Analysis of the Energy Dependence of the European Union

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Abstract

The *main objective of the research paper* is to accomplish a comparative analysis of the energy dependence of the EU member states. This objective is de-composited in several sub-objectives: First, to make a short literature review and a summary of the main ideas concerning energy dependence; Second, to clarify the methodology used for analysis of the energy dependence of the EU. Third, to analyze the nominal energy dependency of the EU, as well as the Union energy dependency by energy types.Fourth, to analyze the energy intensity of the economy of the European Union countries. *The research and analytical methods* used for the development of the paper involve comparative analysis of the available data on energy security indicators, graphical and table presentation of statistical and empirical data and survey of available legal and analytical research on the topic. Entirely secondary data sources have been used in the research. The *research results* comprise:

- the introduction of two new concepts as a result of the analysis – the nominal energy dependency and the real energy dependency;

- the construction of an energy dependency classifying scheme for the European Union member states;

- the construction of an classification grid of the energy dependence of the EU member states by energy type. The research results present the author contribution to the research field of energy dependency. They add value not only in analytical terms but also pave the road for formulating further ideas and evidence-based recommendations on policy measures.

Keywords: energy dependency of the EU, nominal energy dependency, real energy dependency, energy intensity of the economy

Introduction

Literature Review

Energy system is the "cardiovascular" system of any economy: a well-provided-for electricity, petrol and natural gas economy has one of the major prerequisites of sustainable economic growth. Economic and social welfare of any state depend on many factors, among which safe and reliable energy supply[1]. (Vassileva, A., S. Boneva, 2015). Many authors argue that the availability of energy is a key factor affecting the well-being and smooth functioning of modern economies[2] (Chalvatzis, K.J., E. Hooper, 2009).

In the last decades the requirement to secure energy resources has become dominant to the extent that it drives foreign affairs agendas of countries at all stages of development[3] (Williams P.A., 2006). In the past national energy agendas have focused on security of energy supplies which has been achieved using different (mostly domestic) energy sources. The result can be observed in a large variety of national energy mixes in Europe – with Norway relying on hydro, France on nuclear and Poland on coal sources. These countries have achieved a considerable degree of energy independence. Unlike them, a huge number of European countries import fuels, technologies or electricity to secure their energy supply. The

[1] Vassileva A., S. Boneva, Energy Security And Energy Consumption In Bulgaria, The Review of International Affairs, vol. LXVI, № 1157, January – March, 2015, pp. 27-45

[2] Chalvatzis, K.J., E. Hooper, Energy security vs. climate change: Theoretical framework development and experience in selected EU electricity markets, Renewable and Sustainable Energy Reviews, 13, 2009, 2703–2709

[3] Williams P.A., Projections for the geopolitical economy of oil after war in Iraq, Futures 2006; 38:1074–88.

dependency of the European Union on energy imports, particularly of oil and more recently of gas, are the main policy concerns relating to the security of energy supplies[1] (Eurostat, 2018).

Contemporary environmental concerns increasingly dominate policy and influence the energy mix in new directions[2] (Bishop J.D.K., G.A., Amaratunga, C. Rodrigues, 2008). The threats posed by climate change and local air pollution discredit local fossil energy sources in Europe. Imported nuclear fuel for the EU nuclear power plants and imported natural gas (via existing pipelines from the former USSR countries or liquefied from Northen Africa and the Middle East) have been increasingly promoted as environmentally friendlier solutions, however contributing directly to energy supply dependency. According the IEA methodology of calculating national energy balances, the primary nuclear heat appears as an indigenous resource thus reducing statistically the energy dependence of the countries operating nuclear reactors for electricity generation. The reason behind this is the principle of using the steam from nuclear reactors as the primary energy form for the energy statistics. However, the majority of countries which use nuclear power import their nuclear fuel and if this fact could be taken into account, it would lead to an increase in the supply dependence on other countries[3]. (IEA, EUROSTAT, OECD, 2005) All authors admit that the EU and Russia are energy interdependent – Russia is a major supplier for the EU and the EU is a major market for Russian gas, crude oil and nuclear fuel[4] [5] (Krickovic, A., 2015; Kaveshnikov, N.,2010).

Renewable energy really contributes to reducing energy dependence and reducing the greenhouse gas emissions, except for some specificities of biomass[6] (Finkler, T., 2018). Renewable energy technologies are indeed making headway in research and development, and have actual contribution to the world's energy needs. In the same time, I share the opinion that renewable energy technologies could cause or deepen existing technological dependence for countries that are less innovative in respect to renewable energy technologies and components for them – a fact that is underestimated when national goals and policy measures are set in countries of different stages of economic development and different set of energy mixes. While the importance of renewable energy for the energy mix of the future is indisputable, the above mentioned aspect of renewable technologies distribution is not deeply studied in the literature yet.

2. Methodology and analysis of the energy dependence of the EU

As this paper presents a brief analysis of the energy dependency of the EU, the methodology of its measurements should be clarified in the first place. Energy dependency shows the extent to which an economy relies upon imports in order to meet its energy needs. The methodology used for calculating the energy efficiency indicator is the ratio of *net imports* divided by *the sum of gross inland energy consumption* plus *maritime bunkers* (Formula 1). Net imports are calculated as total imports minus total exports[7]. Gross inland consumption is a cumulative value comprising: Indigenous production + Production other sources + Imports – Exports – International marine bunkers + Stock changes. International Marine Bunkers are quantities of fuels delivered to ships of all flags that are engaged in international navigation which may take place at sea, on inland lakes and waterways, and in coastal waters. Energy dependency may be negative in the case of net exporter countries (e.g. Norway) while positive values over 100 % indicate the accumulation of stocks during the reference year (e.g. Malta).

Formula 1

Energy dependence = Net imports / ∑ {Gross inland energy consumption + International maritime bunkers}

[1] Eurostat, Energy production and imports, 2018, http://ec.europa.eu/eurostat/statistics-explained/index.php/Energy_production_and_imports
[2] Bishop J.D.K., Amaratunga G.A., Rodriguez C., Using strong sustainability tooptimize electricity generation fuel mixes, Energy Policy, 2008; 36(3): 971–80.
[3] IEA, EUROSTAT, OECD, Energy Statistics Manual, 2005, Printed in France by STEDI
[4] Krickovic A., When Interdependence Produces Conflicts: EU-Russia Energy Relations as a security Dilemma, Contemporary Security Policy, Volume 36, issue I, 2015
[5] Kaveshnikov, N., The issue of energy security in relations between Russia and the European Union, European Security, Volume 19, Issue 4, 2010
[6] Finkler, T., Renewable Energy: Status and Struggles, Publication of Renewable Energy Focus Group by Tad Finkler and Kathleen Hannon, 2018, https://web.stanford.edu/class/e297c/trade_environment/energy/hfocus.html
[7] Commission Regulation (EU) No. 844/2010 of 20 September 2010 amending Regulation (EC) No. 1099/2008 of the European Parliament and of the Council on energy statistics.
Regulation (EC) No 1099/2008 of the European Parliament and of the Council of 22 October 2008 on energy statistics.
European Commission, SEC(2008)2869, Green Paper - Towards a secure, sustainable and competitive European energy network
European Commission, COM (2008) 782 final/2, Towards a secure, sustainable and competitive European energy network

The methodology and the common conceptual framework that has been largely used for the calculation of the energy dependency indicator has one shortcoming – it does not take into account the efficiency of generation, transfer, distribution and consumption of energy that vary from country to country. Thus the methodology for calculating energy dependency is appropriate for calculating what I call *nominal energy dependency*.

If one adheres to this methodology he may come to a paradox. A country consuming more energy than the energy it produces will be nominally an energy dependent country. *In real terms* however, the efficiency of generation, transfer, distribution and consumption of energy in this country (e.g. Germany) could be higher than that of another country (or countries) that could be nominally less energy dependent (e.g. Bulgaria) or even energy independent one.

Adhering to these considerations we can conclude that energy dependence is a relative (not absolute) indicator affected by the efficiency of generation, transfer, distribution and consumption of every single unit of energy. Moreover, energy resources impact directly the competitiveness of any economic system not via their availability or scarcity but via the efficiency of their usage for different economic activities.

Therefore analyzing the energy efficiency of the EU one needs to consider:

The main general trends in nominal energy dependency in the EU member states;

The real energy dependency of these countries that could be analyzed when the energy efficiency indicators such as the energy intensity of the economy are accounted for.

The energy intensity of the economy is an indicator defined by the ratio between the *gross inland consumption of energy* and the *gross domestic product* (GDP) for a given calendar year and is measured in kilograms of oil equivalent per 1 000 Euro. It reveals the energy consumption of an economy and its overall energy efficiency. The gross inland consumption of energy is the cumulative gross inland consumption of five energy types: coal, electricity, oil, natural gas and renewable energy sources. Since gross inland consumption is measured in kilograms of oil equivalent (kgoe) and the GDP in 1 000 Euro, this ratio is measured in "kgoe per 1 000 EUR".

Table 1. Energy dependence ranging of the European Union member states and selected neighboring countries

geo\time	**1990**	**2000**	**2010**	**2016**	
Malta	100	100,3	99	100,9	0,9
Cyprus	98,3	98,6	100,8	96,2	-2,13632
Luxembourg	99,5	99,6	97,1	96,1	-3,41709
Italy	84,7	86,5	82,6	77,5	-8,50059
Lithuania	71,7	59,4	81,8	77,4	7,949791
Belgium	75,1	78,1	78,2	76	1,198402
Turkey	52,9	65,7	70,6	74,9	41,5879
Greece	62	69,5	69,1	73,6	18,70968
Portugal	84,1	85,1	75,1	73,5	-12,604
Spain	63,1	76,6	76,7	71,9	13,94612
Ireland	68,6	84,9	86,6	69,1	0,728863
Germany	46,5	59,4	60,3	63,5	36,55914
Austria	68,5	65,4	63,2	62,4	-8,90511
Euro area (19 countries)	57,5	64,1	62,1	61,9	7,652174
Slovakia	77,5	65,5	63,1	59	-23,871
FYRMacedonia	47,7	39,9	43	58,7	23,0608
Hungary	49	55,2	56,4	55,6	13,46939
EU (28 countries)	**44,3**	**46,7**	**52,7**	**53,6**	**20,99323**
Slovenia	45,7	52,8	48,7	48,4	5,908096
Croatia	39,8	48,4	46,6	47,8	20,1005
Latvia	88,9	61	45,5	47,2	-46,9066
France	52,4	51,5	48,9	47,1	-10,1145
Finland	61,2	55,1	47,8	45,3	-25,9804
Netherlands	24,1	38	30,2	45,2	87,55187
Bulgaria	62,8	46	39,6	37,2	-40,7643
United Kingdom	2,4	-16,9	29	35,3	1370,833
Czech Republic	15,3	22,8	25,5	32,8	114,3791

Sweden	38,2	40,7	36,9	31,9	-16,4921
Poland	0,8	9,9	31,3	30,3	3687,5
Serbia	30	13,7	33,2	28,9	-3,66667
Romania	34,3	21,8	21,9	22,3	-34,9854
Albania	6,6	46,6	30,5	21,1	219,697
Iceland	32,9	30,5	13,9	19,2	-41,6413
Denmark	45,8	-35	-15,7	13,9	-69,6507
Estonia	45,1	32,2	13,6	6,8	-84,9224
Norway	-437,1	-733,1	-522,8	-633,4	44,90963

Source: Eurostat

The general trends of development of energy dependency in the European Union can be tracked in the energy dependency ranging presented in Table 1 and in the energy dependency classifying scheme presented in Figure 1 that both outline four groups of energy dependent countries in the Union.

The group of the most energy dependent countries with energy dependency levels over 75% is a quite heterogeneous one, comprising small (Malta and Luxembourg) and big (Italy) European Union member states as well as island countries from the south of Europe (Cyprus, Malta) and much more northern countries (Belgium and Lithuania), each of them having quite different reasons for the high percentage of energy dependency they report as well as each of them representing an external border EU member state.

On the other pole of the classifying scheme is the group of the least energy dependent European countries with energy dependency levels of less than 25% - again, a heterogeneous group of countries from the north (Denmark, Iceland and Estonia) and from the south (Romania, Albania) representing external border countries or neighbor countries of the European Union (with well-established connections with the EU and prospects for EU membership).

As I assume the EU average energy dependency indicator to be a dividing line for this classification (Figure 1), we can outline two more groups of European countries – the group European countries that have total energy dependence levels less than the EU average but more than 25% (12 countries) and the group European countries that have total energy dependence levels higher than the EU average but less than 75% (10 countries).

The excellent presenting European country and net energy exporter – Norway, reports energy dependency levels of -633,4% for 2016. If Norway was a member of the European Union, the Union would report better energy independency levels; in the current political framework the EU could only strive for attracting Norway to be a member of the European Energy Union.

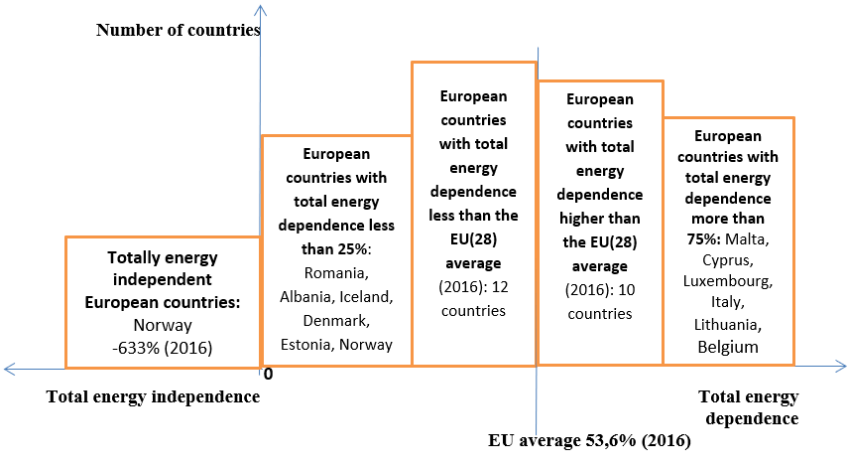

Figure 1. Energy dependency classifying scheme for the European Union member states and selected neighbor countries
Source: the author, based on Eurostat data

Energy dependence in the European Union is obvious by the fact that it imports more than half of the energy it needs from third countries and this tendency is steadily rising decade after decade since 1990. According to Eurostat data virtually

more than half (53.6 %) of the EU-28's gross inland energy consumption in 2016 came from imported sources. The gap between energy supply and demand, caused by the reduction of primary energy production in the EU in this period, caused an increasing dependency on energy imports in most of the EU member states from third countries.

The analysis of the percent change of energy dependency of the European countries for 2016 compared to 1990 shows that only two countries (Estonia and Denmark) reduced significantly (e.g. by more than 50 percentage points) their energy dependence (by -84,92% and -69,65% respectively). Three more countries from Eastern Europe (Latvia and Bulgaria and Romania) considerably reduced their energy efficiency (by -46,9%, -40,76% and -34,99% respectively). The European Union as a whole increased its energy dependency by 20% for the period and the absolute records in increasing the energy dependency belongs to Poland (+3687,5%) and the United Kingdom (+1370,83%). Other EU member states that increased their energy dependency in the last four decades are the Czech Republic, the Netherlands and Germany. The neighbor countries of the EU also worsened their positions – Turkey, Albania, even Norway are much more energy dependent in 2016 than in 1990 (although Norway still remains a net exporter of energy).

The energy dependence of any particular country is to a large extent pre-determined by the available indigenous energy resources in this country as well as from the available infrastructure for energy generation and distribution and other factors. Based on Eurostat data for 2016 we can present the energy dependence of the EU member states by energy sources in a classification grid (Figure 2)

	Total nominal energy dependency	Dependency on coal	Dependency on petroleum	Dependency on natural gas
More than the EU average	Malta, Cyprus, Luxembourg, Italy, Lithuania, Belgium, Greece, Portugal, Spain, Ireland, Germany, Austria, Slovakia, Hungary	Portugal, Austria, Cyprus, Luxembourg, Italy, Latvia, France, Belgium, Denmark, Slovakia, Lithuania, Croatia, Netherlands, Sweden, Spain, United Kingdom	Slovenia, Latvia, Greece, Portugal, Malta, Luxembourg, Belgium, Ireland, France, Bulgaria, Spain, Netherlands, Germany, Sweden, Czech Republic, Poland, Lithuania, Finland, Austria, Italy	Greece, Lithuania, Estonia, Finland, Slovenia, Luxembourg, Portugal, Spain, Sweden, Belgium, France, Ireland, Italy, Slovakia, Czech Republic, Austria, Germany, Bulgaria
Less than the EU average	Romania, Denmark, Estonia, Poland, Sweden, Czech Republic, UK, Bulgaria, Netherlands, Finland France, Latvia, Croatia, Slovenia	Finland, Ireland, Germany, Hungary, Slovenia, Bulgaria, Romania, Greece, Estonia, Poland, Czech Republic	Slovakia, Hungary, Estonia, Romania, United Kingdom, Denmark	Poland, Hungary, United Kingdom, Croatia, Romania, Denmark, Netherlands
Countries with highest energy dependency rates	(over 75%) Malta, Cyprus, Luxembourg, Italy, Lithuania, Belgium	(over 90%) Portugal, Austria, Cyprus, Luxembourg, Italy, Latvia, France, Belgium, Danemark	(over 100%) Slovenia, Latvia, Greece, Portugal, Malta, Luxembourg	(over 100%) Greece, Lithuania, Estonia, Finland
Countries with lowest energy dependency rates	(below 25%) Romania, Albania, Iceland, Denmark, Esonia, Norway	(below 20%) Romania, Poland, Greece, Estonia, Czech Republik	(below 80%) Estonia, Romania, United Kingdom, Denmark	(below 70%) United Kingdom, Croatia, Romania, Denmark, Netherlands

Figure 2. Classification grid of the energy dependence of the EU member states by energy type

Source: The author, based on Eurostat data for 2016

The analysis of the energy dependence of the EU member states by energy type (energy source) shows that more half of them are import dependent on petroleum products (20 countries), natural gas (18 countries) and coal (16 countries). The reasons for this dependence are the primary energy production facilities that are currently in use (for coal), the well-known, established decades ago and functioning older and newer pipelines and transport routes bringing natural gas from Russia and the former Soviet countries to the EU and liquefied natural gas from Northern Africa and the Middle East, and the import of the indisputably scarce petroleum from different petroleum exporting countries to the EU.

Table 2. Energy intensity of the economy for the EU and selected neighbor countries (kgoe per 1000 Euro)

geo\time	1996	2006	2016	percent change 2016/1996	
Ireland	138,1	91,4	59,2	-57,13251267	
Denmark	115,1	84,1	66,4	-42,31103388	
Norway	94,8	87,3	79,5	-16,13924051	
Malta	:	154,1	82,6	-46,39844257	*
Luxembourg	144,7	126,1	87,9	-39,2536282	
United Kingdom	168,4	124,3	91,1	-45,90261283	
Italy	113,8	113,2	98,4	-13,53251318	
Austria	128,9	119,4	106,8	-17,1450737	
Spain	136,1	135,2	110,5	-18,80969875	
Germany	163,2	139,7	111,1	-31,92401961	
Euro area (19)	156	137	114,6	-26,53846154	
Sweden	206,5	138,9	116,2	-43,72881356	
Netherlands	170,4	135,7	116,8	-31,45539906	
France	164	138,3	117,2	-28,53658537	
EU (28)	175,6	145	118,6	-32,46013667	
Greece	150,3	130,1	130,8	-12,9740519	
Portugal	144,7	147,8	133,1	-8,01658604	
Cyprus	179,2	148	133,5	-25,50223214	
Belgium	207,1	166,5	147,6	-28,73008209	
Turkey	:	177,4	165,3	-6,820744081	*
Slovenia	269,9	208,4	178,2	-33,9755465	
Finland	248,1	200,6	181,5	-26,84401451	
Croatia	256,5	210,9	186,3	-27,36842105	
Latvia	467,8	233,6	202,9	-56,62676357	
Lithuania	606,5	300,8	203,7	-66,41384996	
Slovakia	485,2	324,7	208,9	-56,94558945	
Romania	547,8	341,4	214,5	-60,84337349	
Hungary	386	269,2	231,4	-40,05181347	
Poland	510,1	318,2	231,4	-54,63634581	
Czech Republic	394,1	313,9	239	-39,35549353	
Estonia	727,4	331,1	345,9	-52,44707176	
Bulgaria	951,1	593,2	422,6	-55,56723794	
Iceland	402,3	418,1	451,3	12,1799652	
Serbia	891,9	610,4	495	-44,50050454	

Source: Eurostat

The analysis of the EU energy dependency will be incomplete without taking into account the energy intensity of the economy of the European countries which are included in this analysis. Energy intensity is a measure of an economy's energy efficiency. The most energy inefficient country of the EU (Bulgaria, reporting 422,6 kgoe per 1000 Euro energy intensity of the economy for 2016) is 7 times more energy intensive than the most energy efficient one (Ireland, reporting 59,2 kgoe per 1000 Euro energy intensity of the economy for the same year). It should be noted that the economic structure of an economy plays an important role in determining energy intensity, as service-based economies a priori have relatively low energy intensities, while economies with heavy industries (such as iron and steel production) may have a considerable proportion of their economic activity within industrial sectors, thus leading to higher energy intensity.

The available Eurostat data prove that the least energy-intensive economies in the EU in 2016 were Ireland, Denmark, Luxembourg, Malta and the United Kingdom; they used the lowest amount of energy relative to their overall economic size (based on gross domestic product, GDP). The most energy-intensive EU Member States were Bulgaria, Estonia, Czech Republic, Poland and Hungary (Table 2). Any impartial analysis should note that all of the top 10 countries with the highest energy intensity rates in the EU are Eastern European countries and belong to the group of the relatively new members of the EU.

Between 1996 and 2016 the energy intensity of all EU economies fell. The biggest reductions in energy intensity however were recorded in Lithuania, Slovakia, Latvia, and Bulgaria (-66,41%, -56,95%, - 56,63% and -55,57%), where the amount

of energy required to produce a unit of economic output (as measured by the GDP) fell by more than 50% between 1996 and 2016. By contrast, the smallest decreases in percentage terms were recorded for Portugal (-8,02%), Greece (-12,97%) and Italy (-13.53%); these were the only Member States where the reduction in energy intensity was below 15.0 %.

Conclusions:

Since most of the Eastern European EU member states hold the first places in energy intensity of the economy (and energy inefficiency respectively) and most of them have high energy dependence levels as well, the main strategic recommendation for these countries will be to enter and active members of the European Energy Union. Thus these European territories will become less energy dependent. To become more energy efficient as well, these countries should formulate new policy measures aimed at reducing their energy intensity that should be implemented at national level as well as coordinated at EU level.