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Enhancing Europe's sustainability through innovation and technology

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Abstract

Innovation plays a vital role in achieving sustainability goals, promoting a prosperous society and driving economic recovery. The EU needs disruptive innovation to meet its climate targets, decarbonise industries and ensure that citizens are not left behind. The technologies developed through innovation can enhance the EU's competitiveness as well as creating jobs and GDP growth, and also hold significant potential for addressing climate challenges and supporting the delivery of the UN Sustainable Development Goals.

Some studies emphasise that both digital and energy technologies have a significant carbon footprint, given that, for example, the manufacture of computers, the transportation of power-generation technologies from place of manufacture to place of deployment, the raw materials used to build smartphones and the energy consumed by these devices all entail environmental impacts. But the picture is more complex than this. This article argues that the development of these technologies should be seen as a great opportunity to enhance Europe's sustainability and the EU's policies for the green transition and its goals. The European Green Deal has proposed an ambitious agenda for achieving climate neutrality in the EU by 2050. This will not happen without investing in several 'clean' and disruptive digital and energy technologies, or without promoting policies that provide an enabling environment for these innovations to emerge.

Keywords

Innovation, Decarbonisation, Sustainability, Energy efficiency, Digital technologies, Green energy technologies, Clean technologies, Economic growth, EU policies

Introduction

This article first explores which, why and how innovation and the development of technologies present a significant opportunity to enhance Europe's sustainability goals and green agenda. It aims to give a balanced view regarding the significance of

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the information and communications technology (ICT) sector and technologies' carbon footprint, dispelling several common assumptions. The article then presents how this carbon footprint is improving, and how digital technologies, as well as green and clean energy ones, can drive further energy efficiency. Technological development and innovation are creating sustainable jobs, economic growth, and solutions for healthcare and climate challenges. The article then analyses a number of policy and regulatory considerations, outlining areas which require careful focus from policymakers and other stakeholders, and elements that they must avoid or address to ensure the sustainability of the EU's economy and society in the digital world.

Growing recognition of digital technologies as drivers of sustainability and the green transition

Technologies are key enablers for the attainment of the sustainability goals of the European Green Deal, which is the European Commission's ambitious agenda for achieving climate neutrality for the EU by 2050 (European Council 2023). Today, many policymakers in Europe believe that technology and sustainability should go hand in hand to facilitate the achievement of this objective. Many countries and companies understand that technologies—including digital and 'clean' technologies harnessing green energy sources—hold the potential to achieve greater sustainability. They are now racing to seize the opportunity they offer to enhance societal progress and economic prosperity.

Green, but also digital and innovative: the cornerstones of EU policy

Innovation in general and technologies in particular are a strategic stimulus as they can provide the impulse needed for economic development based on a digital transformation that is adapted to the demands of sustainability targets. The Commission itself has recognised that one of the ways the ICT sector can contribute most to its own decarbonisation and that of other sectors is through 'the power of data', that is, through digitalisation (European Commission 2020b).

The European Green Deal has placed renewed attention on the ICT sector, innovation and technologies, and this provides an opportunity to champion a digital transition that contributes to building a greener economy.

Why innovation is needed to drive sustainability

It is worth recalling why the EU needs to innovate to achieve a greener Union, a prosperous society and an economy that works for all: innovation can provide solutions to achieve the climate targets of the EU Green Deal, the decarbonisation of our industry and the economic recovery. In particular, without disruptive innovation it will take more time and more money to achieve the EU's climate goals ahead of 2050, along with an increased risk that citizens are left behind.

Innovation also offers an opportunity to boost the EU's competitiveness. This is particularly true of clean technologies, which include green hydrogen, deep geothermal, renewable electricity and a mix of technological decarbonising solutions. The *2022 World Energy Outlook* of the International Energy Agency (IEA) assessed that clean energy technologies are now providing more jobs and adding more to GDP than fossil fuels. Specifically, 'clean energy jobs are already exceeding those in fossil fuels worldwide and projected to grow from around 33 million today to almost 55 million in 2030' in the IEA's scenarios (IEA 2022a, 22). At EU level, the *2020 State of the Energy Union* report mentioned that the competitiveness of clean energy technologies is 'outperforming conventional energy source technologies' in labour productivity and employment growth (European Commission 2020a, 13). And, 'in terms of GDP, the clean energy sector is gaining importance in the EU economy, whereas the importance of conventional energy sources is decreasing' (European Commission 2020a, 13).

'Deep tech' innovations are also particularly likely to help the EU make the biggest gains in terms of climate, competitiveness and the economic recovery. These innovations are technologies and business models considered to be located at the technological frontier (Basilio Ruiz de Apodaca et al. 2023, 2). They include advanced technologies, from artificial intelligence (AI) and biotechnology to quantum computing, robotics and the development of advanced materials such as semiconductors (European Commission, Directorate-General for Research and Innovation 2018). Deep tech start-ups in Europe are developing solutions that can help address the world's biggest challenges and support the delivery of the UN Sustainable Development Goals (Romasanta et al. 2021; Walid 2023; Chen and Eliens 2022). If Europe's deep tech start-ups are successful, they could produce the volume of electric car batteries, sustainable construction materials and green hydrogen geothermal energy needed to achieve the EU's net-zero goals.

Europe has many assets in both clean and deep technologies, and in terms of their development, the trends are encouraging. The 'Climate and Purpose' category of European tech put together by London-based European venture capital firm Atomico is 'currently the third largest theme to attract investment in European tech, after Fintech and Software, capturing 18% of all funding, up from 15% in the first half of 2022' (Wauters 2023).

The carbon-footprint debate

Europe and the world are undergoing huge economic transformations, with digitalisation and decarbonisation at the centre. It is worth repeating that the relationship between these two processes is hugely complex, with direct and indirect effects that mutually impact each other. The ICT sector, like many others—if not all—faces challenges in its efforts to decarbonise and needs to undergo its own green transformation.

There is more to decarbonising than meets the eye. Emissions come from many different sectors and sources, with three-quarters coming from energy use (Ritchie et al. 2020). This energy use includes not just power, but also transportation, industry, buildings and

agriculture. It is a complicated system, with a lot of built-in infrastructure to tackle. According to several reports (*Arcep* 2023; The Shift Project 2019c; Heinze 2022), the sector that authors vaguely refer to as 'digital' (in *Arcep*, '*le numérique*') represents 3% to 4% of greenhouse-gas emissions worldwide, and 2.5% of our carbon footprint. The digital sector thus forms a relatively small part of energy consumption, but has effects on other sectors' emissions, both direct and secondary (Bergmark 2022; Kamiya 2021). For example, the use of a smartphone and GPS has effects on city infrastructure and transportation. While the production of smartphones has a significant carbon footprint (Abd El Aziz 2022), the mobile applications individuals use can provide solutions that make cities more liveable, for example by improving traffic, or by facilitating public transport planning or waste management. Technologies' impact varies depending on the industries they are used in. For instance, while the financial sector mainly provides intangible services such as loans and insurance, it uses ICT much more than other sectors (Rosso 2023). ICT represents 45% of this sector's carbon footprint. The same is true for large tech companies, where the figure stands at 41%. In comparison, in the retail, energy or manufacturing sectors, the use of ICT forms a much smaller portion of the carbon footprint—around 10% to 12% (Rosso 2023). It is therefore vital to nuance the energy-intensive picture often attributed to the ICT sector.

It is worth mentioning that there is a shortage of data on how ICT is contributing, or otherwise, to the fight against climate change, and on where the balance lies between greater energy efficiency and greater use of ICT (Naujokaitytė 2021). In addition, claims that ICT's carbon footprint is out of control misrepresent the facts. For example, streaming services are often associated with energy use and carbon emissions from devices, network infrastructure and data centres. The IEA itself debunked an assumption, widely covered by the media, that watching a 30-minute show on a streaming app such as Netflix emits as much carbon dioxide as driving 6 km in a car (The Shift Project 2019b; 2019a). In fact, the IEA demonstrated that the impact of streaming on the climate is actually modest compared to other sectors and activities (Kamiya 2020).

In recent years, the ICT sector has made progress towards decarbonisation. In fact, it is one of the few sectors that is on track to decarbonise and is the first to have developed sectoral, science-based targets to limit global warming (Cunliff 2020). What is more, the industry is producing powerful technologies such as AI, data analytics and smart grids, which support other sectors' energy-efficiency goals. Many promising methods are being developed to reduce energy use in the ICT sector, such as designing more energy-efficient hardware and systems to train algorithms or validate blockchain transactions (Xu 2022; Agur et al. 2022).

There have been concerns that the dramatic growth in demand for digital technologies and ICT would result in catastrophically higher energy consumption. But these expectations have not materialised. While there has been and will likely continue to be rapid and strong growth in data centre services and connected devices, rapid improvements in the efficiency of computing, data centres and data transmission networks have moderated the impact of the tech sector on energy consumption. Since 2010, emissions have grown

only modestly (Malmodin 2020), despite rapidly growing demand for digital services. Data centres' energy use has been mitigated, despite the huge growth in Internet traffic, through energy-efficiency improvements in computing, renewable energy purchases by ICT companies, the better handling of data centres' service demands and progress on procuring renewable electricity (IEA 2022b; Digital Europe 2020; IEA 2022c; Masanet et al. 2020). In an examination of the efforts made by the industry to improve energy efficiency in data centres and infrastructure, the IEA found that 'since 2010, data center energy use (excluding crypto) has grown only moderately despite the strong growth in demand for data center services, thanks in part to efficiency improvements in IT hardware and cooling and a shift away from small, inefficient enterprise data centers towards more efficient cloud and hyperscale data centers' (Princeton Digital Group 2023, 48; Microsoft 2020; Morgan 2021).

Furthermore, new technologies developed by the ICT sector represent an essential part of the decarbonisation toolkit. So-called climate technologies could deliver approximately 60% of the emissions abatement that will be needed to stabilise the climate by 2050. While significant progress still needs to be made, the drive to develop and scale such technologies is accelerating. The problem is that the technologies needed to solve the net-zero equation have not yet all been exploited, developed, deployed, made available or commercialised (Hellstern et al. 2021).

The promise of technologies to deliver sustainability

While ICT uses energy, it is at the heart of many solutions that reduce energy use and emissions. Digital technologies have the potential to enable a 20% reduction in global carbon dioxide emissions by 2030, saving almost 10 times as many emissions as they produce (*Digital Europe* 2021; Fryer 2019).

Potential areas of application for technologies through which to decarbonise sectors are multiple and include digital transport solutions, decentralised energy systems and smart climate-neutral communities. For example, technologies can help to track electricity needs, which results in increasing energy efficiency as less oil or coal is burnt (European Commission 2020b). Connected devices gathering data can streamline processes in construction and industry, which leads to a reduced use of resources and greater material efficiency. The digitalisation and transformation of products into digital services can cut wasteful overproduction, and could optimise or replace traditionally energy-intensive non-ICT activities (Simon 2020).

Digitalisation can enable the smarter use of energy in buildings, manufacturing, transportation, cities and a host of other areas. The creation of meat alternatives, improved energy storage techniques and better batteries for electric vehicles are crucial components in solving the climate crisis. Solar deployments and battery manufacturing are growing much faster than expected and, together, could help us to achieve net-zero carbon emissions by 2050 (Hellstern et al. 2021).

Examples of energy-efficient digitalisation:

- *Telework* reduces the energy consumption associated with commuting for work and business travel.
- *Precision agriculture*, an approach to farming that uses data to optimise inputs such as water, fertiliser and pesticides to maximise crop productivity, can prevent the overapplication of chemicals, which are a key source of greenhouse gas emissions in the agricultural sector.
- *E-commerce* reduces consumer travel, often resulting in lower carbon emissions than conventional retail. And while cloud computing centres use a significant amount of energy, much of that computing load replaces on-premise facilities that are far less energy efficient.
- *Driverless and connected cars* in the logistics sector could optimise the energy use of transport.
- *Digitising our grid systems* in the energy sector and in individual homes offers more flexibility, more clarity on supply and reduces waste. A *smart grid* gives energy users access to consumption data and pricing, enabling them to make smarter energy choices, reducing both overall and peak demand (which usually involves inefficient and dirty energy production), as well as leveraging distributed energy resources such as residential solar, wind and hydro power sources, and batteries.
- One tangible project the EU is working on is developing a digital replica of the Earth that will allow researchers and policymakers to better predict weather phenomena and test climate policies (European Commission 2023a).

AI powers many of the aforementioned systems. It is a good example of technologies' potential to enhance sustainability. Recent growth in computing power, the availability of data and progress in algorithms have turned AI into a strategic technology that can deliver significant energy efficiencies. The technology also offers tremendous benefits key to sustainability, especially in healthcare, for instance with the discovery of new treatments. AI can help improve and expand the current understanding of climate change itself, and can contribute to combating the climate crisis effectively (Cowls et al. 2021). Machine learning could help to build smarter, more efficient electricity systems, monitor emissions in agriculture, and develop new, lighter or stronger materials (CCAI 2019).

Yet despite its potential for energy efficiency, monitoring, balancing and minimising the net effects of digitalisation, innovation and technological development on energy use and emissions, and thus on climate, will require new approaches and policy choices. For example, it may be that automated vehicles are widely used for ride sharing in the future, leading to a drop in energy demand, but it could also mean that people opt to use vehicles more if ride sharing is cheaper. As another example, while telework involves high levels

of energy consumption due to increased heating and cooling demands, this could be offset by less energy being used for commuting. However, more people teleworking may mean that more people will move away from the cities; they may use different transport modes, buy a car and/or occupy a bigger home. It is hard to predict the future energy consumption patterns that new technologies will create as we do not know how they will be used, what applications might consume energy or whether energy efficiency trends can keep up.

It would be misguided to rely on efficiency alone to suppress the growth in energy use of technologies: this growth is too rapid. For instance, the efficiency of the hardware used in mining blockchain and cryptocurrencies may be improving drastically, but its energy use and footprint continue to grow. There will be a surge in demand for ICT, and we need to rely on even greater progress in renewables and energy efficiency to reduce emissions over the next 10 years.

Recommendations

As this article demonstrates, technologies can help reduce emissions, but can also increase them. It is not a given that digital solutions will support climate goals. This will rely on the implementation of strong and fair climate policies that incentivise the development and use of digital solutions. To achieve net-zero goals and advance clean energy, innovation and digitalisation are crucial. However, many of the technologies needed to reach our net-zero targets by 2050 and 2070 have not yet been commercialised. The private sector must increase its investment in clean and green tech to drive progress towards net-zero goals.

The EU should encourage digital adoption, voluntary improvements, and research and development in energy-efficient ICT to support industry efforts. Treating the tech sector as part of the solution, the EU's Green Deal policy proposals present an opportunity to leverage digital solutions to reduce carbon emissions. Energy-efficiency rules for the tech sector should remain proportionate, flexible and compatible with the diverse targets of different companies.

The EU has initiated various programmes to promote sustainability policies and technologies as part of the 'twin' green and digital transitions, such as the strategy and public–private partnership for hydrogen. However, these initiatives should be expanded to encompass more promising clean technologies. Deep geothermal, for instance, could meet a significant proportion of Europe's energy needs, but for this to happen it needs to be used more widely (European Commission 2023c).

To ensure a successful transition, the EU should focus on supporting the business models of the next generation of innovators, including green, clean and deep tech innovations from established companies, start-ups and investors. Overcoming barriers to innovation, such as a lack of cohesion among programmes and policies, limited risk

finance and risk-averse business environments, is crucial. The EU must translate its green and digital transition rhetoric into operational actions through increased research and development investments (IEA 2021) and not simply by repackaging existing funding (Bourgery-Gonse 2023a). Allocating a larger share and volume of funds to green energy in the EU's recovery initiatives would demonstrate the seriousness of its net-zero ambitions (Bourgery-Gonse 2023b; European Commission 2023b; Naujokaitytė 2023).

To unlock the EU's potential, public–private tech ecosystems should be established, enabling sustainable global competitiveness. Additionally, international agreements on trade, intellectual property and climate change should be consistent to close the green tech gap. Like-minded countries and trade partners should align their policies in areas such as the environment, science, technology, innovation and industry. International trade cooperation is essential, with trade rules permitting developing countries to protect emerging green industries through tariffs, subsidies and public procurement. A global initiative and multilateral fund could be launched to provide information on low-carbon products and to stimulate green innovation (UNCTAD 2023).

Conclusions

Given its ambitions to deliver on the multidimensional ambitions of decarbonisation, global competitiveness and digital transformation, the EU has work to do. The article noted that while innovations powered by the ICT sector use energy, they also create many technological solutions that reduce energy use and emissions: telework, precision agriculture, e-commerce and the smart grid being examples of these. Clean, green and deep tech innovations in particular have the potential to drastically reduce global carbon-dioxide emissions while increasing the competitiveness of our economy. While costly and risky, investing in these technologies should be a no-brainer.

At the same time, although technologies can significantly contribute to reducing emissions, they do not automatically enhance energy efficiency. Their decarbonisation potential therefore needs to be deployed through a mix of industry and policy efforts, with a proportionate level of voluntary measures and regulatory scrutiny. A greater understanding of energy flows and the tech value chain is also needed (Fryer 2019), along with the promotion of new and better practices to decrease the carbon footprint of the ICT which information systems and networks use.

Furthermore, the economy of today and tomorrow is a digital economy. This means that countries are racing to harness technologies to stay ahead in an increasingly competitive geopolitical and economic environment. Being in the lead by investing in technologies means that Europe will be able to ensure greater economic and societal prosperity for its citizens. It will also give Europe the means to remain in charge of its future and, therefore, to preserve its values.

The EU has put in motion a number of policies that aim to deliver a more digital, greener economy and contribute to a more sustainable world. And Europe is home to

many innovative companies that have the potential required. With the right kind of support and environment, they can help to make Europe an innovation powerhouse, a greater economic power that is strong in the digital economy, without leaving anyone behind.

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