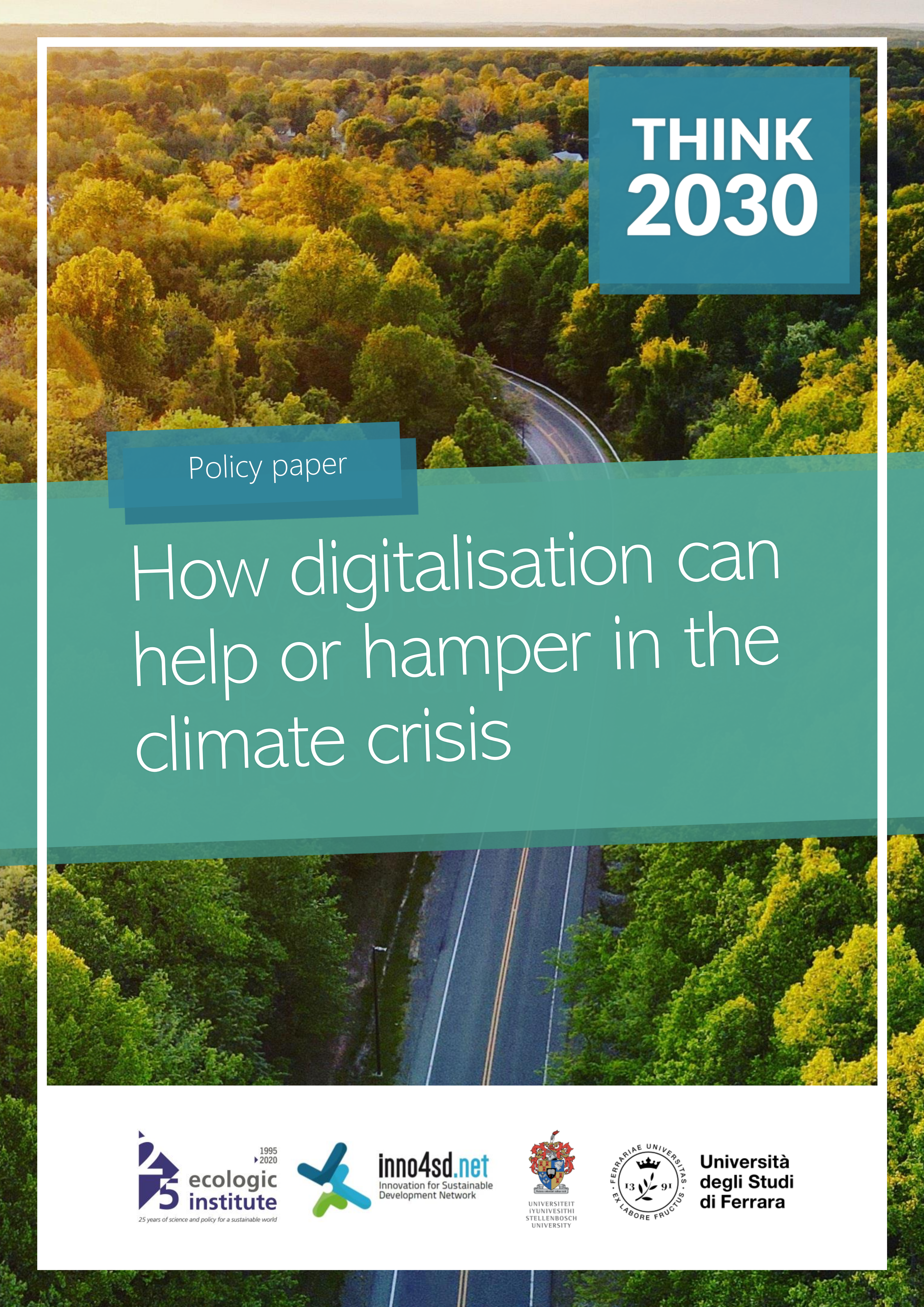

THINK 2030

Policy paper

How digitalisation can help or hamper in the climate crisis

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THE REPORT SHOULD BE CITED AS FOLLOWS

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Contents

Introduction

The future impact of digitalisation on Earth's climate is unknown.

This uncertainty stems partly from the unpredictable breakthroughs and hard-to-imagine emergent phenomena that characterise digital developments, which in turn are linked to systemic and interconnected changes. Another reason is that a single word -- "digitalisation" -- encompasses an enormous range of technologies and socio-economic processes, some of which help the climate while others either directly or indirectly increase negative climate impacts. Despite these complex and sometimes countervailing effects, one thing is certain: digital disruptions will continue.

Another reason we cannot foresee the future climate impacts of digitalisation is that important collective decisions regarding how to steer digitalisation have not yet been taken. The EU and its Member States are still at the beginning stages of finding a way to effectively guide the Digital Revolution toward making a sizable and net-positive contribution to addressing the Climate Crisis. The European Green Deal has the potential to be a meaningful and integrating context for ensuring digitalisation innovations in Europe are of better service to economic productivity, social well-being, and environmental health, including the prevention of catastrophic climate change.

Addressing digitalisation in context

Digitalisation is one of the radical changes societies face, along with the policy and technological trajectories related to climate change and the circular economy. To be understood and managed, these interlinked trajectories should be analysed in a complementary fashion, assessing synergies and trade-offs, taking as references the effects stimulated by policies (induced innovation) and the exogenous long-run trends (EEA, 2019; FEEM, 2019).

The transition towards the 2050 climate targets could induce a '6th technological revolution' (Perez, 2010), an "age of a low carbon – resource efficient economy"' (Mazzanti and Rizzo, 2017). This would be a step beyond the 5th technological revolution[1] that introduced information and communication technologies, which among other effects has led to a dematerialisation of economic activities, while leaving the energy-intensive development paradigm in place.

The 6th technological revolution is thus endogenously determined by the need to maintain the global rise in temperature below 2°C to avoid irreversible damage, which could be accomplished through a 90% cut in GHG emissions with respect to 1990 levels and by using only 38% of existing fossil fuels reserves (McGlade and Ekins, 2015). Digitalisation should be analysed as a potential synergistic pattern in those contexts. This is why when referring to the relevant innovations that systems need to achieve targets, the concept of complementarity is relevant[2]. Complementarity may be considered a radical asset in itself, one which can strongly enhance innovation, economic and environmental performances by delivering higher-than-linear effects.

[1] The 5th technological revolution is also known as the 3rd industrial revolution. Additionally, "Industry 4.0" is a "term applied to a group of rapid transformations in the design, manufacture, operation and service of manufacturing systems and products. The 4.0 designation signifies that this is the world's fourth industrial revolution, the successor to three earlier industrial revolutions" (European Parliament, 2015).

[2] See the seminal works by the recent Nobel prize winner, Paul Milgrom, on complementarity strategies (Milgrom and Roberts, 1995) and applications in the economics of innovation and environmental innovation realms (Mohnen and Roller, 2005; Gilli et al. 2014; Antonioli et al. 2013).

Recent development in the EU

Europe has set a path for achieving climate neutrality by the year 2050. The digital transformation and technological innovation are considered key drivers for achieving such an ambitious goal (European Commission, 2020c).

Until very recently, EU policy on digitalisation has focused primarily on economic growth, innovation and competitiveness with little priority given to its interrelation with environmental concerns (Liu et al., 2019, p. 20). A shifting approach became prominent in 2019, first in June when the European Council stressed "the need to consider and adequately address the opportunities and challenges of digitalisation for environmental, climate and nature protection through targeted policy-instruments at EU level" (Council of the European Union, 2019) and then most significantly in December 2019 with the announcement of the European Green Deal (see Box 1).

Box 1. Text excerpt from European Commission's Communication on the European Green Deal, connecting the sustainability and digitalisation agendas

"Digital technologies are a critical enabler for attaining the sustainability goals of the Green Deal in many different sectors. The Commission will explore measures to ensure that digital technologies such as artificial intelligence, 5G, cloud and edge computing and the internet of things can accelerate and maximise the impact of policies to deal with climate change and protect the environment. Digitalisation also presents new opportunities for distance monitoring of air and water pollution, or for monitoring and optimising how energy and natural resources are used. At the same time, Europe needs a digital sector that puts sustainability at its heart. The Commission will also consider measures to improve the energy efficiency and circular economy performance of the sector itself, from broadband networks to data centres and ICT devices. The Commission will assess the need for more transparency on the environmental impact of electronic communication services, more stringent measures when deploying new networks and the benefits of supporting 'takeback' schemes to incentivise people to return their unwanted devices such as mobile phones, tablets and chargers."

Source: European Commission (2019a)

The European Commission's Communication "Shaping Europe's digital future" provides additional details about the role of digitalisation in achieving climate ambitions

and the UN Sustainable Development Goals (SDGs). Digital solutions are seen as key components of the circular economy, as enablers of carbon neutrality of economic sectors (e.g. transport, energy, agro-food), and as mechanisms to decrease the environmental and social footprint of products. In particular, the document identifies the pressing need to 'green' the ICT sector and to adopt a fully circular approach in order to mitigate its environmental footprint and energy-intensity (e.g. ICT equipment, data centres and communications) by the year 2030. To that end, under the pillar of "an open, democratic and sustainable society", the European Commission has proposed a number of actions including: a circular electronics initiative beyond the current mandate of the Ecodesign directive; initiatives for climate-neutral, highly energy- efficient and sustainable data centres; and transparency measures about the environmental footprint of operators. One of the proposed activities is the European Product Database for Energy Labelling (EPREL), containing information about energy labels and information sheets for 14 consumer electronic products (e.g. air conditioners, lamps, televisions, etc.). Such a platform should be operational by the end of 2020[3]. The communication in preparation for the launch of the Sustainable Product Initiative has incorporated provisions regarding more sustainable digital products and services[4]. Nonetheless, the full scope and focus of those actions remains to be seen regarding climate neutrality and circularity of digital technologies.

Policy initiatives to address the sustainability potential and impacts of digitalisation are also emerging at national and local levels within the EU. A notable example is Germany. Box 2 provides an overview of current developments in Germany, which has also made sustainable digitalisation one of its priorities in the current context of its EU Presidency, which runs from Jul - Dec 2020[5].

Box 2. Country snapshot: Germany

New developments at the federal level

In 2019, Germany's Federal Ministry for the Environment (BMU) presented initial ideas for what climate-friendly digitalisation could look like. In February 2020,

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[3] https://ec.europa.eu/info/energy-climate-change-environment/standards-tools-and-labels/products-labelling-rules-and-requirements/energy-label-and-ecodesign/product-database_en

[4] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12567-Sustainable-Products-Initiative

[5] https://www.bmu.de/en/eu-council-presidency-2020/our-goals-for-the-german-eu-council-presidency/

the BMU published its *Digital Policy Agenda for the Environment*, its first-ever strategic framework on the issue, which outlines four packages of measures:

- **Future Programme for Environmentally Friendly Digitalisation** - measures to reduce the energy needs and resource consumption of digital infrastructure and technologies, including longer-lived electronic products.
- **Transparency initiative** - measures to improve knowledge of environment-related aspects of production and consumption, better environmental monitoring and the prevention of rebound effects due to digitalisation.
- **Digitalisation for social and environmental restructuring** - measures to foster digital innovations that tackle environmental challenges, including the targeted use of artificial intelligence.
- **Environmental policy 4.0** - measures that facilitate the effective employment of digital technologies to enhance environmental administration, including improved access to environmental data.

All told, the Digital Policy Agenda identifies over 70 specific measures, including existing measures, planned measures and measures still in development. Some of these measures stem from existing government programmes, including the Climate Action Programme 2030, the National Artificial Intelligence Strategy, the German Resource Efficiency Programme (ProgRess) and the National Programme for Sustainable Consumption. The Digital Policy Agenda thus acts as an integrating framework for coordinated governance across policy areas.

New developments in Berlin

In October 2020, the city of Berlin published a so-called "green book" of its digitalisation strategy, which focuses on strategic challenges as well as Berlin's particular strengths and needs for action, and serves as the discussion basis for further strategy development and adoption of a comprehensive policy framework. The plan mentions the explicit interconnection of digitalisation and sustainability objectives and specifically addresses the topics of transport, energy and environment.

Sources: BMU (2020a, pp. 6, 11) and Federal State of Berlin (2020).

Sustainability impacts of digitalisation, both positive and detrimental

There is a predominant view across manifold policy areas where the digital sector is considered to have a key role in addressing societal challenges. Fostering a rapid economic transformation and guiding radical change to meet the 1.5°C target are two of the many climate-policy objectives where digitalisation is considered a game changer. Digitalisation is also considered a key factor for the emergence of sustainable business models and the consolidation of a circular economy (c.f. Antikainen, et al., 2018). Without a doubt, "mature" ICT solutions already play an important role in many actions related to climate adaptation and mitigation. For example, GIS systems, sensors, drones, as well as open-source modelling tools using satellite imaging and data are just a few examples of digital solutions successfully used to monitor air pollution and traffic congestion, deforestation and land erosion, disaster prevention and early warning systems, water allocation and irrigation systems management, etc. (c.f. ITU, 2019; IEA 20017). In addition, "emerging" digital solutions focusing on digitalisation via robotics and synthetic biology, artificial intelligence, cloud computing, 5G and the Internet of Things (IoT) have been heralded as having an even larger potential for aiding climate action (Falk, et. al. 2019). The potential of emerging digital solutions to *decarbonise* the economy is very often associated with the energy and material savings potential across sectors (IEA, 2017). However, most digital technologies present issues which are rather detrimental to the environment and are implicated in aggravating specific social challenges. Box 3 briefly describes how three key digital technologies negatively impact the environment.

Box 3. The negative environmental footprint of key digital technologies

Digital technologies have important environmental and social impacts. A recent study by GreenIT.fr identified the existence of 34 billion pieces of ICT equipment in use worldwide (Bordage, 2019). Its global environmental impact has been estimated at 6,800 TWh of primary energy (PE) consumption (4.2% of the total PE), 1,400 tonnes of greenhouse gas (GHG) emissions (3.8% of the total GHG)[6], 7.8 million cubic meters of water consumption (0.2% of the total water), and an abiotic resource depletion (ADP) of 22 million tonnes of antimony. The same study estimates the electricity use of the digital sector to be about 5.5% of total

[6] Other sources estimate the GHG emissions of the digital sector to much lower, in the order of 2 % (e.g. EC 2019; Falk et al 2019).

electricity consumption.

Five types of ICT solutions in particular have some of the most pressing sustainability footprints: microprocessors, smartphones, screens/displays and connected objects, and data centres. These technologies are core aspects of the digital sector, comprised of users, networks and data processing and storage centres. According to the above-mentioned study by Bordage (2019), the environmental footprint of the digital sector is likely to double in the next 15 years. Currently, the manufacturing of user equipment (e.g. smartphones) represents the highest environmental footprint, followed by its electricity consumption.

- *Smartphones*

There are over 7 billion smartphones on the planet. Smartphones' negative footprint are due to planned obsolescence, material sourcing (conflict minerals), water, chemicals use, and electricity use (Bordage, 2019). Regarding the latter variable, it has been estimated that about 968 terawatt hours (TWh) have been used to manufacture smartphones since the year 2007 (Greenpeace, 2019). In terms of GHG emissions, available studies have estimated the global warming potential (GWP) of several models to be in the range between 16 to >100 kg CO_2e (assuming an operating lifetime of 3 years) (c.f. Clement, et al. 2020). The type of integrated circuits (microprocessor), printed circuit boards, storage capacity (memory) and display size have been identified as the most pressing components in terms of environmental impacts (Clement, et al. 2020).

- *Microprocessors and memory drives / chips*

It is difficult to identify recent and sufficiently representative studies to present a general impact of the environmental footprint of all available microprocessors and memory drives/ chips. Nonetheless, a couple of examples can be provided for each type of technology. A seminar study by Williams et al (2002) found that the manufacturing of a 2-gram 32 MB DRAM chip required 1,600 g of fossil fuels; 72 g of (hazardous) chemicals, 32,000 g of water and 700 g of elemental gases. The LCA analysis of a (Seagate) Makara 3.5 HDD hard drive suggests an impact of 358 kg CO_2e for a 5-year operation.[7]

Microprocessors and memory drives/chips are also causing a major stress on the availability of critical raw materials, in particular conflict minerals and other rare earths. Numerous studies reveal a market saturation of smartphones (using

[7] https://www.seagate.com/files/www-content/global-citizenship/en-us/docs/seagate-makara-enterprise-hdd-lca-summary-2016-07-29.pdf

microprocessors and flash drives)[8]. However, the number of connected objects is estimated to grow exponentially to the year 2025 (many of them using memory drives / storage units). The impact of 1 billion devices in 2010 to 48 billion is already aggravating the situation of resource availability due to the low uptake of sustainable mining. Policy responses in Europe have emerged for five conflict metals, which are addressed by the forthcoming EU Conflict Minerals Regulation[9]. However, the issue of pollution and human right issues around cobalt mining is an issue that remains unaddressed[10].

- *Data centres*

It is estimated that about 67 million servers are in operation somewhere in the world (Bordage, 2019). The IEA estimates that global data centre electricity demand in 2019 amounted to 200 TWh (0.8% of global final demand).[11] In Europe, the energy consumption of data centres were estimated to in 104 TWh in the year 2015 and 130 TWh in 2017 (European Commission, 2019b). There are no accurate estimates of the total number of data servers powered by renewable or clean energy Some optimistic estimates indicate that the sector could reach 13% of clean renewables by 2025. The IEA suggests that the major ICT companies are big players in renewable energy certificates (e.g. Google 10 TWh; Apple 1.3 TWh). As a result, data centres are being considered as inherently green. However, this is not at all the case according to the GreenICT.fr study (Bordage, 2019). The manufacture of equipment hosted by data centres is responsible for 17% of the of primary energy consumption, 15% of GHG emissions, 7% of water consumption, and 8% of the ADP of the digital sector's impact (associated with the manufacturing of user equipment). As an illustrative example, the environmental impact of a single data centre in Sweden was estimated in 12,900 kg CO_2e (Honee, et al 2012).

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8 https://www.economist.com/leaders/2019/01/12/the-maturing-of-the-smartphone-industry-is-cause-for-celebration

9 With the notable exception of Cobalt mining, the European regulation will apply to the mining of gold, tin, tungsten and tantalum minerals and metals. See: https://ec.europa.eu/trade/policy/in-focus/conflict-minerals-regulation/regulation-explained/

10 See for example, the report by the think tank SOMO describing pressing and controversial issues of Cobalt mining in Katanga, southern Democratic Republic of Congo. https://goodelectronics.org/wp-content/uploads/sites/3/2016/04/Cobalt-blues.pdf

11 https://www.iea.org/reports/data-centres-and-data-transmission-networks

While the greening of the ICT sector itself is one issue, the environmental impact of ICT in manufacturing is another important aspect. Sector studies of the ICT sector that analyse efficiency can be limited insofar as related value chains are not considered. Life-cycle analysis and multi-criteria analysis should be used to convey a more comprehensive perspective. To date, the integration of ICT and environmental innovation/economics studies has not been significant. Among others, Antonioli, Cecere and Mazzanti (2018) analyse the complementarity between ICT and environmental innovations in SMEs. They conclude that: "Empirical evidence shows that there are still wide margins to improve the integration between [environmental innovations] and ICT in order to exploit their potential benefits on productivity. The awareness of specific synergies seems to mainly characterise the heavy polluting firms that are subject to more stringent environmental constraints, while some trade-offs tend to emerge for the remaining firms". Environmental and industrial policies are necessary to enhance complementarity innovations and related performance effects. Empirical studies and evidence are relevant to increase our knowledge on relatively overlooked synergistic effects (e.g. digitalisation and eco-innovations, artificial intelligence and sustainability, etc.).

Box 4. Country snapshot: Italian manufacturers

A new survey[12] on Italian manufacturing, based on 4,650 observations[13] on circular economy and energy efficiency/climate innovations provides some evidence on the relationship of Industry 4.0 and eco-innovation adoption. The table below offers a first view of the synergy in a key industrial country (evidence refers to the years 2017-18).

Of the companies interviewed, 29.8% introduced at least one environmental innovation that took advantage of the Industry 4.0 programme. Moving to more specific realms of innovation adoption, it can be shown that there is room for enhancing the complementarity between the two spheres. In particular, for each type of environmental innovation, the percentage of companies that also exploited the Industry 4.0 programme were as follows:

- Reduction of water use: 2.6%
- Reduction in the use of materials: 6.4%
- Use of energy from renewable sources: 4.6%
- Reduction in the use of electricity: 7.8%

[12] Carried out in between March-July 2020.

[13] Source: University of Ferrara, CERCIS research centre.

- Reduction of waste emitted: 6.0%
- Reuse of waste: 3.8%
- Transfer of its waste to other companies: 4.8%
- Ecodesign to minimize the use of raw materials: 3.6%
- Ecodesign to maximize their recyclability: 2.8%
- Reduction of greenhouse gas emissions: 2.8%

Though the shares are higher for some circular economy oriented innovations, and very low for carbon dioxide reduction, the picture highlights a lack of synergy in a relevant EU country.

Digitalisation - transformational across all dimensions of sustainability

While this paper focuses primarily on the environmental dimensions of sustainability, digitalisation's effects are pervasive across economic and social dimensions also. For example, the coronavirus pandemic has resulted in the rapid adoption of various digital technologies over an extremely short timeframe with profound economic benefits (see Box 5). More negatively, in recent years, digitalisation has had a defining role in undermining social cohesion and the underpinnings of democratic governance (see Box 6).

Box 5. Digitalisation has cushioned the economic impact of COVID-19

In the context of the COVID-19 pandemic, digital technologies have played a decisive role in enabling many economic activities to continue despite the need for social distancing. Already, economic recovery has been aided by digitalisation in the form of preventing economic losses from being even more severe than they are today. The rapid transition to remote working and the dramatic curtailment in business travel have provided millions of workers across the EU with a direct experience of virtual meetings, with potential long-term implications for the logistical, spatial and environmental attributes of work. The pandemic has accelerated digital adoption.

Box 6. Digitalisation and democracy

The social dimension of sustainable development includes effective governance as one of its elements, with SDG 16 calling for countries to "promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels". A target within SDG 16 is to "Ensure responsive, inclusive, participatory and representative decision-making at all levels." Digitalisation has disrupted the media ecosystem in multiple ways that are undermining democratic capacities worldwide (e.g. undermining business models for traditional media; developing algorithmically targeted "filter bubbles", fostering unmoderated discussion of social issues, and enabling rapid sharing of misinformation and propaganda). By undermining societal capacities for informed, reasoned discourse, these developments heighten the difficulty of addressing complex societal challenges such as

global climate change.

Other facets of digitalisation have been positive for democracy, including capacities for increasing transparency and access, low-cost ways of informing the public and fostering novel approaches to address complex social challenges. Innovative policy approaches are needed to maintain these capacities while addressing digitalisation's negative impacts on effective governance.

Core policy recommendations: digital innovation for a green recovery

The Digital Revolution will continue to have profound effects on economic, social and environmental systems as well as our lives as individuals. Digitalisation will also continue to have countervailing effects on the Earth's climate--with its net effects determined in large part by the frameworks of rules and incentives put in place by governments. There is enormous scope for a positive contribution of digital technologies to addressing the climate crisis.

- **Embedded digitalisation** - Digital strategies should be explicitly embedded in both the concept of sustainable development (anchored to the SDGs) as well as the fight against climate change (anchored to climate targets and international climate commitments).
- **Getting the incentives right** - Specific technological solutions should not be dictated if a more flexible approach can be implemented to achieve environmental objectives, especially when technology can change rapidly. Because digitalisation is so pervasive and flexible, public policy should help ensure that price signals tell the environmental truth and that regulatory frameworks are ones that foster innovation and spur creative solutions.
- **Complementarity effects** - For systemic issues like digitalisation and climate change, the effectiveness of any individual policy regime can be further increased by understanding synergies and complementarities with other policy aims. The European Green Deal provides an excellent framework for institutionalising such an approach at scale within the EU.
- **Green input | Green processing | Green output** - Processing inputs and outputs is the essence of computing. This extends beyond information to include physical aspects: the supply chains of materials into electronic devices, the amount and types of energy used to power them, the purposes to which digital capabilities are put, and how obsolete technologies are returned full circle to become the raw materials for new devices. Along every part of this path, opportunities exist to reduce negative environmental impacts and increase positive ones.
- **Addressing algorithms** - the Internet of Things, big data and artificial intelligence (and the algorithms that drive them) are frequently tied to ethical choices with complex systemic effects that can scale rapidly. Better interdisciplinary work is needed across the digitalisation and environmental policy communities to develop effective policy measures for these novel developments.
- **Governance and democracy** - Central elements of democratic governance and civil society are under threat via developments in social media, disruptions to

the business models of media outlets, and growing levels of disinformation and propaganda. Effective climate and environmental policies are dependent on functioning governance frameworks and the erosive dynamics of the present moment should not be ignored by those concerned about effective environmental policy in a democratic context.

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