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## Decoupling Economic Growth from Emissions in Poland on the Background of EU Countries

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# Decoupling Economic Growth from Emissions in Poland on the Background of EU Countries

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**Abstract.** Nowadays studying CO<sub>2</sub> emissions play a focal role in the current debate on environment protection and sustainable development. CO<sub>2</sub> has been recognized by most scientists as a major source of global warming through its greenhouse effects. Another reason is that CO<sub>2</sub> emissions are directly related to the use of energy, which is an essential factor in the world economy, both for production and consumption. Access to relatively cheap electricity determines economic competitiveness on the market. Therefore, the relationship between CO<sub>2</sub> emissions and economic growth has important implications for environmental and economic policies. The main aim of the article is researching the dependencies between emissions and economic growth. The phenomenon of decoupling the economic growth from the emission level in European Union countries has a very complex nature. As a test sample, eight largest electricity producers in the European Union were presented, responsible for 75% of CO<sub>2</sub> emissions in the entire European Union. As a measure of economic growth, the widely used Gross Domestic Product per capita was adopted; which is currently heavily criticized due to the fact that its average value per capita of the country does not really show real income due to significant differentiation of income levels among various social groups. The examination of Pearson correlation coefficient between emissions and economic growth for the several European Union countries such as: Germany, UK, France, Italy, Poland, Spain, Sweden and Netherlands confirmed that developed countries would be able to achieve economic growth and at the same time decrease of emissivity was achieved.

## 1. Introduction

Economic growth is a process of creating and increasing the real size of social product. The process is accompanied by changes in the structure of domestic product and the whole economy. Economic growth and the assisting structural changes are defined altogether as economic development. An economic policy is mainly directed at ensuring economic growth, i.e. the economic capital growth of societies. Economic development depends on both natural resources accessibility and human capital. Economic growth has been a prime mover behind the development of modern societies, while markets have become the basic principle for organizing production and consumption, which are most often measured by the major economic measurement instrument – GDP (Gross Domestic Product).

Economic growth is one of the most important policy goals across the world, commonly accepted by the society [1].

The steady growth of global population and constant strive to increase society's welfare bring about negative environmental effects on a global scale (excessive use of natural resources – deposits exploitation, an increase in greenhouse gases emission, accessibility to fresh water), which in the long term might become irreversible. Hence, the current challenge for well-developed countries is to



preserve the stability of economic growth taking into account regeneration possibilities of the natural environment, which are implemented within the sustainable development strategy.

Generally sustainable development concerns achieving balance in three main dimensions at once. i.e. in the economic dimension signifying the pursuit of sustainable economic development; in the social dimension signifying the protection of public health and social integration; and in the environmental dimension placing a significant emphasis on environmental protection and natural resources in a way as not to endanger the capabilities to meet the needs of future generations [2], [3], [4], [5], [6].

Implementing the concept of sustainable development and monitoring its realization require precise methods of its measurement and determination of standards serving this goal. The relationship between the concept of development and its standards, including model development concepts, has a mutual character. On the one hand, the standards are carriers for the development concept, but on the other hand they reflect the scale and structure of development processes. In this context the role of sustainable development standards is also emphasized by possibilities resulting from their practical application, which allows for a reliable evaluation of the current state and a scientifically proved forecast of economic effects as well as social and ecological impact.

The most popular definition of sustainable development is from *Our Common Future* also known as the Brundtland Report:

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"[7].

Although the definition seems uncomplicated, it is still too nondescript and insufficiently precise, especially regarding the differences in civilization development of individual members of the European Union. For this reason, there is no consensus on the question whether all dimensions of sustainable development, i.e. economic, social and environmental ones, are equally important or whether one order may be treated as a priority and more important than the others depending on domestic conditions. In turn, problems connected with measurement may be identified during each stage of constructing a synthetic indicator. At the stage of selecting variables researchers come across difficulties connected with shortage of data depicting numerous dimensions of sustainability, particularly in the case of developing countries and indicators of sustainability's social dimension. Despite the fact that a number of requirements are formulated for the variables, they are rather of an aspirational nature as it is difficult to find a set of indicators which would fully meet them. Based on the example of variables presented by the Eurostat it is possible to identify certain ambiguities which hinder an interpretation of synthetic indicators constructed on their basis. At the stage of standardizing partial indicators there occurs a serious problem of determining the reference point, often identified with the state of balance. Although there are certain solutions to this problem, none of them are decidedly convincing. At the aggregation stage some mechanisms of weighing up individual constituents of the synthetic indicator may be questioned because, as a rule, they might be of a subjective nature.

Despite presented inconveniences referring to research on measuring the degree of sustainable development on domestic levels, there exists a set of standards on the basis of which it is possible to monitor progress in realizing the sustainable development strategy.

The objective of the article is to analyse two subject areas of sustainable development, i.e. the social and economic development, which is frequently measured by GDP/capita, as well as the subject area of climate change and energy, whose measure is CO<sub>2</sub> eqv. emission and energy intensity indicator.

The article attempts to study the relationship between the GDP level and the emissivity level of the economies in the European Union. It presents the analysis between 2006 and 2015 for selected EU countries - the largest energy producers such as: Germany, France, Great Britain, Italy, Spain, Poland, Sweden and Netherlands.

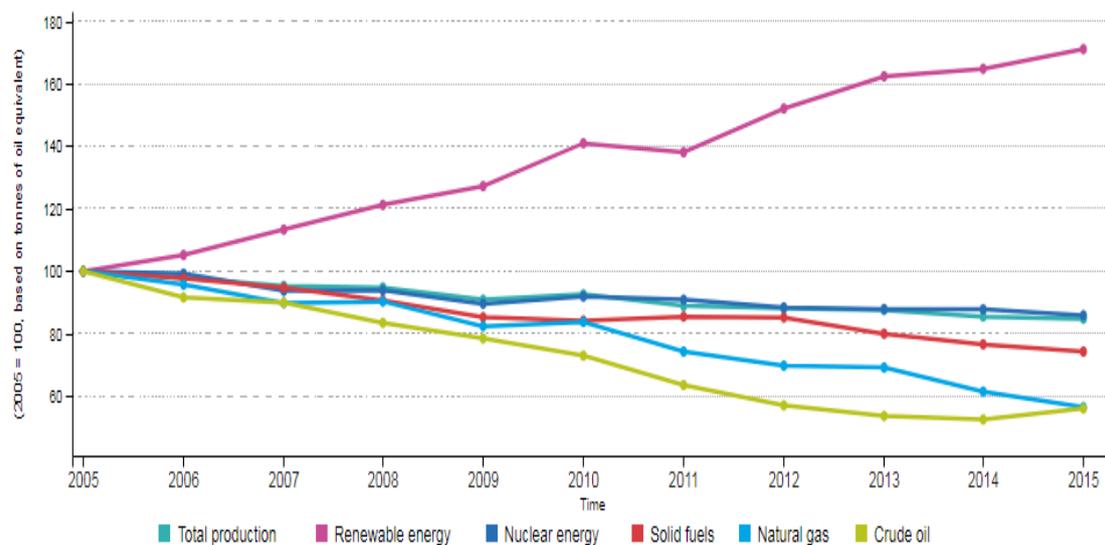
## 2. Determinants of the emissivity level of European economies

The economic development has caused an increase in greenhouse gases (GHG) emission, especially carbon dioxide (CO<sub>2</sub>), which results from fossil fuels burning (mainly hard and brown coals). One tonne of greenhouse gases emitted globally has the same impact on the environment irrespectively of the emission place.

Climate scientists have observed that carbon dioxide (CO<sub>2</sub>) concentrations in the atmosphere have been increasing significantly over the past century compared to the pre-industrial era level of about 280 parts per million (ppm). In 2016 the average concentration of CO<sub>2</sub> (403 ppm) was about 40% higher than in the mid-1800s with an average growth of 2 ppm/year in the last ten years. Significant increases have also occurred in the levels of methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O).

From the late 1980s until the early 2000s coal and oil were each responsible for approximately 40% of global CO<sub>2</sub> emissions with emissions from oil generally exceeding those from coal by a few percentage points. However, the trends differed at a regional level. Fuel with the highest level of CO<sub>2</sub> emission is coal and it amounts to 44% of global emission, then crude oil 35%, the third is natural gas 20% and 1% are the others [8].

The major determinants of the emissivity level of European economies include the structure of fuels usage, the so-called energy mix, as well as the level of electrical energy production. Figure. 1 presents development of the production of primary energy by fuel type, EU-28, 2005-2015



**Figure 1** Total production of primary energy in all EU countries in 2005-2015 by fuel type  
Source: [9].

The European Union members significantly differ in types of fuels they use to produce electrical energy. It is conditioned by natural resources accessibility, development of energy infrastructure and technological development. Energy production in the EU dropped in 2015 compared to 2005 by 137.6 [mln tonnes of oil eqv]. On average, nuclear energy with 28.9% and renewable energy with 26% have the biggest shares in the EU energy mix. Table 1 presents the total production of primary energy (mln tonnes of oil equivalent) for the largest EU energy producers.

**Table 1.** Total production of primary energy [mln tonnes of oil equivalent] in selected countries.

	2005	2015	2015/2005	Nuclear energy	Solid fuels	Natural gas	Crude oil	Renewable energy
EU	904.2	766.6	137.6	28.9%	18.9%	14%	9.8%	26.7%
Germany	136.8	119.8	-17	19.80%	35.90%	5.30%	3.00%	35.50%
France	135.6	136.7	1.1	82.50%	0.00%	0.00%	0.80%	15.70%
UK	204	118.3	-85.7	15.30%	4.30%	30.10%	39.30%	10.00%
Poland	77.9	67.3	-10.6	0.00%	79.60%	5.50%	1.40%	12.80%
Netherlands	62.47	47.6	-14.87	2.20%	0.00%	82.00%	4.30%	10.10%
Sweden	34.2	33.6	-0.6	43.20%	0.30%	0.00%	0.00%	54.60%
Italy	30.3	36.1	5.8	0.00%	0.10%	15.30%	16.10%	65.20%
Spain	30	33.4	3.4	44.20%	3.70%	0.20%	0.70%	50.50%

Source: own elaboration based on: [10].

France is a country with the highest share of nuclear energy in the energy production structure (as much as 82.5%). The leader in developing renewable energy is Germany, where the level of energy production from this source was the highest in the EU and exceeded 42 [mln tonnes of oil eqv]. The successive countries were Italy 23 [mln tonnes of oil eqv], France 21 [mln tonnes of oil eqv], Sweden 18 [mln tonnes of oil eqv] and Spain 16 [mln tonnes of oil eqv]. Poland is a country with a specific structure of the energy mix because it is extremely dependent on fossil fuels combustion [11]. 79.6% energy produced in Poland comes from coal and the production level in 2015 amounted to as much as 67.3 [mln tonnes of oil eqv].

According to the long – term analysis from 1965 to 2015 shown that the changes in Polish energy balance into renewables are very slow [12].

The table 2 presents a relation between the volume of electrical energy production and the emissivity level expressed in CO<sub>2</sub> eqv. unit.

**Table 2.** Emissivity and energy production in EU countries in from 2007 to 2015.

	2007	2008	2009	2010	2011	2012	2013	2014	2015
EU-28 Thousand tonnes of CO <sub>2</sub> eqv	5 293 764	5 179 481	4 803 586	4 909 518	4 758 665	4 693 240	4 598 845	4 423 738	4 451 813
EU-28 Thousand tonnes of oil equivalent (TOE)	861 257	858 641	821 386	837 528	805 281	797 108	792 082	773 976	767 430

Source: own elaboration based on [13].

On the basis of the data included in the table the level of Pearson correlation coefficient was determined, which was 0.981401. Due to the fact that the level of carbon dioxide emission is positively correlated to the volume of electrical energy production, the next research stage will include an emissivity analysis of European economies.

### 3. Analysis of the level of emissivity in selected EU countries

The most popular measure of the emission level of countries is total emission in thousand tonnes of CO<sub>2</sub>eqv. The highest level of GHG emission in the EU is generated by Germany 20.9%, the second place goes to Great Britain 12.7%, then France 10.7%, Italy 9.7%, Poland 8.6%, Spain 7.8% and the Netherlands 4.5%. The group of these 7 countries is responsible for 74.9% of the total EU emission.

Another important measure of the level of emissions is conversion per capita. The level of emission in the EU countries per capita is significantly varied. The highest level of emission per capita was noted for example in Luxemburg (21.62 tCO<sub>2</sub>eqv), Great Britain (8.67 tCO<sub>2</sub>eqv), France (7.16

tCO<sub>2</sub>eqv), Italy (7.04 tCO<sub>2</sub>eqv), Poland (10.05 tCO<sub>2</sub>eqv), Spain (7.37 tCO<sub>2</sub>eqv), the Netherlands (11.73 tCO<sub>2</sub>eqv).

The level of emissivity depends on the energy consumption, so the next indicator is carbon intensity.

Carbon intensity shows how CO<sub>2</sub> intensive energy use is in different countries. i.e. how many tonnes of CO<sub>2</sub> emissions are generated to meet the energy needs. Its determination can be also made as a ratio between the greenhouse gas emissions (CO<sub>2</sub> equivalents) and GIC (energy consumed within the borders of a country measured in thousands TOE) for a given period [14].

$$\text{Carbon intensity (CI)} = \frac{\text{CO}_2 \text{ equivalents emissions}}{\text{GIC}} [\text{tCO}_2 \text{ per TOE}] \quad (1)$$

Eight EU Member States produce 79% of the total European Union energy. The biggest energy producers in the EU are Germany, France, Great Britain, Italy, Spain, Poland, Sweden and Netherlands. Table 3 shows carbon intensity index for selected EU countries.

**Table 3.** Greenhouse gas emissions intensity of energy consumption Index (2000 = 100).

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
EU	100	100	99	99	98	97	96	96	95	94	93	93	92	91	89
Germany	100	99	100	100	98	96	94	96	96	95	95	97	98	98	96
Spain	100	98	101	99	100	102	99	100	95	91	87	89	89	86	87
France	100	97	95	96	94	95	94	92	91	91	90	87	88	87	83
Italy	100	101	100	99	99	96	96	94	94	91	91	91	89	86	86
Netherlands	100	101	99	98	97	96	94	95	97	97	98	97	94	94	94
Poland	100	99	98	98	99	98	97	96	93	93	92	91	92	91	90
UK	100	101	99	99	99	98	99	101	100	97	97	96	97	96	93
Sweden	100	97	98	103	97	94	97	95	92	95	93	88	83	81	79

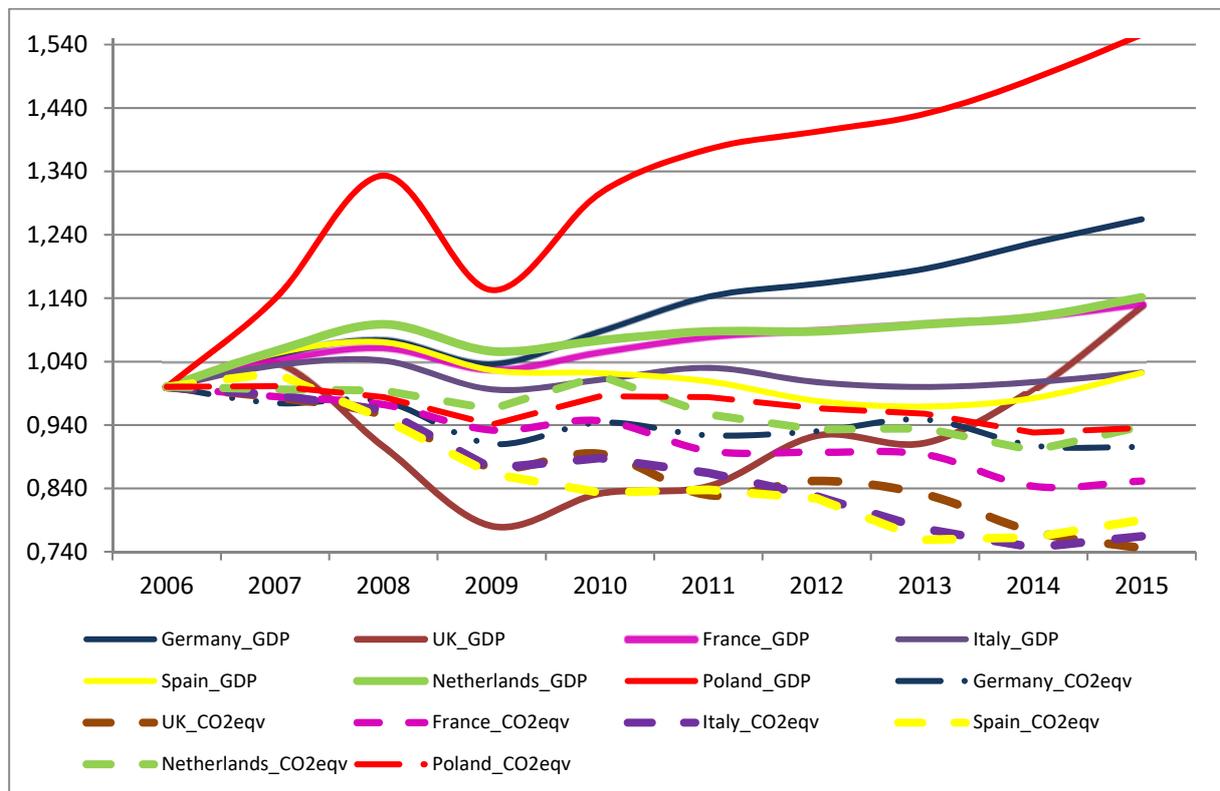
Source: Own elaboration based on data form Eurostat

All countries among the largest energy producers in the EU have recorded a decrease in the energy intensity level, which must be interpreted as a positive phenomenon in relation to climate protection. However, it is important to be aware that it is a result of lowering electrical energy production and consumption in EU members.

The highest drop in the energy intensity level was recorded in Sweden (21%), then France (17%), whereas Germany had a drop only by 4%, Netherlands by 6% and the UK by 7%.

#### 4. Results and discussions

As a result of a research the analysis of dependence of economic growth and emissivity are shown in figure 2. Gross Domestic Product is another determinant indicated by researchers of the emissivity level of economies. Growth rate of actual GDP per capita is defined as the main development indicator in the socio-economic development area because is the most popular and easiest one to use and measure. On the basis of statistical data the figure 2 presents the GDP level compared to the emissivity level with 2006 as the base year for the analysis.



**Figure 2.** Dependence of economic growth and the level of emissivity

Source: own elaboration based on data from Eurostat

As the graph shows all studied countries (the largest energy producers in the EU) are able to achieve economic growth simultaneously with reducing greenhouse gases emission.

The highest level of economic growth measured by GDP in 2015 compared to 2006 was recorded in Poland (55.6% with a drop in the emissivity level by 6.5%) and Germany (26.4% with a drop in the emissivity level by 9.5%). The highest drop in emissivity by 25.4% was recorded in the UK.

Studies on the relationship between economic development and greenhouse gases emission are currently an extremely important subject matter. Socio-economic changes in developed countries significantly influence the demand and type of consumer goods. A strong dependence of the EU members on energy resources import results in a search for alternative energy sources which would at the same time meet restrictive environmental standards.

Due to a large number of data shown in the figure, they are also presented in the table 4.

**Table 4.** Correlation between economic growth and the level of emissivity.

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Correlation Pearson index GDP and CO2eqv	
Germany_GDP	1,000	1,051	1,075	1,037	1,088	1,142	1,163	1,186	1,227	1,264		
UK_GDP	1,000	1,040	0,906	0,781	0,832	0,843	0,923	0,912	0,997	1,128		
France_GDP	1,000	1,041	1,062	1,027	1,055	1,079	1,089	1,099	1,110	1,130		
Italy_GDP	1,000	1,034	1,042	0,996	1,011	1,030	1,008	1,000	1,008	1,023		
Spain_GDP	1,000	1,053	1,070	1,026	1,022	1,009	0,978	0,969	0,982	1,022		
Netherlands_GDP	1,000	1,056	1,099	1,056	1,073	1,088	1,088	1,099	1,110	1,141		
Poland_GDP	1,000	1,139	1,333	1,153	1,306	1,375	1,403	1,431	1,486	1,556		
Germany_CO2eqv	1,000	0,975	0,977	0,910	0,944	0,924	0,930	0,949	0,908	0,905		-0,6889
UK_CO2eqv	1,000	0,984	0,955	0,874	0,894	0,830	0,852	0,831	0,772	0,746		-0,1285
France_CO2eqv	1,000	0,985	0,972	0,932	0,947	0,899	0,897	0,893	0,843	0,852		-0,8931
Italy_CO2eqv	1,000	0,987	0,963	0,872	0,888	0,864	0,828	0,776	0,747	0,765		0,3336
Spain_CO2eqv	1,000	1,022	0,950	0,863	0,833	0,838	0,824	0,759	0,763	0,790		0,6392
Netherlands_CO2eqv	1,000	0,996	0,994	0,965	1,018	0,957	0,933	0,935	0,900	0,937		-0,6073
Poland_CO2eqv	1,000	1,001	0,984	0,941	0,985	0,984	0,966	0,958	0,928	0,935	-0,6349	

The use of correlation Pearson index confirmed that the highest level of decoupling between economic growth from the level of emission reached France (correlation coefficient level was -0.8931) then Germany (-0.6889) next Poland (-0.6349) and Netherlands (-0.6073).

It is also important that this analysis should be deepened with the aspects and data in terms of the level of the real consumption in EU from other countries, in which the levels of emission increased such as Asian countries. However, this requires access to more detailed data. The time interval of the analyses is also very important, because the occurring trends in the studied period of the analysis do not mean the long-term dependencies. Therefore, the research material presented in the article becomes a contribution to further discussion in this regard.

## 5. Conclusions

The European Union takes steps not only to increase the share of renewable sources in energy production, but also in the interest of energy effectiveness and energy-saving technologies, which is confirmed by statistical data of the carbon intensity rate. Implementing more restrictive norms and rules for environment protection may, on the one hand, lead to an increase in demand for ecological commodities. Such a phenomenon must be interpreted as a positive one because more wealthy societies are willing to purchase more expensive, but at the same time ecological goods. On the other hand, there may occur a phenomenon of carbon leakage, which means migration of dirty industries to those world regions where the restrictive environmental regulations are not in force.

Thus, the Author's suggestions point at the necessity of conducting further analyses on the subject matter, which would allow us to determine the impact of other variables on the environment quality. In particular, the studies should be complemented by international trade and commodities import to the European Union members. Currently, for the sake of statistical data, an approach has been adopted to calculate the level of emission which occurs on the territory of a given country. However, the practice shows that an increasing number of goods are imported, so the emission from these products concerns the countries which manufacture them. Therefore, studies on the emissivity level of countries should also include the emission level of all commodities consumed in them, including imported ones. Such an approach, however, shows problems of practical nature, i.e. which most favourable methodology

shall be used for calculations. Hence the need to make an attempt to construct research methods adequate for the subject matter.

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