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New trends in energy production and utilization

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Abstract

Energy has been the engine of nations' development, and this has driven mankind towards growing energy needs, in particular for transportation, agricultural and industrial activities and buildings. Energy for transportation is based on oil derived fuel, whereas energy in buildings consists mainly of electricity, which is produced from fossil fuels, nuclear power and/or from renewable energy sources, such as hydro and solar. Agricultural and industrial activities use a combination of fossil fuels and electric energy. To increase the sustainability of energy production and efficient energy use, it is urgent that better monitoring and control systems are used, and increase the energy production from renewable sources. This drives the energy sector towards the need for Life Cycle Analysis of energy processes to support the selection and implementation of more sustainable energy systems, as well as to develop better and more intelligent electric energy grids, where storage energy systems plays an essential role. These questions will be briefly discussed in this paper, focusing in the current situation, existing problems and potential solutions, and expected developments.

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1. Introduction

Energy has long been associated with nations' development, ever since ancient times, when man started using fire for heating, cooking or safety purposes. Energy availability promoted the growth and development of population.

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The most conventional and renewable energy sources – sun, water, wind, biomass – became insufficient to fulfill the energy needs, and the utilization of coal, natural gas and oil allowed for the possibility of using larger amounts for new applications, such as industrial production or mobility/transportation, air conditioning and ventilation, communications, etc. But this endless cycle, where people need energy to further progress and where development demands the use of growing amounts of readily available energy, has its drawbacks: use of fossil fuel (FF) and fossil derived energy (FDE) is limited by the capacity of extraction and by the existence of reserves (limited and not evenly distributed in the world) [1]; use of FF and FDE contributes to the emission of large amounts of CO₂, volatile organic compounds (VOCs), sulfur (SO_x) and nitrogen oxides (NO_x), which in turn have acidification, eutrophication and ozone depletion potential, thus largely contributing to global warming and other severe environmental problems, such as acid rain and eutrophication [2,3]. Therefore, three main approaches have been used to solve the problem of energy availability: 1) reducing the amount of energy needed, through increasing efficiency of energy distribution (smart grids) and usage; 2) using other sources of energy, in particular nuclear energy (although recent years have proven that it poses significant risks and is also not available everywhere) or mainly through the use of renewable energy sources, including residual materials; and 3) developing new and more efficient energy storage systems. Furthermore, decision makers are starting to define their policies based on studies that take into consideration the whole life cycle of energy production: from the extraction of raw materials, considering transportation, construction and exploitation of the power units, and even their dismantling and reconversion, until the end of life, in a Life Cycle Assessment (LCA) perspective. Thus, in this paper it will be presented a brief insight of all of these approaches with their corresponding interactions, showing the new trends in the energy sector.

1.1. Energy demand

World development increased dramatically ever since the Industrial Revolution, in particular after WWII, which drove the rise of energy consumption. Thus, energy consumption in the World has been growing continuously in the past 50 years. The highest fraction corresponds to FDE: oil, followed by coal and natural gas; which increased by more than 280 % each. Energy from hydroelectric sources increased by 500 % during the same period. However, its share is still much lower than that of fossil fuels. Nuclear energy has also increased significantly but in the past 5 years has stabilized, possibly due to higher public awareness of the risks associated with it, following the accidents in nuclear power plants like the one that occurred in Fukushima in 2011. Growth in the consumption of other renewable energy sources increased in the last 10 years. However, its share is still insignificant (< 7 %), when compared to any other energy source [4]. The population growth in developing countries, like China and India, suggests that energy consumption in the World will be even higher, which is not sustainable. Thus, measures must be taken to revert this situation.

1.2. Energy sources and problems

As stated before, coal, oil and gas have been the main energy sources in the past 50 years. These are controllable but are not available in unlimited amounts neither evenly distributed. In what concerns nuclear power plants, although it is one of the most modern and secure energy producing technologies, the fact is that in case of an accident there is little that can be done to prevent from a world level catastrophe. The recent Fukushima tsunami made world leaders rethink their energy policy. The decision to postpone the closure of some nuclear power plants that are attaining their end of life was reverted, and Japan decided to change its energy policy on depending almost exclusively on nuclear energy.

It is consensual nowadays that current energy consumption and production patterns are unsustainable in the long term. Thus, current and future energy sources have to be more sustainable. In particular, it is necessary that they are renewable and cause lower negative impacts in all the three main dimensions of sustainability: environmental, economic, and societal. In fact, the availability of clean energy is one of the fundamental requirements for the sustainable development of modern societies. This is recognized both at governmental, institutional and even company levels, and a strong commitment exists among all relevant stakeholders that it is necessary to develop more effective and resilient Renewable Energy Systems (RES), and to increase its share in the global energy mix.

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