Innovations in Electronics – Friend or Foe in Achieving Sustainability?

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Extended Abstract — Remarkable developments in electronics were made in the recent decades to reduce the energy consumption of modern societies. Many engineers and scientists are working on sustainability projects with great dedication and are committed to ensuring that future generations can live in balance with the natural resources of our planet, see e.g. the many the articles in *IEEE Spectrum Climate Tech Alert*. It seems indisputable that technical innovations are essential in order to achieve the sustainable development goals (SDGs) set by the UN. But is this really the case? This contribution endeavors to answer the question by comparing two example innovations.

The development of photovoltaics (PV) represents one of the most significant innovations towards sustainable energy generation. The development began in the middle of the 20th century and PV already covered 7.37 % of the European electricity demand in 2022 [1]. The development of mobile telephony also began in the last century, making it possible to communicate in real time from almost any location. Later, the cell phone became a smartphone through the integration of Internet functions, of which around 7 billion are in use worldwide today [2]. In 2020, the storage of smartphone data in data centers and mobile data traffic in Europe alone required electrical energy on the order of ca. 160 TWh [3]. And, remarkably, the amount of electricity generated by photovoltaics in Europe in 2020 was of the same order of magnitude, namely 148 TWh [1].

No one involved in photovoltaic research at the end of last century could have imagined this development. Rather, everyone assumed that the electricity generated by PV in the 21st century would be used to reduce the amount of electricity produced by fossil fuels to supply households and industry. Nor did they foresee that the operation of 100s of millions of smartphones would consume practically all of Europe's solar energy harvest [2]. The hoped-for savings potential was thus lost to a new consumer and the hoped-for substitution of fossil-fuel-generated electricity did not take place. As if on an innovation highway, smartphone technology overtook PV and is now claiming all solar-generated electricity for its use.

The example shows that it is not enough to simply look at the potential for reducing emissions that electronic innovations offer. Rather, a more comprehensive view is required in order to avoid the effectiveness trap already recognized by Jevons in 1865 [4]. Because today we are in a similar situation: technologies that are currently under development, such as green hydrogen and others, may deliver significant contributions to the electricity supply in the future. However, at the same time, AI and augmented reality, e-mobility, smart cities, the exponentially growing IoT net, e-fuels, etc. are demanding more and more electricity and threaten to neutralize all renewable energy growth.

The dilemma can only be solved by distinguishing between (i) useful and (ii) harmful innovations from the point of view of sustainability. Obvious examples are (i) PV or technologies developed for low-energy lighting and (ii) the production of cryptocurrencies based on the proof-of-work principle, such as bitcoins, which consume enormous amounts of electricity, i.e. about 120 TWh in 2023 [5]. In particular, bitcoins are socially superfluous as currencies already exist and harmful as they are used for criminal money transfers, e.g. in ransomware and other cyber-attacks .

So far, organizations such as the IEEE are still hesitating to make the necessary public statements and are continuing to invoke the importance of technical innovations - while energy consumption and greenhouse gas (GHG) emissions continue to rise. Many other scientific organizations are already taking a more determined stance [6] and have recognized that praising digital innovations alone comes close to greenwashing the ICT sector. But we need to act quickly. It is already evident that we will have used up the remaining GHG emissions allowed by the Paris Climate Agreement much earlier than by 2030. At the same time, energy consumption in the ICT sector has risen continuously [7] and will continue to rise without regulatory interventions.

A paradigm shift thus lies ahead of electronics, during the course of which we have to liberate ourselves from the idea that sustainability can be achieved by technical innovations alone. Instead, we need to recognize that social innovations and political regulations are also required. This has already been expressed by the *Fridays-for-Future* movement and others campaigning for climate justice. The latter should be recognized as a guiding principle in every electronics project.

References

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