

Retrospective analysis of the evolution of industrial production in relation to energy consumption

Carmen-Elena STOENOIU

Department of Electrical Machines and Drives, Faculty of Electrical Engineering
Technical University of Cluj-Napoca
Cluj-Napoca, Romania
Email: Carmen.Stoenoiu@emd.utcluj.ro

Abstract— The study allows to know the evolution, for ten years, of the production in industry and of the energy consumption for the 27 countries of the EU. A comparative analysis was performed in which it can be seen how each country evolved, then the countries where the increase of production determined the increase of energy consumption were established, but also the countries where this connection is not direct. At the same time, the evolution of the production by activity sectors was determined, this allowing the knowledge of the sectors from each country that contribute to the achievement of the gross domestic product and of the economic well-being.

Keywords—consumption optimization, sustainable development, industrial production

I. INTRODUCTION

Energy has become a fundamental factor in the functioning of systems and allows the organization of society and the creation of a certain standard of living [1]. Although we can produce much more, more diverse and in a shorter time, this acceleration has created social pressures [2], has led to increased complexity of society [3], and in final to the modeling of the world system [4-5] which is increasingly dependent on energy. Globalization has led to increased geospatial separation of production and consumption, and this has an impact on the UN Sustainable Development Goals (SDGs) and the Paris Agreement. On the other hand, in a globalized economy where economies are increasingly open, indirectly using funds from other countries, political and economic conflicts often occur precisely due to trade [6-7].

The international distribution of resources allows all countries to take steps towards global growth [8]. The existence of scarce natural resources makes the poorest countries attractive in terms of international agreements, which play a crucial role in their conservation and sustainability [9-11].

Sustainable consumption and production as well as sustainable industrial policy are objectives included in the EU action plan [12]. Optimizing the structure of energy consumption is an important component of economic development, and many researchers have explored methods to reduce urban energy consumption [13]. It is considered that the

relationship between a sustainable environment and economic growth is closely linked to the relationship between energy consumption and economic development [14-15]. There are studies that suggest that energy consumption is one of the important factors for achieving production and decreasing energy consumption to minimize pollution would lead to lower economic development [14, 16-17]. Other studies argue that there is no link between growth and energy consumption [18-19].

The aim of this paper is to identify the existence of a link between production and consumption, for the EU countries that were studied. We also wanted an analysis of production in industry by sector of activity, for the ten years studied, to see the changes that have occurred within each country.

II. MATERIAL AND METHOD

This study used data provided by the Eurostat database for the period 2010-2019 for 27 EU countries. A retrospective analysis was performed in which two indicators were used: production in industry and final energy consumption, values of the two indicators being expressed as a weight compared to 2015. Thus, the individual progress registered for the two indicators was followed for each country by comparing the data from 2019 with those from 2010.

Subsequently, a comparative analysis of the two indicators was performed and an attempt was made to identify whether there is a direct causal link that would justify the evolution of these indicators. The analysis of production in industry by activity sectors tried to capture the production of 2019 compared to the average recorded in the ten years studied.

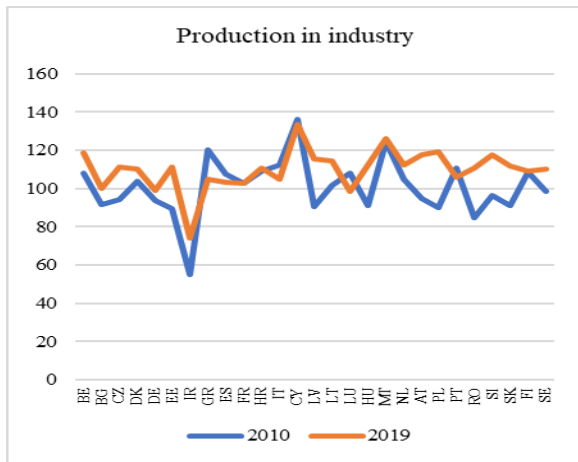
Production in industry is an indicator of the activity cycle that shows the production activity, its objective being to measure changes in the volume of production at the level of each year. It provides a measure of the trend in the volume of value added over a given reference period.

Final energy consumption covers the energy consumption of end-users, such as industry, transport, households, services, and agriculture. Excludes consumption in the energy sector itself and losses that occur during energy transformation and distribution (eg. power plants, thermal power plants, oil refineries, coke ovens, furnaces).

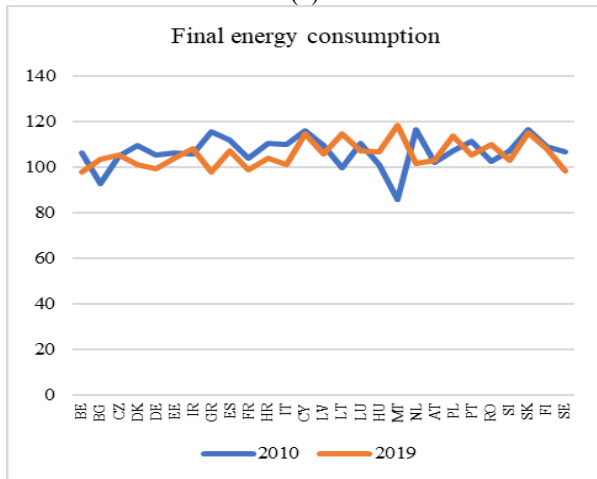
III. RESULTS AND DISCUSSION

Industry has become the main production sector in most European countries. Thus, the production obtained from the industry is the activity that allows the transformation of the available resources into goods and services destined for consumption. As the optimization of energy consumption is an important component of economic development, in the following a comparative analysis of 2010 with 2019 was carried out to capture the transformations that took place in the ten years in the 27 EU countries.

Figure 1 shows the evolution of two indicators: production in industry and final energy consumption.



(a)



(b)

Fig. 1. The situation of the evolution of production and consumption.

The analysis of Figure 1a shows that production in industry increased in 2019 compared to 2010 in most EU countries. The only countries that registered a decrease are GR (-15.47%), LU (-9.57%), IT (-7.07%), PT (-4.77%), ES (-4%), CY (-2.6%). The largest increases in production are recorded by the following countries: PL (29.4%), RO (26.23%), LV (25.10%), AT (22.53%), EE (22.07%), SI (21.3%), HU (21.23%), SK (20.63%), IR (19.17%), CZ (17.33%), LT (13%), SE (11.77%),

BE (11%), BG (8.6%), NL (7.57%), DK (6.23%), DE (5.27%), MT (1.7%), HR (1.6%), FI (0.37%), FR (0.13%).

The analysis of Figure 1b shows that the final energy consumed in 2019 compared to 2010 decreased in most EU countries. The only countries in which there is an increase are: MT (32.39%), LT (14.9%), BG (10.82%), RO (7.25%), PL (6.6%), HU (5.35%), IR (2.04%), AT (1.07%), CZ (0.42%). The largest decrease in consumption is registered by the following countries: GR (-17.68%), NL (-14.86%), IT (-9.01%), BE (-8.47%), DK (-8.42%), SE (-8.31%), HR (-6.35%), PT (-6.14%), DE (-5.8%), FR (-4.75%), ES (-4.55%), SI (-4.17%), LV (-3.76%), LU (-2.96%), EE (-2.54%), CY (-1.51%), SK (-1.34%), FI (-0.89%).

Analyzing both Figures (1a and 1b) although production in industry has increased in most countries, final energy consumption has not followed the same trend.

In Figure 2 we have the comparative analysis of the two indicators, where in 2019 we can see the differences between production in industry and energy consumption.

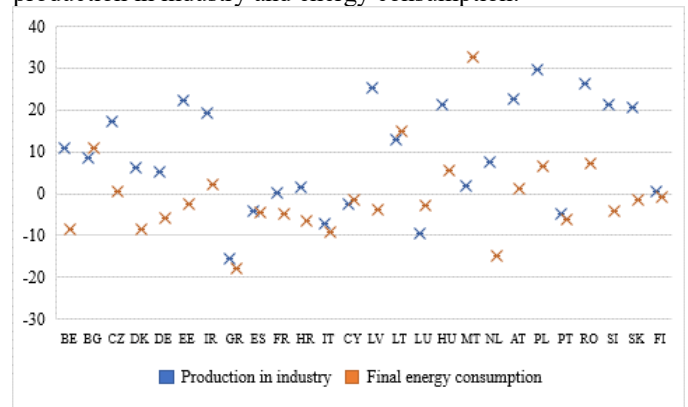
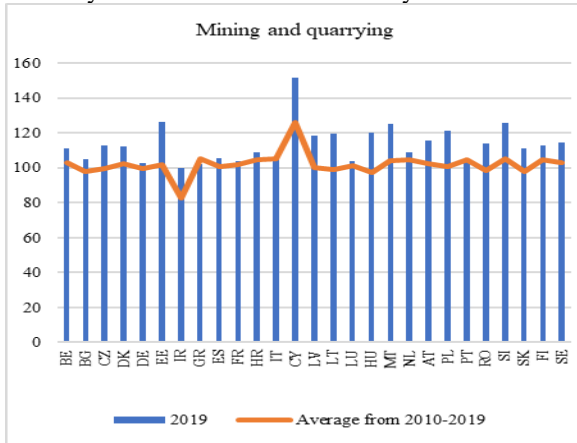


Fig. 2. Comparative analysis of production and consumption.

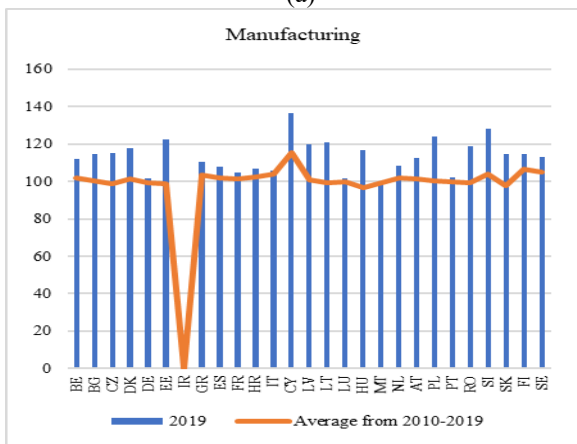
From the comparative analysis of the two indicators, from Figure 2, the increase in production in industry (P) does not determine in all countries the increase in final energy consumption (C). Thus, the following countries registered an increase in production in industry in a smaller proportion than the increase in energy consumption: MT (P: 1.7% ÷ C: 32.39%), LT (P: 13% ÷ C: 14.9%), BG (P: 8.6% ÷ C: 10.82%). Other countries recorded an increase in production in a higher proportion than the increase in energy consumption: PL (P: 29.4% ÷ C: 6.6%), RO (P: 26.23% ÷ C: 7.25%), HU (P: 21.23% ÷ C: 5.35%), IR (P: 19.17% ÷ C: 2.04%), AT (P: 22.53% ÷ C: 1.07%), CZ (P: 17.33% ÷ C: 0.42%). There are also countries that have registered the increase of production in industry and the decrease of final energy consumption: LV (P: 25.10% ÷ C: -3.76%), SE (P: 11.77% ÷ C: -8.31%), BE (P: 11% ÷ C: -8.47%), NL (P: 7.57% ÷ C: -14.86%), DK (P: 6.23% ÷ C: -8.42%), DE (P: 5.27% ÷ C: -5.8%), HR (P: 1.6% ÷ C: -6.35%). And also countries where the decrease of energy consumption was in a higher proportion than the decrease of production in industry: GR (P: -15.47% ÷ C: -17.68%), EE (P: 22.07 ÷ C: -2.54%), SI (P: 21.3% ÷ C: -4.17%), SK (P: 20.63% ÷ C: -1.34%), FI (P: 0.37% ÷ C: -0.89%), FR (P: 0.13% ÷ C: -4.75%), IT (P: -7.07% ÷ C: -9.01%), PT (P: -4.77% ÷

C: -6.14%), ES (P: -4% ÷ C: - 4.55%), but also countries where the decrease in consumption is in a smaller proportion than in production: LU (P: -9.57% ÷ C: -2.96%), CY (P: -2.6% ÷ C: - 1.51%).

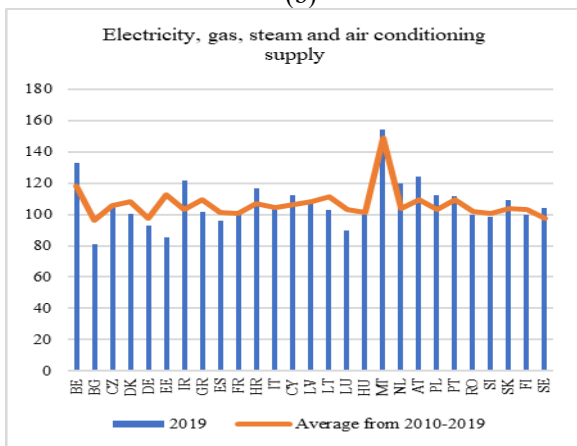
In Figure 3 a-c we present the evolution of production in industry according to existing economic activities. Thus, an analysis of 2019 was made compared to the average recorded in the 10 years, which allows the observation of changes in each country in terms of economic activity.



(a)



(b)

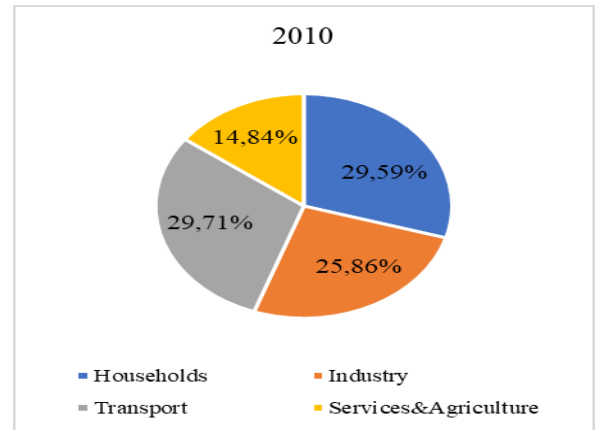


(c)

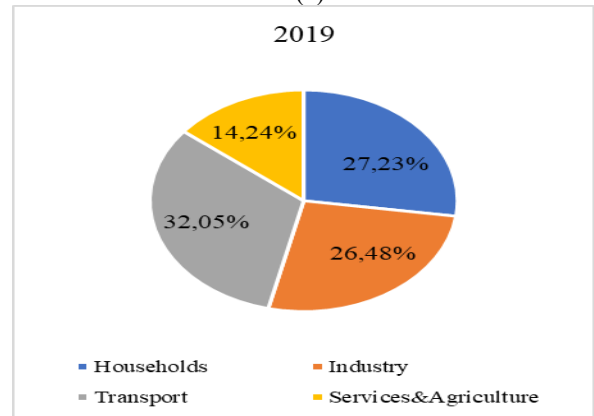
Fig. 3. Production in industry by economic activities.

At the level of the 27 countries, the activity of Mining and quarrying increased by 1.95%, Manufacturing by 3.29% in 2019 compared to 2010 and the activity of Electricity, gas, steam, and air conditioning supply decreased by 5.24%. If we analyse Figure 3a we can see that in this activity in 2019 there is an increase compared to the average in almost all countries, except for the following countries that recorded a decrease: GR (-3.55%) and PT (-0.84%). The highest increase is registered by the Mining and quarrying activity in the following countries: CY, EE, SI and MT. If we analyse Figure 3b we notice that the only country for which there are no statistical data on the Manufacturing activity is IR. Most countries register an increase in 2019 compared to the average of 10 years, low values compared to the average being recorded only by MT (-0.43%). The highest growth in Manufacturing activity is registered by the following countries: CY, SI, PL, and EE. From the analysis of Figure 3c it can be seen that there are several countries where in 2019 lower than average values are recorded: BG (-15.76%), DK (-7.78%), DE (-4.67%), EE (-27.73%), GR (-8.04%), ES (-5.34%), FR (-1.11%), IT (-0.76%), LV (-0.35%), LT (-8.42%), LU (-13.28%), HU (-1.66%), RO (-2.09%), SI (-2.13%), FI (-3.6%). In the Electricity, gas, steam, and air conditioning supply activity, the highest increase is registered in the following countries: MT, BG, AT, IR, and NL.

Figure 4 shows the final energy consumption by consumption sectors.



(a)



(b)

Fig. 4. Final energy consumption by sector.

From the analysis of Figure 4 a and b the final energy consumption per sector, calculated as a share in total in 2019, has changed compared to 2010, as follows: Households recorded a decrease of 2.36%, Industry an increase of 0.62 %, Transport an increase of 2.34%, Services & Agriculture a decrease of 0.6%.

Final energy consumption by total in 2019 (902,849 thousand tons of oil equivalent) compared to 2010 (942,430 thousand tons of oil equivalent) decreased by 4.20%, for a total of 27 EU countries. If we refer to each sector and calculate within the sector the share between 2019 compared to 2010, we notice that only in Transport there was an effective increase of 3.36% and in the other sectors there was a decrease: Households (11.85%), Industry (1.92 %), Services & Agriculture (8.08%).

IV. CONCLUSIONS

Sustainable industrial development is an approach that requires sustained effort to determine the factors that contribute to increasing economic performance. For this, each country recognizes and strives for the development of professional skills, technology, foreign direct investment and for the creation of a modern infrastructure capable of enabling development. From the analysis it can be said that the values registered, by the production indicator in industry, increased in 2019 compared to 2010 in most countries, which shows that these countries have registered economic growth while achieving additional added value. The highest increases of the production indicator in industry, in 2019, were obtained in the following countries: PL (29.4%), RO (26.23%), LV (25.10%), countries with emerging economies that strive to overcome the gap with countries with developed economies.

Energy demand depends on the pace of economic growth that each country registers, on the standard of living, but also on the evolution of the industry. Due to the increase of the living standard but also of the changes in the industry, it is found that the final energy consumption registers an increase in most EU countries. From the analysis of the final energy consumption indicator, it increased in 2019 compared to 2010 in some countries: MT (32.39%), LT (14.9%), BG (10.82%), and in others it decreased: GR (-17.68%), NL (-14.86%), IT (-9.01%). The analysis of energy consumption by activity sectors in total consumption shows that there is an increase in Industry (0.62%) and Transport (2.34%) and a decrease in Households (2.36%) and Services & Agriculture (0.6%).

Although the main challenge for producers and consumers is to achieve more by consuming fewer resources, this is still a difficult goal to achieve for many countries.

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