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THE TRINOMIAL SUSTAINABLE DEVELOPMENT - ECONOMIC GROWTH – ENERGY IN EUROPEAN CONTEXT

Daniela Cristina MOMETE
"POLITEHNICA" University of Bucharest, Romania

Abstract. This paper has in view the emphasis of the importance of energy for human development and economic growth, but also its impacts on sustainability. In a trinomial approach, it concisely presents the negative effects of energy consumption on environment, and at the same time its positive effects on economic growth. In a pursuit to identify overall effects of energy, the energy consumption is correlated with the economic growth and CO_2 emissions, by using energy and CO_2 intensities, at the European Union level, taken into comparison with the rest of the world. The paper argues that sustainable development must be perceived as another dimension of the economic growth that can be only achieved by a sustainable energy production and use.

Keywords: sustainability, economic growth, energy intensity

1. Introduction

Energy is the main driver of poverty eradication, as it improves the general welfare and raises living standards. However, many factors are to be considered when tackling the energy for tomorrow: the extensive exploitation of the fossil fuels – oil, coal and gas –, depletion of resources, energy dependency and the need to ensure the access of all countries to energy resources, geopolitical hazards [1], environmental concerns and high atmospheric concentrations of greenhouse gasses (GHG). Six gases are considered when computing GHGs, namely, CO_2, CH_4, N_2O, hydroflorocarbons (HFCs), perfluorocarbons (PFCs) and SF_6.

The energy stands as an essential pillar of today's lifestyle and welfare, but, at the same time, it represents an enormous cost for human health and different ecosystems. Energy consumption has impacts on all domains of national economies, from external duties of a nation (generated by the fuels imports) to the political stability of a given region. Current methods of energy production, distribution and use have dramatic environmental impacts affecting air, water, soil that are to be used by present and future generations.

Sustainable development is a concept that represents the keystone of all European Union (EU) policies, actions and strategies and implies a three-dimensional approach: economic, environmental and social aspects that are to be designed and implemented in a mutually reinforcing way [2].

The energy type and quantities consumed by a country are influenced by several factors: the gross domestic product (GDP), the size of population, the economic environment, available resources, corporate and governmental policies [3] (regulations, enforcing of appropriate product standards, investments in infrastructure, liberalization of energy markets, subsidy policies, different types of taxation, promoting energy saving and energy efficiency in all domains, promoting renewable energy sources - RES).

2. The link between economic growth and energy consumption

2.1. Economic growth

The energy economics is correlated with the economic growth of a country, the energy resources constituting both the material conditions and the driving force for development and welfare [4]. Energy is at the same time a fundamental requirement of economic growth and a consequence of it.

The economic growth puts upward pressure on energy consumption and thus on CO_2 emissions. Regardless of how much the production will rise, the satisfying of all the human society needs is almost impossible, as they exponentially grow and diversify at the same time with the progress registered in all economic and social sectors. The energy demand is mainly driven by: the size of a country (in terms of population), economic growth (in terms of GDP), industrial development and technology progress and change.

The first factor, the population, may be analysed by the growth rate that will continue to rise in the next period. The growing rate is foreseen to maintain at 1%/year [5] up to 2020, leading to a population size of 7.4 billion in 2020, from 6.1 billion in 2000. This will put a tremendous pressure on energy resources and environment.

The economic growth is directly linked to energy consumption, at least to a certain point [6]. For instance, the increased income of population generates the acquisition of large residents, characterised by larger energy consumptions. Moreover, luxury items are also acquired as for example energy-consuming appliances, larger and heavier cars, with larger fuel consumptions. But above a critical point, the economic growth leads to structural changes in the developed economies that are reducing their energy intensities (energy consumed per unit of economic output, expressed as GDP). Therefore, the developed countries enter in the post-industrial era, where intensive consuming industries tend to be relocated in developing countries and more emphasis is set on capital and labour, instead of raw materials and energy.

2.2. Energy consumption

In certain regions of the globe the energy consumption surpass 6 toe/capita/year [7], while in others the consumption is situated at pre-industrial levels (as for instance in Bangladesh, where the primary energy consumption/capita in 2002 was of 0.4 toe, being 20 times smaller than in United States of America).

Large differences exist even among developed countries, as for instance in EU and Japan, where the energy consumption per capita are lower than those registered in North America. The resource endowment is a major factor of influence. Developed countries, as USA and Canada based their economic growth on fossil fuels that are sufficiently abundant and cheap. Japan, a country poor in resources, specialized in industries that are belonging to the modern post-industrial era, based on knowledge, labour and capital. Therefore, although these countries have a similar GDP/capita, their energy mix is very different. As might be noticed in figure 1, energy consumption per capita in USA is larger than in EU. This does not imply a quality of life largely different in the two regions, the USA consumption being 50% larger that EU, while the welfare (measured as GDP/capita) is only 20% larger. It is clear, that a high level of development does not necessary require a continuous growth of consumption per capita.

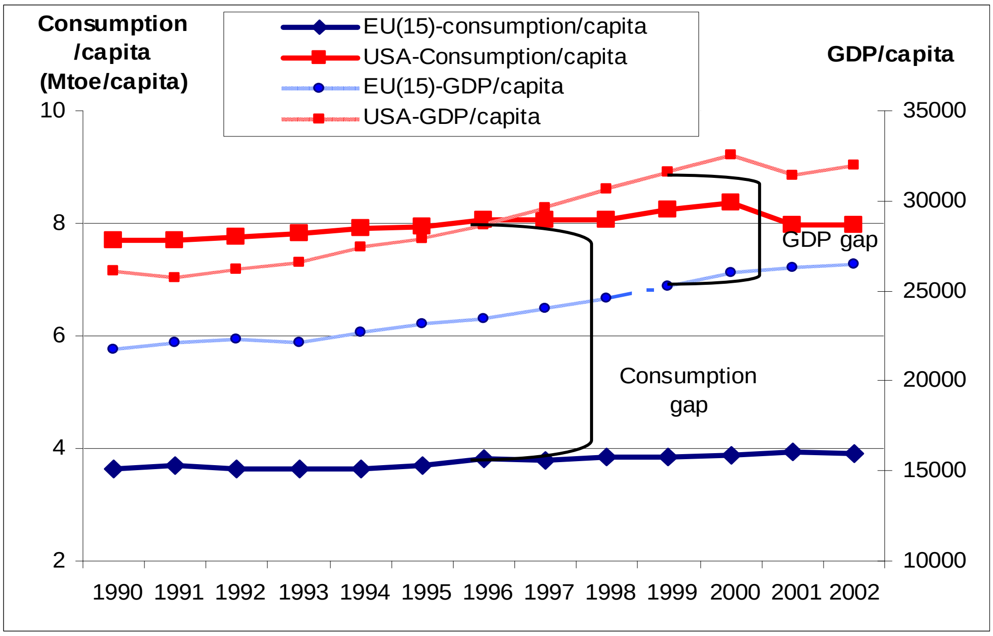

Figure 1. GDP/capita and energy consumption/capita in EU (15) and USA
Source: calculations based on data from EIA, "International Energy Annual 2002", 2004

3. CO2 emissions and energy consumption

Today, the largest GHG emitter countries are characterised by large economies (measured as GDP) or large populations, or both. This mean that, even though per capita emissions may be small, the population place a country among the top emitters, as for instance China, that ranks the second with about 15% of global emissions after USA [8] (see table 1).

Table 1. Top 10 GHG emitters in the world, 2000

Country/region	GHG emissions (Mt CO_2 equivalent)	% of world GHG emissions
USA	6928	20.6
China	4938	14.7
EU (25)	4725	14.0
Russia	1915	5.7
India	1884	5.6
Japan	1317	3.9
Germany	1009	3.0
Brazil	851	2.5
Canada	680	2.0
United Kingdom	645	1.9

Source: Baumert K., Herzog T., Pershing J., “Navigating the Numbers: Greenhouse Gas Data and International Climate Policy”, World Resource Institute, 2005

Table 2. Annual energy consumption/capita and CO_2 emissions/capita in selected countries, 2001

Country/region	Primary energy (toe/capita)	CO_2 emissions (tonnes/capita)
USA	8.00	19.84
Norway	5.90	8.41
France	4.36	6.32
Russia	4.29	10.50
Germany	4.26	10.32
Japan	4.10	9.00
UE-15	3.94	8.46
Romania	*1.64*	*4.09*
Brazil	1.07	1.81
China	0.90	2.43
Ethiopia	0.30	0.41
Bangladesh	0.15	0.23

Source: calculations on World Bank, “World Development Indicators”, Washington, 2003 and EIA, “Annual Energy Review 2003”, 2004

Another fact that determines the magnitude of CO_2 emissions is the energy mix of a given country, and this mix strongly depends on the dependency on fossil fuels and domestic resources. Data from table 2 are examining consumption and emissions per capita, since the focus on absolute figures of a country gives only a partial understanding of the emission picture, as a certain levels of emission might be correlated with population growth.

4. Energy and CO_2 intensities

4.1. Energy intensity

The importance of quantitative indicators, as production or consumption/capita or the growth rate of energy production or consumption, tends to diminish in the favour of qualitative indicators, as energy intensity. There is a direct correlation between the global economic growth, measured as GDP, and the energy consumption, expressed as energy intensity [9]. The energy consumption of a country over a time period, generally one year, for the production of one unit of output, expressed as GDP, represents the ***energy intensity (EI)***. The energy consumption is expressed by the equation 1, described below.

Energy consumption = primary energy + recovered products + imports + stocks exchange– exports – bankers (1)

The EI indicator quantifies the energy consumption efficiency, but with some limitations referring to the growth dynamics of each country, production structure and the structure of a national economy, as a whole. The reduction of this indicator generally expresses an increase in production efficiency that in turn develops lower energy consumption. This decrease must be associated with actions aimed to reduce energy consumption, without jeopardizing the quality of products or services offered to consumers.

The use of this indicator is recommended as the denominator allows the computation for both macro and microeconomic levels, on different sectors, where the specific consumption for each product type is difficult to achieve. Thus, depending on the available statistical data, the primary EI (defined as the energy intensity), or the final EI or the electric EI might be computed. Between the economic growth and energy consumption growth there is a complex process of mutual inter-conditioning, as showed in figure 2. The values recorded for 30 countries show a very complex picture, with values ranging from EI values above 1, as Romania, to values that are below 0.1, as Japan. Accordingly, countries with similar values of energy consumption/capita possess very different development levels (expressed as GDP/capita), fact that reveals the irrelevance of quantitative indicators (see the case of Russia and France that are characterised by similar values of energy consumption/capita, but very different values of GDP/capita). At the same time, countries with comparable development levels have very different energy consumption, the macroeconomic structure being the main reason (see the case of USA and Germany, the last consuming sensible lower energy/capita than the first).

Another fact that might be noticed in figure 2 is that countries with similar values of EI might have very different both energy consumption and development levels, as the case of Bangladesh and Canada that are characterised by similar EI values. This implies that the EI must be used in the case of countries with similar economic structure. Thus, although some countries overpass the values recorded by EU, this comparison does not reflect a lower technological level, but mainly a difference in the macroeconomic structure. The most important factor is how a GDP is constructed, a focus on the industry determining a large EI value, and therefore the macroeconomic structure of that country is energy-intensive, and not necessary technologically obsolete.

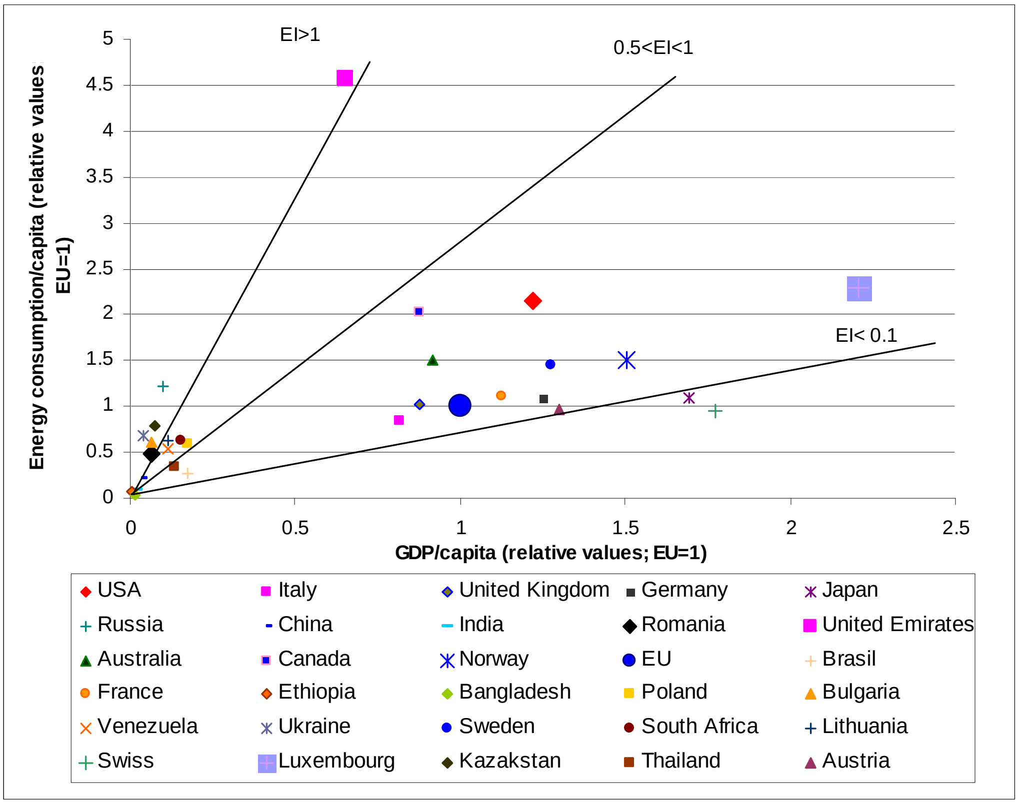

Figure 2. The correlation between energy and economic growth

Source: calculations based on data from EIA, "International Energy Annual 2002", July 2004

4.2. CO_2 intensity

The global emissions of GHG are foreseen to increase by more than 50% by 2025, if nothing is done, and energy supply and use represent the main contributor to the worldwide CO_2 emissions.

The Kyoto Protocol [10] requires a target of 8% reduction from base-year level (1990) of the CO_2 emissions by 2012 for EU(15). The 2004 picture of the EU(15) shows a decline of only 0.9% of the CO_2 emissions compared with the 1990 level [11], proving that there much to be done on the way towards the 8 % target set by Kyoto Protocol. As the economic growth continue to put significant pressure on energy, emission levels will more definitely continue to grow, but the important fact is that the CO_2 intensity to be reduced. The CO_2 intensity is defined as emissions per unit of economic output, measured at national level by GDP [12].

However, reducing CO_2 emissions in absolute terms, in developing countries, is synonymous with limiting development for those countries. There are studies that suggested that the emissions growth is correlated with economic growth mainly through population among developed countries, while the emissions growth is linked to development among the developing countries [13]. That is why the intensities are better to be used as they can be interpreted as performance of a national economy. Nevertheless, the emissions intensity must decrease faster than the economic growth and must be based on energy efficiency.

The CO_2 intensity has declined in EU(15) from 1990 to 2001 (see figure 3), indicating a decoupling between economic growth and resource consumption. In this period, the CO_2 emissions rose at a slower rate than GDP. To stabilize the GHG concentrations at the preset level, the rate of decline in CO_2 intensity rate must be equal with the rate of growth in GDP. To reduce of the GHG emissions, the CO_2 intensity must strongly decrease, as the other option, the decrease in GDP leading to economic recession, is an undesirable method to achieve the targets set by Kyoto Protocol.

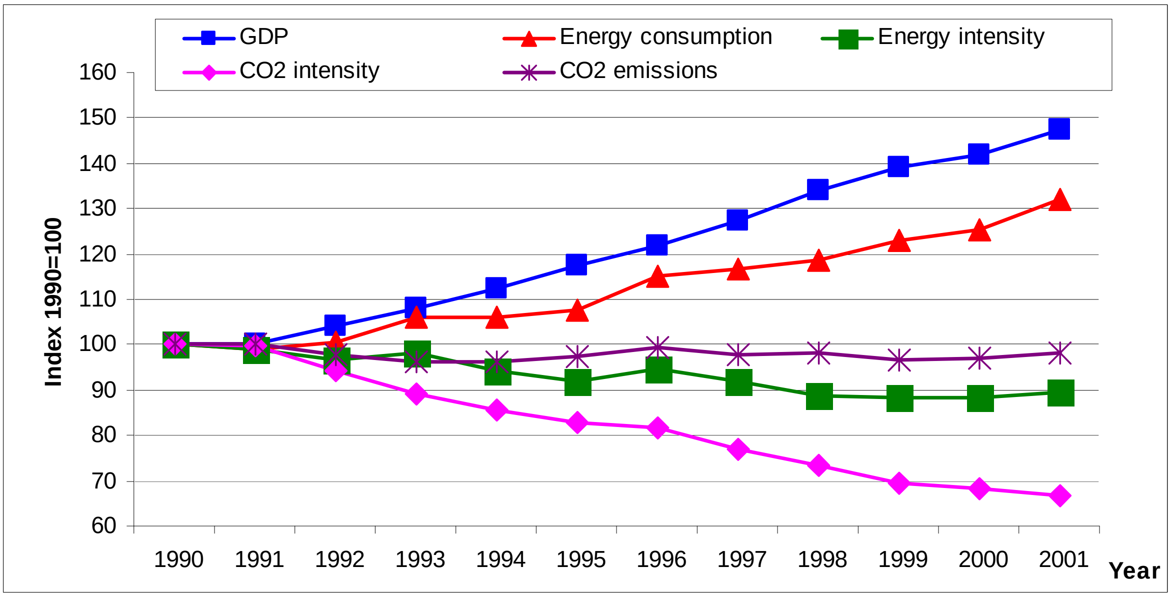

Figure 3. Development in energy consumption, GDP energy and CO_2 intensities
Source: EIA, "International Energy Annual 2002", July 2004 and UNFCCC, European Environmental Agency, European Topic Centre on Air and Climate change

5. Sustainable energy

Unfortunately, many of the current methods of energy supply and use are environmentally unsustainable, throughout the energy chain that links resource extraction to the provision of energy services [14].

The energy mix, the economic structure and energy efficiency of a country, expressed as energy intensity, are the main driving forces of CO_2 emissions. The decline of CO_2 intensity is mainly driven by the reduction of energy intensity. However, the ways through which this is achieved is very important for the emissions level, the main policy being the change of primary energy mix.

Economic growth will continue, especially if the policy makers continue to believe that high GDP rates are desirable. However, this growth must be sustainable, and sustainable development must be perceived as another dimension of the economic growth that can be only achieved by a sustainable energy production, distribution and use. The methods of energy production and use that are sustaining the human development in the long run, in all the economic, social and environmental aspects represent the sustainable energy. In other words, a source of continuous and constant energy is not enough, but the energy production and use must be compatible with the welfare of population in long term, respecting the fragile environment balance. These targets might be achieved by effective investments in RES, sustainable energy in transport and buildings, and increasing energy efficiency throughout the energy chain (from resource extraction to lighting systems and appliances).

6. Conclusions

This paper emphasised the importance of energy in the contemporary world, and showed its two contradictory effects: on one hand it stands as an essential pillar of today's lifestyle and welfare, and on the other it represents an enormous cost for human health and different ecosystems. In a pursuit to identify the overall energy effects, the energy consumption was linked to the economic growth and CO_2 emissions. The energy intensities were considered as important indicators of the energy consumption efficiency and values were assessed for 30 countries. At the same time, CO_2 intensities were considered for EU(15) and a decoupling between economic growth and resource consumption was identified. This paper showed that the decline of CO_2 intensity is mainly driven by the reduction of energy intensity, and this might be achieved by the change of primary energy mix and effective investments in sustainable energy throughout the energy chain.

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