The European Energy Union (EEU): From Dream to Reality

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Abstract The European Energy Union represents a desiderate that is analysed in this chapter. The chapter starts with the evolution of the energy sector and the transition to a society, where the renewable energy sources will play a significant role for the future sustainability strategies on a global scale. This is a response to the objective of the long-term decarbonisation of the European energy system and to the new EU strategies 2020, 2030 and 2050. The chapter further introduces the role of energy security, energy efficiency and competitiveness within the concept of European Energy Union. Furthermore, the main statistical indicators are presented in the energy sector for the case of the European Union with explanation of certain correlations and their meaning for the evolution towards a sustainable development for EU member states.

The key points of the chapter are the following ones:

1. Understanding the concept of the European Energy Union (EEU)
2. Analyzing the European Union priorities in the energy field
3. Identification of the importance of energy security in the EEU
4. Role of energy efficiency and competititveness in the EEU
5. Understanding the main statistical indicators in EU

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1 Introduction

The energy sector has encountered a broader diversification in the past decade than ever before, renewable energies have significantly improved their share in production and financial gains capturing the attention of the regulatory institutions. These renewable energy sources, such as wind, solar, biomass and water, emerge as main sources of sustainable energy for the future. Most likely, they will replace the traditional, less environmentally preserving energy sources of coal and petrol. However, energy policies still need to evolve accordingly to provide the financial and regulatory support of energy markets, as well as for their producers and consumers. To date, no global scheme towards renewables is emerging, and also the development in Europe is unclear. Policies towards strengthening renewable energies compete with those that still subsidize fossil fuel, and renewable energies are liable to market externalities of non- or under-priced carbon emissions.

The main objective of this chapter is to analyze the European Union's energy policy with regard to the EU as a business environment. Secondary objectives refer to:

- Understanding the status quo of European energy policy and the concept of the European Energy Union and identification of their main advantages and disadvantages,
- Identifying the role of energy security, energy efficiency and competitiveness within the concept of European Energy Union,
- Understanding the importance of the main statistical indicators in the energy sector in the European Union.

These aspects will offer a broad insight into the evolution of the energy sector, which is constantly contributing to major innovations in technology and renewable sources development, counteracting the high pressure from limited energy resources, increasing energy needs of populations and industries.

2 Energy Policy in the EU and the European Energy Market

All member states of the European Union (EU) have their own policy for energy supply and production, specifically with regard to a transition to an energy system based on renewable energies. However, the individual nations' approaches towards this are very heterogeneous in terms of scope, speed, transition paths favoured, etc. (REN21 2016; Ellenbeck et al. 2015; Szulecki et al. 2015, compare also IEA 2016). The reasons for this can be found in very diverse perceptions on how to ensure energy security, introduce decarbonisation and maintaining the interests of the respective state's present energy system. There is hence no unified European energy market as of today, but a fragmented, albeit intertwined and partially linked system of national markets and energy systems in all areas of energy supply (electricity, heat, cooling etc.) (European Commission 2015). Current (2014) energy production and consumption in the EU are given in Fig. 1.

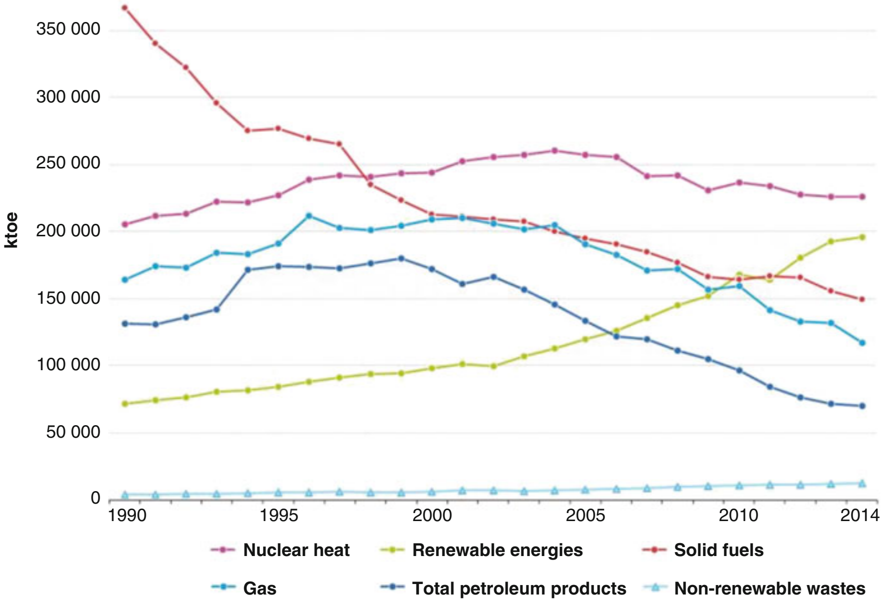

Fig. 1 Primary energy production, EU 28 1990–2014. Source: Eurostat

While the figures do show a positive trend, they also indicate that there is still a long way to go until a climate neutral energy system will be reached.

The EU and its member states have set substantial goals for future development and integration of the energy sector. A major overarching target is the long-term decarbonisation of the European energy system(s) (Ellenbeck et al. 2015; European Commission 2015). This is directly linked to other goals, namely ensuring energy security and creating a climate friendly, i.e. CO_2-neutral, energy system to fulfill the European climate and sustainability strategies (ibid.). The creation of a common market and thus integration of the national markets is another hallmark strategic goal to reach this (Ellenbeck et al. 2015). However, for these aims to be met other measures are yet required; these concerns intensified efforts in improving the share of renewable energies, the establishment of a common trading system, compatible, linked and smart European grids, the promotion of energy efficiency etc. (see e.g. Deloitte 2016, Newbery et al. 2016). In its approaches to change the energy system, the European Union has developed strategies regarding 2020, 2030 and 2050. These strategies are linked to the goals mentioned and a complementary Energy security strategy exists as well.

Goals affiliated with the 2020 strategy are a reduction of greenhouse gases by at least 20%, an increase of renewable energy within the Union's energy mix to at least 20% of consumption, as well as the improvement of energy efficiency of at least 20% (all goals to be reached by 2020, European Commission 2010). The 2030 strategy has further reaching goals, which include a 40% reduction of Greenhouse gas emissions in comparison to 1990, a share of 27% of renewable energy, a 27% increase of energy efficiency, which can be raised to 30% dependent on progress made, and completing an internal energy market. This goal is measured by realizing an energy interconnection of 15% between EU countries by 2030 (European Commission 2014a, b). The 2050 strategy relates to a roadmap and scenarios that project the development of the energy system and GHG emissions. Its main concern is the realization of the EU's GHG–reduction goals for 2050 of minus 80% to minus 95%. This analysis concludes that the decarbonisation of the system is both feasible and in the long run potentially even cheaper than maintaining the present system. Core ingredients of reaching such a status are the further rollout of renewable energies and significant improvements in energy efficiency. Moreover, timely investments into energy-related infrastructure are demanded, noting that an important share of the European infrastructure needed replacement, which could be used to install low-carbon technologies. Lastly, an integrated European solution promises a more efficient and thus cheaper transformation than one based on the actions of single countries (European Commission 2011). Consequently, several different policy instruments have been developed and are being used to different degrees and shares in the member countries. Some important measures among these are: Feed-in tariffs, Feed-in premiums, Quota obligations with tradable green certificates, Loan guarantees, Soft loans, Investment grants, Tax incentives, Tendering schemes, Training, Education and Support for start-ups and innovation (Climate Policy Info Hub 2016; RES Legal Europe 2012). In its analyses and impact assessments until today the European Commission acknowledges considerable advances already, stating the decoupling of GDP-growth and greenhouse gas emissions has already seen some success (e.g. European Commission 2015): "The EU economy is currently the most carbon efficient major economy in the world. It has been particularly successful in decoupling economic growth and greenhouse gas emissions. Between 1990 and 2014, the combined gross domestic product grew by 46%, while total greenhouse gas emissions decreased by 23%. The EU is one of only three major economies that generate more than half of its electricity without producing greenhouse gases." (European Commission 2015, p. 3)

However, as the Commission acknowledges in the same document 27% points of energy production are created through nuclear power, which is not intensive in GHG emissions but has a lot of other problems. Given the findings above, it can be seen that the EU has ambitious goals but a truly unified approach on the side of the member states that would actually produce the energy transformation aspired to be completed by 2050 has yet to be reached. The European Energy Union is a most decisive component for accomplishing these goals.

3 The European Energy Union (EEU): Framework of a European Energy Market

As pointed out the EU does not resemble a coherent market or system in terms of energy production, distribution and sales. Policy makers across the EU are faced with differential systems of energy production (technologies and resources), distribution (e.g. layout and functionality of grids), and consumption. They therefore also pursue very different, and partially competing or even contradicting policies for their respective states (Ellenbeck et al. 2015).

It is the European Energy Union's declared goal to change this and to work as a hub that integrates and coordinates the national policies to arrive at a more effective shared approach. It is therefore embedded in and linked to other EU policies that seek to improve sustainable energy and resource production and consumption (European Commission 2016a, b, c). In this the EEU stands in a long history of energy oriented policy within the EU. Important milestones of these are among others the European Coal and Steel community, which indeed represents one of the pillars the EU was founded on, the European reaction to the oil crises and the energy strategies.

The EEU was funded out of concern for systemic risks for European energy security, specifically with regard to potentially unsafe energy supply. It was proposed in 2014 by then Polish president Donald Tusk and was quickly regarded as a chance to evoke fundamental change for European energy policy (Zachmann 2015). Another motivation came from a review process concerning the results of European energy and climate policy of the previous decade. The investigation showed that the European Union had not succeeded in meeting its alleged goals. Much to the opposite, the internal market seemed to be more fragmented than ever before. This became even more obvious, when the suggestions made by several member states for the content and goals of the EU turned out to be diverse and contradictory (ibid., Szulecki et al. 2015).

However, being in place today and being part of the EU priority "EU and Climate" the European Union's goals are set as follows: "A EEU will ensure that Europe has secure, affordable and climate-friendly energy. Wiser energy use while fighting climate change is both a spur for new jobs and growth and an investment in Europe's future" (European Commission 2016a, b, c). The Energy Union's strategy hinges on five key dimensions: Creating security, solidarity and trust, establishment of a fully integrated energy market, enhancement of energy efficiency, climate action to decarbonise the economy as well as efforts in research, innovations and competitiveness to support and spur the transformation of the current energy systems (ibid., see also Andoura et al. 2015). In this, it stands in close relation to the energy strategies for the next decades mentioned above.

If the EU will succeed in achieving its goals through these strategies remains to be seen. The first two evaluations conducted by the Commission itself are optimistic (European Commission 2015). However, the prevalent state of rather uncoordinated national energy systems and markets remains as one the greatest obstacles. Member states have very different strategic perspective on the Union's goals based no their own situation with regard to resource possession, industry needs and structure, state of transformation and supply security, etc. However, this is not the only challenge.

Others refer to the closeness of many states to their present energy utilities that fear the threat of a unified market. Also, the realization of a real Energy Union would require massive investments into infrastructure in terms of grids, ports, pipelines, etc. which are as of yet not well-integrated (James 2015). Bureaucracy is another hampering factor in the Union's progress slowing the emergence of an effective Union further down. In an evaluative article the Guardian also points toward inconsistency in the strategy itself, e.g. the plan would favour renewable technologies but relies on fossil fuels for energy security (see Guardian 2015 also on other issues named here). Moreover, the role and potential of nuclear power remains unsolved between the states to date (James 2015). Hence, in an overview paper Zachmann (2015, p. 3) formulates five key challenges for the EU to be solved:

1. Ensuring security of supply—refers foremost to independence from Russian natural gas. This is particular challenge for many eastern member states that to date heavily rely on this energy resource and its constant supply.
2. Counteracting a growing renationalisation of energy and climate policy—induced by the member state's self-interests these heavily deviate due to different energy system conditions (see above).
3. Executing the sustainable transformation of the energy system—an issue that does not just concern energy production but also consumption, affiliated, behaviour distribution, etc., and therefore is a tremendously complex task.
4. Lowering energy demand and thus improving energy efficiency—earlier efforts towards this goal. The diverse climatic and natural conditions of the member states could indicate that strategies based on subsidiarity could work best.
5. Maintaining (and establishing) a competitive energy industry in global comparison—as the costs of energy provision differ drastically on a global scale the EU is required to ensure its competitiveness as a location for businesses.

How and if these goals are met and if the challenges are eventually overcome will be seen in the coming decades. It is to be assumed that climate change, resource scarcity, and volatile resource and energy prices could raise the pressure on the EU and its members, potentially strengthening the position of the EU. However such progress still needs to be assessed, and viable indicators are required.

How to remove barriers for a single energy market in Europe is a question that has to be answered based on clear measures that have to been achieved in Europe. The main measures consist in market opening, upgrading, and integrating the energy network and empowering the consumers.

4 Role of Energy Security, Energy Efficiency and Competitiveness in the European Energy Union

The goal of EU is to give to EU consumers a secure, sustainable, competitive and affordable energy. Nowadays, the EU has energy rules set at EU level, but in practice each state has its national regulatory framework. Figures 1 and 2 already showed that there is a need for a fundamental transformation of European energy

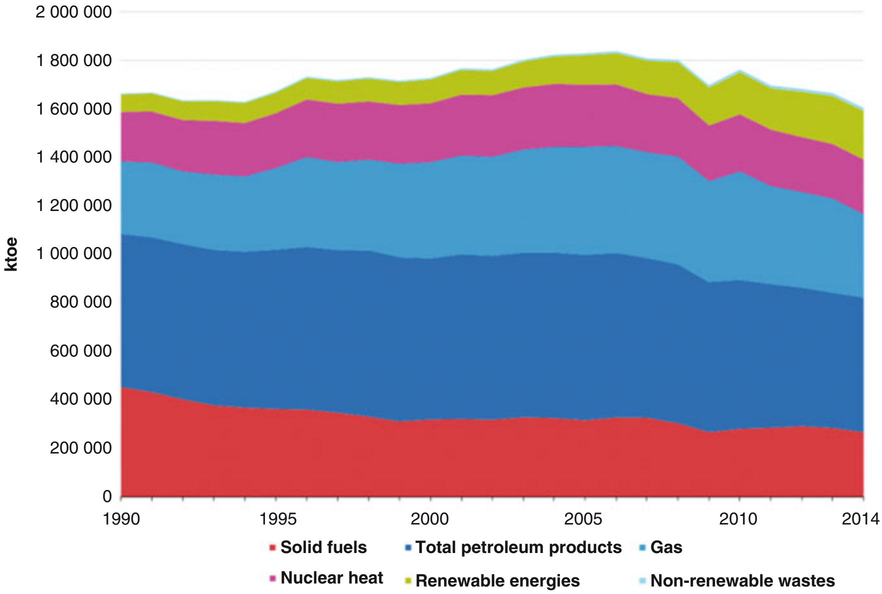

Fig. 2 Gross inland energy consumption EU-28, 1990–2014. Source: Eurostat

system with some progress made. But a secure energy market, more competition and to increase market efficiency through a better use of energy generating facilities across the EU and to produce affordable prices for consumers in some parts of the EU is still lacking but will be required for a functioning renewable system. These issues are presented in an overview in this chapter.

4.1 Energy Security

Energy security represents a main pillar of European Union's Energy Policy and for the Energy Union Strategy (EU 2016a, b, c).

The analysis of energy security based on scientific principles has its roots in 1975 in USA where high levels for the energy consumption and also for the oil imports were registered. The main objective of research studies in that period was to identify the possibilities to increase the energy security in USA in order to reduce the large amount of oil that was imported (Elkind 2010).

In parallel, the International Energy Agency (IEA) was established in Paris in 1974 as a response to the oil crisis that started in 1973. The IEA is nowadays also playing an important role in the global energy security system.

Based on this point of view energy security is first defined as the continuity of energy supplies relative to demand (Winzer 2011, for further input insight also see Narumon et al. 2007, and Sovacool 2011). In this traditional approach, energy security includes energy availability. Availability means that the energy has to be not only produced but also transformed and transported without infrastructural disturbances to the end users (Jonsson et al. 2015). From a technical point of view the reliability of the energy infrastructure is then a main indicator for its security (see Augutis et al. 2015 on indicators and components of energy security). Regarding fossil fuels the availability and finite nature of these resources need to be taken into account (Jonsson et al. 2015).

Concerning energy security in the EU three main problems have to be solved. The first energy security problem in Europe is that an increasing dependence on energy imports from non-members countries is registered. In 2014, 53.5% of gross inland energy consumption of the EU was imported, compared with 40% in 1980 and 43.1% in 1995. The dependency is very high for petroleum and related products (87.4% in 2014) and for natural gas (67.4% in 2014) (Table 1).

The second problem of energy security of the EU is that imports were procured only from few external suppliers (Eurostat 2016a, b, c, d, e; EU 2016a, b, c, see Table 2) and the third one is related to energy prices in EU that are higher than the prices in e.g. USA due to higher energy taxes resulting in (at least hypothetical) competitive disadvantages.

This third problem is reflected also in a second pragmatic definition of energy security that is promoted by the IEA: According to the IEA "energy security is defined in terms of the physical availability of supplies to satisfy demand at a given price" (IEA 2015). Close to this definition there are also specialists that view energy security through its impact on the economy and on consumer welfare. In this

Table 1 Energy import dependency at the EU level (Source: EU (2016))

	1995	2000	2005	2010	2013	2014
Solid fuels	21.5	30.6	39.4	39.5	44.1	45.6
of which hard coal	29.7	42.6	55.7	57.9	64.5	67.9
Petroleum and products	74.1	75.7	82.1	84.5	87.4	87.4
of which crude and NGL	73.0	74.4	81.3	84.6	88.0	87.9
Natural gas	43.4	48.9	57.1	62.2	65.2	67.4
Total	43.1	46.7	52.2	52.6	53.1	53.5

Table 2 Imports of crude oil and of gas at EU level in 2014 (EU 2016)

	Oil import (from total of 494,241 kton)	Gas import from total (11,796,884 TJ-GCV)	
Russia	30.4%	Russia	37.5%
Norway	13.1%	Norway	31.6%
Nigeria	9.1%	Algeria	12.3%
Soudi Arabia	8.9%	Quatar	6.9%
Kazakhstan	6.4%	Not specificied	6.5%
Irak	4.6%	Lybia	2.1%
Azerbaidjan	4.4%	Nigeria	1.5%
Algeria	4.3%	Trinidad &Tobago	0.9%
Other non-EU suppliers	18.8%	Other non-EU suppliers	0.7%

approach energy insecurity is defined “as the loss of welfare that may occur as a result of a change in the price or availability of energy” (Bohi et al. 1996, in Winzer 2011). The concept of energy security defined by IEA and also the concept of energy insecurity defined by Bohi, includes next to the availability of the energy from a technological perspective, also the availability of energy from a social perspective (Le Coq and Paltseva 2009). In this approach the affordability aspects of energy and the functioning of an energy system is analysed based on the energy prices and their volatility. At EU level the concept of energy poverty is conceptualized to come into effect when the income level of a family can sustain only the minimum amount of its energy needs. This minimum amount could consist in the energy for cooking, lightning or other basic needs (Lidell et al. 2012; Moore 2012; Price et al. 2012).

Also for companies a high price of energy presents a real disadvantage in the competition with other producers from states where the energy price is lower. And hence a reduced price for energy is an important factor that contributes to the investment decisions.

Today’s energy security package has to be seen in the light of the new global and universal agreement on climate change, adopted by world leaders on 12th December 2015 in Paris (CO21). The main goal of this agreement is to have a global response to the threat of climate change and to limit the global worming below 2 °C above pre-industrial level. There is also an optimistic scenario which estimate that there is a need for measures in order to limit the temperature increase to 1.5 °C. Through this global agreement clean energy is promoted as a necessary factor to reduce the climate change process and is also seen as prerequisite of a sustainable environment (UNFCCC 2016). For this—as in the EEU goals—there is therefore a need of transformation from conventional fossil fuels to low-carbon alternatives in parallel to an increase of energy efficiency.

Based on this assumption a third definition of energy security is promoted as “provisioning of uninterrupted energy services in an affordable, equitable, efficient and environmentally benign manner (Narula and Reddy 2016). This approach is effectively implemented by the EU due to the objectives for reducing greenhouse gas emissions by 80% by 2050 (EU 2011a, b, I, II).

With regard to these three definitions for energy security specialists consider energy security as a multidimensional concept integrating elements such as security of supply, security of demand, energy affordability and energy poverty, environmental protection, geopolitical aspects and energy revenues (Jonsson et al. 2015).

The main principles for increasing the energy security are based on planning of a security margin. This could be obtained through the development of the energy production capacity or through increasing the energy storage capacity that could be used for crisis situations, or through expanding the interconnections between national energy networks (Yergin 2006).

In order to increase energy security the European Commission is promoting a new Energy Security Strategy since 2014 (EU 2014). The main measures that are promoted in the EU are the diversification of energy suppliers and supply routes (specially new infrastructures for gas and LNG), increasing the emergency stocks for oil and petroleum products and increasing competitiveness on the energy markets (market integration for power and gas). In parallel, there is a need seen for the diversification of energy options, the transition to renewable energy and to explore unconventional resources. All these policies and measures will have to be supported by improvements in the power infrastructure with new interconnections and new structures as gas reverse flows, smart grid, demand responses and other potential solutions. Another dimension of energy security is the promotion of a low energy intensity strategy that is focused on improving energy efficiency in buildings and appliances (Strambo et al. 2015, p. 4). Energy efficiency also means a reduction of energy consumption in the industry and to find ways for cleaner production in the manufacturing industry. It will be addressed in the following paragraphs.

4.2 Energy Efficiency

In general, improvement of *energy efficiency* means using less energy to provide the same result. From a general quantitative perspective energy efficiency represents the ratio of useable output of a process to the total energy input into that process or, using a more simple way to define it, energy efficiency is service output divided to energy input.

Every improvement in energy efficiency potentially represents a reduction of greenhouse gas emissions but also an improvement in energy security supply.

Promotion of the efficient use of energy in EU has its roots in the oil crisis in the 1970s. In the specific context of a high increase of oil prices it was necessary to reduce the dependency on oil that was imported. The response of EU Policy generated structural changes of the economies and enabled member states to perform a relative decoupling of economic growth from energy consumption (Filippini et al. 2014). In order to achieve a desired energy efficiency, the EU devised important documents regarding energy efficiency. One is the Energy Efficiency Directive (EED 2012/27/EU). The Energy Efficiency Directive from 2012 was a direct response to increase the energy efficiency with 20% by 2020 compared to projections by saving of 20% of the EU primary energy consumption. In the Directive, the primary energy consumption was defined as the gross inland energy consumption by excluding the energy consumed for other purposes then producing useful energy (non-energy use) (EU 2012).The process of increasing energy efficiency in the EU was continued with the decision of European Council in October 2014 that set energy targets for 2030. The target for increasing the energy efficiency was set at 27% (European Council 2014). This process has to be supported by national energy efficiency targets that are defined in a comparable, transparent and verifiable manner. However, the reality has to be seen differently because there was not fixed a precise definition that could be used in order to have a proper monitoring process on an EU level and the situation is that the EU members are using different metrics regarding energy efficiency. Another inconvenient fact regarding the process of monitoring energy efficiency is a result of the reduced number of studies in different countries in this field. Most of the studies to date are focused only on a specific technology or on a certain sector or from a geographical point of view, mostly on emerging or developing countries (Knoop and Lechtenböhmer 2016).

Another factor that has to be taken into account for achieving the EU energy efficiency target for 2030 is the energy efficiency national potential. In energy efficiency potential studies we distinguish between: technical, economic and achievable potential. The technical energy efficiency potential represents the ideal scenario which add all energy efficiency measures that can be implemented taking into account technology limitations. The economic energy efficiency potential represents the fraction of the technical potential that is effective from a cost perspective. The achievable energy efficiency potential is a fraction of the economic potential that can be achieved taking into account the infrastructure and the social and market limitations.

For promoting energy efficiency in EU member states instruments such as performance standards, financial incentives, informative programs and labelling were introduced. Moreover, new performance standards were implemented such as insulation standards for buildings, performance standards for electrical products, heating systems and high efficiency (condensed) boilers with a long lifetime which were also supported by financial incentives.

The adoption of measures for increasing energy efficiency has to take into account the discrepancy between a market with perfect competition and the actual market conditions in EU. This gap is explained in economic theory by concepts of market failure (Sorrell et al. 2004).

4.3 The EU Energy Market and Competition

Market failures or market imperfections can be identified e.g. in the form of imperfect competition, information imperfections or asymmetries, incomplete markets, non-priced externalities, etc. In this approach barriers to energy efficiency may be also classified as market failures.

The EU energy market is a market with specific differences from state to state. High levels of concentration are registered in Bulgaria, Cyprus, Estonia and Malta. On the other side Germany, Italy, Finland, and the Netherlands have relative low levels of market concentration. Increasing the competition on the energy markets especially in EU members where concentration is high could lead to a higher productivity. In the scientific literature, the increasing of competition has impact on three main dimensions: within firms, between-firms and innovation (CMA 2015). The within-firm effect represent the difference between the most efficient behaviour that a company can achieve and its real behaviour in practice. This effect demonstrates that competition induces pressure on managers and they have to be more efficient. The between-firms effect enable the reallocation of market shares from inefficient to efficient companies. Through competition the more efficient companies are increasing their market share, while inefficient firms are forced to exit the market. The innovative effect is explained through the technological improvements and the creation of new products and services as a result of a new competition intensity. The innovation process can improve the quality, can reduce the costs or can open new markets. The stronger the competition is companies are more motivated to innovate to be more competitive.

A further reality is that the EU electricity and gas markets for wholesale and for retail are very concentrated. Therefore, the end-user prices are strongly regulated in many countries (EU 2016a, b, c). In order to improve the functioning of the retail market and thus erase further market failure, there is a need to provide consumers with the possibility to control their energy costs. For example, many households in EU have too little possibilities for choosing their energy suppliers. There are also households which are depending on their energy bills due to energy poverty. Therefore, energy powerty is defined as a income level that is sufficient only to sustain the bare minimum energy needs (Barnes et al. 2010) or as powerty and lack access to modern forms of energy (Modi et al. 2006). This concept is relative to the needs that a consumer might have regarding to its electrical and heating needs.

The Commission is looking on instruments that could promote market liberalization further in order to improve the functioning of energy markets. This objective could be achieved through continuing the integration process of the EU energy markets based on expanding the market connections capacities between the EU states.

5 Economic Indicators in the European Energy Union

5.1 Definition of the Main Energy and Economic Indicators in the European Union

Energy efficiency plays a crucial role in contemporary society and business environment. Since the 1973 oil crisis, that imposed an oil embargo on major global regions, such as the United States of America, the United Kingdom, Netherlands, Japan and Canada, leaving them in a major lack of energy sources and increasing drastically the price of oil (Venn 2013), more focus was concentrated on developing new energy sources and energy security strategies.

Since then monitoring of the energy efficiency development has been supported by several energy and economic indicators, which are also published on the main sources of public economic information regarding different regions of the world, such as Eurostat for the European Union or the International Energy Agency for global energy data.

The following energy indicators are considered as some of the main factors for monitoring the evolution of the energy field and efficiency, also published annually by specialized institutions, such as Eurostat: energy intensity, energy dependence, market share of the largest generator in the electricity market, electricity prices depending on type of consumers, primary energy production by type of energy, primary production of renewable energy:

(a) Energy intensity is defined as the ratio of the gross inland consumption of energy to Gross Domestic Product (GDP) calculated for a calendar year (according to the European Environment Agency).

Practically, energy intensity measures energy consumption per unit of activity in each field. A high level of energy intensity of a sector implies more energy is consumed per unit of activity. Energy intensity is one of the most important indicators of observing the evolution of energy efficiency depending on factors such as: the degree of industrialisation, size of a region, number of households, industries, etc.

A country that is economically productive and uses energy efficiently, will tend to have a lower energy intensity, and thus be more energy efficient, than a land which *ceteris paribus* is consuming a high amount of energy through producing inefficiently and, thus, has a high energy intensity.

Overall, the energy intensity of the European Union has decreased by 30% from a level of 172,9 since 1995 until 2014 (Eurostat 2016a, b, c, d, e). As shown in Fig. 3, countries such as Germany, Finland, Denmark, Sweden, the United Kingdom, the Netherlands have a low energy intensity, and therefore a low consumption of energy per GDP. On the opposite, Bulgaria is at the extreme peak of high energy intensity with an indicator of 445,2, the highest of the European Union in 2014, followed by Estonia with 390,5.

(b) Energy dependence, which refers to the degree of dependence of a country or region to imports of energy. The calculation formula provided by Eurostat is:

Energy dependence = (Net import of energy)/(Sum of gross inland energy consumption plus bunkers.)

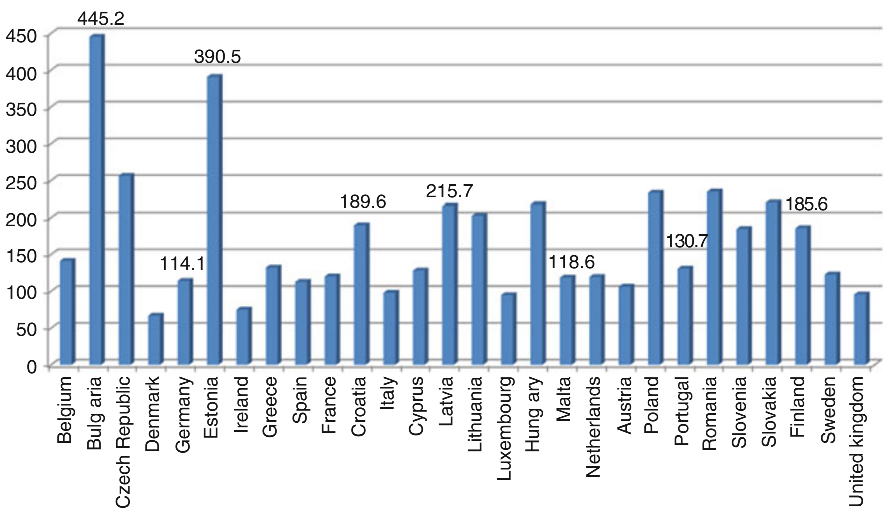

Fig. 3 Energy intensity of the economy in the European Union 2014 (Gross inland consumption of energy divided by GDP (kg of oil equivalent per 1000 EUR)) (Source: Eurostat 2016)

This indicator is significantly important to monitor the dependence of certain economies on imports of energy as traditional energy sources of energy are concentrated in certain geographical areas and are becoming more scarce in time. If a country is highly dependant on energy imports this often implies that the dependant economy is more exposed to price volatility and additional conditions or standards from the of energy exporters.

(c) Market share of the largest generator in the electricity market – % of the total generation is defined as the market share captured by the largest generator of the electricity market of the total production.
(d) Electricity prices depending on type of consumers, such as individuals or industrial consumers. Electricity prices of industrial consumers benefit often from discounted prices in comparison to household consumers as revealed by Eurostat data of recent years (Eurostat 2016a, b, c, d, e).
(e) Primary energy production by type of energy meaning the exploitation of energy sources, like in coal mines, but not the transformation from one energy source to another.
(f) Primary production of renewable energy measures the primary production of renewable energy sources depending on the type of renewable energy source, including e.g. wind, solar PV, geothermal, biomass and hydropower.

Since more than a decade ago the production of renewable energy, from sources such as: wind power, solar power, water, geothermal energy, tidal energy, biofuels, has become a main element of development globally as the need for sustainable energy sources increased drastically.

The 20-20-20 objective of the European Union imposes sustainability standards to be reached by the members of the European Union until the year 2020, so that progressively the traditional, environmental damaging sources of energy are replaced by renewable, non-polluting energy as mentioned in Sect. 1.

As a consequence, the following indicators in the field of renewable energy represent the monitoring tools for the development in the production and consumption of renewable energy globally: share of renewable energy in gross final energy consumption, electricity generated from renewable sources, the greenhouse gas intensity of energy consumption, primary production of renewable energy, final energy consumption in households by fuel.

(a) Share of renewable energy in gross final energy consumption defined as the ratio of renewable energy consumed and the gross final energy consumption. The consumption of renewable energy sources from the final gross energy consumption has developed in the last years and has reached even 50% in some countries, such as in the case of Sweden (52.6%), the country with the largest share of renewable energy in final energy consumption (see Fig. 4).

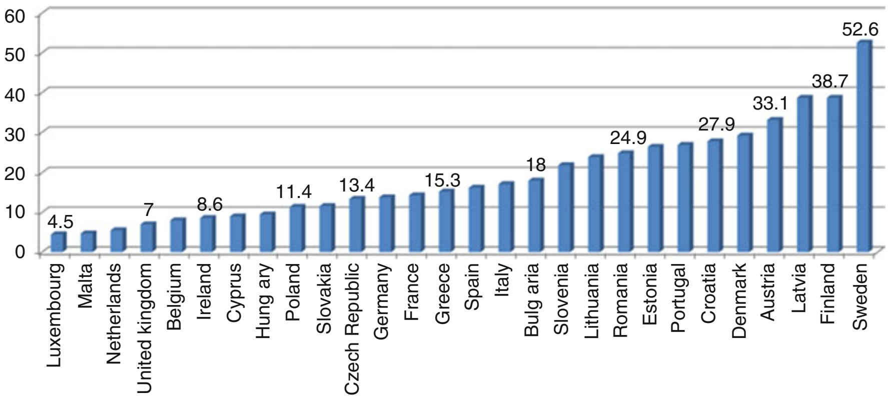

Fig. 4 The share of renewable energy in gross final energy consumption in 2014 in the European Union in ascending order (Source: Eurostat 2016)

At the opposite side, Luxembourg (4.5%), Malta (4.7%), the Netherlands (5.5%) and the United Kingdom (7%) have the lowest levels of this indicator.

(b) Electricity generated from renewable sources measuring the electricity from renewables and the gross national electricity consumption for a calendar year.
(c) The greenhouse gas intensity of energy consumption is "the ratio between energy-related greenhouse gas emissions (carbon dioxide, methane and nitrous oxide) and gross inland energy consumption" as defined by Eurostat.
(d) Primary production of renewable energy includes the production of renewable energy from the exploitation of primary renewable energy sources, including wind energy, solar energy, hydropower, biomass, geothermal energy.
(e) Final energy consumption in households by fuel shows the percentage of consumption of types of fuels, such as gas, electrical energy, renewable energy, solid fuels and derived heat in final household energy consumption. This indicator is significantly important for measuring energy intensity of households and for the future improvement of energy efficiency newly builds and households.

The economic indicator that is mostly used in correlation with the energy indicators is the gross domestic product (GDP). The GDP comprises the financial value of the finished goods and services produced within a specific period, usually a quarter or a year. Furthermore, GDP per capita is the GDP divided by the number of citizens of a population within a country.

In orthodox economics living standards of a country are assumed to be better the higher the GDP and GDP per capita. The GDP per capita allows even a better comparison of the situation of different countries as the population size is also taken into consideration.

In the European Union Luxembourg is considered an exception with a high GDP per capita in 2015 although the population number was reduced. This can be explained by the developed financial sector. As for the rest of the European countries, the highest values of GDP per capita were found in Ireland (55,000

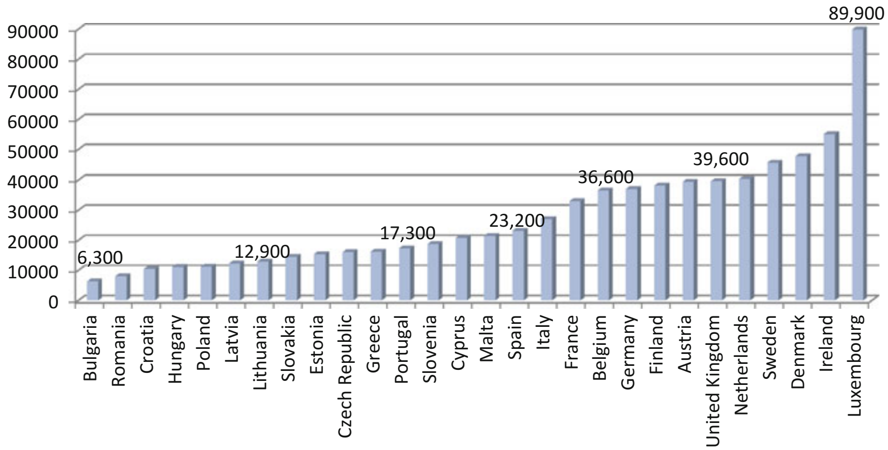

Fig. 5 GDP per capita in the European Union 2015 (Source: Eurostat 2016)

Euro/capita) and Denmark (47,800 Euro/capita), while the lowest value of this indicator was attributed to Bulgaria (6300 Euro/capita) (Fig. 5).

Another key economic indicator is the knowledge economy index (KEI) that shows a country's capability in the sense of being prepared to compete in a knowledge-based economy. This indicator is calculated as an average based on four factors: Economic Incentive and Institutional Regime, Innovation and Technological Adoption, Education and Training, Information and Communications Technologies Infrastructure (World Bank 2012). The importance of the knowledge economy index is emphasized by the speed of innovation, technology development, increased educational standards, that pressure the countries' economies to compete more and more in knowledge based markets in several activity fields.

5.2 *Correlations of Energy and Economic Indicators in the European Union and Their Impact-Methodology*

The energy and economic indicators can be analysed individually or in correlation with other factors, that can show their direct or indirect proportional dependence, as well as positive, negative or no correlation. For example, while some of the economic indicators can have high values for some countries, the energy indicators of the same countries can be decreased, meaning they have a negative correlation.

Linear dependence of two factors is calculated based on the Pearson coefficient.

The formula for calculation of the Pearson coefficient is:

$$\frac{E[(X-E(X))(Y-E(Y))]}{\sigma X \sigma Y}$$

Table 3 Type of correlations (Source: Aerd Statistics 2016)

Correlation	Positive	Negative
Weak	0.1 to 0.3	−0.1 to −0.3
Average	0.3 to 0.5	−0.3 to −0.5
Strong	0.5 to 1.0	−0.5 to −1.0

Where E(X) and E(Y) represent the variables of the variables X and Y, and the denominator elements are the standard deviations of the X and Y variables (Meissner 2014). The Pearson coefficient shows the linear correlation between two variables, for example, X and Y.

A positive correlation denotes when a factor is increasing, the other factor is also increasing. A Pearson coefficient of 0 means no correlation. Correlations measured through the Pearson coefficient can have different levels between −1 and 1 (Aerd Statistics 2016), indicating weak, average or strong correlations, as shown in Table 3.

For the following case study the EU were taken into consideration, namely: Belgium, Bulgaria, the Czech Republic, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxemburg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden and the United Kingdom.

The values of the five indicators that were included in the correlations' analysis were taken from Eurostat and referred to: gross domestic product of a country per capita in PPS index (GDP) (expressed in index where EU28 = 100); RWE is the share of renewable energy in gross final energy consumption; the energy intensity (EI) of a country is the gross inland consumption of energy divided by GDP (kg of oil equivalent per 1000 EUR); the greenhouse gas emissions (GE) (CO_2 equivalent) in thousands of tones, knowledge economy index (KEI) is an indicator of the World Bank, that measures a country's ability to compete in a knowledge based economy, thus to produce, adopt and spread knowledge (Eurostat 2016a, b, c, d, e; World Bank 2016).

The relevance of the analysis is to determine possible correlations between the selected economy and energy indicators, in order to observe possible directions of development of the inquired variables, possible causes and measures that could be taken into consideration for future development.

5.3 Correlations of Energy and Economic Indicators in the European Union and Their Impact-Findings

By using the Pearson coefficient to determine correlations between the five selected economy and energy indicators, the following results were obtained, as shown in Table 4. The three main correlations that were found were between: GDP per capita and energy intensity, GDP-KEI and KEI-EI.

As the study of Nichifor et al. (2013) showed, GDP per capita and energy intensity were negatively correlated with an index of −0.55. This implies

Table 4 Correlations between GDP, EI, RWE, GE, KEI 2011 (Source: Nichifor et al. 2013)

	GDP per capita in PPS Index (EU28 = 100)	RWE or Share of renewable energy in gross final energy consumption (%) in 2011	EI or Energy intensity of the economy Gross inland consumption of energy divided by GDP (kg of oil equivalent per 1000 EUR) 2011	GE or Greenhouse gas emissions – total emissions • 1000 tonnes of CO_2 equivalent	KEi or Knowledge Economy Index
GDP	1				
RWE	−0.15195	1			
EI	−0.5533	0.105464	1		
GE	0.074496	−0.23522	−0.28689	1	
KEI	0.595015	0.166902	−0.57911	0.197468	1

European Union countries with a high GDP had a low energy intensity, and thus are more energy efficient in consumption of energy, while European Union countries with a lower GDP tended to have a high energy intensity and are less energy efficient in their consumption.

İn the cases of Estonia, Slovenia, Bulgaria, for example, the energy intensity was high, the highest level being in Bulgaria from the 28 selected countries. This implied that these countries tended to consume energy more inefficiently and thus have a high energy intensity.The tendency was that countries with a higher GDP had a lower energy intensity, thus being more efficient. The countries with a lower GDP tended to have a higher energy intensity, thus needing to make more efforts in the following periods in order to decrease energy intensity consumption.

In comparison to this negative correlation the GDP and KEI were positively correlated, meaning EU countries with a high GDP and thus high living standards tend to have a higher KEI, meaning they are more prepared to compete in a knowledge based economy.

For example, countries like Germany, Denmark, the Netherlands, Sweden were countries with a high GDP and a high KEI, while countries like Romania, Bulgaria, Greece, Latvia had lower levels of both GDP and KEI.

The KEI-EI correlation (−0.579) also indicated countries with a higher knowledge economy index tended to have a lower energy intensity level, thus, being more energy efficient in consumption. On the contrary countries with a lower KEI level tended to have a higher energy intensity.

Correlations may be used to determine the evolution of linear dependence of two factors in a certain period and thus, they can also be used to establish strategies to improve economic, energy, political strategies weaknesses in order to improve the less developed parts of a region's or country's economy, especially in the key fields relevant for the mid-term or long-term future.

6 Conclusions

The EU is still far way from a unified energy market. However, the challenges faced make stronger efforts towards integrated strategies almost mandatory. Steps that have to be fulfilled in order to intensify the process of a unified energy market are: to transform the energy supply to a sustainable one, to reduce resource dependency, to ensure energy security and reliability, and to maintain competitive energy prices. The EEU may be the decisive institution to realize this mandate. However, in the first instance it will have to align the member states. These will have to arrive at a shared position of what the European energy future could look like in practice in order to achieve the energy and sustainability goals set. Acknowledging the different existing infrastructures, energy economies and path dependencies will thus be a first step in this line. However, given the pressures mentioned above, this should be a short step to ensure the attractiveness of doing business in Europe from the energy side.

Energy security, energy efficiency and competitiveness are main objectives of the European Energy Market. The new approach regarding energy security is more complex and is a response to the energy needs of this generation and those to come but also a signal to insure a clean energy for the future generation. In this context, energy efficiency and competitiveness on the market are responses that will increase the energy security.

The monitoring of energy efficiency has been supported by several energy and economic indicators. For the EU, Eurostat is publishing each year the values for the main energy indicators in EU as: energy intensity, energy dependence, market share of the largest generator in the electricity market, electricity prices depending on type of consumers, primary energy production by type of energy, primary production of renewable energy. Promotion of renewable energy in Europe is supported by new indicators: share of renewable energy in gross final energy consumption, electricity generated from renewable sources, the greenhouse gas intensity of energy consumption, primary production of renewable energy, final energy consumption in households by fuel. They will allow for an improved and systemic management approach for more security, efficiency and competition to ensure the most important long term goal: a climate friendly energy system which is sustainable in all three ways: economic, environmental and social.

Questions and Activities

1. What is the European Energy Market (EEM)?
2. Which are the EU objectives that have to contribute to the new EEM?
3. Which are the key challenges for the Energy Union that have to be solved?
4. What does a high level of energy security in Europe mean?
5. Which are the main advantages of high energy efficiency for the EU?
6. How can improve the energy efficiency the energy security in EU?
7. Explain the energy security impact on the EU economy.

8. Which are the main indicators for the energy field in the EU and what is their importance?
9. Which indicators could contribute to the promotion of renewable energy in the EU?
10. Characterize the relationship between Energy indicators and GDP.
11. Can you determine the degree of energy poverty through a ratio to GDP?
12. Study alternative indicator sets. What are their additional implications for the energy future beyond GDP?

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