

Dynamics of global energy consumption in the context of climate change

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Dinamica consumului global de energie în contextul schimbărilor climatice. Societatea umană este dependentă de energie, atât de electricitate, cât și de combustibili. Consumul tot mai mare de energie din ultimele decenii, ca urmare a creșterii populației sau dezvoltării socioeconomice, a însemnat și emisii însemnate de gaze cu efect de seră și alte forme de degradare a mediului. Politicile naționale și internaționale în domeniul schimbărilor climatice nu au avut, până în prezent, rezultate mulțumitoare. Pentru deceniile următoare, îngrijorările sunt legate de faptul că cererea globală de energie va fi în creștere, mai ales în cadrul statelor în curs de dezvoltare, iar sursele regenerabile de energie și măsurile de eficientizare energetică nu vor putea asigura suficientă energie pentru a diminua considerabil consumul de combustibili fosili.

Cuvinte cheie: consum energetic, schimbări climatice, factori de influență, energie regenerabilă.

Dynamics of global energy consumption in the context of climate change. Human society is dependent on energy, derived both from electric power and fuels. The increasing energy consumption in recent decades, as a result of population growth or socioeconomic development, has also meant significant emissions of greenhouse gases, as well as other forms of environmental degradation. So far, national and international climate change policies have not had satisfactory results. The concerns of the coming decades are that global energy demand will be growing, especially in developing countries, and that renewable energy sources and energy efficiency measures will not be able to provide enough energy to significantly reduce the consumption of fossil fuels.

Keywords: energy consumption, climate changes, influencing factors, renewable energy.

1. INTRODUCTION

Energy is a key factor in socioeconomic development, but continued growth and current energy consumption practices have a considerable negative impact on the environment, including the climate. The burning of fossil fuels in thermal power plants, car engines or households generates greenhouse gases and pollution. The concentration of CO₂ in the atmosphere reached 410.5 ± 0.2 ppm in 2019, a considerable increase compared to the level of the pre-industrial period (mid-eighteenth century), estimated at 278 ppm (WMO 2020, NOAA-ESRL 2013).

According to the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC), from 2014, the expected effects of climate change in this century will have a major impact on the environment and human society, the anthropogenic activities (especially the burning of fossil fuels) representing the main cause of global warming. The global warming process and the impact on the climate system are considered unequivocal, being confirmed by an increase in global average temperature of about 0.9°C compared to the average temperature in the pre-industrial era (with a higher increase in the past 50 years). The widespread and significant effects of climate change are already obvious in natural and human systems (melting glaciers, shrinking Arctic ice, rising sea levels or biodiversity reduction). According to this report, in order to avoid serious effects on the environment and to be able to meet the internationally adopted target of keeping global average temperature rise below 2°C (target reconfirmed by the Paris Agreement of 2015) compared to the pre-industrial period, urgent measures are needed to reduce greenhouse gas emissions, because the measures taken so far have been insufficient.

Air pollution and especially climate change have led to significant alterations in global energy policies, in the sense of streamlining energy consumption and especially increasing the share of renewable energy in global energy consumption. In the last three decades, over 80% of global primary energy consumption has come from fossil fuels (Our World in Data, 2021). Renewable energy is also needed due to the fact that fossil fuels are depletable resources and without new discoveries, in the coming decades they will start to dwindle. On the other hand, the widespread use of traditional biomass can lead to other environmental problems, such as reduced biodiversity or soil degradation.

According to IRENA (2019), energy-related carbon dioxide emissions should be reduced by 70% by 2050, in comparison to current levels, in order to meet the climate targets. About 60% of this decrease could be obtained from the large-scale shift to electric power from renewable sources. If renewable energy sources for heating and transport were taken into account, the decrease could be 75%, and if energy efficiency were to increase, the decrease could reach 90%.

In the future, additional amounts of energy will be needed to meet the needs of the population, including mobility. Many people still do not have access to electric power or

their consumption is low, as is the case of many developing countries, especially in Africa. According to U.S. Energy Information Administration (2019), global energy consumption will increase by almost 50% between 2018 and 2050. Also, the final electric power consumption will increase by almost 80% during this period. Most of this growth will come from non-member countries of the Organization for Economic Co-operation and Development (OECD), especially those in Asia. The estimated increase is 30% in industry, agriculture and construction, about 40% in transport and 65% in the residential and commercial sector.

Thus, in the context of increasing global energy consumption and climate change concerns, the widespread use of renewable energy sources is a necessity. The big challenge will be to produce enough energy from renewable sources to replace fossil fuels used in electricity and heat production or transport, in the context of population growth, economic development, urbanization or the expansion of electric mobility. The purpose of this paper is to raise the awareness regarding the impact of energy consumption on the environment, the prospect of increasing energy needs and the need for much faster development of renewable energy, in order to achieve the global goals of climate change and environmental protection in general.

2. METHODOLOGY

This paper aims at analyzing global energy consumption and its correlation with demographic, socioeconomic, electric mobility and renewable energy trends. The statistical data used were taken from the databases of the International Energy Agency (IEA), U.S. Energy Information Administration, International Renewable Energy Agency (IRENA) or Our World in Data, which collect and publish energy data periodically. The data on global energy consumption were represented on graphs and were correlated with a number of indicators such as population growth and economic growth. Last but not least, the results were analyzed in close connection with the dynamics of renewable energy.

3. RESULTS AND DISCUSSION

Population growth, urbanization and economic development. The dynamics of final energy consumption (electricity and heat, fuels for heating homes, fuels for transport and industrial processes) has been determined over time, to a large extent, by population growth, urbanization and economic development (Figures 1 and 2). The world's population continues to grow, although the growth rate is declining. From about 7.8

billion people today, the world's population will reach 9.7 billion by 2050 (the average forecast). The highest growth will occur in the developing countries in Africa and Asia. It is estimated that many of these countries, which currently have about 6.5 billion inhabitants, will double their population by 2050 (UN, 2019). Thus, as a result of population growth by almost 2 billion inhabitants by 2050, we expect an increase in energy demand.

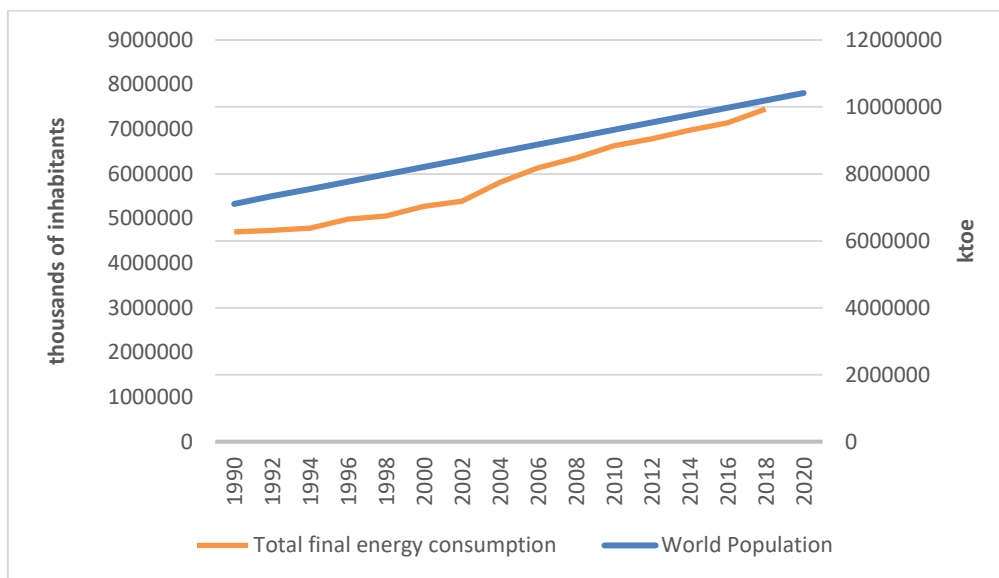


Figure 1. Correlation between population growth and total final energy consumption

Source: UN (2019) and IEA (2021)

In the twentieth century, especially in its second half, urbanization grew rapidly. If in 1950, only 29% of the world's population lived in cities and only New York and Tokyo, whose urban agglomerations exceeded 10 million inhabitants, were classified as mega-cities, today about 55% of the population lives in urban settlements and there are 28 mega-cities that concentrate a large part of the urban population of Asia and Latin America. In 2050, more than two-thirds of the population (68%) is expected to live in cities (UN, 2019). Compared to rural areas, in cities, especially in the large ones, energy consumption is higher, especially due to mobility. Although the urbanization process has been associated with beneficial socioeconomic transformations, in many cities inadequate expansion has led to pollution, degradation of the natural environment, and unsustainable consumption patterns. It is estimated that 60-70% of the anthropogenic greenhouse gas emissions are directly or indirectly related to urban areas, and especially to the rich cities (Dodman, 2009).

Economic growth is by far the most important factor in energy demand. The connection between energy demand and economic development is close. As a large part of the population resides in developing countries, raising their socioeconomic level will require a lot of energy.

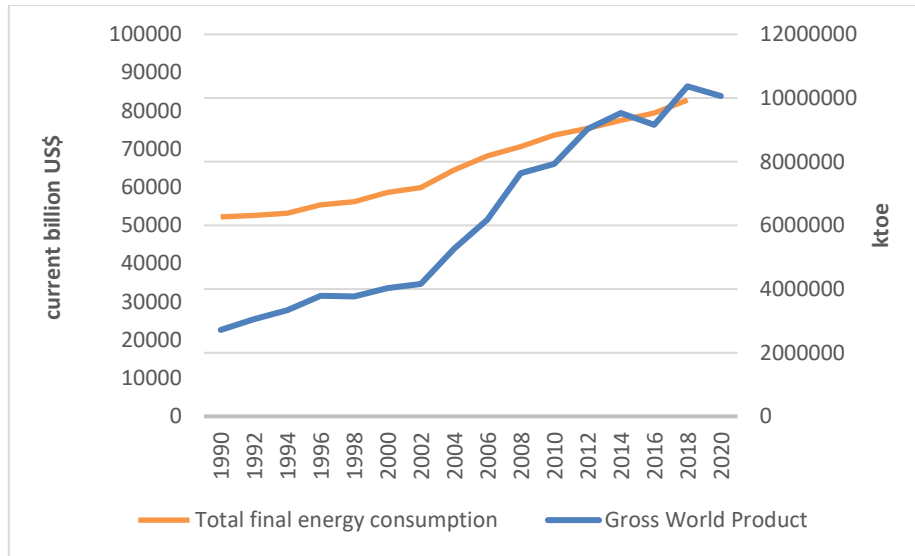


Figure 2. Correlation between gross global product and total final energy consumption
 Source: World Bank (2020) and IEA (2021)

Economic development can also lead to an increase in the amount of electric power consumption per capita. Electric power is most frequently used in residential areas, for lighting and household appliances, in industrial processes, for the production of various goods, as well as in transport, for supplying electric vehicles (Figure 3). The increase in consumption can be partially offset by energy efficiency measures.

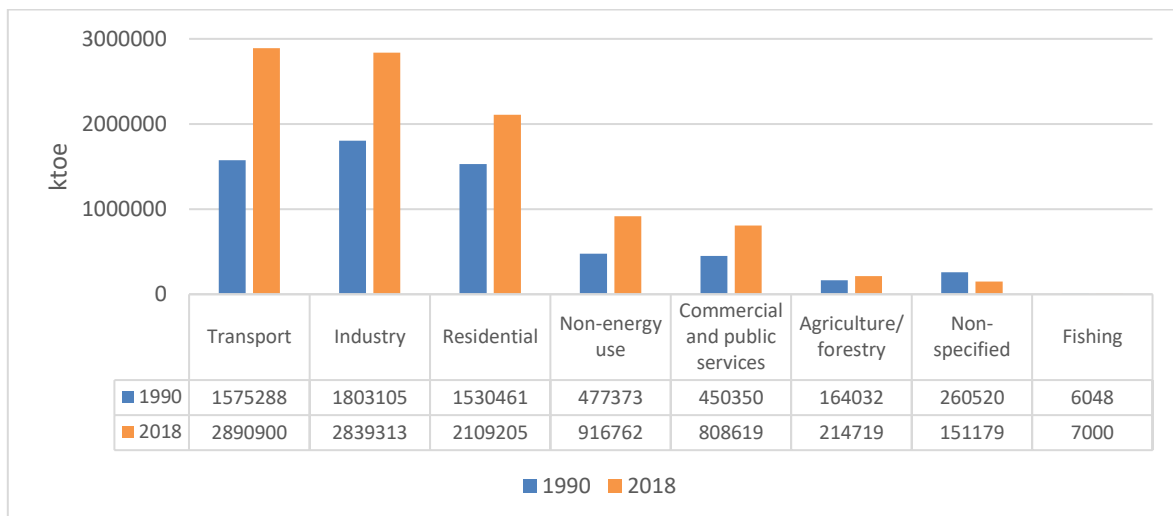


Figure 3. Total final consumption by sector
 Source: IEA (2021)

Access to electric power and electric power consumption per capita. Globally, the number of people without access to electric power is very high, of about 770 million in 2019, although their number has decreased in recent years (IEA, 2021). The vast majority of the population without access to electric power (about 75%) is in Africa. In some countries on the continent, such as the Democratic Republic of Congo and Nigeria, the number of those without access to electric exceeds 70 million. In the past two decades, the global trend has been upward, the share of population with access to electric power increasing from 73% in 2000 to almost 90% in 2019.

As far as the average annual electric power consumption per capita is concerned, this varies considerably. In economically developed countries, annual consumption exceeds 4000 kWh/inhabitant (Spain, Germany, France, USA), reaching 17600 kWh/inhabitant in Canada and 25000 kWh/inhabitant in Norway. On the other hand, in many poor countries of the world, the consumption values are less than 200 kWh/inhabitant (Democratic Republic of Congo, Niger, Chad). Global electric power consumption per capita increased from 2.2 MWh/inhabitant in 1990 to 3.5 MWh/inhabitant in 2018 (Our World in Data, 2021) (Figure 4). The increase in per capita electric power consumption in the economies of less developed non-OECD countries was more than double between 2000 and 2017, compared to an almost stable trend in the economies of OECD countries (US Energy Information Administration, 2020).

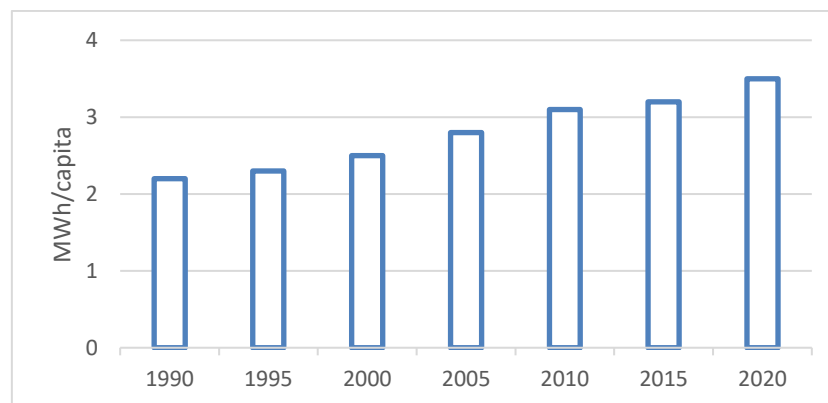


Figure 4. Electricity consumption per capita

Source: Our World in Data (2021)

Increasing electric mobility. Electric vehicles are a solution to reduce both air pollution in densely populated areas and greenhouse gas emissions. However, in order to be fully environmentally friendly, the electric power used to charge electric cars must come from renewable energy sources. In recent years, more and more electric vehicles run on the world's roads, and their contribution to electric power consumption is increasing. If in 2005 only 1890 light electric passenger cars were in use, in 2019 their

number exceeded 7.1 million (of which 2.38 million are plug-in hybrid electric vehicles) (Figure 5). Together with buses (about 500 thousand), light commercial vehicles (about 380,000) and trucks (about 6,000), the total number of electric vehicles exceeded 8 million units. In addition, the number of electric vehicles with two or three wheels (scooters, mopeds, bicycles, scooters) has increased considerably, exceeding 350 million units (IEA, 2018 and 2020).

The share of electric vehicles in the total number of vehicles in operation worldwide, which exceeds 1.28 billion units (OICA, 2021), is still very low, less than 1%. In 2019, electric vehicles accounted for 2.6% of global car sales, recording an increase of about 40% from year to year.

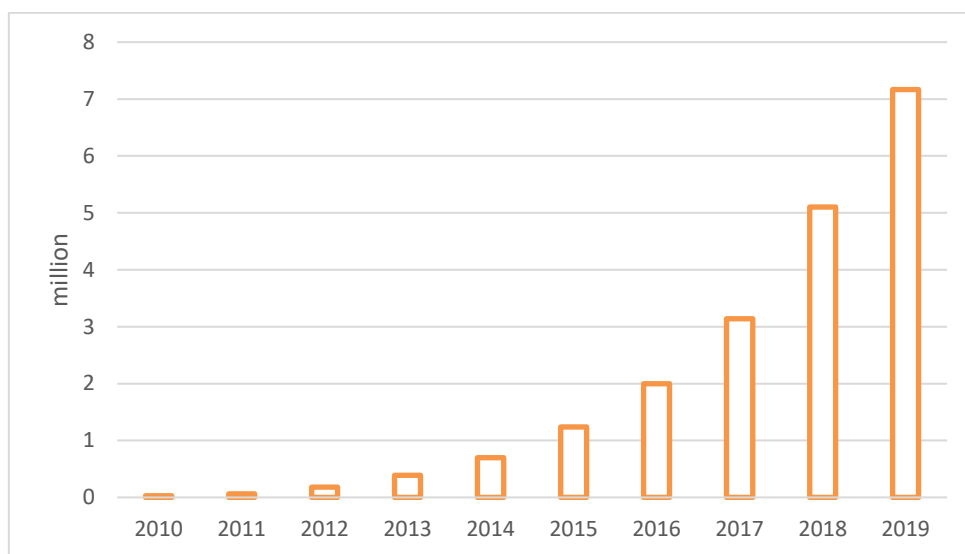


Figure 5. Global electric car stock
Source: Global EV Outlook (2020)

Although currently the electric power consumption of electric vehicles is still very low, estimated at 54 TWh, i.e. 0.2% of the electric power consumed globally (IEA, 2018), in the future, electric mobility could put significant pressure on the energy system, especially in times of high electric power demand. It is estimated that in 2030 the electric power consumption of electric vehicles (including those with two and three wheels) will be between 505 and 1000 TWh (IEA, 2020).

The share of renewable energy. According to the International Energy Agency, since 1990 renewable energy sources have grown at an average annual rate of 2.0%, with much higher increases in solar photovoltaic (36.5%) and wind (23%) energy. (Figures 6 and 7). However, in 2018, of the total energy supplied worldwide, only 13.5% came from renewable energy sources: biofuels, hydropower, municipal renewable waste, wind, solar (photovoltaic and thermal), geothermal or tidal energy. Solid biofuels (such as wood

vegetation) are the largest source of renewable energy and they are still widely used in developing countries for heating and cooking, while the second largest renewable energy source is hydropower. If we refer only to the production of electric power, the share of renewable energy sources exceeds 25%, thus coming second after coal.

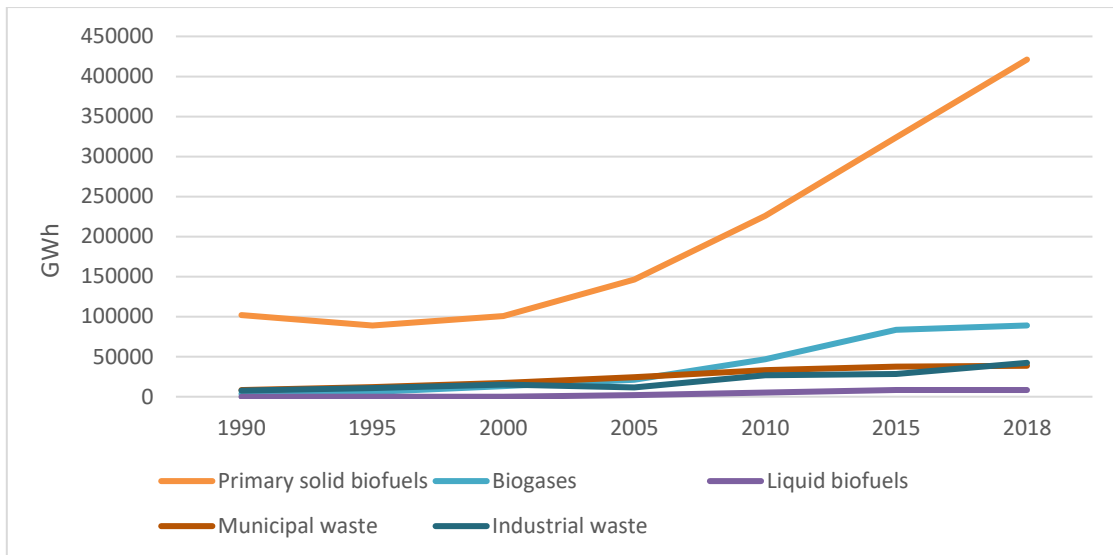


Figure 6. World electricity generation from biofuels and waste (1990-2018)
Source: IEA (2021)

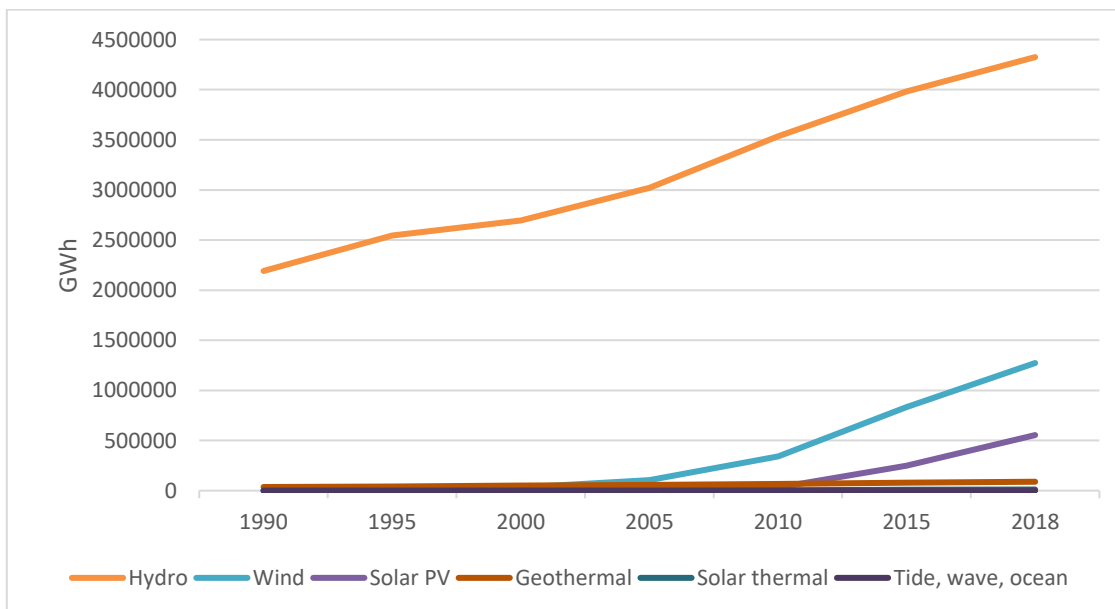


Figure 7. Renewable electricity generation (non-combustible)
Source: IEA (2021)

In the context of climate change, along with energy efficiency, renewable energy is the main solution for reducing greenhouse gas emissions. Thus, the share of renewable

energy in total energy consumption will have to increase significantly by 2050, reaching about two thirds (IRENA, 2019). However, this increase is not certain. According to U.S. Energy Information Administration (2019), although renewable energy sources will increase by more than 3% per year between 2018 and 2050, their share in global energy consumption will not exceed 28%.

4. CONCLUSIONS

It is already a certainty that human society is facing environmental problems, such as climate change and air pollution. These problems are largely caused by the burning of fossil fuels, and the consequences for human health, the economy and natural ecosystems are among the most serious. The world's states must make every effort to reduce greenhouse gas emissions from burning fossil fuels both through the widespread use of renewable resources and through energy efficiency. Although the share of renewable energy in global energy consumption has increased in recent years, it still remains at a low level. In order to keep the global temperature rise below 2°C, the energy field needs to replace fossil fuels with renewable energy sources much faster. However, this will not be easy to achieve in the short or medium term.

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