NUCLEAR USE FOR BASELOAD POWER

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1. Introduction

Projections on the increase of the world population indicate a growth of 1.7 billion inhabitants in the next couple of decades, getting to a total of 9.2 billion inhabitants by 2040. Much of this increase will be established in urban centers reaching, in 2040, 2 billion living in cities, where large energy demand compounds will concentrate [1].

It is estimated that, until 2040, the global demand for primary energy will increase by around 30%, with the industrial sector accounting for almost half of this increase. The industrial sector consumes practically 50% of primary energy, the residential and commercial sector 30% and transport 20%. The expected increase will be generated mainly by the pronounced development of the emerging countries economies, such as China and India, which will represent about 2/3 of the increase in consumption.

The tendency to a greater substitution of combustion processes by the use of electric power will be accentuated, reaching about 70% of the increase in primary energy to be produced by the power industry [1].

2. Sources of energy

Figure 1 indicates the expected distribution of the sources that will be used globally to generate primary energy until 2040 [1].

Renewable energies will have a growth of approximately 40% in this period and natural gas will grow, in percentage, more than coal or oil sources.

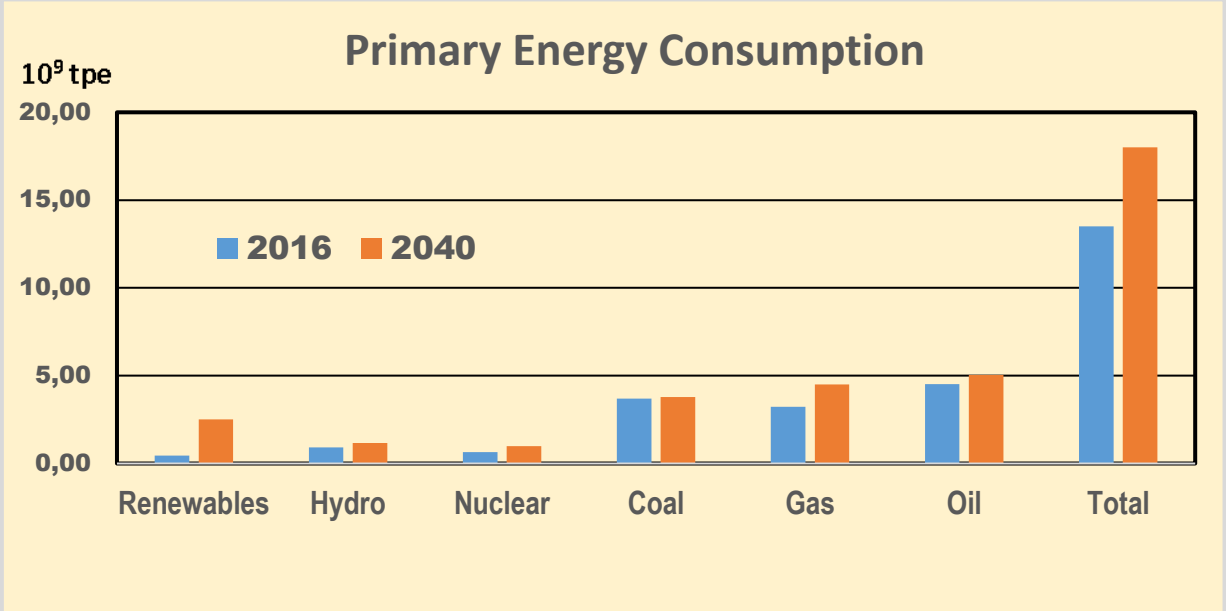

Figure 1

3. New boundary conditions for sustainable development

a) The concept of sustainable development, established some 30 years ago, is globally accepted as a condition for the social evolution of nations. Based on this concept, 17 sustainable development objectives have been defined by the U.N., among which the following:

- Ensure access to affordable, reliable, sustainable and modern energy for all;
- Take urgent action to combat climate change and its impacts;
- Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss, protect biodiversity and the homes of indigenous populations.

These objectives impose conditions for the selection of energy sources that will be used in the future, as well as for the limitation of options of units to be installed. For example, the construction of hydropower dams with reservoirs that affect either biodiversity stocks, or a sustainable supply of river water, or rights of indigenous people, may be incompatible with these objectives, requiring then solutions of "run-of-river" type units.

b) With regard to climate change, the 2015 Paris Agreement established that:

- The levels of global emissions of greenhouse gases will not allow to achieve the conditions necessary for an increase of average global temperatures of 2^{o}C upon pre-industrial levels, since the estimated emissions will be about 38% higher than required;
- Therefore, during the second half of this century, the signatory countries must proceed to a rapid reduction of their greenhouse gas emissions to achieve a balance between anthropogenic sources emissions and removals by natural or artificial sinks [2].

The estimates of primary energy supply allow assessing carbon emission values generated in the period up to 2040. These values are shown in Figure 2 [1].

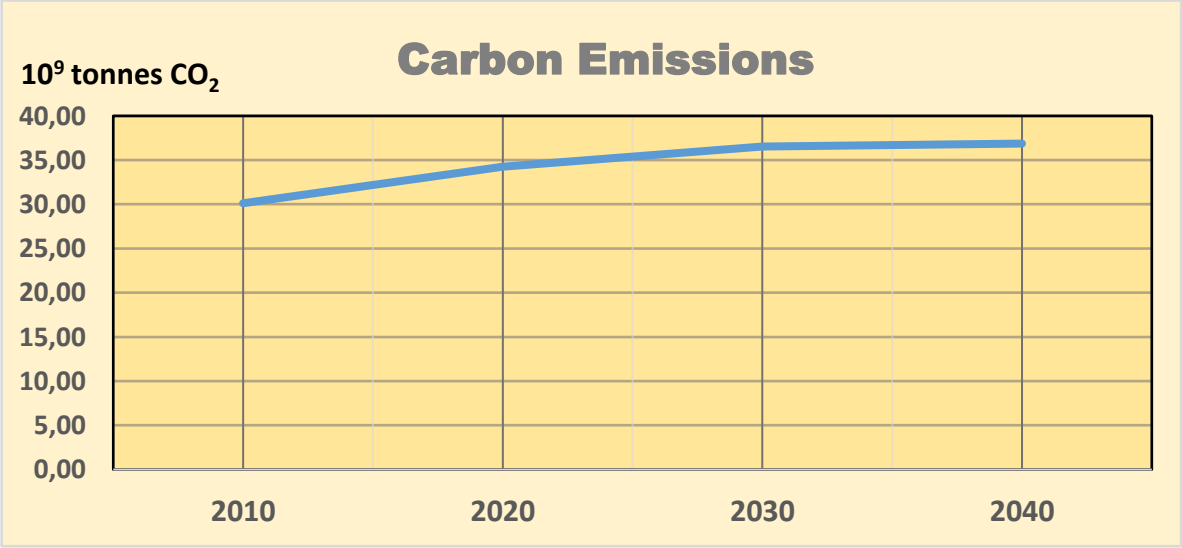

Figure 2

It can be seen that carbon emissions produced by the expansion of energy consumption will increase close to 10% from 2016 to 2040. Although this rate of growth is lower than the 55% experienced in the last 25 years, it is much higher than the amounts set up in the Paris Agreement.

In order to comply with the guidelines of the Paris Agreement, a significant reduction of combustion processes from fossil sources will be needed.

4. Effects on power transmission systems

Due to the growth of greenhouse gases in the atmosphere, which leads to major climate changes, more and more electric power will be used and the primary energy supply will drastically reduce combustion as the most used process to generate energy. This will lead to the replacement of fossil fuels by non-emitting sources of greenhouse gases such as renewables (hydro, wind, solar, bio-fuels) and nuclear power.

Although all these sources of energy will be used, requirements of baseload power to supplement the generation by intermittent supply - such as by wind, solar and "run-of-river" hydro, will have to resort to nuclear power utilization. Currently, fossil fuel thermal power, hydropower with important reservoirs and nuclear power are used to generate baseload.

The stability of the transmission lines to keep the electric frequency constant is a necessary condition for their operation. Frequency variations, resulting from inability to meet demand at a given time, result in blackouts. The existence of baseload guarantees a constant electric frequency. Plants with adequate capacity, particularly near consumption centers - with high concentrations of inhabitants and industries - ensure baseload supply.

5. A future with clean energies

Actions for drastic reduction of carbon emissions lead to the use of technologies that limit the combustion of fossil fuels. This trend will lead to a more pronounced use of so-called clean energies - those without the release of greenhouse gases - such as renewables and nuclear. For industrial, domestic and land transport uses, clean supply of power will be adopted. Utilization of fossil fuels will continue for some time for air, space and maritime transport.

Since power generation with fossil fuels will be abandoned, baseload will be supplied by hydropower plants with reservoirs and by nuclear power plants. If the tendency is to build hydropower plants without reservoirs, there is no other alternative than nuclear power. Obviously, such a comment would be invalid if there were technologies that would allow to store adequate amounts of energy for baseload use when intermittent sources of energy could not generate power (low flow in rivers in the case of "run-of-river" hydro plants, or lack of sunlight for photovoltaic installations, or periods without wind for wind power plants).

The nuclear industry is the only one that contains, processes and controls its solid, liquid and gaseous wastes before releasing them safely to the environment. In countries with intense use of nuclear energy, the annual amount of fission products - stored in controlled premises - is less than 0.004% of all wastes produced by its inhabitants in a year. For this reason, nuclear energy is considered a "clean energy".

Built near consumption centers, without long transmission lines, nuclear units require little space for installation. It is a technology that has the highest energy density per unit volume - between 45 million to 70 million times greater than that produced by fossil fuels, such as oil, coal or natural gas [3]. This makes nuclear technology a highly suitable solution for installing baseload power plants close to consumption centers, occupying relatively smaller spaces.

6. Conclusions

Pursuant to policies based on implementing the United Nations sustainable development goals, the installation of fossil fuel plants, as well as of hydropower plants with large reservoirs, will be discontinued or largely reduced.

Primary energy supply will drastically diminish combustion as the most used process to generate energy. Fossil fuels will be replaced by clean energy sources, such as renewables and nuclear.

Due to the growth of greenhouse gases in the atmosphere, electric power will be used in large scale.

The stability of the transmission lines to keep the electric frequency constant is a necessary condition for their operation. The existence of baseload power guarantees a constant electric frequency.

It will be necessary to ensure a generation of baseload power that accompanies generation by intermittent energy sources such as renewables. To provide clean baseload power in sufficient scale, near the consumption centers, the proven and available technology that exists is nuclear power.

7. References

[1] BP Energy Economics, BP Energy Outlook 2018 Edition, https://www.bp.com/en/global/corporate/energy-economics/energy-outlook.html, 2018.

[2] J. Spitalnik, Nuclear Energy in the Context of the COP-21 Climate Change Agreement, Proceedings 20th Pacific Basin Nuclear Conference, 2016, Beijing, China.

[3] Jenifer Baxter, What future energy technologies could look like, BP Energy Scenarios, March 2018.