links between energy security and low-carbon policies and will introduce a methodological framework to assess their interactions. Section II will outline the modelling tools used for this assessment, and will elaborate on the input assumptions guiding the scenario analysis. Section III will present the results and discuss them in the context of the methodological framework set out in the first section. This will be followed by a conclusion and recommendation for future research.

4.2 Conceptualising the links between energy security and low-carbon policies

The de-carbonisation of the global energy supply chain requires a radical overhaul of the existing system. Herculean efforts in policy-making, technological innovation and behavioural change are all necessary to move away from today's situation, in which 82% of all useful energy in the world is derived from fossil fuels – oil, coal and natural gas - and towards a more diversified system based on significant amounts of renewable energy sources (RES), such as wind, solar and hydropower. Energy transitions of this scale portend significant challenges for the long-term security of the existing system. Indeed, a low carbon transition implies huge behavioural changes for virtually all stakeholders – firms, consumers, and governments. Moreover, the implementation of low-carbon policies may generate unintended consequences; for example, the increased electrification of final energy consumption in a low-carbon system may shift the focus from the security of energy supply to the security of energy transformation, which is determined not only by the availability of primary sources but also on the stability of complex interconnected infrastructures.

Due to the vast complexity of our domain of inquiry (the energy system) as well as the dynamic synergies and trade-offs between low-carbon policies and energy security, conceptual precision and analytical rigour is required to effectively navigate this terrain. Several studies employ a wide set of indicators which attempt to cover, by proxy, the whole spectrum of energy policies. For example, one study attempts to empirically link energy security policies (understood in terms of fossil fuel resource concentration) with carbon emissions in key OECD countries (Lefèvre 2007). Similarly, a recent evaluation of the interactions between climate and security policies in Europe analyses the short-, medium- and long-term impacts of a baseline versus 450 ppm scenario on a set of security indicators such as import dependence and the reserves/production ratio (Guivarch et al. 2012). However, the lack of a structured framework to analyse the relevance of these metrics to different properties of a secure energy system tends to implicitly obscure a great deal of other aspects of the energy supply chain that may prove particularly salient in the climate/security nexus (e.g. energy transport, production or conversion processes may affect, or be affected by, climate policies).

Thus, the use of energy security indicators must be avoided, as they have been repeatedly flagged up as insufficient for a proper analysis of the links between climate change and energy security (Jewell, Cherp, and Riahi 2014). Indeed, indicators such as import dependence or fossil fuel diversity are 'reductionist' tools that tend to obscure rather than illuminate the actual vulnerability of the energy system to adverse events; the conceptually elusive nature of energy security belies the use of a highly aggregated value that fails to depict the actual behaviour of the energy system in response to risks or adverse events.

While indicators can reveal the trade off and synergies between technological, political and social dimensions, in order to meaningfully assess how climate change policies may impact on energy security and vice versa, there must be a disciplinary refinement of indicator-based assessments, given their partial and simplified view of energy security. A conceptual and methodological framework must be developed which accounts for the multi-dimensional nature of energy security and its 'systemic' quality encompassing the entire energy supply chain. Only in this way can the catalogue of various threats and opportunities emanating from climate change policies be ordered, interpreted and assessed according to their impact on the properties of a 'secure' energy system. These properties, in turn, must be differentiated according to the nature of threats affecting different parts of the system. For example, the operational stability of the energy system requires a different set of methodological tools and considerations than an assessment of longer-term market adequacy, which ensures that the system is able to balance supply and demand by responding correctly to investment signals and incentives.

4.2.1 Energy security as a system property of the energy supply chain

Having questioned the conceptual and methodological utility of indicator-based methodologies, an alternative paradigm must be proposed, one which goes beyond the epistemological deficiencies of the reductionist approach and reflects the ‘polysemic’ and multi-dimensional nature of energy security.

A systems approach, which recognises the energy supply chain as one of the fundamental ordering principles of modern economies, potentially offers a great deal of insight into the conceptualisation of energy security and the categorisation of the wide range of threats to the interconnected system. After all, taken as a whole this system includes all the extremely complex, interrelated chains of commodities and processes linking the extraction of primary energy to the satisfaction of the demands for energy services. This extended concept is much wider than the typical analytical confines of the global crude or natural gas markets. It encompasses all the energy vectors and all steps of each energy chain, from the oil reservoir or coal mine to the passenger kilometres or the warm water demanded by end users (Tosato 2008). This insight represents the key point of departure from the prevailing discourse on the links between climate change and energy security; indeed, enlarging or minimising the system means changing one's domain of analysis and accompanying risk criteria for assessing energy security. The system may be as wide as *the whole set of* *technologies, physical infrastructure, institutions, policies and practices, located in and associated with a geographical area, which enable energy services to be delivered to consumers"* (Chaudry 2009). *Or*, given that the energy system constitutes a part of the *macroeconomy*, which, in turn, exists in *nature* and impacts on the environment, the system can include the non-energy economy and the factors of production (labour and capital) that drive it, as well as the natural world in which human activity takes place.

Enlarging the scope of analysis to the energy system as a whole means it is necessary, when assessing energy security, to focus on its behaviour. Indeed, the actual capacity of an adverse event, such as those discussed in the previous section, to affect an energy system depends on the way the latter can cope with this event, and is contingent on the structural (physical and non-physical) characteristics of the system at the time it is affected by the event. As a consequence, the wide range of factors that can exercise a stabilizing influence on the energy services delivery system must be identified and thoroughly analyzed, together with their relations and interactions/synergies (Jansen 2009). Accounting for the dynamic interaction of all of these components is no easy task. A system-level approach seeks to take into account as much of this complexity as possible. In this context, energy security must be viewed as a product of the interactions and interdependencies of a complex system, one whose properties are not fully explained by an understanding of its component parts. Conceding this idea effectively means eschewing explanations based on a handful of assumptions about the level of supply diversity or the political risks of energy dependency. Indeed, the debate about energy security is often conducted in terms of individual technologies, i.e. in terms of their potential to lead to better security; while "such arguments may sometimes have merits they are incomplete without an accompanying analysis of the overall system effect of the proposed change. Security always needs to be seen in terms of system impacts.

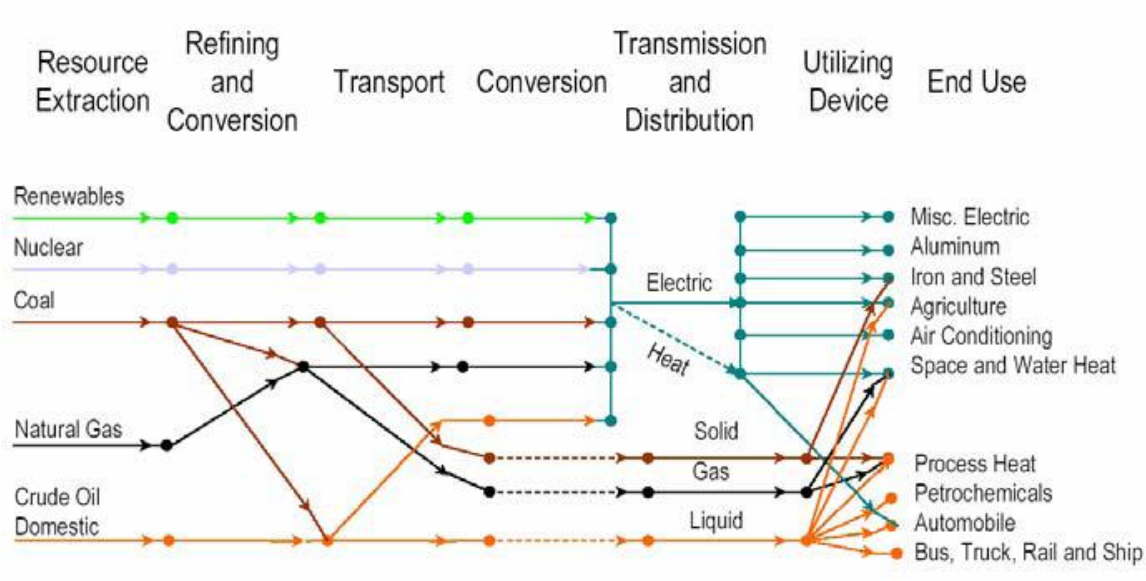


Fig. 28 - The energy supply chain

From the discussion above we define a secure energy system as one that is *evolving over time with an adequate capacity to satisfy the energy service needs of its users* *under any circumstance*. This definition implicitly includes the traditional view of energy security as "the uninterrupted availability of energy sources at an affordable price"[56]. However, it is a broader definition, as it is centered on the actual capacity of the energy supply chain to cope with adverse events.

But how can the security of an energy supply chain be conceptualized and practically assessed? The term "energy security" represents an all-encompassing phrase for issues as different as efficient investment, maintenance, and operation and is related to the whole value-chain resource extraction and/or import to the end user. From the risk identification phase it quickly becomes clear that the supply chains making up the energy system are subject to a wide range of different threats; accordingly, a 'secure' energy system must possess a number of different types of properties that act as coping mechanisms to manage such threats. Following the risk identification framework set out above, it is apparent that certain types of risks may be addressed by improving certain properties of the energy system. Five such properties have been identified for present purposes – stability, flexibility, resilience, adequacy and robustness. These properties have been elaborated elsewhere (Gracceva and Zeniewski 2014), but they are summarised in table below.

[56] See for instance http://www.iea.org/topics/energysecurity/. The same definition is adopted in the EU Green paper (COM(2000) 769 final): the EU's "long-term strategy for energy supply security must be geared to ensuring, for the well-being of its citizens and the proper functioning of the economy, the uninterrupted physical availability of energy products on the market, at a price which is affordable for all consumers (private and industrial)". However, the EU definition is expanded to "environmental concerns and sustainable development, as enshrined in Articles 2 and 6 of the Treaty on European Union".

	Definition	**Risks**	**Location in energy supply chain**	**Temporality**
Stability	the capacity of the highly interconnected energy system to maintain its operation within acceptable technical constraints	Sudden disruptions of critical system components	Transportation, Refining/Conversion, Transmission and Distribution	Seconds to minutes
Flexibility	ability of a system to cope with the short-term uncertainty of energy system variables (whatever the cause), by balancing any deviations between the planned or forecast supply and demand, on one side, and the actual outturn in real time, on the other side.	Statistical variability of energy variables	From resource extraction to end Uses	Minutes to hours
Resilience	the energy system can source alternative modes of production or consumption in response to sudden and transient shocks (high impact/low probability events), such as the interruption of a major supply source.	Sudden/transient disruption, deliberate use of market power	Resource Extraction to Transport/ Transmission	Hours to weeks
Adequacy	the reasonable expectation that the system as a whole is able to meet all demand at all times under all anticipated conditions, taking into account market conditions and the regulatory regime	Market failures, faulty market design	Resource Extraction to End Use	Weeks to years
Robustness	Actors in the energy market are allowed to choose from primary energy sources at cost-oriented prices, without being hindered in their choice by economic or (geo)political constraints on energy resources and infrastructures.	Enduring pressure on energy resources and/or infrastructures, hindering choice of energy sources at cost-oriented prices	Resource Extraction to End Use	Years to decades

Tab. 14 - A Summary of the main energy security dimensions

Taking into account the five properties described above, the objective of the energy security assessment is to define combinations of the identified events that may jeopardise the correct performance of the energy supply chain, and assess its consequence by observing the whole response of the energy system. A secure energy system, therefore, will be one which is stable, flexible, adequate, resilient and robust in the face of short-, medium- and long-term threats. However, it is important to recognise the link between the system properties and the system components that require analysis, since each property requires a different analytical scope and framework. Quantitatively assessing the resilience of an energy system to a cut of natural gas supply, for example, requires a tool that can account for the flows, capacities, storages, contractual bounds and demand-side responses that can be used to absorb the shock over a short- to medium-term horizon. Assessing the system's robustness over several years requires a different emphasis, one that is more strongly linked to market design and optimisation as well as the regulatory conditions impacting on investments in all available energy infrastructures.

4.2.2 Modelling the security of energy systems

From the discussion above it is clear that an assessment of the impact of unconventional gas on the security of an energy system taking a low-carbon pathway requires consideration of the multi-dimensional nature of energy security. This systemic vision must be matched by the use of appropriate tools, which are able first of all to assess the complex interactions between climate change and other energy policies, so as to develop cost-effective strategies that maximise their results in both policy areas. As such, a key feature of the methodology is its capacity to address the systemic nature of the global energy system, to capture the interactions between different geographical and sectoral energy markets. Moreover, as energy systems are dynamic, i.e. continuously adapting to changing physical, societal and regulatory conditions, understanding their potential evolution under different conditions is key towards the design of sound energy policy decisions.

Energy system models are powerful quantitative tools enabling analysts to study the dynamic interdependency between supply- and demand-side developments. Holding other variables constant, system models enable exploration of systemic change as a result of different political, geological or economic assumptions (e.g. high/low carbon tax, abundant/scarce resources or costly/cheap energy extraction). Varying these assumptions can reveal the synergies and trade-offs occurring at each link of the energy value chain, while providing insights on system dynamics. Thus, energy system models are well suited to analyse potential development pathways for different energy systems under a unified and coherent set of data and assumptions. The global nature of such models allows gas supply and demand developments in different world regions, and the resulting decisions to invest in new gas infrastructure, to be made endogenous. For present purposes, we analysed the impact of different European climate change policy scenarios on the robustness of the energy system using a complex multi-regional energy system model, ETSAP-TIAM (Energy Technology Systems Analysis Program-TIMES Integrated Assessment Model)[57].

[57] ETSAP-TIAM is a partial equilibrium model of the energy systems of the entire world divided in 15 regions. It belongs to the TIMES family of models, i.e. a group of bottom-up, cost-

4.3 Assessing energy security in a low-carbon pathway

We explored a scenario consistent with the objective of halving global CO_2 emissions by 2050 to limit the global temperature increase to 2ºC, while the reduction is 85% in Europe. The Low Carbon state of the world developed through the global energy system model TIAM shows how the success in achieving a low-carbon energy system in Europe requires deep structural changes affecting the whole energy supply chain. In particular, the relationships between the demand for energy services and energy consumption and between energy consumption and CO_2 emissions will be explored. This can occur through a reduction of the energy use per unit of activity within each end-use sector, through a change in the fuel shares among end-uses and through the decarbonisation of energy carriers.

Comparing the results from the Business-as-Usual and Low Carbon 'states of the world', it appears that, notwithstanding significant economic growth (EU GDP is assumed to increase by 1.5% per year), total primary energy supply (TPES) remains more or less constant in both cases between 2010 and 2050. In the LC case the demand for fossil fuels is about 40% lower compared to 2010 levels and about 35% lower compared to the unconstrained scenario: there is a noticeable shift away from coal, which by 2050 falls to about a tenth of 2010 levels. Liquid fuel demand stabilises at around today's levels, but with a very strong increase of liquid biofuels (making up two-thirds of fuel use for transportation) and hydrogen (~10% of transport). As a consequence, in the Low Carbon system by 2050 final consumption of oil reaches only half of the current level, while natural gas becomes the dominant fuel in TPES, making up 30% of the total (assuming its emissions are managed by CCS), and in fact is the least penalised fossil fuel when transitioning to a low-carbon system. A significant part of this gas is unconventional, which continues to increase throughout the whole time horizon, such that internal production can be sustained above current levels.[58]

Electricity is at the core of the future clean energy system in Europe and becomes the dominant energy carrier in final consumption, as a result of increased electrification of end-use sectors, decarbonisation of electricity generation, and energy efficiency improvements. In the LC scenario electricity demand almost doubles with respect to

optimization models that identify least-cost solutions for the energy system under given sets of assumptions and constraints and for a given time horizon. ETSAP-TIAM covers the entire energy system from the extraction of resources, to conversion of primary energy carriers, to the trade of all the main energy commodities and to the use of final energy carriers in end-use technologies across different demand sectors (as for the latter, TIAM distinguishes 42 demand sectors). Currently, TIMES models (and its predecessors MARKAL models) are used in about 100 institutions in nearly 70 countries for the compilation of long term energy scenarios and in-depth national, multi-country, and global energy and environmental analyses. Global energy system models based on MARKAL/TIMES are used quite extensively for long-term energy system analysis (e.g. the periodic IEA study Energy Technology Perspective is based on a TIMES model), as well as for systematic analysis of global energy issues, such as climate mitigation options (Labriet, Kanudia, and Loulou 2012), a fully renewable energy system (Føyn et al. 2011) and long-term decarbonisation scenarios (Kannan and Strachan 2009; Kannan 2009), and the deployment of alternative fuels and technologies for transportation (Gül et al. 2009; Densing, Turton, and Bäuml 2012).

[58] Bearing in mind that this result depends on optimistic assumptions about the production cost and resource size of shale gas (see (Gracceva and Zeniewski 2013)); a specific sensitivity is carried out later in this paper.

the current level (a greater increase than in the BaU scenario), as efficiency improvements in electricity use are offset by increased electricity demand, mainly from the rising use of heat pumps for heating and cooling. By 2050, heat pumps deliver almost 50% of useful energy demand for space heating.

In the LC scenario, power generation is also the largest contributor to the reduction of CO_2 emissions. Assuming the relatively widespread availability of CCS, in the long-term electricity generation is almost decarbonised in the LC scenario: natural gas is the only remaining fossil fuel used in electricity generation by 2050, with a share of 27% (roughly the same as today). Renewables produce half (with wind and solar together comprising almost 30% of the mix at European level). Nuclear power takes a quarter of the total electricity generation share while biomass assumes the remainder (see figure 6). Interestingly, while gas-fired generation gains an even stronger role in the LC system than in the BaU case, coal is completely phased-out. This is due to the fact that natural gas plants are best placed to provide peak-load and back-up capacity to balance the variability of renewable energy sources. Moreover, the competitiveness of unconventional gas resources along with its softer carbon emissions profile relative to coal leads to larger-scale deployment of gas plants with CCS at the expense of coal CCS. However, if CCS is unavailable, the change in results is dramatic: gas-fired power generation drops by 87%, with nuclear, wind and solar power picking up the slack.

Final energy consumption is 5% lower in the LC scenario than in the BaU, thanks to energy efficiency in buildings and transportation. Fuel use in the demand sectors is also more diversified, as new fuels such as biofuels and hydrogen significantly impinge on oil's dominance in the transport sector.

(mtoe)	Coal	Crude Oil	Oil Products	Natural Gas	Nuclear	Hydro	Renewables	Biofuels & waste	Elc	Heat	Total
Production	169	194	0	241	239	48	29	124	**0**	**1**	*1.047*
Conventional											
Unconventional											
Trade	121	460	38	218	0	0	0	6	**1**	**0**	*844*
Total Primary Energy Supply	**296**	**654**	**-52**	**467**	**239**	**48**	**29**	**131**	**1**	**1**	**1.817**
Electricity Plants	-145	1	-14	-89	-236	-48	-22	-23	252	0	*-326*
CHP Plants	-65	0	-11	-63	-3	0	-1	-23	58	44	*-63*
Heat Plants	-5	0	-1,0	-8	0	0	0	-6	0	16	***-4***
Refineries	-22	-674	668	0	0	0	0	0	0	**0**	***-25***
Other Transformation	0	16	-17	0	0	0	0	0	0	**0**	***-5***
Energy industry own use and losses	*-6*	*0*	*-37*	*-19*	*0*	*0*	*0*	*0*	*-24*	*-5*	*-91*
Total Final Consumption	**54**	**5**	**532**	**284**	**0**	**0**	**5**	**79**	**266**	**51**	**1.275**
Industry	32	2	34	87	0	0	0	24	99	16	*293*
Transportation	0	0	312	3	0	0	0	13	6	0	*334*
Residential	17	0	47	124	0	0	4	38	79	21	*329*
Commercial	2	0	21	50	0	0	1	2	77	10	*162*
Agricultural	1	0	18	4	0	0	0	2	5	0	*30*
Non-Energy Use	1	2	98	13	0	0	0	0	0	0	*114*

Tab. 15 - Energy Balance for Europe, 2010
Source: IEA

(mtoe)	Coal	Crude Oil	Oil Products	Natural Gas	Nuclear	Hydro	Renewables	Biofuels & waste	Electricity	Heat	Hydrogen	Total
Production	11	2	0	294	358	57	178	484	0	0		*1.383*
Conventional		*2*		*53*								*55*
Unconventional				*241*								*241*
Trade	15	310	-20	282	0	0	0	0	0	0		*587*
Total Primary Energy Supply	**26**	**312**	**-20**	**576**	**358**	**57**	**178**	**484**	**0**	**0**	**0**	**1.970**
Electricity Plants	0	0	0	-201	358	-57	-169	-18	454	0		
CHP Plants	-8	0	0	-27			0	0	18	17		
Heat Plants	0	0	0	-23			0	-25	0	41		
Refineries	0	-329	292	-7			0	0				
Other Transformation	-9	10	-11	-1			0	-6				
Hydrogen Production	0	0	0	-53			0	0	-1	0		
Energy industry own use and losses	*5*		*26*	*12*			*0*	*12*	*44*	*1*		
Total Final Consumption	**3**		**235**	**252**			**9**	**422**	**426**	**57**	**39**	**1.443**
Industry	1		24	138			0	103	116	29	0	*411*
Transportation	0		66	0			0	279	0	0	39	*384*
Residential	0		6	71			1	35	189	10	0	*313*
Commercial	0		1	12			4	2	97	18	0	*134*
Agricultural	2		5	9			2	3	25	0	0	*46*
Non-Energy Use	1		134	21			0	0	0	0	0	*155*

Tab. 16 - Energy Balance for Europe, Low Carbon System 2050

2050

(mtoe)	**Coal**	**Crude Oil**	**Oil Products**	**Natural Gas**	**Nuclear**	**Hydro**	**Renewables**	**Biofuels & waste**	**Electricity**	**Heat**	**Hydrogen**	**Total**
Production	90	33	0	363	116	48	94	250	0	0		*994*
Conventional		32		47								*79*
Unconventional		1		316								*317*
Trade	234	414	79	294	0	0	0	0	0	0		*1.020*
Total Primary Energy Supply	**324**	**446**	**79**	**657**	**116**	**48**	**94**	**250**	**0**	**0**	**0**	**2.014**
Electricity Plants	-176	0	0	-41	116	-48	-85	-100	310,1	0,5		
CHP Plants	-33	0	-1	-36		0	0	-7	31,0	28,8		
Heat Plants	-18	0	0	-1		0	0	-2	0,0	17,5		
Refineries	-1	-472	418	-10		0	0	0				
Other Transformation	-8	14	-6	-14		0	0	0				
Hydrogen Production	0	0	0	-33		0	0	0	0	0		
Energy industry own use and losses	*11*		*33*	*18*				*12*	*29*	*1*		
Total Final Consumption	**76**	**0**	**457**	**504**			**9**	**128**	**312**	**46**	**25**	**1.558**
Industry	74		23	155			0	25	113	18	0	*408*
Transportation	0		258	71			0	64	0	0	25	*417*
Residential	0		37	172			1	35	85	10	0	*341*
Commercial	0		1	75			4	2	90	18	0	*189*
Agricultural	2		5	9			2	3	25	0	0	*46*
Non-Energy Use	1		134	21			0	0	0	0	0	*155*

Tab. 17 - Energy Balance for Europe, Business as Usual 2050

4.3.1 New challenges for system robustness

Any given energy policy tends to place a stress on the energy system, as it constrains the options available to it while narrowing the range of permissible outcomes of its behaviour. Carbon policies are no exception, as they are designed to limit the resources and technological investment options available to the system. This is a long-term risk related to the system's robustness, inhibiting its freedom to choose from primary energy sources at cost-oriented prices.

The TIAM model is well-placed to consider the robustness of the European energy system. In line with our systemic framework, we assess the robustness of the low carbon system by measuring the impact of long-term stresses on total system cost (broken down into investment, operating and maintenance, and import expenditure). At the outset it is notable that from 2030-2050 a low-carbon system will impose a total additional cost of 12% relative to the business-as-usual system. Indeed, the carbon constraint leads to an increase in the price of all fossil fuels, with a direct impact on the cost of electricity generation. Secondly, the reduction of fossil fuel imports is achieved thanks to significantly higher expenditure on low-carbon technologies, which are typically characterised by high initial investment costs. The offsetting of these increased costs by the reduced need for fossil fuels (and, in particular, imports) is not enough to confer a positive value on the transition to a low carbon system.

One clear message emanating from the present analysis is that the successful transition to a LC system is dependent on the availability of technologies such as nuclear power and CCS, which require a great deal of investment and long-term policy commitment. Of course, one limit of the TIAM model is that it cannot assess if these investments will be available as there is no real feedback between the energy model and the macroeconomy. Nevertheless, robust policies related to these technologies are inhibited by a lack of public acceptance of the former and a high degree of techno-economic uncertainty in the latter. Indeed, while nuclear power is one of the most important energy resources identified in the LC scenario, the current projections of its deployment by 2025 will be significantly below levels required to achieve carbon emissions targets. This is partly due to the aftermath of the Fukushima accident in Japan in late 2011.

As a low-carbon EU energy system orients itself away from fossil fuels, its robustness with respect to traditional long-term stresses, such as resource depletion, production limits or resource nationalism, can be expected to increase. However, the scenario analysis shows an increase in the regional concentration of imported sources, as the number of producers decrease. The probability of market power abuse may therefore increase, even if its impact may be moderated by the lowered reliance on fossil fuels. Nonetheless, the denial of key technologies enabling a low-carbon transition along with a reduction in the diversity of fossil fuel imports would constitute a clear case of a trade-off between climate policies and long-term energy security. However, synergies exist that lie outside the scope of this analysis; whilst difficult to quantify, the reduced risk and/or consequences of climate change events (such as sea level changes or extreme weather events) in the LC scenario may very well offset any of the above-named challenges to energy security.

4.3.2 New challenges for system and market adequacy

The LC scenario depicts a future where fossil fuel consumption is dramatically different from the BaU case. The huge uncertainty on the actual implementation of stringent climate policies, and the consequent impact on future energy demand, particularly for fossil fuels, may affect investment decisions in supply capacity and infrastructure worldwide (and first in producing countries), leading to heightened risk of insufficiently matching forecasted supply with demand. The strong impact of a high demand scenario on the cost of a low-carbon system reveals its sensitivity to an efficient allocation of resources to meet planned energy demand. It may also transpire that global energy markets become tighter as carbon policies are implemented. An extension of the current analysis with a myopic version of the energy system model could provide more insights on this point.

At European scale, in the aftermath of the economic crisis, there is currently overcapacity in many national markets. However, given the massive deployment of low- or zero-carbon technologies implied by the LC scenario, a critical issue is the availability and cost of capital to finance the transformation of the energy system in deregulated markets. A key challenge is the substantial network upgrades, both for electricity and gas, needed to enable the use of flexible resources in the LC system (Glanchant and Kalfallah 2011). The investments in flexibility required by the LC scenario can be difficult to achieve in liberalised markets, as the market does not properly value the benefits of flexible resources. For instance, the LC power system is characterized by a new market rationale, where the merit order is replaced by net demand. As gas plants increasingly provide peak load, the lowering of the capacity factor threatens the viability of existing plants and detracts from investment in new plants. Moreover, prices in the day ahead electricity market are often very low and the profile of the price curve is now different from the demand curve (Haas et al. 2013; Baritaud 2012; Batlle and Rodilla 2010). A more detailed analysis of this wide low-carbon energy system scenario in terms of the short-term power market equilibrium can provide additional insights.

The energy system must adapt to market-related challenges of low-carbon policies by devising new regulatory mechanisms to manage the interaction between incumbent fuels and infrastructures and the less carbon-intensive technologies that are meant to replace them. For example, capacity mechanisms, which aim at keeping sufficient dispatchable generation capacity online even though it may not necessarily be used, can address the viability of generators with low reserve margins. The costs and benefits of this scheme, however, require detailed analysis.

Finally, in the longer-term, the investments needed for the revolution of the infrastructure system in the transport sector, required by the introduction of biofuels and hydrogen, can be a further challenge.

4.3.3 New challenges for system resilience

The Low Carbon EU energy system is characterised by a slightly higher diversification for energy portfolios (as measured by the Herfindahl-Hirschman Index, which yields values of .32 and .28 for the BaU and LC systems, respectively), as the share of the dominant fossil fuels in TPES decreases and is compensated for by nuclear power and different forms of renewable energy. Following Stirling's framework, this increase in diversity can potentially provide protection against 'unknown' risks and therefore this outcome can be seen as beneficial for enhancing the resilience of the system to short-term disruptions of energy supply. However, a closer look reveals a more complex picture: for instance, the lower total gas consumption relative to the BaU case is accompanied by a lower diversification of the sources of import. This is because the sources of supply which are marginal under BaU demand conditions are effectively cut out in the LC scenario, due to lower gas demand. Looking beyond primary energy, the increased importance of electricity in final energy consumption in the low-carbon system lowers the diversity of demand, which may also have an impact on system resilience.

Having to select the 'right' diversity measures to capture the relationship between carbon policies and energy security is problematic to say the least. Eschewing their use, a more precise assessment of the impact of the LC scenario on the resilience of the EU system requires an integration of a wide energy system analysis provided by TIAM with an analysis accounting for the peculiarities of an individual sector (e.g. a gas network model).

4.3.4 New challenges for system flexibility

A critical implication of the increased electrification resulting from the LC scenario is a substantial need for additional power system flexibility. On the supply side, variable energy resources (VER) (wind and solar) reach 28% by 2050 and rise to 46% if CCS is unavailable, compared with less than 5% today. Their increased role creates a new set of operating challenges for the power system, impacting on issues such as peak load adequacy, minimum load balancing and capacity margins, ramp-up rates of residual demand and the predictability of VER (Baritaud 2012; Venkataraman et al. 2010). Interestingly, the ratio of peak to average demand is in fact 10% lower in the LC scenario than in the BaU case. This is due to the increased electrification of final energy consumption, which smoothens the load curve for demand as electricity finds a greater number of applications. At the same time, however, the increased call on heat pumps significantly increases the spread between summer and winter days, since these pumps are most likely to be employed during the latter period, which also coincides with peak demands for electricity for other uses. Moreover, if heat pumps are operated on a time-of-day cycle, similar to many central-heating timers, this could lead to substantial additional peak electricity demand (an estimated addition of 22% in the OECD, according to (IEA 2012)).

In light of these challenges, the electricity system must be highly flexible – able to rapidly ramp its output up or down in response to fluctuations in either supply or demand. However, currently, not even ENTSO-E assessments focus on the flexibility of the EU power system (Commission 2012a), meaning that its flexibility remains uncertain (Buchan 2012). Moreover, as gas plants are generally expected to provide a key source of flexibility for the power system, a substantial impact can be expected on the gas market too, as it will face growing diurnal swing (Commission 2012b). Clearly, the appropriate level of flexibility in a LC scenario is an issue deserving more in-depth analysis, for instance by passing the results of the energy system analysis to a model with a more detailed representation of the operational requirements of power and gas systems (Deane, Chiodi, et al. 2012).[59]

4.3.5 New challenges for system stability

For the large-scale and highly complex interconnected power system, the challenge to maintain the system frequency within very strict limits at all times across the whole network is magnified by the dynamic nature of flows and the operational complexity in liberalised markets (IEA 2005). The strong role of distributed generation in the LC Scenario can impose additional burdens in terms of managing generation, given the lack of centralised (or co-ordinated) monitoring and control systems for medium and low-voltage networks. An additional risk emanating from the LC scenario is the possibility of more common and widespread electricity disruptions due to the increase in bilateral electricity transfers (which may be amplified in cases where this trade is based upon large-scale solar and wind power plants). In light of these challenges, the future stability of the power system rests on a smarter, more unified and integrated system. Deployment of 'smart grids' can result in an increase in available system capacity, a reduction of congestions and the possibility to implement a range of operating paradigms previously not feasible, key among which is the full participation of residential customers in generation and demand-side flexibility services. Whereas the TIAM model is well placed to draw attention to the increased transfer of electricity across borders, a rigorous assessment of the stability of the system requires a detailed network simulation using a power system model. These models can show security margins, changes in load profiles and responses to N-1 situations. The next step to assess the implications of this low carbon scenario on network stability, therefore, would be to combine the energy system analysis with a more detailed network simulation.

4.4 Concluding remarks

The purpose of this section was to introduce a novel systemic approach to the dual problem of defining energy security while considering its complex interaction with climate change policies. Unlike most existing approaches which limit their discussion of security to a handful of indicators, this approach considers security dynamically in terms of the entire energy supply chain – from extraction to end-use - with all of its various feedbacks and interdependencies that evolve over various timeframes.

On a practical level, it is apparent that a low carbon system will bring about fundamental changes to the energy system. Change means risk, but it can also bring about new opportunities; the current emphasis in the literature on both the trade-offs as well as the synergies between energy security and climate change policies is an appropriate starting point. The challenge is to develop a sound methodology for assessing these trade-offs and synergies while accounting for the multiple technologies, processes, fuels, policies and actors that make up the global energy system. The systemic approach adopted in this paper used a scenario analyses to

[59] The authors are currently linking the output from the energy system model (TIMES-TIAM) with a detailed power system model (PLEXOS), see (Deane, Gracceva, et al. 2012) The methodological framework introduced in this paper will serve as a guide to practically assess the interactions between energy security properties through linked models.

analyse how structural changes to the EU energy supply chain creates threats that require mitigation and/or management through the strengthening of the five properties of a "secure" energy system – stability, flexibility, resilience, adequacy and robustness.

	Impact of low-carbon transition	*Further analysis needed*
Stability	× De-centralised generation imposes control risks × Electrification, including inter-regional electricity transfers, amplify probability/impact of disruption	Assessment of power flows in an electrified energy system (e.g. power network model)
Flexibility	× Intermittent RES increase variability of system variables	Optimisation of flexible resources such as back-up, interconnections, storage (e.g. short-term sector model)
Resilience	✓ More RES increase fuel mix diversity × Lower fossil fuel use decreases import diversity × Decreased demand diversity as a result of electrification	Need for greater interconnections, storage, contracts, demand-side response (e.g. sectoral flow model)
Adequacy	× Investment uncertainty × Tighter energy market and heightened sensitivity to demand	Market valuation of externalities Costs and benefits of capacity mechanisms (e.g. sectoral market model)
Robustness	✓ Minimised impact of climate change on energy system ✓ Less resource depletion ✓ Less resource nationalism ✓ Greater adaptability to fossil fuel availability × Less freedom to choose PES at cost-oriented prices (including technology constraints) × Greater sensitivity to technological constraints (e.g. on Nuclear / CCS)	Further analysis of potential long-term stresses, such as impacts on economic growth or biodiversity (e.g. energy system model linked with macro-economic and/or environmental models)

Tab. 18 - Summary of impacts of a low-carbon transition on the five properties of energy security

The analysis provides several insights about the complex interactions between energy security and climate change policies, revealing how no simple answer to the question is possible. A low-carbon scenario has a wide range of implications for the security of the energy system. Multiple options can help to minimize the potential trade-offs. It is only by thinking in terms of complete systems that optimum solutions can be found.

The analysis has provided a more nuanced alternative to the prevailing assumption in the existing literature that a low-carbon system - by virtue of increasing primary energy diversity while obviating the need for imported fossil fuels - can increase the robustness of the system. It is apparent that different stresses can impact differently depending on the 'state of the world'; since a low-carbon scenario must evolve within a narrow band of possibilities, constraining technological options that enable this trajectory is bound to impose higher costs than a scenario in which energy use is less restricted by carbon policies. The point may seem trivial, but it is often under-examined when analysing the long-term impact of a low-carbon system on energy security.

The present analysis constitutes a first step in devising a comprehensive framework to explore in greater depth the wide range of impacts of a low-carbon scenario on energy security. Indeed, there are different possible pathways towards a low carbon system, each of them implying radical structural changes. This paper has demonstrated the key role played by energy system models in identifying areas of change in a consistent way, The next step in this endeavour is to combine such models with more detailed sector models of the different energy markets, which can provide a more accurate assessment of the differentiated properties of a secure energy system.

Conclusions

Deliverable 1.4 is the last of a series of four scientific reports constituting Work Package 1, which aims to analyse energy policies, trends, relations, and actual and potential critical nodes concerning energy security in Europe at different geographical scales, from the local to the global.

In order to develop these perspectives, first of Deliverable 1.1 has developed a conceptual framework functional to (a) the exploration of the historical evolution of energy policies in their various dimensions (in terms of political, social, economic, environmental perspectives) at the global and European scales; (b) the analysis of the evolution of international debates concerning energy security and low-carbon transition; (c) an overview of the methodological requirements needed for analysing energy systems.

Secondly, a critical comparative review of macro-regional energy scenarios and key trends proposed in the scientific literature has been developed and discussed in Deliverable 1.2, which as well proposed and a geographical-chronological analysis of different technological solutions and ongoing trends has been provided.

Thirdly, Deliverable 1.3 has developed (a) a review of European trends in terms of energy consumption and energy production; (b) an analysis of European policies and strategies for a low carbon society and their implications on environmental and energy policies; (c) an examination of economic, social and environmental trends in the EU and national energy scenarios (Italy, Germany, Poland).

Deliverable 1.4 explores energy security in a geopolitical perspective. Problems concerning energy in a global scenario have been considered, with particular attention to relevant topics concerning the availability of stable and sustainable energy sources, the global competition for energy sources, and trends towards the exhaustion of fossil fuels. All these elements are today crucial in global geopolitics, and for this reason many scholars have argued that we are entering in a ‘new’ energy world order, in which a county’s energy surplus or deficit strongly contributes to determine its position in the global world-system. Therefore, Deliverable 1.4 specifically investigates the strategic role played by traditional fuels as oil, gas and coal in the international affairs of the European Union.

The problem of the differentiation of energy sources strongly emerges from the analysis. Particularly, in geopolitical terms, the question of the differentiation of energy sources is strictly connected to the strategic relations developed with Russia and with other key regions. In line with the highly visual and qualitative approaches characterizing geopolitics, the report proposes some qualitative maps and synthetic geographical representations of key areas for EU Energy Security, strategic spatial development zones, key corridors and functional-energetic macro-regions from the perspective of the EU. It is important to stress once more that qualitative representations – differently from the other quantitative representations proposed in this report – have not to be evaluated in terms of their ‘precision’ and ‘accuracy’, but on the basis of their ‘practical usefulness’, that is their capability to suggest and to provoke ideas, alternative conceptualizations and interpretations, possible scenarios and solutions.

The second section of Deliverable 1.4 approached the problem of energy security in a different way, by looking at the potential contribution of renewable energy sources, specifically by providing a punctual evaluation of two mega-projects: Desertech and North Sea Offshore Grid. Not only renewable energy mega-projects may have different impacts on energy security, depending for example on the current energy mix and energy governance mechanism; renewable energy mega-projects have also a geopolitical nature, having meaningful influences on spatial relations, for example in terms of potential development of national and international alliances. The analysis of Desertech and North Sea Offshore Grid allows the development of some general considerations about the alternative and complex ways in which systems may be optimised, for example in terms of local supply, resilient mix, the lowest-cost option or environmental concerns. The concept of 'optimization' is therefore highly political, and in technological terms there is evidently not a single, univocal and 'right' answer to the question of optimization. Once more, the transition towards a decarbonised and energy secure future through the development of energy mega-projects poses a number of geopolitical questions, concerning shifts in energy dependence, the rising role of new economic and political powers (for example global investors), the need for new delivery infrastructures. All these questions have also evident major cultural and social consequences both inside and outside Europe.

Sections three and four of the report explicitly link energy security to the problems of greenhouse gas emissions and climate change. Specifically, Section 3 proposes a detailed statistical analysis (2005-2012) of the emissions of greenhouse gasses in Europe at the national level, with distinction between direct emissions from the burning of fossil fuels plus industrial production within country area (territorial-based production emissions) and the emissions associated with the consumption of goods and services (consumption-based emissions). Specifically, the analysis emphasises changes in the relation between the renewable energy production and the gross final energy consumption by each country, and differences between the targets assigned by NREAP (Renewable Energy Action Plans) and the projections made in each country. National analysis allows to emphasise the unevenness of the energy question in Europe, as different countries are characterized by very different performances. National data have been also aggregated in macro-regional areas, in order to provide a regionalization of Europe according to emitting patterns.

Section 4 proposes a systemic approach to the analysis of energy security and climate change policies, in order to develop an effective methodology for assessing trade-offs and synergies while accounting for the multiple technologies, processes, fuels, policies and actors that make up the global energy system. Through a scenario analyses, it has been discussed how structural changes to the EU energy supply chain creates threats that require mitigation and/or management through the strengthening of the five properties of a 'secure' energy system: stability, flexibility, resilience, adequacy and robustness. Multiple options can help to minimize the potential trade-offs between these elements and goals. It is only by thinking in terms of complete systems that 'optimum' solutions can be found. Of course, the analysis constitutes a first step in devising a comprehensive framework to explore in greater depth the wide range of impacts of a low-carbon scenario on energy security. Indeed, there are different possible pathways towards a low carbon system, each of them implying radical structural changes. Once more, and in line with the considerations proposed in section 2, it is important to stress that there is not a single and linear path towards optimizations, because alternative trajectories, characterized by alternative costs and risks, may be conceptualized and evaluated. Models and evaluations have therefore to be intended as meaningful inputs in order to inform political and collective decisions; this kind of approach is justified, as seen, by the increasing interdependence of the world's nations in the context of energy. As underlined also in other projects (for example POLINARES) the proposed solutions will be directed at those choices which are collaborative, because the scale and nature of the challenges are such that unilateral solutions are unlikely to be effective in the long-run.

Work Packages 2 and 3 – currently in progress – will continue the work in the field of secure energy provision by identifying social conditions that facilitate (or, conversely, hinder) the transition towards post/low-carbon societies, through the analysis of various European local and regional anticipatory experiences.

5. References

Chapter 1

Aalto P. (ed.) (2008), *The EU-Russian energy dialogue: Europe's future energy security*, Ashgate, Aldershot.

Acuto M. (2010), "High-rise Dubai urban entrepreneurialism and the technology of symbolic power", *Cities*, 27(4), pp. 272-284.

Agnew J. A. (2003), *Geopolitics: re-visioning world politics*, Routledge, London.

Ago F. Y., Saw M.O.E. (2005), "Peak oil production may already be here", *Science*, 1106.

Al-Husseini M. (2006), "The debate over Hubbert's peak: a review", *GeoArabia*, v. 11, n. 2, pp. 181-210.

Armao F. (2003), "Why is Organized Crime so Successful?", in F. Allum and R. Siebert (eds.), *Organized Crime and the Challenge to Democracy*, Routledge, London, pp. 27-38.

Barnes T. J. and Duncan J. S. (1992), "Introduction. Writing worlds", in T. J. Barnes and J. S. Duncan (ed.), *Writing Worlds. Discourse, Text & Metaphor in the Representation of Landscape*, Routledge, London, pp. 1-17.

Behr P. (2010), "Energy Nationalism: Do Petrostates Threaten Global Energy Security?" in *CG Global Researcher,* v. 1, n. 7, pp. 151–180.

Bosse G. (2011), "The EU's geopolitical vision of a European Energy Space: when 'Gulliver' meets 'white elephants' and Verdi's Babylonian king", *Geopolitics*, 16 (3), pp. 512-535.

Börzel T. A. (2012), *Roads to regionalism: genesis, design, and effects of regional organizations*, Ashgate, Farnham.

British Petroleum (BP) (2013), Statistical Review of World Energy 2013, http://www.bp.com/en/global/corporate/about-bp/energy-economics/statistical-review-of-world-energy-2013.html

Bradshaw M.J. (2009), "The Geopolitics of Global Energy Security", *Geography Compass,* 3(5), pp. 1920-1937.

Brunet R. (1989), *Les villes européennes*, Datar-Reclus, La Documentation Française, Paris.

Carmody P.R., Owusu F.Y. (2007), "Competing hegemons? Chinese versus American geo-economic strategies in Africa", *Political Geography*, 26 (5), pp. 504-524.

Champion M. (2006), "Russian Energy Grip Splits EU," Wall Street Journal, November 13th, available http://online.wsj.com/news/articles/SB116338183831721008

Cohen S.B. (1991), "Global geopolitical change in the post-Cold War era"*, Annals of the Association of American Geographers,* 81 (4), pp. 551-580.

Conférence des Régions Périphériques Maritimes d'Europe (Crpm) (ed.) (2002), *Study on the Construction of a Polycentric and Balanced Development Model for the European Territory*, CRPM, Rennes.

Cornelius P., Story J. (2007), "China and Global Energy Markets", *Orbis*, 51 (1), pp. 5–20.

Correlje A., Van der Linde C. (2006), "Energy supply security and geopolitics: a European perspective", *Energy Policy*, 34(5), pp. 532-543.

Curtis F. (2009), "Peak globalization: Climate change, oil depletion and global trade", *Ecological Economics*, 69(2), pp. 427-434.

Dabashi H. (2012), *The Arab Spring: the end of postcolonialism*, Zed Books, London.

Datar (2000), *Aménager la France de 2020. Mettre les territoires en mouvement*, La Documentation française, Paris.

Deffeyes K. (2001), *Hubbert's Peak: The Impending World Oil Shortage*, Princeton University Press, Princeton.

Department of Energy United States (DOE) (2010), International Energy Outlook 2010, http://www.energy.gov/

Dieleman F. A., Faludi A. (1998), "Randstad, Rhine-Ruhr and Flemish diamond as one polynucleated macro-region?", *Tijdschrift voor economische en sociale geografie*, 89 (3), p. 320-327.

Dicken P. (2007), *Global Shift. Mapping the Changing Contours of the World Economy*, Sage, London.

Dodds K. (2007), *Geopolitics. A short introduction*, Oxford University Press, Oxford.

Dühr S. (2003), "Illustrating spatial policies in Europe", *European Planning Studies*, 11 (8), pp. 929-948.

Dühr S. (2007), *The Visual Language of Spatial Planning. Exploring Cartographic Representations for Spatial Planning in Europe*, Routledge, London.

European Commission (EC) (2013), EU energy statistics pocketbook 2013 http://ec.europa.eu/energy/observatory/statistics/statistics_en.htm

Economides M.J., Wood D.A. (2009), "The state of natural gas", *Journal of Natural Gas Science and Engineering*, 1(1), pp. 1-13.

Energy Information Administration (EIA) (2010), Annual Energy Outlook 2009, EIA.

Energy Information Administration (EIA) (2013), Annual Energy Outlook 2012, EIA.

Favennec J.P. (2011), *The Geopolitics of Energy*, Technip Editions, Paris.

Ferguson J. (2006), *Global Shadows. Africa in the Neoliberal World Order*, Duke University Press, Durham and London.

Gokay B. (ed.) (2001), *The politics of Caspian oil*, Macmillan, London.

Gokay B. (2006), "The power shift to the East: the 'American Century' is ending", Pravda, May 18th.

Goldsmith E., Meadow P. (1972), *The limits to growth*, Universe books, New York.

Goldthau A., Witte J. M. (eds.) (2010), *Global energy governance: The new rules of the game,* Global Public Policy Institute, Berlin.

Goodstein D.L. (2004), *Out of Gas*, W.W.Norton, New York.

Graham S. (ed) (2004), *Cities, war, and terrorism: towards an urban geopolitics*, Blackwell, Oxford.

Gregory D. et al. (2009), *The dictionary of human geography*, Wiley-Blackwell, Chichester.

Hall C.A., Day J.W. (2009), "Revisiting the limits to growth after peak oil", *American Scientist*, 97(3), pp. 230-237.

Harley B. (1989), "Deconstructing the map", *Cartographica*, v. 26, n. 2, pp. 1-20.

Helm D. (2002), "Energy policy: security of supply, sustainability and competition", *Energy policy*, 30(3), pp. 173-184.

Hisane M. (2006), "Japan's New Energy Strategy," Asia Times, January 13th, available http://www.atimes.com/atimes/Japan/HA13Dh01.html

Hurst C. (2010), "The militarization of Gazprom", *Military Review*, September-October.

Jojarth C. (2008), *The end of easy oil: estimating average production costs for oil fields around the world*, Center on Democracy, Development, and The Rule of Law-

Stanford, Published by Program on Energy and Sustainable Development Working Paper, 72.

Kaldor M. (1999), *New and Old Wars. Organized Violence in a Global Era*, Polity Press, London.

Kaplan R. D. (2000), *The Coming Anarchy: Shattering the Dreams of the Post Cold War*, Random House, New York.

Kardaş Ş. (2011), “Geo-strategic position as leverage in EU accession: the case of Turkish–EU negotiations on the Nabucco pipeline”, *Southeast European and Black Sea Studies*, 11(1), pp. 35-52.

Klare M. (2001), *Resource Wars: The New Landscape of Global Conflict,* Metropolitan Books, New York.

Klare M. (2004), *Blood and Oil: The Dangers and Consequences of America’s Growing Dependency on Imported Petroleum*, Metropolitan Books, New York.

Klare M. (2008a), *Rising powers, shrinking planet*, Oneworld, Oxford.

Klare M. (2008b), The New Geopolitics of Energy, The Nation, May 19th, available http://www.jmhinternational.com/news/news/selectednews/files/2008/05/20080501_Nation_%20TheNewGeopoliticsOfEnergy.pdf

Kruyt B., van Vuuren D.P., de Vries H.J.M., Groenenberg H. (2009), “Indicators for energy security”, *Energy Policy*, 37 (6), pp. 2166-2181.

Li Zhi Dong (2003), “An Econometric Study on China's Economy, Energy and Environment to the Year 2030,” *Energy Policy,* 31 (11), pp. 1137-1150.

Merrill K.R. (2007), *The Oil Crisis of 1973-1974: A Brief History with Documents*, Bedford/St. Martin’s.

Olesen K. and Richardson T. (2011), "The Spatial Politics of Spatial Representation: Relationality as a Medium for Depoliticization?" International Planning Studies, v. 16, n. 4, pp. 355-375.

Paklone I. (2011), "Conceptualization of Visual Representation in Urban Planning", Limes: Cultural Regionalistics, v., n. 2, pp. 150-161.

Peters S. (2004), “Coercive western energy security strategies: ‘resource wars’ as a new threat to global security”, *Geopolitics,* 9 (1), pp. 187-212.

POLINARES project - The changing oil value chain: Implications for security of supply (www.polinares.eu)

Reimer A. W. (2010), "Understanding Chorematic Diagrams: Towards a Taxonomy", *The Cartographic Journal*, v. 47, n. 4, pp. 330-350.

Reynaud A. (1981), *Société, espace et justice*, PUF, Paris.

Roberts P. (2004*), The End of Oil: On the Edge of a Perilous New World*, Houghton Mifflin, Boston.

Selley N. (2013), *The New Economy of Oil: Impacts on Business, Geopolitics and Society*, Routledge, London.

Shaffer B. (2001), “A Caspian alternative to OPEC”, *The Wall Street Journal*, 11 July.

Starling R. (1998), "Rethinking the power of maps: some reflections on paper landscapes", *Ecumene*, v. 5, n. 1, pp. 105-108.

Stern J. P. (2005), *The future of Russian gas and Gazprom*, Oxford University Press, Oxford.

Strange S. (1996), *The Retreat of the State. The Diffusion of Power in the World Economy*, Cambridge University Press, Cambridge.

Sukhanov A. (2005), “Caspian oil exports heading East”, Asia Times, 10 February.

Taylor P. J., Watts M. J. and Johnston R. J. (1995), Remapping the world: what sort of map? What sort of world?, in R. J. Johnston, P. J. Taylor and M. J. Watts (ed.), *Geographies of Global Change. Remapping the World in the Late Twentieth Century*, Blackwell, Oxford, pp. 377-385.

Umbach F. (2010), “Global energy security and the implications for the EU”, *Energy Policy*, 38, pp. 1129-1240.

Vanolo A. (2010), "The border between core and periphery: geographical representations of the world system", *Tijdschrift voor Economische en Sociale Geografie*, v. 101, n. 1, pp. 26-36.

Victor D.G., Jaffe A.M., Hayes M.H. (eds.) (2006), *Natural gas and geopolitics: from 1970 to 2040*, Cambridge University Press, Cambridge.

Volkov V. (2004), “Hostile Enterprise Takeovers: Russia’s Economy in 1998–2002”, Review *of Central and East European Law*, 29 (4), pp. 527-548

Watts M.J. (ed.) (2008), *Curse of the Black Gold: 50 Years of Oil in the Niger Delta,*Brooklyn NY: Powerhouse Books.

Winzer C. (2012), “Conceptualizing energy security”, *Energy Policy*, 46 (C), pp. 36-48.

Youngs R. (2009), *Energy security: Europe’s new foreign policy challenge*, Routledge, London.

Chapter 2

50Hertz Offshore GmbH. 2010. “Kriegers Flak Project Continues with Danish and German Participation.”

ACWA Power. 2013. “Local Solar Industry Opportunities & Challenges”. Slideshow presented at the Forum hosted by Masen, January 21.

Almaouja - Le magazine du renouveau des territoires au Maroc. 2012. “Interview avec M. Amrane du MASEN□: l’impact de la centrale solaire sur Ouarzazate.” September 19. http://www.almaouja.com/solaire-ouarzazate/310-interview-amrane-masen-impact-centrale-solaire-sur-ouarzazate.

Bahgat, Gawdat. 2012. “The Impact of the Arab Spring on the Energy Sector: Opportunities and Risks”. The World Financial Review. http://www.worldfinancialreview.com/?p=2469.

Baumann. 2009. “How to Assess Rangeland Condition in Semiarid Ecosystems? The Indicative Value of Vegetation in the High Atlas Mountains, Morocco”. PhD thesis, Cologne: Universität zu Köln. http://kups.ub.uni-koeln.de/2869/.

Benelux. 2012. “The North Seas Countries’ Offshore Grid Initiative Initial Findings”. Final Report. http://www.benelux.int/NSCOGI/NSCOGI_WG1_OffshoreGridReport.pdf.

BMU, and BMWi. 2010. “Energy Concept for an Environmentally Sound, Reliable and Affordable Energy Supply”. Federal Ministry of Economics and Technology (BMWi). I:ecologic-internprojects01_ongoing_projects2715_CECILIA01_WP1_Taking_Stock_Ecol ogicTask 1.2_UCLCase_study_GermanyLiteratureBundesregierung_2010_Energy_Conc ept_en.pdf.

Bobai, Francis Danjuma. 2012. "An Analysis of the Relationship between Petroleum Prices and Inflation in Nigeria." *International Journal of Business and Commerce* Vol. 1 (August), No.12: (ISSN: 2225-2436)

Bryden, John, Lily Riahi, and Romain Zissler. 2013. “MENA Renewables Status Report”. Abu Dhabi: International Renewable Energy Agency, Renewable Energy Policy Network for the 21st Century, United Arab Emirates Ministry of Foreign Affairs. http://www.ren21.net/Portals/0/documents/activities/Regional%20Reports/MENA_2013_lowres.pdf.

Danish Energy Agency. 2012. “Accelerating Green Energy Towards 2020”. Ministry of Climate, Energy and Building. http://www.ens.dk/sites/ens.dk/files/dokumenter/publikationer/downloads/accelerating_green_energy_towards_2020.pdf.

———. 2013. “Kriegers Flak”. Document no. 13 - 93260 - 684. Denmark.

Delucchi, Mark A., and Mark Z. Jacobson. 2010. “Providing All Global Energy with Wind, Water, and Solar Power, Part II: Reliability, System and Transmission Costs, and Policies.” *Energy Policy* 39 (December): 1170 – 1190.

Dorminey, Bruce. 2012. “US Biomass: Where Do All the Wood Pellets Go?” *RenewableEnergyWorld.com*. June 14. http://www.renewableenergyworld.com/rea/news/article/2012/06/where-do-all-the-wood-pellets-go.

Eberle, Andrew, Eike Karola Velten, Lena Donat, Matthias Duwe, and Anna Poblocka. 2014. “Assessment of Climate Change Policies in the Context of the European Semester. Country Report: Denmark”. 071201/2012/635684/SER/CLIMA.A.3. Ecologic Institute and eclareon.

E-Bridge. 2010. “Kriegers Flak Combined Grid Solution Feasibility Study”. Feasibility Study.

EEA. 2013. “Overview of the Electricity Production and Use in Europe (ENER 038).” *European Environment Agency*. March. http://www.eea.europa.eu/data-and-maps/indicators/overview-of-the-electricity-production/assessment.

El Nokrashy, Hani. 2005. “Renewable Energy Partnership: Europe - Middle East - North Africa.” In Amman. http://www.menarec.org/resources/RenewableEnergyPartnershipEUMENA_MENAREC2.pdf.

EnBW AG. 2014. “EnBW Baltic 2.” Accessed February 5. http://www.enbw.com/unternehmen/konzern/energieerzeugung/neubau-und-projekte/enbw-baltic-2/technik.html.

Energinet.dk. 2013. “Kriegers Flak Offshore Wind Farm.” November 26. https://www.energinet.dk/EN/ANLAEG-OG-PROJEKTER/Anlaegsprojekter-el/Havbaseret-elnet-paa-Kriegers-Flak/Sider/default.aspx.

European Climate Foundation. 2011. “Power Perspectives 2030: On the Road to a Decabonised Power Sector”. Den Haag. http://www.roadmap2050.eu/attachments/files/PowerPerspectives2030_FullReport.pdf.

European Commission. 2009. “Baltic Energy Market Interconnection Plan”. Final Report of the High Level Group. Energy Infrastructure. http://ec.europa.eu/energy/infrastructure/events/doc/2009/2009_11_25_hlg_report_170609.pdf.

———. 2011. “Energy Roadmap 2050.” http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0885:FIN:EN:PDF.

———. 2012. “Antitrust: Commission Opens Proceedings against Gazprom.” *Press Release*. September 4. http://europa.eu/rapid/press-release_IP-12-937_en.htm.

———. 2013a. “Annual Report 2013 on the European Union’s Development and External Assistance Policies and Their Implementation in 2012”. Commission Staff Working Document SWD(2013) 307 final. Brussels. http://ec.europa.eu/europeaid/multimedia/publications/documents/annual-reports/europeaid_annual_report_2013_full_en.pdf.pdf.

———. 2013b. “Offshore Wind. Baltic-Kriegers Flak: Combined Grid Solution.” http://ec.europa.eu/energy/eepr/projects/files/offshore-wind-energy/baltic-kriegers-flak_en.pdf.

———. 2013c. “Energy: Projects of Common Interest.” October 14. http://ec.europa.eu/energy/infrastructure/pci/pci_en.htm.

European Network of Transmission System Operators for Electricity. 2013. “The North Seas Countries’ Offshore Grid Initiative (NSCOGI).” October 1. https://www.entsoe.eu/about-entso-e/system-development/the-north-seas-countries-offshore-grid-initiative-nscogi/.

European Wind Energy Association. 2011. “Maritime Spatial Planning: Supporting Offshore Wind and Grid Development.” http://www.ewea.org/fileadmin/ewea_documents/documents/members_lounge/1._Make_the_right_connections/Offshore_Wind_Industry_Advisory_Group/110921_EWEA_briefing_on_Maritime_Spatial_Planning.pdf.

Eurostat. 2012a. “Energy Balance Sheets”. Luxembourg: European Union. http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-EN-12-001/EN/KS-EN-12-001-EN.PDF.

———. 2012b. “Net Imports of Primary Energy, 2002-2010.” October. http://epp.eurostat.ec.europa.eu/statistics_explained/index.php?title=File:Net_imports_of_primary_energy,_2002-2010.png&filetimestamp=20121012131900#

Forte, Rosa and Rui Moura, 2013. "The Effects Of Foreign Direct Investment On The Host Country's Economic Growth: Theory And Empirical Evidence," *The Singapore Economic Review (SER)*, World Scientific Publishing Co. Pte. Ltd., vol. 58(03), pages 1350017-1-1.

Friedman, Lisa. 2011. “Can North Africa Light Up Europe With Concentrated Solar Power?” *The New York Times*. June 20. http://www.nytimes.com/cwire/2011/06/20/20climatewire-can-north-africa-light-up-europe-with-concen-79708.html?pagewanted=all.

Gaëtan, Masson, Marie Latour, Manoël Rekinger, Theologitis Ioannis-Thomas, and Myrto Papoutsi. 2013. “Global Market Outlook for Photovoltaics 2013-2017”. European Photovoltaic Industry Association. http://www.epia.org/index.php?eID=tx_nawsecuredl&u=0&file=/uploads/tx_epiapublications/GMO_2013_-_Final_PDF_01.pdf&t=1395135459&hash=6e3f9b7a58ef43604bf09c18585f195b779e2c8e.

German Aerospace Centre. 2006. “Trans-Mediterranean Interconnection for Concentrating Solar Power”. Germany: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.

———. 2014. “enerMENA Capacity Building Program.” Accessed February 10. http://www.dlr.de/sf/desktopdefault.aspx/tabid-8679/.

Granheim, Øystein. 2012. “Kriegers Flak: How Will Policy, Law and Financing Affect a Combined Solution Project”. Aarhus University.

Grünig, Max, Adam Pearson, Andrew Eberle, Eike Karola Velten, and Mira Wenzel. 2013. “Report on Main Trends in European Energy Policies”. MILESECURE2050 Project Deliverable D1.3. http://www.milesecure2050.eu/en/public-deliverables.

Hernandez, R.R., S.B. Easter, M.L. Murphy-Mariscal, F.T. Mastre, M. Tavassoli, E.B. Allen, C.W. Barrows, et al. 2014. “Environmental Impacts of Utility-Scale Solar Energy.” *Renewable and Sustainable Energy Reviews* 29: 766–79.

IEA Energy Technology Network. 2014. “Solar Power and Chemical Energy Systems: Morocco”. English. *SolarPACES*. Accessed February 10. http://www.solarpaces.org/News/Projects/Morocco.htm.

International Energy Agency. 2011. “World Energy Outlook 2011: Energy for All - Financing Access for the Poor”. Paris. http://www.iea.org/media/weowebsite/energydevelopment/weo2011_energy_for_all.pdf.

International Energy Agency, and International Renewable Energy Agency. 2013. “Global Renewable Energy - Morocco.” *IEA/IRENA Joint Policies and Measures Database*. http://www.iea.org/policiesandmeasures/renewableenergy/?country=Morocco.

International Renewable Energy Agency. 2012. “Wind Power”. Working Paper Volume 1: Power Sector. Renewable Energy Technologies: Cost Analysis Series. Bonn: International Renewable Energy Agency. https://www.irena.org/DocumentDownloads/Publications/RE_Technologies_Cost_Analysis-WIND_POWER.pdf.

Kaminker, Christopher, and Fiona Stewart. 2012. “The Role of Institutional Investors in Financing Clean Energy”. 23. OECD Working Papers on Finance, Insurance and Private Pensions. OECD. http://www.oecd.org/finance/private-pensions/WP_23_TheRoleOfInstitutionalInvestorsInFinancingCleanEnergy.pdf.

Khakee, Anna. 2010. “Assessing Democracy Assistance: Morocco”. FRIDE. http://www.fride.org/download/IP_WMD_Morocco_ENG_jul10.pdf.

King of Morocco. 2012. “SM le Roi adresse un discours à la Nation à l’occasion de la Fête du Trône.” *Kingdom of Morocco*. July 30. http://www.maroc.ma/fr/discours-royaux/sm-le-roi-adresse-un-discours-%C3%A0-la-nation-%C3%A0-loccasion-de-la-f%C3%AAte-du-tr%C3%B4ne.

Kristensen, Anders H. 2013. “Danish Policy on Underground Cabling of HV Lines”. Slideshow Danish Energy Agency. http://renewables-grid.eu/fileadmin/user_upload/Files_RGI/Anders_Kristensen_Danish_Energy_Agency_Danish_Policy_on_Underground_Cabling.pdf.

Kwasniewski, Nicolai. 2013. “Desertec on the Ropes: Competitors and Local Opposition Threatens Desertec Solar Plan.” *Spiegel Online*. April 3. http://www.spiegel.de/international/europe/competitors-and-local-opposition-threatens-desertec-solar-plan-a-892332.html.

Lee, April, Owen Zinaman, and Jeffrey Logan. 2012. “Opportunities for Synergy Between Natural Gas and Renewable Energy in the Electric Power and Transportation Sectors”. Technical Report NREL/TP - 6A50 - 56324. National Renewable Energy Lab. http://www.nrel.gov/docs/fy13osti/56324.pdf.

Lesser, Ian O., Geoffrey Kemp, Emiliano Alessandri, and S. Enders Wimbush. 2012. “Morocco’s New Geopolitics a Wider Atlantic Perspective.” Wider Atlantic Series. Washington D.C.: The German Marshall Fund of the United States. Electronic copy available.

Lesser, Pamela. 2009. “Greening the Mediterranean: Europe’s Environmental Policy toward Mediterranean Neighbors.” *Mediterranean Quarterly* 20 (2): 26–39. doi:10.1215/10474552-2009-003.

Levitan, Dave. 2013. “Is Anything Stopping a Truly Massive Build-Out of Desert Solar Power?” *Scientific American*. July 1. http://www.scientificamerican.com/article/challenges-for-desert-solar-power/.

Malik, Adeel, and Bassem Awadallah. 2011. “The Economics of the Arab Spring”. Briefing note MEI Insight No. 46. National University of Singapore: Middle East Institute. http://www.mei.nus.edu.sg/wp-content/uploads/2011/11/Download-Insight-46-Malik-Awadallah-HERE.pdf.

Meiner, Andrus, and Johnny Rekker. 2013. “Balancing the Future of Europe’s Coasts - Knowledge Base for Integrated Management”. 12/2013. Luxembourg: European Environment Agency. http://www.eea.europa.eu/publications/balancing-the-future-of-europes.

Ministère de l’Energie des Mines de l’ Eau et de l’ Environnement. 2012. “Les caractéristiques du secteur énergétique marocain en 2011”. Morocco: Central Planning Commission. http://www.abhatoo.net.ma/maalama-textuelle/developpement-economique-et-social/developpement-economique/energie-et-mines/energie-et-mines-generalites/les-caracteristiques-du-secteur-energetique-marocain-en-2011.

Moroccan Investment Development Agency. 2014. “Wind Energy.” *Invest Opportunities*. Accessed February 4. http://www.invest.gov.ma/?Id=67&lang=en&RefCat=3&Ref=146.

Newberry, David, Goran Strbac, Danny Pudjianto, and Pierre Nöel. 2013. “Benefits of an Integrated European Energy Market”. Amsterdam: Booz & Company. http://ec.europa.eu/energy/infrastructure/studies/doc/20130902_energy_integration_benefits.pdf.

Newman, Harold R. 2012. “2010 Minerals Yearbook: Morocco and Western Sahara”. United States Geological Survey. http://minerals.usgs.gov/minerals/pubs/country/2010/myb3-2010-mo-wi.pdf.

Piria, Raffaele, and Loukianos Zavolas. 2013. “Priorities in the North Sea Grid Debate”. SEFEP working paper 2012-3. Smart Energy for Europe Platform.

Reisz, Todd. 2013. “The Orderly Pleasures (and Displeasures) of Oil Urbanism.” *Portal 9*, October. http://www.portal9journal.org/blogdetails.aspx?id=16#sthash.SYZyzKKj.dpuf.

Rignall, Karen. 2012. “Theorizing Sovereignty in Empty Land: The Land Tenure Implications of Concentrated Solar Power in Pre-Saharan Morocco.” In *Land Deals Politics Initiative*. Ithica: Cornell University. http://www.cornell-landproject.org/download/landgrab2012papers/rignall.pdf.

Schinke, Boris. 2013. “Energy Transition in a Changing Arab World? Discussing Human Development Requirements for Future Large Scale Renewable Energy Projects in the MENA Region.” Workshop Report. World Social Forum in Tunis: Germanwatch. http://germanwatch.org/en/download/7552.pdf.

Schinke, Boris, and Jens Klawitter. 2013. "It's Springtime in the Desert: Safeguarding the Sustainable Implementation of the DESERTEC Concept". Briefing paper 13-2-05e. Bonn: Germanwatch. http://germanwatch.org/en/download/7489.pdf.

Schinke, Boris. 2014. "Social Acceptance of the Ouarzazate CSP Project." Telephone.

Steinmetz, Oliver. 2011. "DESERTEC – Clean Power from Deserts" December 9, Academy of Athens & the European Academies Science Advisory Council (EASAC). http://www.academyofathens.gr/Documents/solar_energy_concentrating_solar_power/desertec.pdf.

Sweeney, James L. 2000. "Economics of Energy." *Encyclopedia of the Social and Behavioral Sciences* 4.9 (article 48). http://www.stanford.edu/~jsweeney/paper/Energy%20Economics.PDF.

The DESERTEC Foundation. 2007. "The DESERTEC Concept." http://www.desertec.org/concept/.

The Guardian. 2010. "US Embassy Cables: Moroccan Sacking Exposes King's Business Role." December 6. http://www.theguardian.com/world/us-embassy-cables-documents/151131.

The World Bank. 2011. "Project Appraisal Document on a Proposed Loan in the Amount of US$200 Million and a Proposed Clean Technology Fund Loan in the Amount of US$97 Million to the Moroccan Agency for Solar Energy (MASEN) with the Guarantee of the Kingdom of Morocco for the Ouarzazate I Concentrated Solar Power Plant Project". 64663-MA. Sustainable Development Department.

———. 2013. "Plan d'acquisition de terrain lie aux infrastructures communes". Environmental Assessment E2644 v3. The World Bank. http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2013/02/19/000356161_20130219153822/Rendered/PDF/E26440v30FRENC0pitre0ICESIA0v150113.pdf.

United States Agency for International Development. 2013. "Clean Energy: Supporting Sustainable Low Emission Growth." http://www.usaid.gov/sites/default/files/documents/1865/GCC_Clean_Energy_30oct13.pdf.

United States Central Intelligence Agency. 2014. "Western Sahara." *The World Factbook*. January 10. https://www.cia.gov/library/publications/the-world-factbook/geos/wi.html.

United States Department of State. 2013. "Morocco 2012 Human Rights Report". Annual report. Washington, D.C. http://www.state.gov/documents/organization/204586.pdf.

United States Energy Information Agency. 2013a. "Germany Country Analysis." March. http://www.eia.gov/countries/country-data.cfm?fips=GM&trk=m.

———. 2013b. "Morocco." September. http://www.eia.gov/countries/country-data.cfm?fips=MO.

Velten, Eike Karola, Lena Donat, Matthias Duwe, and Ingrid Bozsoki. 2014. "Assessment of Climate Change Policies in the Context of the European Semester. Country Report: Germany". 071201/2012/635684/SER/CLIMA.A.3. Ecologic Institute and eclareon.

Volk, Dennis. "Electricity Networks: Infrastructure and Operations." Insights Series 2013. Paris: International Energy Agency.

http://www.iea.org/publications/insights/insightpublications/ElectricityNetworks2013_FINAL.pdf.

Wenger, H.J., J. Schaefer, A. Rosenthal, B. Hammond, and L. Schlueter. 1991. “Decline of the Carrisa Plains PV Power Plant: The Impact of Concentrating Sunlight on Flat Plates.” In San Ramon, CA: IEEE. doi:10.1109/PVSC.1991.169280. http://www.researchgate.net/publication/3520429_Decline_of_the_Carrisa_Plains_PV_power_plant_the_impact_ofconcentrating_sunlight_on_flat_plates.

Wille, Joachim. 2013. “Sahara: Sonnige Aussichten”. Magazine. *klimaretter.info*. November 5. http://www.klimaretter.info/energie/hintergrund/13636-ouarzazate.

Wiser, Ryan, and Mark Bolinger. 2008. “Annual Report on U.S. Wind Power Installation, Cost, and Performance Trends: 2007”. Washington, D.C.: United States Department of Energy. http://www.nrel.gov/docs/fy08osti/43025.pdf.

Wouters, Jan, and Sanderijn Duquet. 2013. “The Arab Uprising and the European Union: In Search Of a Comprehensive Strategy”. Working Paper Working Paper No. 98. Leuven: Leuven Centre for Global Governance Studies. https://ghum.kuleuven.be/ggs/publications/working_papers/new_series/wp91-100/wp-98-duquet-wouters-2.pdf.

Zickfeld, Florian, and Aglaia Wieland. 2012. “2050 Desert Power: Perspectives on a Sustainable Power System for EUMENA”. Munich, Germany: Dii and the Fraunhofer Institute for Solar Energy Systems. http://www.dii-eumena.com/fileadmin/Daten/Downloads/Desert%20Power%202050/dp2050_study_web.pdf.

Chapter 3

(Quere 2012) C. Le Quere et al. *The global carbon budget 1959–2011* ESSDD 5, 1107–1157, 2012

(Quere 2013) Le Quere et al. *Carbon Budget 2013 –An annual update of the global carbon budget and trends* ESSD-D doi: 10.5194/essdd-6-689-2013

(EREC 2011) A. Zervos, Ch. Lins, L. Tesnière *Mapping Renewable Energy Pathways towards 2020 EU ROADMAP* European Renewable Energy Council. March 2011

Chapter 4

Baritaud, Manuel. 2012. Securing power during the transition. Generation investment and operation issues in electricity markets with low-carbon policies. In *Insights*. Paris: IEA.

Batlle, C., and P. Rodilla. 2010. "A critical assessment of the different approaches aimed to secure electricity generation supply." *Energy Policy* no. 38 (11):7169-7179. doi: http://dx.doi.org/10.1016/j.enpol.2010.07.039.

Brown, Stephen P.A., Alan J. Krupnick, and Margaret A. Walls. 2009. Natural Gas: A Bridge to a Low Carbon Future? : National Energy Policy Institute.

Buchan, David. 2012. Europe's misshapen market: Why progress towards a single energy market is proving uneven. In *Comment*. Oxford: Oxford Institute for Energy Studies.

Change, Intergovernmental Panel on Climate. 2013. Fifth Assessment Report. Intergovernmental Panel on Climate Change.

Chaudry, Modassar 2009. Building a Resilient UK Energy System. UKERC.

European Commission. 2012a. Consultation Paper on generation adequacy, capacity mechanisms and the internal market in electricity. Brussels: European Commission.

———. 2012b. Study on synergies between electricity and gas markets. In *Consultation Paper on generation adequacy, capacity mechanisms and the internal market in electricity*. Brussels: COWI Belgium.

Deane, J. P., Alessandro Chiodi, Maurizio Gargiulo, and Brian P. Ó Gallachóir. 2012. "Soft-linking of a power systems model to an energy systems model." *Energy* no. 42 (1):303-312. doi: http://dx.doi.org/10.1016/j.energy.2012.03.052.

Deane, J.P, Francesco Gracceva, Alessandro Chiodi, Maurizio Gargiulo, and Brian P Ó Gallachóir. 2012. Modelling Power System Energy Security by Soft-Linking TIMES with PLEXOS. In *Reference Documents for Science and Policy*. Petten: JRC Institute for Energy and Transport

Densing, Martin, Hal Turton, and Georg Bäuml. 2012. "Conditions for the successful deployment of electric vehicles – A global energy system perspective." *Energy* no. 47 (1):137-149. doi: http://dx.doi.org/10.1016/j.energy.2012.09.011.

Føyn, T. Helene Ystanes, Kenneth Karlsson, Olexandr Balyk, and Poul Erik Grohnheit. 2011. "A global renewable energy system: A modelling exercise in ETSAP/TIAM." *Applied Energy* no. 88 (2):526-534. doi: http://dx.doi.org/10.1016/j.apenergy.2010.05.003.

Glanchant, Jean-Michel , and Haikel Kalfallah. 2011. Identifying benefits and allocating costs for European cross border infrastructure projects. In *Policy Brief*: Florence School of Regulation.

Gracceva, Francesco, and Peter Zeniewski. 2013. "Exploring the uncertainty around potential shale gas development – A global energy system analysis based on TIAM (TIMES Integrated Assessment Model)." *Energy* no. 57 (0):443-457. doi: http://dx.doi.org/10.1016/j.energy.2013.06.006.

———. 2014. "A systemic approach to assessing energy security in a low-carbon EU energy system." *Applied Energy*.

Guivarch, Celine, Stephanie Monjon, Julie Rozenberg, and Adrien Vogt-Schilb. 2012. Evaluer Les Interactions entre Politique climatique et Sécurité énergétique en Europe. Paris: Centre International de Recherche sur l'Environnement et le Développement.

Gül, Timur, Socrates Kypreos, Hal Turton, and Leonardo Barreto. 2009. "An energy-economic scenario analysis of alternative fuels for personal transport using the Global Multi-regional MARKAL model (GMM)." *Energy* no. 34 (10):1423-1437. doi: http://dx.doi.org/10.1016/j.energy.2009.04.010.

Haas, Reinhard, Georg Lettner, Hans Auer, and Neven Duic. 2013. "The looming revolution: How photovoltaics will change electricity markets in Europe fundamentally." *Energy* no. 57 (0):38-43. doi: http://dx.doi.org/10.1016/j.energy.2013.04.034.

IEA. 2005. Learning from the Blackouts: Transmission System Security in Competitive Electricity Markets Paris: OECD.

———. 2011. Are we entering a golden age of gas? In *World Energy Outlook*. Paris: Organisation for Economic Co-operation and Development

———. 2012. Energy Technology Perspectives 2012 -- Pathways to a Clean Energy System. Paris: IEA.

Jansen, J.C. 2009. Energy services security: concepts and metrics In *Expert paper submitted as input to the ongoing IAEA project: 'Selecting and Defining Integrated Indicators for Nuclear Energy'*: Energy Research Centre Netherlands (ECN).

Jewell, Jessica, Aleh Cherp, and Keywan Riahi. 2014. "Energy security under de-carbonization scenarios: An assessment framework and evaluation under different technology and policy choices." *Energy Policy* no. 65 (0):743-760. doi: http://dx.doi.org/10.1016/j.enpol.2013.10.051.

Kannan, R. 2009. "Uncertainties in key low carbon power generation technologies – Implication for UK decarbonisation targets." *Applied Energy* no. 86 (10):1873-1886. doi: http://dx.doi.org/10.1016/j.apenergy.2009.02.014.

Kannan, Ramachandran, and Neil Strachan. 2009. "Modelling the UK residential energy sector under long-term decarbonisation scenarios: Comparison between energy systems and sectoral modelling approaches." *Applied Energy* no. 86 (4):416-428. doi: http://dx.doi.org/10.1016/j.apenergy.2008.08.005.

Labriet, Maryse, Amit Kanudia, and Richard Loulou. 2012. "Climate mitigation under an uncertain technology future: A TIAM-World analysis." *Energy Economics* no. 34, Supplement 3 (0):S366-S377. doi: http://dx.doi.org/10.1016/j.eneco.2012.02.016.

Lefèvre, Nicolas. 2007. Energy Security and Climate Policy. Paris: IEA.

Levi, Michael. 2013. "Climate Consequences of Natural Gas As a Bridge Fuel." *Climatic Change* no. 118:60-623.

Tosato, Giancarlo. 2008. Energy security from a systems analysis point of view: introductory remarks. In *Proceedings of the 1st International Conference of the FP7 project REACCESS*. Turin, Italy.

Venkataraman, Sundar, Gary Jordan, Richard Piwko, Lavelle Freeman, Udi Helman, Clyde Loutan, Grant Rosenblum, Mark Rothleder, June Xie, Hong Zhou, and Michael Kuo. 2010. Integration of Renewable Resources; Operational Requirements and Generation Fleet Capability at 20% RPS. California-ISO.