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THE IMPACT OF TECHNOLOGICAL INNOVATIONS ON THE ENERGY STORAGE DEVICES: A PRELIMINARY STUDY

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Abstract

Technological innovations are present in our daily lives and play an important role for the society. The increase in energy consumption caused by technologies has made the search for sustainable sources and storage systems an important area of research and technology. Thus, this work aimed to understand the impact generated by technological developments and how current technologies can contribute to the effects on society and the environment.

Keywords: technological innovation, environmental impact, batteries.

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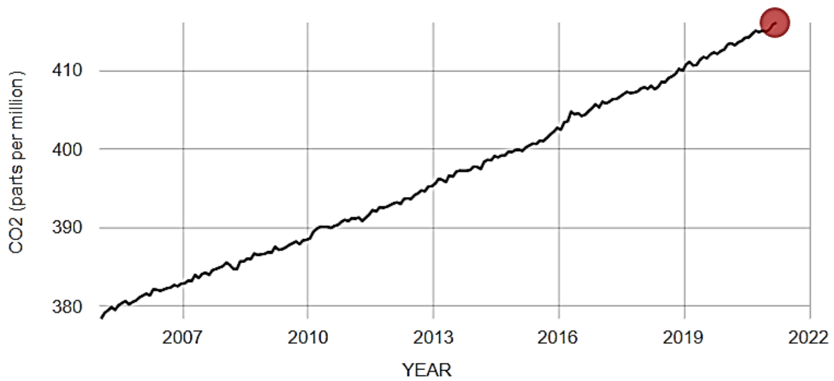
1. Introduction

Technology has become increasingly fundamental in the daily life of society around the world. Technological development has led to countless transformations in contemporary society, bringing about achievements such as space travel, robots, electronic payments that previously made up a fiction world. These advances benefit the lives of people by surrounding technological resources such as production processes, telecommunications systems and transportation in general [1].

However, the everyday lifestyle has caused significant environmental impacts. In 1959, global CO2 levels were at 313 parts per million (ppm). Just six decades later, the CO2 levels reach values that are 100 ppm higher and recently surpass 412 ppm in September of 2019, as can be seen in Figure 1 [2] According to NASA records, human activities have raised atmospheric concentrations of CO2 by 48% above pre-industrial levels found in 1850. To compare, this is more than what had happened naturally over a 20,000 years period when increased from 185 ppm to 280 ppm from Last Glacial Maximum to 1850 [3].

Figure 1 - Growth of CO2 concentration in the last 15 years.



Source: Adapted from Change, N.G.C. Carbon dioxide concentration — NASA global climate change. Accessed April 21, 2021. https://climate.nasa.gov/vital-signs/carbon-dioxide

Energy technology is important because the most basic of the energy services it delivers are fundamental human needs. Energy-technology innovation (ETI) is the set of processes that lead to new or better energy technologies that can increase energy resources and improve the quality of energy services, in addition to reducing the economic, environmental or political costs associated with energy supply and use. ETI over the past century has led to large improvements in the quality of energy services, but there are still many challenges such as reducing dependence on oil, improving energy services for the poorest population and increasing sustainability concerns environmental impacts. [4]

Since the industrial revolution, sustainable energy has been a pillar for prosperity and economic growth. Solar, biofuels and water-based are a few examples of alternatives to clean, affordable and reliable energy. Electrification and related technologies continued the revolution in the nineteenth and twentieth century. [5] Besides renewable energy sources, the need for storage devices that allow for efficient and more sustainable transport is evidenced by the latest technological advances such as electric vehicles and the new generation of electronic devices [2,6]. Energy storage systems are a possible solution for mitigating the effects of intermittent renewable resources, allowing increased renewable energy utilization, and providing flexibility and ancillary services for managing future electricity supply/demand challenges [7].

Electrical Energy Storage (EES) refers to a process of converting electrical energy from a power network into a form that can be stored for converting back to electrical energy when needed. Storage technologies for electricity can also be classified by the form of storage into the following: [8]

- Electrical energy storage: Electrostatic energy storage including capacitors and supercapacitors; Magnetic/current energy storage including SMES.
- Mechanical energy storage: Kinetic energy storage (flywheels); Potential energy storage (PHS and CAES).
- Chemical energy storage: Electrochemical energy storage (conventional batteries such as lead-acid, nickel metal hydride, lithium ion and flow-cell batteries such as zinc bromine and vanadium redox); chemical energy storage (fuel cells, molten-carbonate fuel cells – MCFCs and Metal-Air batteries); thermochemical energy storage (solar hydrogen, solar metal, solar ammonia dissociation–recombination and solar methane dissociation–recombination).
- Thermal energy storage: Low temperature energy storage (Aquiferous cold energy storage, cryogenic energy storage); High temperature energy storage (sensible heat systems such as steam or hot water accumulators, graphite, hot rocks and concrete, latent heat systems such as phase change materials).

In this work the current energy storage technologies will be addressed besides the promising solutions for the future in the technological innovation focusing on battery systems.

2 Batteries technology

Batteries are very popular devices for storing energy. They are present everywhere as in smartphones, notebooks and electric vehicles, being the key to these technologies. In this area, the development of high-density batteries is so important in recent years. The first rechargeable batteries were lead and nickel-cadmium (Ni-Cd) which, despite representing an important technological leap, presented problems related to their disposal. The Nickel Metal Hydride (Ni-MH) technology present operational features similar to Ni-Cd batteries. On the other hand, it has higher energy density and less problems related to disposal [9].

Lithium-ion batteries (LIBs) feature high energy density, high discharge power, and long service life. Research on LIBs started in the early 1980s and the first one was commercialized in 1991. Since then battery performance has risen dramatically. Nowadays, the application of LIBs to electric vehicles and large-scale storage systems makes then a promising solution for challenges of environmental preservation and resource conservation [10]. LIB's made a revolution in portable electronics which led to an explosive increase in research interests through the years. Despite the significant growth in research, the objective continues to reduce the weight and size of batteries, maintaining safety and reducing costs [11].

Table1 – Comparing batteries technology

	Nickel-Cadmium (Ni-Cd)	Nickel Metal Hydride (Ni-MH)	Lithium Ion (Li-ion)
Specific Energy	40-60 Wh/kg	60-120 Wh/kg	100-265 Wh/kg
Energy Density	50-150 Wh/L	140-300Wh/L	250-693 Wh/L
Specific Power	150 W/kg	250-1000 W/kg	250-340 W/kg
Loading/UnloadingEfficiency	70-90%	66-92%	80-90%
Self-unloading	10%/mês	1,3-2,9%/mês a 20˚C	-
Life cycles	2000 cycles	180-2000 cycles	400-1200 cycles

Source: Adapted from Odunlade E. Different Types of Batteries and their Applications. Published 2018. Accessed April 14, 2020 https://circuitdigest.com/article/different-types-of-batteries

The energy density is the total amount of energy that can be stored per unit mass or volume. This determines how long your device stays on before it needs a recharge. The life cycles are the stability of energy density and power density of a battery with repeated cycling (charging and discharging) needed for the long battery life required by most applications [12].

Even with the advancement of technology, the increase in electronic devices consumption evidence the disposal problems. Since the 1970´s, there has been evidence of environmental problems caused by batteries that influenced the retreat of batteries composed mainly by cadmium, lead and mercury. However, except for LIBs, the most common rechargeable batteries, Ni-Cd, Pb-acid and Ni-MH, have mercury in their composition [13]. The reverse logistics is the way to companies to assist their clients how to handle pos-consumption appliances. This solution aims to reduce the environmental impacts generated and encourage product recycling [14].

A recent solution has been explored to the new generation of batteries. The discovery of graphene has opened up new possibilities for modern devices with greater durability, charge capability, fast loading, weight reduction and flexibility [15]. Flexible energy storage devices are attracting increasing attention as they show unique promising advantages, such as flexibility, shape diversity and light weight [16]. Recently, the intrinsic capacitance of single-layer graphene was reported to be $\sim$750 $F.g^{-1}$, superior to double layer electrical capacitance (EDL) of all other carbon-based materials. Thus, for example, supercapacitors based on graphene could, in principle, achieve an EDL capacitance as high as $\sim$550 $F.g^{-1}$ if the entire surface area can be fully utilized. Pure graphene can also be used as anode for LIBs with an improved capacity, and ultrafast charge and discharge rate [17].

Conclusion

It is important to consider the impact of technological innovations mainly on environmental issues. In contrast, we can consider that technologies, especially energy storage devices such as batteries, play a fundamental role in promoting a sustainable future and innovations that benefit society.

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