



[EPS EDITORIAL]

Energy: a never-ending battle

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Energy has been essential to human life since the dawn of time. As early as the Paleolithic era, the production and preservation of fire were crucial for survival. Throughout the development of humanity there has been a constant need to control energy sources. This goes from wood and coal to oil and gas, plus, with the advent of technology in the modern era, chemical, electrical, or nuclear energy. Physics entered the game early enough, behind the technological progresses made in energy generation, storage, and utilisation stands one unifying discipline: physics.

Thermodynamics governs every heat engine, power plant, and refrigeration cycle, establishing the efficiency limits that drive innovation in energy conversion. Electromagnetism forms the basis of electrical generation, transmission, and storage, while quantum mechanics explains the behaviour of semiconductors and the operation of photovoltaic cells and LEDs. Advances in plasma physics drive research in nuclear fusion, potentially the most transformative energy source of the 21st century. Advances in condensed matter physics underpin the search for new battery chemistry and solid-state materials that can store renewable energy safely and efficiently. Meanwhile, progress in nanophotonics and quantum optics continues to improve the light-harvesting efficiency of solar cells. Even classical mechanics continues to guide the optimisation of turbines, fluid systems, and structural designs in renewable energy infrastructure.

The importance of physics goes beyond invention: it is vital for sustainability. Physics teaches us that energy can neither be created nor destroyed, only transformed — a principle that urges efficiency and responsibility in every policy and design we adopt. Energy underpins all activities within modern economies and constitutes a fundamental driver of societal development. However, it is a perilous misconception to assume that a society can sustain a high standard of living and the provision of advanced services (digital technology, hyperproduction of data, etc) while simultaneously achieving a drastic reduction in the consumption of energy and natural resources. Consequently, technological innovation plays a pivotal role in enabling the transition from fossil fuels to sustainable, carbon-free energy sources. Sustained investment in fundamental, technological and industrial research is required.

An interesting example is the attempt to produce energy from nuclear fusion. Ever since nuclear fusion was understood in the 1930s, scientists have tried to recreate and control it. Now in an international effort, a collaboration of physicists from 33 countries under the control of the International Atomic Energy Agency (IAEA) is on its way at the ITER facility located in Cadarache (France). There are three main motivations for supporting such a project: the fuel (deuterium and tritium) is abundant, the process is not supposed to produce long lived nuclear waste, and no greenhouse gases are emitted in the atmosphere.

An important issue is the energy storage problem. The number of photovoltaic power stations (often called solar farms) and wind power plants is rapidly increasing. Due to the inherent intermittency of production, storage is a necessity for these installations if one wants to smooth out the distribution of the electricity they produce. Any successful energy storage system should provide high overall efficiency, large capacity, as well as long storage life. Although batteries represent a promising solution for decarbonisation, the environmental consequences associated with their production and the reliance on critical raw materials warrant careful consideration. Energy storage is the subject of intense research activity, allying solid state physics, quantum physics, plasma physics, as well as chemistry.

While energy policies can enhance national wealth and autonomy, their implementation is profoundly shaped by political dynamics, with positions ranging from opposition to nuclear technologies to the disregard of environmental challenges.

An ambition I had for my EPS presidency was that EPS helps Europe's economic independence. After extensive discussions and overcoming the difficulties arising from sometimes conflicting viewpoints, we have finalised an EPS position paper on energy. Our hope is that this paper serves as a strategic guide for the European authorities, helping them adopt the most effective policies while continuing to invest in research and education. ■

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