Can digital technology and the environment coexist?

A contribution from three different perspectives.

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Version 010524, published in June 2024 and available at www.alternumeris.org

Introducing the team

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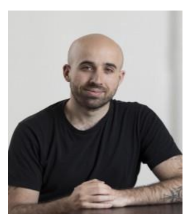

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Acknowledgement

Authors warmly thank **Natalie Dickson** and **Ciler Omer** from the Service Langues et Internationalisation de l'UMONS (FTI-EII)) for this **translation**.
We also thank Christine Michaux and Ornella Martini for their help.

Summary

The digital and environmental pairing combines two joint impulses of our modern societies, each running their own course, two concomitant "transitions" still too often described as separate issues. The question of their compatibility is now being openly and urgently raised: do these two issues reinforce or contradict each other? Are they compatible? Should they be linked, and if so, in what way and on what terms?

These questions call for different perspectives:

- The **expert** perspective: what do we know about the interactions between digital technology and the environment, and how is this knowledge structured?

- The **political** perspective: how can we link the digital and environmental transitions to the social projects we consider desirable?

- The **citizen** perspective: how can we understand and position ourselves with regard to the information circulating on the subject in the public arena?

It is from these three points of view that this report discusses the sometimes difficult cohabitation between digital technology and the environment.

Executive summary

When it comes to digital technology, polarisation is often the watchword. When the term is used in conjunction with the environment, debates become heated. Some see digital technologies as a universal solution that will reduce energy costs. Others call for radical digital sobriety to protect the environment. When discussions go beyond simply stating positions, they invoke a jumble of industrial strategies, expert reports and scientific contributions. It's not always easy to find one's way through these often impassioned discussions, full of multiple interests, or to get a clear idea of the terms of the debate.

Be that as it may, there is a growing sense of urgency about the way in which digital technology and the environment should coexist. The European Union has set itself the target of reducing emissions by at least 55% by 2030, compared with 1990 levels.[1] These commitments, coupled with the adoption of strategies to accelerate digitisation, should force public authorities to clarify the terms of the interactions between digital technology and the environment. Secondly, other environmental issues can no longer be ignored: think of the pollution generated by the extraction of the rare metals needed to manufacture equipment, or the pollution linked to electronic waste.

Public awareness is growing: "85% of French people believe that reducing the impact of digital technology on the environment should be a priority in the years to come (...) with, once again, a relatively homogenous judgement across all generations".[2] For manufacturers in the sector, the economic and financial impact of the energy challenge and environmental tensions are forcing them to react: in the rare metals sector, for example, supply problems are likely to multiply and put pressure on globalised production chains.[3]

The digital and environmental pairing combines two joint impulses of our modern societies, each running their own course, two concomitant "transitions" still too often described as separate issues. The question of their compatibility is now being openly and urgently raised: do these two issues reinforce or contradict each other? Are they compatible? Should they be linked, and if so, in what way and on what terms?

These questions require us to adopt different perspectives: **expert** (what do we know about the interactions between digital technology and the environment, and how is this knowledge structured?), **political** (how can we link the digital and environmental transitions to the social projects we consider desirable?) and **citizen** (how can we understand and position ourselves with regard to the information circulating on the subject in the public arena?). It is from these three perspectives that this report discusses the sometimes difficult cohabitation between digital technology and the environment.

The **first perspective, the expert perspective,** should make it possible to objectify the state of knowledge about the links between digital technology and the environment. It has to be said that the research and knowledge produced on the effects of digital technology on the environment is still in its infancy and varies in content. Delving into it will help to establish what is currently considered to be known, and will also highlight the coexistence of reports offering digital technology as a solution - therefore suggesting the acceleration of digitisation to the benefit of the environment - and reports putting forward digital technology as an uncontrolled source of environmental footprint - and therefore the essential need to control its use.

The **second perspective, the political perspective,** aims to reposition the relationship between the environment and digital technology in terms of a political issue. In a previous report, we highlighted the social imaginations underlying the technical debates and controversies surrounding 5G. Here, on the basis of existing work, we will look at scenarios for linking the digital and environmental transitions. These scenarios are associated with a range of possible futures.

The **third perspective, the citizen perspective,** involves both deconstructing the underlying mechanics of digital environmental impact assessments and understanding how they are formed. Figures are frequently circulated in the public arena, accompanied by analyses based on this type of assessment. How can we, as citizens, position ourselves when faced with such seemingly technical information? This third look offers a framework for forming a position on studies of this kind. To illustrate this approach, the *Digital4Climate* report, published in Belgium in 2022, provides an opportunity to put this framework into practice.

The expert perspective, in a nutshell

What is the state of knowledge on the interactions between digital technology and the environment? Publications on this complex issue vary in quality, methodology and transparency. Some assess the impact of digital technology on a global scale, while others focus on a specific territory (e.g. Europe, France, Wallonia). Some assess the environmental challenges of digital technology in the broadest sense, while others focus on greenhouse gas emissions or electricity consumption.

Despite these disparities, there are some areas of convergence:

* Studies show that the digital sector produces between 2% and 4% of the world's **greenhouse gases** (2018): that's the equivalent of the world's truck fleet at the same time, and more than civil aviation, which is often singled out for criticism.
Forecasts indicate a rapid increase in these emissions (from 4% to 6% per year).

* The sector's **electricity consumption** during digital usage phase represents 5 to 8% of global electricity consumption (between 2019 and 2021). Put another way, if "digital usage" were a country, it would be the 3rd largest consumer of electricity in the world, just after China and the USA.
With no limits on usage, significant growth in this consumption is expected as a result of the explosion in data volumes.

In addition to scientific studies, a series of publications commissioned by representatives of the **industrial sector** do not refute the above-mentioned upward trends, but justify this increase in direct impacts by greater indirect gains: structural effects in other sectors would enable savings to be made in energy and greenhouse gas emissions. As detailed in our analysis, these studies only look at positive indirect effects, not negative indirect effects, so they are biaised.

Finally, reports from major institutions (UN, WHO, EU, etc.) highlight the environmental pollution (soil, air, water) associated with electronic waste and the extraction of materials needed for the digital and energy transition.

This first perspective leads to three observations:

- Firstly, the **undisputed negative direct impact of digital technology on the environment.** The extraction, production, use and end-of-life of the physical equipment that enables digital services have a considerable direct negative impact on the planet. The digital-environment nexus must therefore finally be recognised as a problem of general interest.
- Secondly, it is clear that **the digital-environment** relationship is being **debated** and that various players are mobilising (with figures and reports to back them up) to frame the way in which the two transitions should be linked.
- Lastly, **the contradictory reports** (between those produced by industry pushing for an acceleration of digitisation, and those from think tanks urging its rapid reduction) leave room for uncertainty and **sow doubt** as to the overall impact of digital technology on the environment.

Finally, this initial overview leads us to conclude that the digital and ecological transitions do not have a natural tendency to reinforce each other. The youth and scarcity of existing studies means that we need to be cautious and use precaution before concluding that digitisation is necessary at every level.

The political perspective, in a nutshell

Various scenarios emerge in response to the question "how can we reconcile the digital and environmental transitions?" Each scenario reflects a particular 'way of life' in terms of our habits of mobility, production, consumption, housing, our relationship with time and each other, and our involvement in community life. Digital technology is no exception: its place and role, how it is distributed and controlled, its link to innovation and its uses are distinct depending on the scenario. Thinking about how these transitions fit together leads to a number of observations:

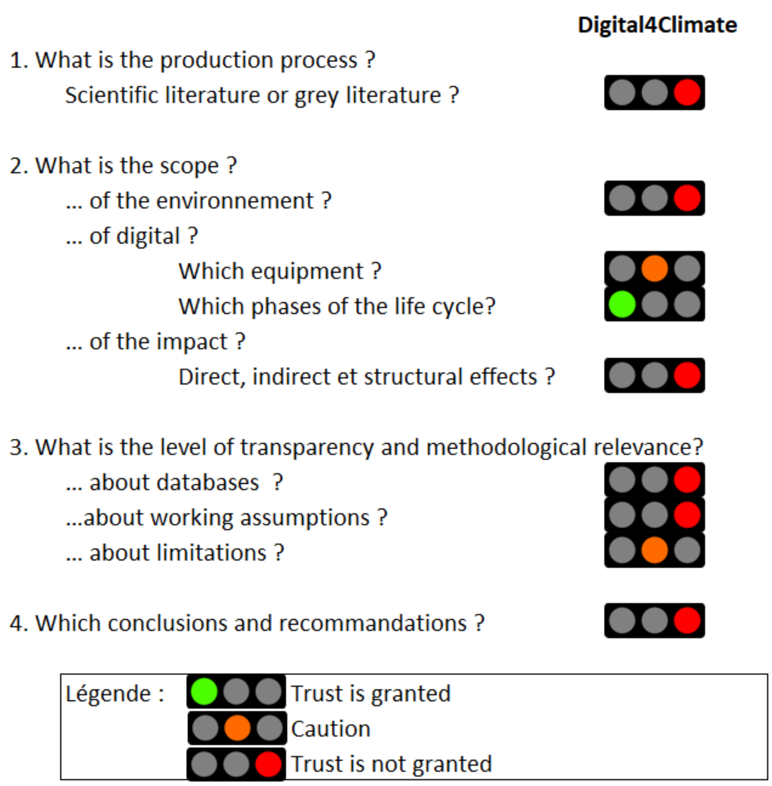
- **A digital policy cannot be separated from its environmental dimension.**
  All too often, the digital transition is discussed in isolation, by sector, linked to a particular use and decoupled from the environmental transition. The presented scenarios put an end to this dissociation. They place the digital age within a vision of the future that clarifies attitudes and sheds light on the consequences - explicit or otherwise - of the digitisation of society.
- **A digital policy is built around the categories of sobriety and efficiency.**
  The scenarios - and the political positions they represent - are permeated by doses and articulations of the two poles of sobriety and efficiency. We need to recognise the need to scale up these two dimensions collectively.
- **A digital policy is based on a public action programme.**
  The public action programmes on which digital policies are based must be identified: techno-capitalism, social democracy and radical sobriety.

The citizen perspective, in a nutshell

Taking a citizen's view of a publication on the environmental impact of the digital sector can be complex, and even confusing. How much trust should be placed in studies on the subject? What assessment criteria should be applied? How do you distinguish between alarmist conclusions and those encouraging more and more digital technology?

This document provides the general public with a framework for reading the various reports published in a critical way. This reading grid is based on **four main axes**, through which the flaws and intrinsic qualities of a publication are revealed. These assessment axes lead to **nine confidence indicators** (green/orange/red) producing a dashboard that can be consulted at a glance, as illustrated opposite.

By way of illustration, the latest *Digital4Climate* study by a Belgian lobby will be analysed. Our analysis reveals a single positive indicator encouraging confidence, two mixed indicators and six indicators encouraging distrust. **This assessment suggests that the use of the *Digital4Climate* report in a political decision-making context would be inappropriate, or even counter-productive for the environment.**



Conclusion and recommendations

Do the ecological transition and the digital transition reinforce or contradict each other? Are they compatible? Can they coexist, and if so, how?

The expert perspective, which objectively reviews the state of knowledge, leads to the conclusion that these two transitions are indeed linked, but that their relationship is subject to debate - leaving us to wonder about the impact of digital technology on the environment. It is therefore unfounded to assert that these two transitions naturally reinforce each other. The scarcity of existing studies and the fact that they are so recent mean that we need to be cautious and use precaution before concluding that digitisation is necessary at every level.

The political perspective invites us to broaden our field of vision: there are several possible scenarios for this dual transition, each embodying a certain political imagination and a certain way of life. Each discourse must therefore be analysed in the light of the imagination it conveys and the lifestyles it underpins.

The citizen perspective provides a framework for critically reading the various studies published on the impact of digital technology on the environment - and for taking a stand on the issue. The latest '*Digital4Climate*' report by a Belgian lobby (used as a case study in this analytical framework) has a number of significant pitfalls that call for the utmost caution when its conclusions are taken up in the public and political spheres.

In light of these conclusions, the following recommendations can be made:

1. Adopt the three-perspective reflection (expert, politician, citizen) as soon as new knowledge is produced.

We can only be astonished at the way new knowledge is treated by certain politicians, particularly when it is produced by industrial interest groups.
Indeed, the application of the three perspectives to the latest Belgian study (*Digital4Climate)* suggests that the use of this study in a political decision-making context would be inappropriate, and even counter-productive for the environment.
Yet ministers[4] have used the study as a reference.

2. When in doubt, use precaution.

Given the difficulty of determining whether or not the rise of digitisation is leading to a net reduction in the global ecological footprint, and given the increasingly urgent need to reduce it, the simple application of the precautionary principle would lead to the following conclusion: every economic sector must work to reduce its ecological footprint, with no exception being made for digital technology.

Complete file

Introduction

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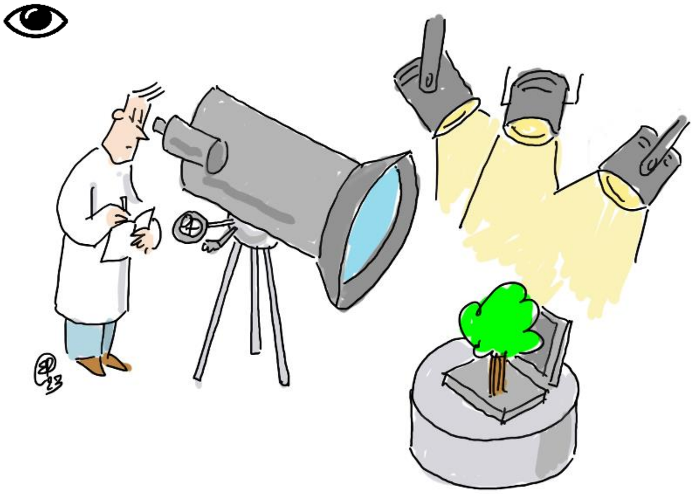
1. The expert perspective 👁



How is the knowledge produced structured? What do we know and how? What is the status and strength of the existing knowledge?

Despite all the talk of dematerialisation, digital technology does in fact rely on a vast physical infrastructure: screens, batteries, millions of kilometres of cables, data centres, networks, etc.[8] The production, use and end-of-life of these components generate an ecological footprint at various levels:

- greenhouse gases (GHGs) include all the gases that contribute to global warming (carbon dioxide CO_2, methane CH_4, ozone O_3 , etc.);
- electricity consumption from different energy sources (gas, coal, nuclear, renewable, etc.);
- chemical and radioactive pollution of soil, air and water.

The challenge, from an expert point of view, is to **assess the digital footprint over its entire life cycle**. When we delve into this field, we have to admit that the existing contributions are still rare, fragile and disparate.

1.1. Examining current knowledge

1.1.1. Greenhouse gases (GHGs)

Estimation of the current overall impact of digital technology on greenhouse gases

Freitag et al. (2020) conducted a review of the existing scientific literature on the subject of global greenhouse gas emissions from the digital sector. They note that the estimated share of ICT in these emissions varies between 1.8% and 2.8% (in 2015[9]). The authors note the variability between existing studies due to the use of different databases, the variety of approaches, the lack of transparency regarding the assumptions made or the delimitation of the scope of the elements considered in the estimate. They point out that the range put forward systematically underestimates this impact to the extent that the contributions do not take account of all the elements in the equipment production chains and the entire life cycle. After adjustment, Freitag et al. estimate that the digital sector's contribution to global greenhouse gas emissions will be between 2.1% and 3.9%.[10,11] In comparison, in 2018, the share attributed to light vehicles (cars, motorbikes, etc.) was 8% and that of civil air transport was 2.5%.

Although the analysis by Freitag et al. contains a number of uncertainties, it undoubtedly summarises the best available knowledge. We did not find any studies in the scientific literature whose estimates differed significantly from those presented. In addition, the reports commissioned by the public authorities seem, directly or indirectly, to use estimates similar to one or other of the scientific studies considered by Freitag et al. (2020).[12] This is in line with those produced by the Body of European Regulators for Electronic Communications, which, in a review of existing literature, summarises current estimates at between 2% and 4%, with a minimum of 1.5% and a maximum of 5%.[13]

Recent trends in the global digital GHG footprint

Estimates of growth in the digital sector's share of GHG emissions are inevitably complicated. Freitag et al., compiling the main estimates for the period 2002 to 2012, suggest growth of around 4% per year.

In addition to this review of the existing literature, various players are also producing figures on the growth of the GHG impact. For the think tank *The Shift Project,*[14] the annual growth rate of digital **emissions** is estimated at 6% between 2013 and 2019, with a significant risk of reaching 9% in the short term.

Compared with all other sectors of activity, the **share** of **emissions** attributable to digital technology is also growing, by an average of 3.2% per year (from 2.9% in 2013 to 3.5% in 2019).

Alongside these upward projections, the technology sector is producing publications that suggest much more optimistic trends. The GSMA, the mobile telecommunications industry association, estimates that mobile technologies have already made it possible to avoid a significant amount of greenhouse gases in 2018, to the extent that 1 gramme of CO_2e invested in digital technology represents 10 grammes of CO_2e avoided in other sectors.[15] It also estimates that direct emissions from the ICT sector will fall to 1.97% of global emissions by 2030. GeSI estimates that the ICT sector could reduce GHG emissions by 20% by 2030 by stabilising their 2015 level.[16] We will come back to how to approach this type of report in the next section.

1.1.2. Overall electricity consumption

Estimation and growth of the impact of digital technology on overall electricity consumption

The table below lists the three main studies frequently cited to assess the electricity consumption required to run digital technology worldwide. The first two publications (Malmodin and Andrae) are scientific publications, while the third comes from The Shift Project and is based on the Andrae model (with updates to the figures available and the addition of hypotheses). The fourth study, from the German Energy Agency *(Deutsche Energie-Agentur)*, compiles the three previous ones, among others; and the last is a study from The World Bank and the International Telecommunication Union (ITU), based on publications by major companies in the sector.

Note that the figures given below are for different ICT perimeters (the studies do not all take the same equipment into account) and for different years.

Publication	Power consumption: Assessments between 2010 and 2021	Power consumption: Forecasts for 2025 - 2030
Malmodin et al.[17]	Stable: around 800 TWh between 2010 and 2015 (i.e., 3.7% of global consumption[18] in 2015)	This study does not make long-term forecasts
Andrae[19]	1607 TWh in 2020 (i.e., 6.7% of global consumption in 2020)	Expected scenario: an average annual growth rate of 4.9% between 2020 and 2030.
The Shift Project[20]	1931 TWh in 2019 (i.e., 8.1% of world consumption in 2019).	Between 2020 and 2025, the average annual growth rate varies between zero (scenario: control of consumption) and 9.8% (scenario: sharp increase in use).
Deutsche Energie-Agentur[21]	~1400 to 1700 TWh in 2020 (i.e., 6 to 7% of global consumption)	Expected scenario: an average annual growth rate of 6% between 2020 and 2030.
The World Bank and ITU[22]	1196 TWh in 2021 (4.7% of global consumption)	This study does not make long-term forecasts

The table above clearly shows that, on the one hand, **electricity consumption linked to digital technology is not negligible** and, on the other hand, **the trend is not downwards.** Five main factors are likely to drive growth in this consumption: (1) the widespread use of smartphones around the world; (2) assisted comfort (connected speakers, personal video surveillance cameras); (3) the rise of the IoT and (4) video (TV, advertising screens, large monitors); and (5) data processing and transport needs not absorbed by technological progress[23] (mobile data traffic, demand for computing capacity (i.e., AI); edge computing).

1.1.3. Materials needed for manufacture

This is one of the other paradoxes of the ecological and digital transition: "To live clean, you need dirty metals".[24] To produce wind turbines, electric vehicles, mobile phones, computers and other digital technologies, around thirty so-called critical raw materials are essential. "Critical" means that there is a high risk of supply shortages for the European Union.[25] Among these, a particular category of strategic metals has become essential: the "rare-earth elements", also nicknamed the "vitamins of the modern age", because they have remarkable properties that enable major performance gains for technologies. Demand for these materials is constantly growing: average annual growth is estimated at +6%, with much higher figures for certain rare metals (i.e., +2,500% for *neodymium* and +750% for *dysprosium*, both of which are needed to manufacture permanent magnets to boost the performance of electric vehicles, offshore wind farms, drones, electronics and robotics).

In addition to the geostrategic and economic issues associated with these resources[26] (they are imported from countries on other continents (mainly China, which dominates the entire value chain)), there are also the significant environmental and social impacts associated with the extraction of these resources, as well as the large quantities of water required for the refining process.

Liste 2020 des matières premières critiques pour l'UE

Antimoine	Hafnium	Phosphore
Baryte	Terres rares lourdes	Scandium
Béryllium	Terres rares légères	Silicium métal
Bismuth	Indium	Tantale
Borate	Magnésium	Tungstène
Cobalt	Graphite naturel	Vanadium
Charbon à coke	Caoutchouc naturel	**Bauxite**
Spath fluor	Niobium	**Lithium**
Gallium	Platinoïdes	**Titane**
Germanium	Phosphate naturel	**Strontium**

From a social point of view, "critical metals are exploited at all costs, sometimes by armed groups, and most often to the detriment of human rights: 40,000 children are said to work in the mines of southern Congo according to a 2012 UNICEF report; 100,000 miners work in the mines for a pittance, according to a long investigation by the Washington Post. Poorly equipped for the work, they are exposed to major risks (fatal accidents, respiratory diseases, malformations in infants, etc.)".[27]

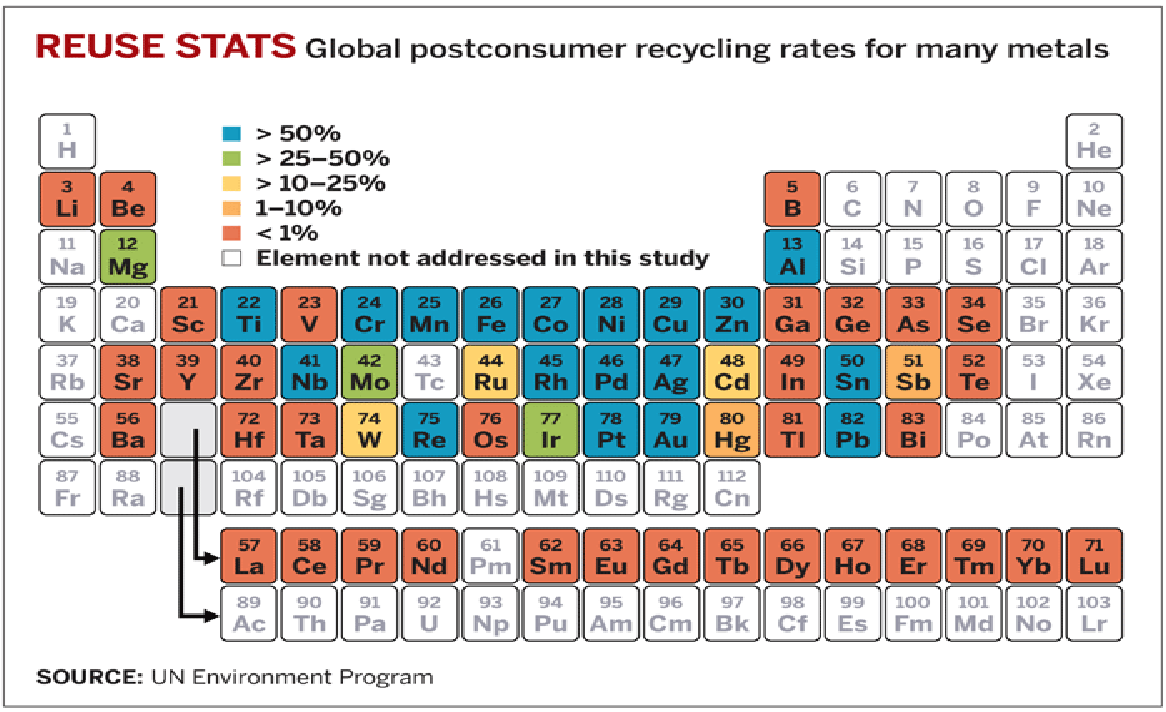
Exploration and mining are harmful to the environment because they produce areas where waste accumulates, with harmful consequences for the environment. But it is, above all, their chemical properties that make the mining of rare metals so environmentally damaging: rare metals are unique in that they are present together in deposits, which means that they have to be separated before they can be used in isolation. Extracting, processing and separating rare-earth elements is very costly in terms of energy, water and chemical products. A huge amount of rock has to be extracted to obtain a meagre quantity of rare-earth elements at the end of the process (i.e., 50 tonnes of rock to produce 1kg of Gallium,[28] which is needed for semiconductors and photovoltaic cells). Digging new mines for rare-earth elements also involves destroying natural environments and their biodiversity. Digging into the ground and dumping chemicals into it leads to the degradation of water quality and groundwater. This pollution is problematic for the workers, who sometimes do not have suitable equipment, and for the local population, whose health declines.[29]

1.1.4. Electronic waste

We currently use around 34 billion digital devices. The telecommunications industry predicts that we will have 50 billion objects connected to the IoT[30] within the next few years. These devices produce large quantities of Waste Electrical and Electronic Equipment (WEEE).

The latest UN report[31] reveals that 53.6 million tonnes of WEEE were produced in 2019. A record figure, up 21% in just five years. This worrying trend makes e-waste the fastest growing household waste stream in the world.
The report, to which the United Nations Environment Programme (UNEP) and the World Health Organisation (WHO) also contributed, also highlights the fact that electronic waste is a real danger to health and the environment (soil, air and water pollution).

Finally, the recycling rate for rare metals is very low, with only 1% for lithium and rare-earth elements.[32] The main reason for this is economic: the current price of these metals is not high enough to make the infrastructure needed for industrial recycling profitable. The use of these metals in minute quantities makes their recycling more complex and increases the number of treatments required - and therefore the costs.[33]



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1.1.5. The digital footprint in Europe and elsewhere

The digital footprint in Europe

There is no systematic literature review of scientific contributions assessing the current impact of digital technology in Europe. Existing studies are more scattered, focusing on GHG emissions and electricity consumption induced by digital technology.

GreenIT.fr assesses the environmental impact of 1 year of digital services in Europe.[34] GHG emissions for digital services are estimated at 4.2% of European emissions. Electricity consumption for digital services during the usage phase represents 9.3% of European electricity consumption. An important element, highlighted in the work of GreenIT.fr, is the different locations of impact: use of resources, minerals and metals, use of fossil resources, climate change, ionising radiation, acidification, particle emissions, and formation of a photochemical ozone.[35]

The local digital footprint

In **France,** the Senate estimates that electricity consumption for digital services corresponds to 10% of French electricity consumption. The carbon footprint of digital services in France is equivalent to 2.5% of France's carbon footprint, since French electricity is four times less carbon-intensive than the European average.[36] Added to this are 62.5 million tonnes of resources used to produce and use digital equipment (a mass of 932 kg per inhabitant), and 20 million tonnes of waste[37] produced per year over the entire life cycle (299 kg per inhabitant).

In **Belgium**, CLIMACT estimates that the use of digital solutions represents around 8% of Walloon electricity consumption (i.e., more than 90% of Walloon wind production and more than the annual consumption of Belgian trains). This estimate does not include the number of Internet of Things (IoT) sensors.

In **Switzerland**, the University of Zurich has analysed the impact of 11 digital products and services on climate protection.[38] The authors estimate that "digital products and services generate more emissions (of CO_2) than they save". This is due to services that are increasingly "fast, convenient, accessible and always available", leading to greater consumption by users and - ultimately - greater electricity consumption.[39]

Future projections of the local digital footprint

In terms of future projections, we find a similar structuring of the figures as observed at global level. The first batch highlights the need to take a series of collective measures to avoid the risk of seeing the digital footprint grow in the years to come. The **French** Senate indicates that the digital footprint could increase significantly if nothing is done to limit it (+60% by 2040, or 6.7% of the national carbon footprint). In **Belgium**, CLIMACT estimates that "the consumption of equipment and infrastructure is likely to experience a significant annual growth rate, particularly from 2025 onwards", linked to the growth in consumption by networks and data centres. In addition, the organisation predicts that GHG emissions will triple by 2030, but in a more linear profile than electricity consumption, given the expected evolution of the Belgian energy mix.

These studies sit alongside other contributions commissioned by digital industry trade associations. These highlight the energy and CO_2 savings associated with the introduction of digital technologies. In the **UK**, the *Tech for Impact* report published by Deloitte, based on the GeSI methodology, shows the efficiency gains generated by digital innovations and their contribution to reducing the country's CO_2 emissions.[40] In **Germany**, the *Climate Effects of Digitization* report states that digital technology is capable of contributing at least half of the country's climate objectives.[41] In **Belgium,** the *Digital4Climate* report points to a 10% reduction in Belgium's total CO_2 emissions by 2030.[42] In October 2022, the telecoms regulator published *Sustainability of Telecommunication Networks and Operators in Belgium*, axiomatically announcing that "the digital transition is one of the main pillars of the ecological transition".[43] Lastly, in the **United States**,[44] the CTIA report states that 5G technology alone would make it possible to achieve one-fifth of the US targets for reducing greenhouse gas emissions by 2025.

1.2. Finding a path through the existing

The figures and studies presented in the previous section lead to a number of observations.

A coupling that nobody disputes - Digital technology impacts the environment in many ways. While it is important to clarify the scope of this issue, it is also necessary to recognise that it has been formulated as a public problem for the general public, politicians and technology companies. Its establishment as a collective issue is not self-evident; for a long time it was considered to be of secondary importance in debates on digital technology. Global trends show that digital technology is clearly interacting with the environment.

A debated relationship - The European Commission has adopted the term *Twin transition* to articulate the environmental imperative and digital ambitions. Both are expected to reinforce each other.[45] In the communication *Shaping Europe's Digital Future*, digital technology is presented as a solution for achieving climate ambitions: "The adoption of digital solutions and the use of data will help to make a successful transition to a climate-neutral, circular and more resilient economy".[46] To achieve this balance, the Commission expects economic players to accept their responsibilities in terms of ecological standards.[47] It recognises, however, that these two transitions are also likely to have a negative impact on each other: energy consumption could increase more rapidly if energy efficiency gains are not achieved, the challenge of waste treatment could be much greater given the greater use of digital technology, and the use of raw materials and rare materials could also explode, not to mention the social and ethical issues raised in the countries concerned.[48] For its part, the IPCC states in its latest technical report[49] that "At present, understanding of the direct and indirect impacts of digitisation on energy consumption, carbon emissions and mitigation options is limited".

Uncertainty and lack of convergence sow doubts - While some figures converge in terms of current energy consumption and carbon emissions,[50] projections for the future diverge. Researcher Gauthier Roussilhe details the two families of projections mentioned above, both of which are in conflict over the impact of digital technology:

- On the one hand, there are reports highlighting the energy efficiency that can be achieved by accelerating digitisation. These reports, produced by manufacturers or industry representatives, point to the complementary nature of the digital and environmental transitions: "Some believe that speeding up digitisation will inevitably have a positive impact, as it will increase the efficiency and optimisation of production and distribution processes - leading to a reduction in energy consumption and greenhouse gas emissions. The environmental issue is then integrated by stating that, by default, digital technology can reduce GHG emissions by up to 20% in all other sectors". As Roussilhe points out, most of the reports promising that digitisation can help the ecological transition are influencing digital policies, despite the fact that they overestimate the effectiveness of digital technology and have major weaknesses. The author points out that there is "no scientific publication offering a global estimate of the emissions avoided by digitisation";[51]
- On the other hand, think tanks (the Shift Project, GreenIT) have highlighted the tensions between digital momentum and the environmental agenda: they believe that the urgency of climate change means that the environmental footprint of digital technology needs to be reduced much more quickly. From this perspective, the estimated annual growth rates of its environmental footprint, and the uncertainty of its positive impacts, appear to be a brake on the ecological transition. In the same vein, the recent study by the D4S European research network, led by the Technical University of Berlin, shows that "digitisation, in its current and dominant form, exacerbates rather than solves many of the pressing social and environmental crises".[52]

- The scarcity of assessments of the net impact of digital technology on the environment further accentuates this dual effect. As the Walloon Digital Agency points out: "It is still difficult to say what *the environmental impact of digital technology is*".[53] Faced with the difficulty of making predictions, but in view of the ambitious targets adopted by governments, a precautious approach is needed, urging each sector to reduce its footprint, and particularly the digital sector, where there is no solid guarantee that this upward trend will be reduced naturally.

The expert perspective, in a nutshell

What is the state of knowledge on the interactions between digital technology and the environment? Publications on this complex issue vary in quality, methodology and transparency. Some assess the impact of digital technology on a global scale, while others focus on a specific territory (e.g. Europe, France, Wallonia). Some assess the environmental challenges of digital technology in the broadest sense, while others focus on greenhouse gas emissions or electricity consumption.

Despite these disparities, there are some areas of convergence:

- Studies show that the digital sector produced between 2% and 4% of the world's **greenhouse gases** (2018): that's the equivalent of the world's truck fleet at the same time, and more than civil aviation, which is often singled out for criticism.
  Forecasts indicate a rapid increase in these emissions (from 4% to 6% per year).

- The sector's **electricity consumption** during the digital usage phase, meanwhile, represents between ~5% and 8% of global consumption (between 2019 and 2021).
  Put another way, if "digital usage" were a country, it would be the 3rd largest consumer of electricity in the world, just after China and the USA.
  With no limits on usage, significant growth in this consumption is expected as a result of the explosion in data volumes.

In addition to scientific studies, a series of publications commissioned by representatives of the **industrial sector** do not refute the above-mentioned upward trends, but justify this increase in direct impacts by greater indirect gains: structural effects in other sectors would even lead to savings in energy and greenhouse gas emissions. As detailed in our analysis, these studies only look at positive indirect effects, not negative indirect effects, and are therefore biased.

Finally, reports from major institutions (UN, WHO, EU, etc.) highlight the environmental pollution (soil, air, water) associated with electronic waste and the extraction of materials needed for the digital and environmental transition.

This first perspective leads to three observations:

- Firstly, the **undisputed negative direct impact of digital technology on the environment.** The extraction, production, use and end-of-life of the physical equipment that enables digital services have a considerable direct negative impact on the planet. The digital-environment nexus must therefore finally be recognised as a problem of general interest.
- Secondly, it is clear that **the digital-environment** relationship is being **debated** and that various players are mobilising (with figures and reports to back them up) to frame the way in which the two transitions should be linked.
- Finally, **the contradictory reports** (between those produced by industry pushing for an acceleration of digitisation, and those from think tanks urging its rapid reduction) leave room for uncertainty and **sow doubt** as to the overall impact of digital technology on the environment.

Finally, this initial overview leads us to conclude that the digital and ecological transitions do not have a natural tendency to reinforce each other. The youth and scarcity of existing studies means that we need to be cautious and use precaution before concluding that digitisation is necessary at every level.

2. The political perspective

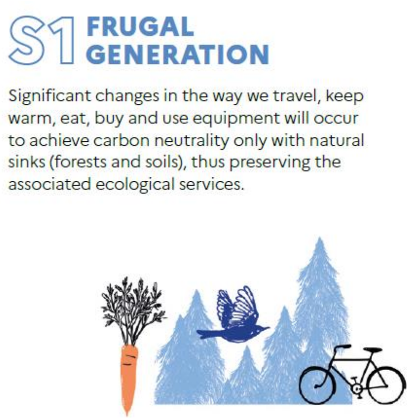
How can we link the digital and environmental transitions? Based on what kind of vision for society? And what instruments should be used to achieve this?

In 2021, a group of experts was commissioned by the Walloon Government to assess the environmental, economic and health impact of 5G. What did they come up with? "Torn experts"[54] and a report revealing "the impossible choice between economic promises and environmental urgency."[55] This case suggests the difficulty of making an explicit choice. But how, then, can political action bring together the ecological and digital transitions? This second perspective considers the options available and the visions of society and public action programmes that could be envisaged for this linkage.

2.1. Transition scenarios

In a previous report, AlterNumeris approached the question of the development of 5G from the perspective of political thinking.[56] Our relationship with digital technology in general, and digital policies in particular, is fed by ways of thinking about innovation and the place of technology. They are based on visions of the world, representations of social life and the meaning of our actions, which underpin our relationship with technology. In a similar, albeit forward-looking, approach, the French Environment and Energy Management Agency (ADEME), the body tasked with supporting the French government in the ecological and energy transition, is considering 4 scenarios for articulating the transitions up to 2050. These scenarios envisage ways of linking digital technology and the environment[57] and are described below. The table summarising the 4 scenarios is available in Appendix 1.

Scenario 1: Frugal generation - Radical sobriety and rapid transformation of lifestyles



This first scenario calls for significant changes in the way we travel, heat, eat, buy and use equipment. It implies the protection of nature, reduced mobility, the promotion of soft mobility, macro-economic indicators focused on income disparities and quality of life rather than GDP growth, the relocation of industries and the priority given to local trade, and industrial production driven by basic needs. It calls for a "drastic change in lifestyles" combined with a de-metropolisation in favour of medium-sized towns and rural areas. The strategy for adapting to climate change is based on local governance and sober behaviour in terms of land management and resource consumption. Decentralisation is maximised and the State sets the objectives, while the choice of means is left to the local level. This scenario involves halving global energy demand and controlling greenhouse gas emissions.[58]

Our relationship with digital technology is guided by the primacy of social innovation over technical innovation, low-tech and reuse/repair mechanisms, mutualisation, collaborative digital technology and the search for a stabilisation of flows to enable the stabilisation of data centre consumption. The digitisation of the world must be limited, constrained and exclusively reserved for uses that meet fundamental needs or guarantee a neutral impact on the environment. This radical sobriety in behaviour goes hand in hand with the search for energy efficiency to reduce greenhouse gas emissions.

Scenario 2: Territorial cooperation - A gradual, negotiated balance between sobriety and efficiency

This second scenario is intended to be less radical, particularly in its approach to sobriety. It is based on housing renovation plans, the attractiveness of medium-sized towns and cities compared with large conurbations, controlled mobility through the development of public transport, the relocation of the economy to local areas to reduce the transport of goods, and the generalisation of a logic of sharing. In this scenario, the link between sobriety and efficiency is more gradual, more negotiated in that it aims for social cohesion and pragmatic cooperation to succeed. It relies on "balanced governance between national and regional levels" involving public institutions, the private sector and civil society, and on ecological engineering for infrastructure programmes and urban policies. It is at local level, as a result of the relationships between all these stakeholders, that the balance between sobriety and efficiency is stabilised. It is expected that energy consumption will be halved and that the carbon footprint will be negative.[59]

While digital restraint is the order of the day, technology is being used to monitor the environmental impact of the changes being made. It focuses on the prevention of natural risks and the production of solutions based on ecological engineering,[60] particularly with a view to regenerating natural areas. Open data is at the heart of the cooperation and is accompanied by the development of new forms of low-energy digital collaboration. Data is not seen as a commercial lever, but as an input for decision-making, for example in the use of water, governed by the principles of frugality.

Scenario 3: Green technologies - Technological development rather than changes in behaviour towards greater sobriety.

This third scenario is based on technological development to decarbonise society without seeking to fundamentally change individual and collective behaviour. It is based on the reconstruction of big cities using the *smart city* model, increased mobility thanks to infrastructure and electrification, the concentration of transport on rail and river routes, and the electrification of vehicles. The focus is on efficiency through the proliferation of optimisation technologies. The strategy aims to control climate risks through technological innovation. Final energy consumption is higher than in the previous scenario, and the carbon gain is lower.[61] The production of digital tools requires a great deal of energy, resources and raw materials.[62] The decarbonisation of industry is achieved through electrification, the use of hydrogen and the "maximum mobilisation of biomass, particularly forest biomass, to produce energy and recover CO_2 to store it underground".[63]

Digital technology is seen as central to this, and the focus is not on reducing negative impacts but on creating positive ones. Intensive agriculture is structured around automated systems and real-time data processing. Sensors, predictive algorithms and artificial intelligence devices regulate cities, industries, infrastructures and homes. Economic policies support the accelerated development of these technologies, based on the intensive exploitation of data. Given the massive rebound effects, the scenario relies on regulatory and pricing policies to contain the explosion in usage.

Society places its trust in its ability to manage and even repair social and ecological systems with more material and financial resources to maintain a liveable world. Carbon capture and storage technologies, which are essential, are uncertain and consume electricity.

Scenario 4: The restoration gamble - Maintaining lifestyles and the hyper-development of intensive, restorative technologies.

This scenario maintains our current lifestyles and mass consumption. It is based on the massive development of carbon capture and storage technologies, and maximum exploitation of natural resources. Buildings are subject to widespread use of home automation (with no effort to renovate), distances travelled increase, cars are connected, and cities are digitally optimised for comfort and safety. Nature (subsoil, sea, heights, remote areas, etc.) is colonised by technology to extract its full potential ("Nature (...) is technicised and dominated thanks to biomimicry: completely green façades, controllable watering, constant measurement of meteorological and climatic parameters to optimise yields from urban agriculture"). Tangible reality is becoming virtual or augmented, with people living partially or totally in metaverses. Globalisation is becoming even more pronounced. Managing security policies, supplying strategic resources (energy and water) and building up stocks to cope with supply tensions are becoming major political issues. Demand for energy is high.[64] Industry relies on massive electrification, intensive recycling policies and artificial carbon sinks. Biomass is being widely used for energy purposes, as are renewable energies, biogas and biofuels. Given the shortfall, we will be relying on imports of low-carbon gas from countries specialising in this type of production. Controlling greenhouse gases will be based on the use of artificial sinks, capture and geological storage of biomass and also of CO_2 in ambient air. The reason this scenario seems like a gamble is that these technologies are at an experimental stage.

Digital technology should make it possible to maintain lifestyles and respond to local ecological issues (pollution, noise, biodiversity, etc.). Nature is being replaced by technological alternatives: "The technical objects produced are characterised by their autonomy, self-regulating and functioning like real organisms, like the robot bees developed to pollinate crops. If we can't save nature, we'll recreate it". Artificial intelligence aims to anticipate and be resilient. Warning systems are being installed. Nature needs to be controlled, risk aversion is particularly high, and, in the event of a threat, tensions need to be brought under control.

2.2. Organising transitions

Examining these scenarios, beyond the projection and debate they allow, opens up two additional lines of discussion: on the one hand, the state of discussions between efficiency and sobriety, and, on the other, the public action programmes enabling their deployment in concrete terms.

2.2.1. The poles of efficiency and sobriety

The link between the digital and environmental transitions is based on distinct balances whose parameters are anchored in the duo of sobriety and efficiency. The first two scenarios approach the issue from the prism of sobriety; the second two are based on the ideal of technical progress anchored in optimisation and efficiency. The ADEME also notes that Scenarios 1 and 4 are borderline scenarios whose adoption appears difficult or even remote.[65]

Efficiency means doing as much (or even more) digital work with less energy. It is based on the idea that technological innovation can generate energy savings and reduce the environmental impact of digital technology.

Sobriety calls for doing less digitally to reduce our environmental impact. This is achieved through changes in behaviour and organisation. "Digital sobriety means moving from instinctive or even compulsive digital use to controlled digital use, which knows how to choose its directions: in view of the opportunities, but also in view of the risks".[66] This means taking a clear stance against "*Digital4Futile*", as described by David Bol, professor at UCLouvain, which is built on the creation of artificial needs, polluting technologies and programmed obsolescence with a proven negative environmental impact. "The question of the 'usefulness' of a contribution is, of course, a subjective one, but one that needs to be asked collectively and explicitly, despite its complexity, if we want to ensure the resilience of the digital system".[67]

While sobriety evokes a reduction in the use of digital technology, it also calls for "a social and political process of coordination and negotiation, aimed at establishing an equitable sharing of efforts to reduce energy consumption".[68] As a political category, it stands apart from approaches that link digital sobriety to individual responsibility. The example of the personal limit on data consumption is illustrative: subscriptions are open to unlimited use, but messages to users are geared towards self-limitation. Understood in this way, sobriety calls for reflection at the level of public policy. "While approaches that focus on efficiency and renewable energies tend to make energy issues technical and de-politicised, institutionalising sobriety (...) would give new impetus to democratic debates on the energy transition (...)".[69] Often associated with positive idealisations (happy sobriety and joyful asceticism) and negative ones (the Stone Age and material regression), sobriety raises questions of social justice, shakes up economic models based on growth, and raises questions about the ethical basis for the distribution of effort.[70]

Sobriety and efficiency thus form two poles of the debate. The projects for society - which are concretely anchored in the ADEME scenarios - articulate these two tracers in different ways.

2.2.2. Public action programmes

While there are many possible futures, they cannot be floating or abstract; they need to be implemented in concrete terms. The instruments used to implement these scenarios are diverse:[71] information, incentives, promotion, investment, regulation, prohibition, sanctions, etc. They can be placed in a number of categories, depending on whether they focus on market mechanisms, direct government intervention, the assumption of responsibility by civil society, and so on. In practice, digital policies, whether explicit or not, are based on different levers of action.

<u>Techno-capitalist programme: the primacy of efficiency</u>

Public intervention is focused on supporting and promoting digital technology as an expected lever for economic growth. The link with the environmental transition is outsourced to other specialised players or to individual consumer responsibility. The environmental issue is dissociated from the digital strategy of a State or region: the digital and ecological transitions run in parallel. This is achieved by providing specific support for digital innovations that have a positive environmental impact, or by contributing to related programmes (such as sustainable development or the circular economy). So, the key to linking these transitions lies in the challenge of efficiency.

Public action is based on the following levers:

- Ensuring self-regulation by the digital sector in adopting sustainability standards
- Ensuring that the digital market operates smoothly and competitively
- Supporting digital innovation, the development of the digital ecosystem and start-ups, particularly in the context of innovation promoting the reduction of environmental impact
- Ensuring public investment in connectivity infrastructure
- Basing technological choices on "market responses"
- Training workers and citizens in digital skills
- Supporting policies to digitise public services
- Protecting against the risks associated with digital use (e.g., cyber security, etc.)
- (...)

In Wallonia, the digital strategy is based on 5 themes: (1) Digital territory (connected to broadband, allowing unlimited access to digital uses, catalysing industrial and economic development), (2) Digital sector (strong sector, cutting-edge research); (3) Economic recovery (strong increase in the digital intensity of businesses); (4) Public services; (5) Education (acquisition of skills and development of uses). The plan is based on four socio-economic indicators: GDP in the digital sector, industrial GDP, the balance of trade in the digital sector, and the level of mastery of digital technologies and uses. The environmental issue is addressed in the *Digital Wallonia 4 Circular* sub-programme, which aims to "support digital solutions in favour of sustainable transition and linked to the development of a greener digital sector in the Walloon economy".

<u>Social democratic programme: negotiating between efficiency and sobriety</u>

This programme represents a different approach from that of the Heads of State. At the end of 2021, the French Senate confirmed the possibility of using other public policy levers.[72] Efficiency is counterbalanced by a penchant for sobriety, characterised by reduction, substitution and the search for greater longevity in the use of digital devices. This family of instruments therefore aspires to modify technology to make it more eco-compatible and to reorganise the relationship between producers and consumers. In their essay on the subject,[73] J. Laïnae and N. Alep refer to this programme combining digital development, green growth, innovation and profitability as "alternamerism". In this programme (supported by organisations such as the Shift Project and Green IT), the State is equipping itself with tools to monitor the articulation of transitions, make sobriety a focus for action, regulate digital practices in terms of production and consumption, force players to adopt behaviours in terms of data use, tax practices, and so on.

Public action is based on the following levers:

- Having the measurement tools and data needed to manage the scenario[74]

- Developing common methods for assessing the environmental footprint of digital technology and setting up an observatory to monitor the environmental impact of digital technology
- Including digital sobriety as a training theme at school and when graduating in electronic and IT engineering[75]
- Investing in digital innovations that have the potential to improve the environment and divesting those that are structurally incapable of doing so
- Extending the life of equipment by extending manufacturers' warranties and making equipment reparable, (...) opening up repair guides and access to spare parts at no extra cost, and introducing a carbon tax targeted at new consumer digital equipment[76]
- Stepping up the fight against planned obsolescence by imposing penalties and increasing the duration of the legal guarantee of conformity for digital equipment
- Reducing VAT on the repair of terminals and reconditioned electronic goods
- Supporting mixed low-tech and high-tech innovation
- Assessing the relevance of digital sobriety certificates as regulatory instruments[77]
- Limiting the deployment of AI to projects with proven overall environmental benefits, encouraging complementary rather than stacked networks (4G and 5G, for example)[78]
- Banning mobile packages with unlimited data access and making pricing at least partly proportional to the volume of data set by the package
- Requiring on-demand audiovisual media services to adapt the quality of downloaded video to the maximum resolution of the terminal and prohibiting the practice of infinite scrolling by online public communication services
- Regulating devices that attract users' attention
- Making data centres sign up to binding commitments to reduce their environmental impact and making tax benefits for data centres conditional on environmental performance criteria
- (...)

This type of programme can be found, for example, in the transition paths proposed by *Québec Circulaire*, the Quebec cluster working to accelerate the transition to a circular economy in Quebec.[79] This plan is based on three ambitions to be achieved by 2040: (1) energy and material sobriety have become the norm for the design, manufacture and use of digital technology; (2) collective prioritisation of digital uses will ensure a fair distribution; (3) digital innovation and financing methods respect planetary limits, and offer accessible tools for the transition. This strategy proposes to mobilise various means of action: collective choice mechanisms to arbitrate digital uses, redirection of investment, introduction of incentive and coercive instruments for the adoption of tools to quantify the digital footprint, control of obsolescence, adoption of practices that contribute to extending the lifespan of devices, diversion of innovations that are not compatible with the transition (e.g., attention economy), etc.

Digital degrowth programme: radical sobriety

A third family of instruments focuses on "the quality of the living environment and attempts to change our relationship with technology, (...) our mode of consumption and production".[80] More than a negotiated balance between efficiency and sobriety, it is a profound transformation of economic and political behaviour that is sought, in the sense of overcoming the capitalist programme of exploiting data and its relationship to economic growth. The "radical sobriety" scenario is part of a programme of digital degrowth defined by Caccamo around the following principles:[81]

- Collective reduction of equipment and mass of data by questioning our needs in terms of digital technologies;
- Application of a sustainability principle aimed at ensuring that the technologies deemed necessary are "minimal, uncomplicated, repairable, user-friendly and resource-efficient". This type of programme can also claim to be based on *small, low* and *slow tech*;
- Application of a principle of self-production aimed at breaking away from the hegemonic models of digital technology and placing it within short circuits and a relocalised production system. The emphasis is on decentralisation and needs-based experimentation: "distributed innovation is observed in situations where heterogeneous players have complementary skills and knowledge, form networks or creative communities, cooperate fairly informally and co-produce technical objects and their uses" (Joly et al., 2015);

- Application of a principle of pooling the value produced by digital technology through the establishment of digital commons.

As Laïnae and Alep suggest, this vision is rooted in a critique of the digital that goes far beyond its environmental dimension, and which posits that regulation, or a digital alternative, is impossible. Articulating transitions means containing, limiting and rolling back digital technology. In other words, environmental ambitions can only be achieved by restricting the role of digital technology in our lives. It is considered that a social-democratic programme is naïve in its hopes of regulation (standards, monitoring indicators, ethical committees, public controls, etc.) which, apart from being ineffective, is destined to create heavy bureaucracy for all the players involved. For Alep, it is a political, productive and cultural break that is at stake; digital de-escalation is not simply a matter of reducing the use of digital technology, but also of organising society differently so as to be able to do without it.[82] This implies not only replacing digital technology with a genuine alternative, but also a vast movement of popular education to ensure that every technical choice is subject to genuine political reflection.

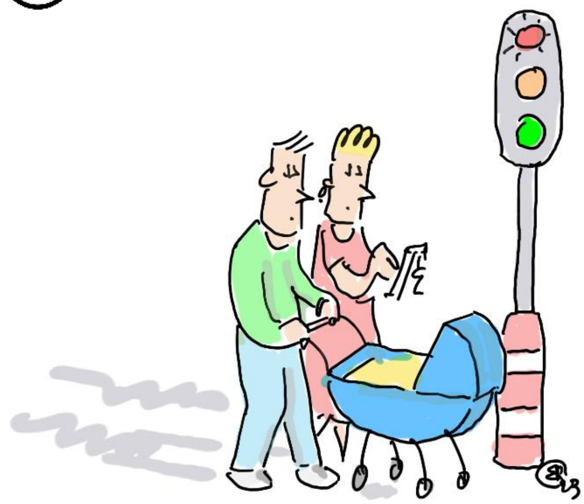
The political perspective, in a nutshell

Various scenarios emerge in response to the question "how can we reconcile the digital and environmental transitions?" Each scenario reflects a particular 'way of life' in terms of mobility, production, consumption, housing, our relationship with time and each other, and our involvement in community life. Digital technology is no exception: its place and role, its distribution and control methods, its link to innovation and its uses are distinct depending on the scenario. Thinking about how these transitions fit together leads to a number of observations:

- **A digital policy cannot be separated from its environmental dimension.**
  All too often, the digital transition is discussed in isolation, by sector, linked to a particular use and decoupled from the environmental transition. The presented scenarios put an end to this dissociation. They place digital technology within a vision of the future that clarifies attitudes and sheds light on the consequences - explicit or otherwise - of the digitalisation of society.
- **A digital policy is built around the categories of sobriety and efficiency.**
  The scenarios - and the political positions they represent - are permeated by doses and articulations of the two poles of sobriety and efficiency. We need to recognise the need to scale up these two dimensions collectively.
- **A digital policy is based on a public action programme.**
  The public action programmes on which digital policies are based must be identified: techno-capitalism, social democracy and radical sobriety.

3. The citizen perspective

How do you approach the information produced? How do you deal with a report produced on the subject and launched into the public arena? What is the status and strength of what is produced?



It is not unusual for figures to appear in the press when a new report or assessment is published. Recent examples: "Digital technology could reduce Belgian CO_2 emissions by 10%, according to Agoria"[83], "At least 10% reduction in CO_2 emissions in 2030 thanks to digital technology, according to a study by Agoria".[84]

How can we, as citizens, position ourselves in relation to this often condensed information? While the first part of this report has looked at the main body of knowledge produced in the field of environmental impact assessment, this part offers an insight into the mechanics of these assessments. To illustrate the point, the *Digital4Climate* report, published by the Belgian technology industry federation in 2022, is used here as a case study.

3.1. The impact of digital technology on the environment: an overview

The proposed reading grid is structured around a number of key questions that enable the reader to position the assessment produced and to approach the results presented in a structured manner. While there is often not enough time to assess current events, these points of reference help readers to adopt a critical stance, aware of what is at stake in the relationship between digital technology and the environment.

What is the production process?
Is this scientific literature or grey literature?

What is the scope?
How do we frame the concepts addressed in the research question?
In this case, the notions of <u>digital technology</u>, the <u>environment</u> and the <u>impact</u>?

What is the level of transparency and methodological relevance?
Whether in terms of the models and databases used, the working hypotheses formulated or the limitations of the work as a whole.

What are the conclusions and recommendations?
Do the conclusions accurately reflect the work as a whole?
Are the recommendations directly linked to the conclusions?

3.1.1. What is the assessment production process?

Scientific literature or grey literature - Although often lumped together, different types of contribution coexist.

Grey literature refers to documents produced by government, industry, higher education and research, services, NGOs, associations, etc., which do not enter the usual publishing and distribution channels.[85] It is possible to distinguish this literature from production that has been peer-reviewed by scientists or reviewed by a scientific committee. This peer review - which is often lengthy and gives rise to numerous exchanges and re-readings - addresses the following elements:

- Are the scientific questions and hypotheses being put forward clear and well-posed?
- Is the method used appropriate to answer the question posed?
- Are the data analyses appropriate?
- Are the conclusions drawn consistent with the results obtained?
- Is the article (...) clear and detailed enough to enable other researchers to reproduce this work?
- Do the results represent a sufficiently important advance in knowledge to merit publication in this journal? Or is it a minor, incremental advance in knowledge, worthy of publication but in a more restricted/specialised journal?[86]

Beyond the interests associated with publication, the publication format must first be questioned. Publication in a scientific journal provides additional guarantees as to the soundness of the research system put in place and the reliability of the assessment produced. Does this mean that any other publication is not reliable or valid? Not necessarily. But it does not provide the additional guarantees that scientific publication and peer review offer.

3.1.2. What is the scope of the study?

If the question of the impact of digital technologies on the environment is to be asked, the analysis calls for a broad spectrum. Generally speaking, without a **holistic vision** of a complex systemic problem, the direct solutions envisaged could simply displace the problems elsewhere (concept of **impact transfer**), or even make them worse. The scope is therefore essential!

> <u>An example from everyday life</u>
> More and more airports are claiming to be "CO_2 neutral". How is this possible? Aside from the organisations that provide no clear figures to back up their claims, or those that are betting on technologies that do not yet exist… the airports that do provide more detailed data have found a rather simple trick: exclude air traffic emissions from their scope of study![87]

In the specific case of a study, the research question can help us to see things more clearly.

What research question? - Asking a question helps to frame the issue. Its formulation is therefore not neutral. To answer the question "What is the impact of digital technology on the environment?", the three fundamental concepts to be framed are *digital technology,* the *environment* and *impact.*

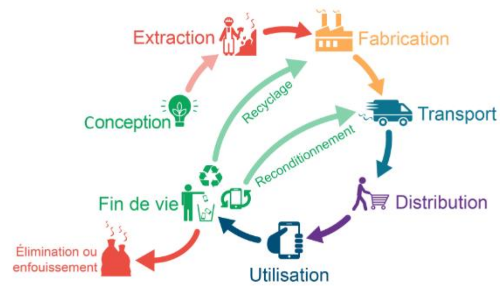
3.1.2.1 What is the scope for digital technology?

Which equipment? - For an impact assessment to be sufficiently exhaustive to be of value, it must be based on an examination of the equipment produced, at the risk of overlooking a significant part of the footprint under consideration. We therefore need to look at:

- Data centres
- Data transmission networks
- Terminals in the hands and homes of users.

The assessment must be as explicit as possible in terms of the scope covered and specify the areas of equipment not taken into consideration. This criterion can lead to significant variations.

Which phases of the life cycle? - As an extension of the previous point, the direct environmental footprint of digital technology can be seen in the three phases of the life cycle of this equipment: (1) the extraction of the necessary raw materials, the manufacture and distribution of the equipment, (2) the use of the equipment and (3) the end of life of the equipment. It is therefore important for anyone wishing to assess environmental impact to consider all three phases, otherwise a significant proportion of the effects could be overlooked.



As Pirson and Bol note, research with the ambition of a complete life cycle review is still rare, despite the fact that general methodologies exist. Very few life cycle analyses exist, for example, to examine the impact of IoT. It is also difficult to compare these assessments because the scope of the equipment and the databases differ from one to another, in a technological context where the arrival of new devices is particularly rapid.[88]

Example of a daily newspaper

We are seeing more and more advertisements mentioning electric or hydrogen vehicles as "zero emission". Apart from the fact that the energy vector used probably comes from carbon sources, we understand that this only refers to the vehicle's use phase (no direct GHG emissions during use), omitting the other phases of the vehicle's life cycle (manufacture and end of life), which do emit GHGs.

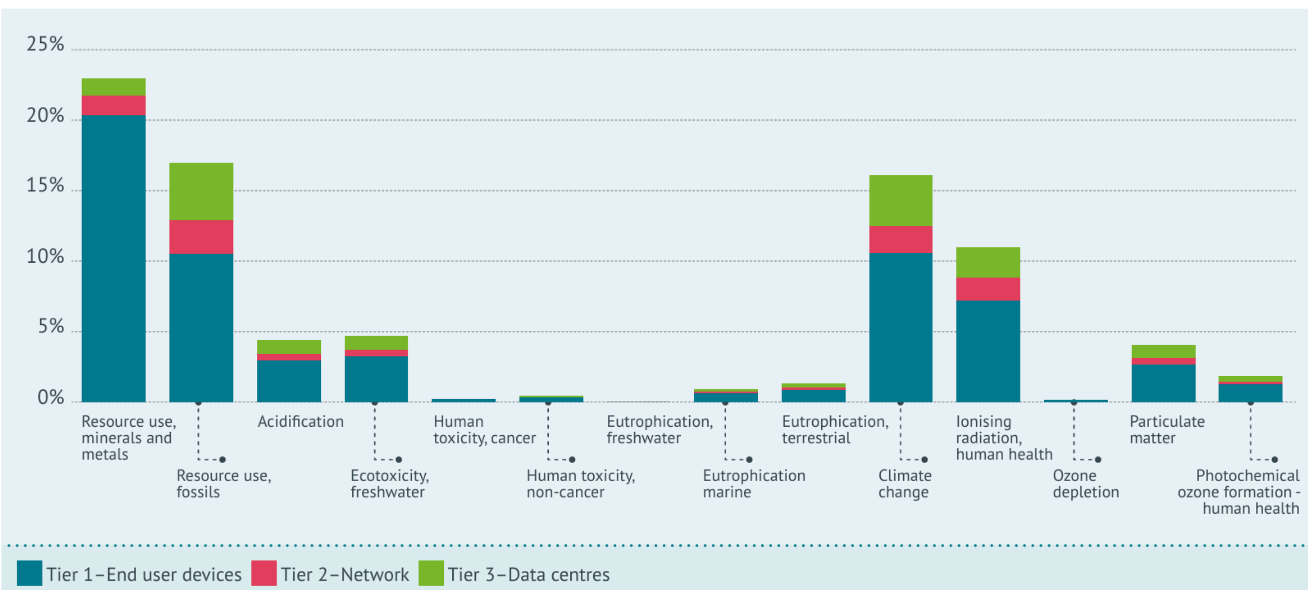
3.1.2.2 What is the scope for the environment?

The concept of the environment is very broad. In its 2013 methodological recommendation for measuring and indicating the environmental performance of products and organisations, the European Union defined **14 categories of environmental impact and their associated indicators.**[89] These include depletion of abiotic resources, acidification, freshwater ecotoxicity, ionising radiation and climate change. All of these indicators are important, in that most of them can be used to assess whether or not humanity is exceeding the **planetary limits.**[90]

However, most reports and studies dealing with the impact of digital technology take into account only one well-defined aspect of the environment: greenhouse gas emissions and, with them, the climate issue. However, if we address the question of the impact of digital technology on the environment, it is only from a very limited angle. Digital technology is likely to have an impact on a number of other factors. However, very few studies take them into account, often because of the complexity of the assessment process. This bias in attention can lead to a "tunnel effect", with a single focus on carbon emissions and the neglect of other areas that are primarily impacted by digital technology.

For the first time, in 2021 GreenIT.fr is assessing the environmental impact of digital technology in Europe using a multi-criteria life cycle analysis.[91] This analysis complies with the ISO 14040:2006 and ISO 14044:2006 standards, with standardisation allowing comparison with global limits. The criteria are made up of eight of the most significant environmental indicators (taken from the European recommendations mentioned above), as well as four flow indicators (material, waste, primary energy and final energy flows linked to digital services). This highlights the fact that the primary impact of ICT on the environment is through the use of resources (metals and minerals), and that **climate change cannot be effectively mitigated without at the same time addressing the other environmental issues associated with an activity such as ICT.**[92]

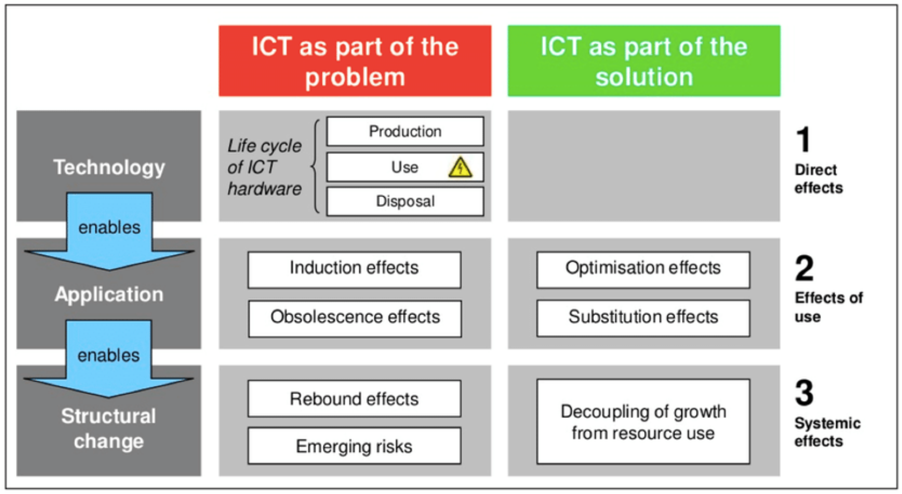
Figure 1 - Normalised and weighted impact distribution along the 3 tiers



This last element is a reminder of the extent to which, despite the impression of immateriality it gives, digital technology is based on equipment, infrastructures and production chains that are very real and very material. Beyond the terminals that fit in the palm of your hand, there are data centres, servers, cables, antenna networks - in short, a complex, meshed material structure whose manufacture, operation and end-of-life are not limited to the effects in terms of CO_2 emissions. There are also real consequences in terms of consumption of water and non-renewable resources, soil, air and water pollution, with consequences for agriculture and for the health of people living around extraction sites and poorly regulated landfill sites.

3.1.2.3 What is the scope of the impact?

An environmental impact assessment must be able to integrate the diversity of effects generated by digital technology on the environment. Hilty's model,[93] a recognised and validated model used in particular by the *Agence wallonne du Numérique*,[94] points to the need to consider the different levels of impact of the technological choices made when balancing ICT as an environmental problem or solution.



Are direct effects taken into account? - Direct effects refer to the impacts generated by a technology at the various stages of its life cycle (production, use, end of life), taken independently of the indirect effects of the use of this technology. In this respect, the environmental and energy cost is always clear, no matter how hard we try to reduce it.

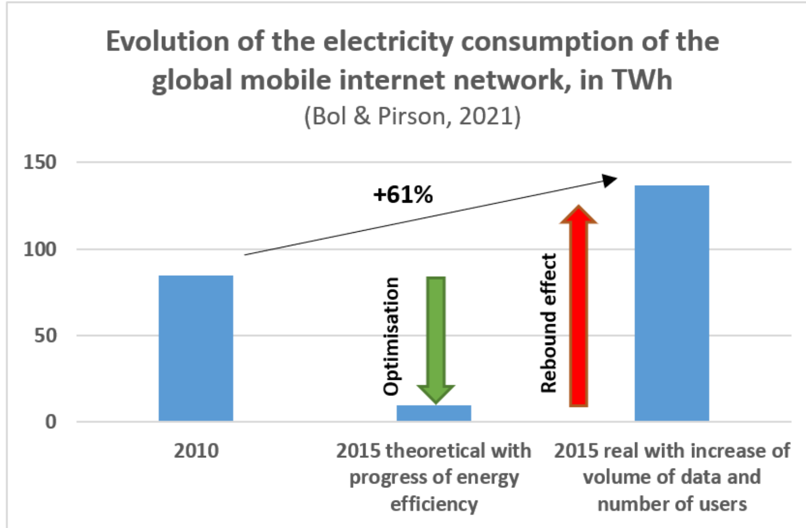
Are indirect effects taken into account? - Indirect effects relate to the consequences of using technologies. On the one hand, these technologies can reduce the environmental balance sheet through optimisation, energy efficiency gains or the replacement of a technology that consumes energy by a more economical alternative. This is the main point made by the promoters of the *IT4Green* message who, starting from a scenario based on the expansion of the use of digital technology, highlight the reduction in electricity consumption and, with it, the reduction in carbon impact. On the other hand, these technologies can also worsen the environmental situation to that extent that they lead to greater consumption, traffic or new uses, and generate problems of obsolescence of the existing infrastructure to the extent that their use requires the replacement of a large quantity of active equipment.

Are structural effects taken into account? - Finally, in the third category of effects, we find a similar duality. On the one hand, digital technology is presented as a solution if, from the point of view of resource exploitation, it can be decoupled from growth. On the other hand, it is likely to generate unexpected effects that run counter to the expected impacts. This latter point is referred to as the rebound effect, which can take various forms:[95]

- "Direct rebound effects occur (...) when a greater quantity of the same resource is consumed following an improvement in the productivity with which that resource is manufactured". One example is the miniaturisation of processors, which are becoming smaller and smaller, requiring less and less material to manufacture. As a result, the fall in their price has led to a drastic increase in demand. Consumption is exploding and the obsolescence of existing equipment is accelerating.
- Indirect rebound effects "occur when more efficient production of a resource leads to a reduction in the price of the goods and services that use it, which in turn leads to an increase in their sales and therefore the consumption of other resources".[96] The example here is teleworking, where the reduction in business travel, which is expected to reduce overall GHG emissions, is being replaced and even exceeded by personal travel.[97] Similarly, compared with face-to-face, paper-based teaching, *e-learning* can generate unexpected effects, for example in terms of electricity consumption and heating, and thus have a greater environmental impact.[98]
- Finally, structural rebound effects, which affect the whole economy, "occur when the fall in the cost of a key resource leads to a reduction in the price of intermediate and final goods throughout the economy, triggering structural changes in production and consumption patterns".[99] For example, the use of greener energy sources, such as photovoltaic panels, is leading to a worldwide increase in electricity consumption of around 30%.[100]

"The rebound effect and induced consumption are a bit like the elephant in the room. Everyone knows it exists, but it's more comfortable to keep it in the back of your mind in the hope that the positive effects will completely erase the negative ones",[101] comments Nicolas van Zeebroeck, Professor of Economics and Digital Strategy (Solvay Brussels School).

In this complex balance that governs the adoption of digital technologies, it is **important to have an exhaustive reading that takes into account these three levels of impact, at the risk of making localised gains but global losses.** Induction and obsolescence effects, as well as rebound effects and emerging risks, must be considered alongside optimisation and substitution effects. It **is the balance of *all* these effects that gives a picture of the environmental impact.**



3.1.3. What is the level of transparency and methodological relevance?

The methodological underpinnings of the approach must be explained as fully as possible, in terms of the **databases** used, the working **hypotheses** formulated and the **limitations** of the work as a whole.

An *assessment of past impacts* must be based on data that is as reliable as possible. A *future impact assessment*, on the other hand, is nothing more than a forward-looking exercise: defining the future consequences of a technological choice. This exercise requires **assumptions to be** made about the expected evolution of energy consumption or the transformation of human behaviour following the adoption of a technology. While the setting of assumptions is inevitable in this type of assessment, it is expected that they are sufficiently supported, justified and relevant.

In both cases described above, the **databases** used must be accessible, and the question of their origin can be an indicator of relevance: are they raw/primary data, or rather secondary data (i.e., extracted from other studies that have already made analytical hypotheses based on primary or even secondary data). And are the data and figures used credible and applicable in relation to the research question?

Transparency is also expected in terms of the choices made and the operations carried out. Ideally, the reader should be able to replicate the steps taken by the authors up to the result presented. Finally, as with any rigorous thought process, a statement of the **limits** of the exercise should be clearly identifiable and as exhaustive as possible.

3.1.4. Conclusions and recommendations

Supported studies are sometimes long, technical and tedious. In order to make the results of these studies accessible to a wider audience, who may not have the time and/or skills to take in the full content, they usually contain an "executive summary" for decision-makers, or an "abstract" outlining the main points of the work.

It is easy to see why the **conclusions** and resulting **recommendations** are so important: they will be the focus of most of the communication regarding the study. It is therefore essential to be able to check that the conclusions faithfully reflect the work as a whole. Do the conclusions (and the communication of them) show the necessary nuances? Are they intellectually honest, or are they (deliberately or not) truncated or even misleading?

As for the recommendations, firstly we expect them to be directly linked to the conclusions and results of the study. Secondly, we can question the conception of the world they outline and the concrete implications they engender.

3.2 Reading: the *Digital4Climate* report

May 2022. Agoria - the Belgian technology industry federation - published the *Digital4Climate* report, after Bitkom - representing German tech companies - and CTIA - the US wireless lobby - had published similar reports a few months earlier, all three commissioning the consultancy firm Accenture.[102] The summary of the Belgian version comes to some blunt conclusions: "By 2030, the impact of digital technology on the climate will be five times more positive than its total footprint".[103] The report argues that the deployment of digital solutions in four key sectors of the Belgian economy is likely to significantly reduce CO_2 emissions, by between 10.4 and 13.3 megatonnes in 2030, or 10% of the country's current total emissions. Further on, echoing the scenarios outlined in the report, we read: "In short, the greater the degree of digitalisation, the greater the reduction in CO_2 emissions".[104] And Agoria concludes, in the summary presented on its website: "The digital transition and the green transition can reinforce each other, ensure sustainable growth and contribute to Belgium's economic and social prosperity".[105]

In the remainder of this section, we will first put the publication of the *Digital4Climate report* into context, and then analyse it using the framework established in the previous section.

3.2.1 Background to the publication of the *Digital4Climate* report

Given the current state of public debate around digital technology, it is clear that the digital momentum is at odds with people's aspirations for environmental sustainability and social justice. Still largely unknown to the general public and the media until recently, the impact of digital technology on the environment is becoming a thorn in the side of many industrial promoters, in Belgium and elsewhere.

The digital sector, for its part, is highly aware of the risks that the environmental issue poses at the various points in its production chain, from extraction and manufacture, through transport, to use and end of life. Given that these chains are globalised, they are highly subject to supply problems. For example, the field of electronic components is linked at least as much to the international context as it is to local climatic hazards and raw materials that are increasingly difficult to extract in a profitable and sustainable way. Fifty years ago, MIT's Meadows report[106] warned us of the limits to growth and the inevitability of a production peak, followed by a period of decline, whether desired or not.

So, it is easy to see how the digital lobbies might be interested in trying to demonstrate that, on the contrary, digital technologies are good for the environment and that, as such, their development should be accelerated.

The studies listed in the table below were commissioned by organisations listed as 'lobby' in the European Commission's transparency register.[107]

Title of the study[108]	Year	Sponsor	Author
Digital4Climate: Study about the contribution of digital technologies to reduce carbon emissions in Belgium	2022	Agoria, Belgian lobby	Accenture
Climate effects of digitization: Study to estimate the contribution of digital technologies to climate protection	2021	Bitkom, German lobby	Accenture
5G Connectivity: A Key Enabling Technology to meet America's Climate Change Goals	2022	CTIA, US lobby	Accenture
Mobile Net Zero: State of the Industry on Climate Action	2022	GSMA, global lobby	GSMA
The Enablement Effect: The impact of mobile communications technologies on carbon emission reductions	2019		
#SMARTer2030: ICT Solutions for 21st Century Challenges	2015	GeSI, global lobby	Accenture

The easy argument would be to consider that, for industrial and commercial reasons, these reports are simply documents promoting the interests of their sponsor to decision-makers. While such cases have already arisen in the past, while the influence of lobbies in digital matters no longer needs to be demonstrated, and while they are quick to use the weapon of discredit to respond to their opponents, to us, it seems more appropriate to delve into the heart of the arguments and methods of demonstration.

The aim of the analysis below is not to incriminate the fact that socio-economic players take public positions aimed at defending their interests or promoting a vision of society - it is to engage with the substance of the arguments. This is where the critical spirit can be fully deployed and where prolific controversy can be engaged.

3.2.2 Analysis of the Digital4Climate report

3.2.2.1 What is the production process for Digital4Climate?

Am I dealing with scientific literature or grey literature?

The sponsor and author of the recommendations: Agoria

The sponsor of the *Digital4Climate* report is Agoria, the **Belgian lobby** representing the interests of technology companies. The organisation's articles of association state: "The purpose of the association is to commit itself fully to the service of its members and to use all its influence with public bodies and private organisations to make the socio-economic environment for its members more favourable to businesses (...) *and* to ensure, in permanent consultation with its members, the promotion of their interests (...)".[109] Its Board of Directors is made up almost entirely of senior executives from Belgian technology companies. In this case, it is neither a public research institute - working on the initiative or at the request of a government - nor a university research centre - aiming to contribute to a field of knowledge. It is an organised interest group defending the economic interests of its members.

The author: Accenture

As sponsor, Agoria commissioned the consultancy firm Accenture to produce the report. Accenture is the author of this study, but also of others of the same style. These studies use the same methods and assumptions, which could explain why they reach the same conclusions. There is also the question of **conflict of interest**, as the consultancy firm Accenture is listed by the GSMA as one of the "suppliers most used by mobile network operators", in the same way as Microsoft, Apple and Google.

Type of literature: Grey Literature

This report is therefore part of the **grey literature**: it is not a scientific publication that has been submitted to an editorial committee. When reading it, it is important to bear in mind the interests defended by its sponsor and the biases that this may induce in its conclusions and recommendations.

3.2.2.2 What is the scope of Digital4Climate?

How do we frame the concepts addressed in the research question? In this case, the notions of digital technology, the environment and impact?

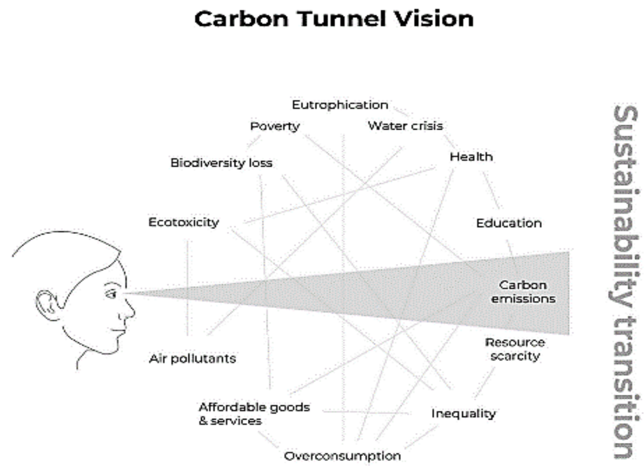
What scope for the environment in** Digital4Climate**?

The research question posed is as follows: "Can digital technologies make a significant contribution to achieving Belgium's climate objectives by 2030?[110]A quick reading of this question highlights the fact that the conclusions to be drawn from this study can only concern the climate footprint in particular and not the environmental footprint - we are therefore dealing with a **single-criteria approach to the environment**.

The report focuses exclusively on greenhouse gas emissions, although it concedes - on the basis of the GreenIT.fr report (which is quoted extensively by the authors*)* - that a multi-criteria analysis should be favoured.[111] Other environmental impacts, such as water use, waste production and the reduction of scarce resources, are not included in the analysis.

Making the link between the digital transition and the ecological transition at the outset of the *Digital4Climate* report is therefore misleading to the extent that it targets only one of the components of the environmental issue, namely greenhouse gas emissions. The *Digital4Climate* report is confined to a narrow vision known as the 'Carbon Tunnel Vision', as illustrated opposite. This vision is dangerous because it ignores the potential transfer of impacts. In other words, it ignores the extent to which accelerated digitisation, implemented in the name of reducing greenhouse gas emissions, is contributing to worsening other aspects of the environmental situation to an even greater extent.

While it should be acknowledged that assessments involving these other environmental dimensions are still rare, it will be important to ensure that the conclusions of the report and the communication about it make it possible to clearly discern the scope attributable to the findings.



Graphic by Jan Konietzko

What scope for digital technology in** Digital4Climate**?

The **equipment taken into** account in this study **covers digital equipment, infrastructures and data centres.**[112] **However,** the report explicitly states that **when it comes to digital equipment, entertainment devices (TVs and games consoles) are not included.**[113] This choice is questionable insofar as: (1) data is available on this subject; (2) these devices have a particularly significant environmental impact.

Finally, the report takes into account **the entire life cycle of technologies**. The calculation of the direct impact includes the production of equipment and its use (generally the two dominant phases in the cycle in terms of climate impact), as well as its end-of-life.[114] Maintenance, upgrades and repairs are not taken into account, for lack of a model and available data.

What is the scope of the impact in** Digital4Climate**?

The positive direct and **indirect impacts** are well taken into account in the *Digital4Climate* report. However, this is not the case for **negative indirect impacts**, such as lock-in or induction effects, or the rebound effect.

The rebound effect is recognised and mentioned in the report. However, it is disqualified by the report on the grounds that research is not yet unequivocal and that it is impossible to calculate in the context of the report.[115] Contradictorily, it then goes on to specify a calculation: if the rebound effect had been introduced, the reduction in digital emissions would still be 2.6 to 2.9 times greater than its direct emissions (compared with five times without taking the rebound effect into account).

Let's remember Hilty's model: it is true that digital technology has direct negative impacts and indirect positive impacts (applications made possible by the use of digital technology), but there are also indirect negative effects. These can take the form of indirect rebound effects (e.g., over-consumption due to e-shopping, increased heating of homes due to teleworking) and there are systemic effects that are very difficult to quantify, both positive and negative. In this context, **keeping a balance sheet between direct negative impacts and indirect positive impacts offers only a very fragmented view of the situation.**

3.2.2.3 How transparent and relevant is Digital4Climate's **methodology?**
This applies to the models and databases used, the working hypotheses formulated and the limitations of the work as a whole.

The methodology of the *Digital4Climate* report does not provide the necessary exhaustive approach. It is based on the same calculation method used in the SMARTer2030 report published in 2015 by the Global e-Sustainability Initiative and Accenture Strategy.[116] This report points out that ICT can reduce greenhouse gas emissions by 20% by 2030, i.e., a reduction in emissions of 12 $GtCO_2eq$ worldwide compared with a *Business as usual* increase in emissions.[117] The report is based on a top-down approach (using available data and projections based on assumptions) and a bottom-up approach (interviews with sector experts). The chapters are listed in the order of the report.

Positive indirect impact - Firstly, the report focuses on the positive indirect impact of certain digital technologies: how can digital technology help to reduce emissions from existing activities? The calculation approach is based on the following formula:

BASELINE × **ADOPTION RATE** × **IMPACT POTENTIAL**

Baseline: The authors use emissions projections for 2030 to measure the potential effect of integrating digital solutions.[118] The 2030 emissions estimate is calculated using 2019 European Environment Agency data projected on the basis of industry forecasts or the "With Existing Measures" (WEM) scenario of the Belgian National Energy and Climate Plan.[119] In doing so, the authors of the *Digital4Climate* report assume that no measures to reduce CO_2 emissions will be taken in Belgium before 2030 (such as the use of renewable energies). This choice is explained to avoid double counting the impact of digital technologies.[120] In view of the formula used, this choice is likely to **artificially amplify the reduction in emissions estimated** in absolute terms.

Adoption Rate: Several sectors are identified (construction, mobility and logistics, energy and production) in which specific technologies are examined (for example, in mobility and logistics: teleworking, *smart traffic lights & signals*, and *smart logistics*). The model is based on a series of assumptions about the rate of adoption of these target technologies between now and 2030. In order to assess their impact, we need to be able to estimate their rate of dissemination in our daily lives. The results for the different areas are summarised in Appendix 2.

The report **gives no information on the** secondary databases used to formulate these adoption rates. The authors point out that they are drawn from "generally recognised sources" and that they have been validated by at least three independent experts for each sector.[121] The report does not mention the sources used to define the adoption rates, or even the function of these experts. However, it is clear that the nature of the source has a major impact on the quality and reliability of an estimate: between an international comparison, a market study, a scientific article, a survey or commercial projections based on sales expectations, the result differs. It is also considered that **when adoption rates are based on behavioural elements, an even greater uncertainty factor must be taken into account**. There is no model that can represent behaviour and scale up to generalisation without facing major uncertainties. It is difficult to predict the effect that the introduction of smart meters will have on consumer behaviour.

Estimates in this area should therefore be treated with caution. Finally, the report uses proxies[122] on several occasions to assess the adoption rate. For example, to assess the adoption of intelligent traffic lights, the situation in the cities of Antwerp and Brussels is taken to represent the situation at national level. Another example: to assess the adoption rate of Smart Logistics in Belgium, German data was used. If this type of approach can be used as a basis for formulating a hypothesis, it is important to explain the reasons for the relevance of such an extrapolation.

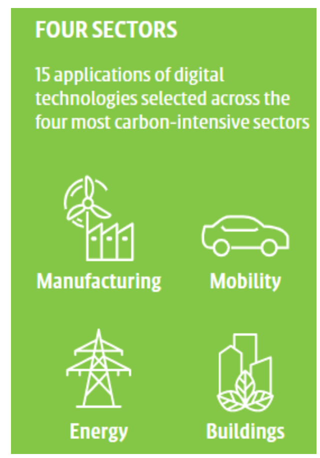
Impact potential - Based on baseline data and an estimate of the technology adoption rate, emissions reductions are calculated. Here, **the *Digital4Climate* report in no way makes it possible to determine the elements on which this final stage of the calculation is based**. The report regularly refers to a model whose components are not known.

In terms of the overall potential impact of these technologies, these findings raise questions about the balance of the national carbon footprint. If the digital sector takes credit for gains in other sectors (construction, mobility, etc.), how will the other sectors integrating these technologies react? This would mean that, from a global emissions accounting point of view, the other sectors would no longer be able to attribute these gains to themselves, even though they are direct gains in their sector. In other words, the other sectors will have to make more "efforts" to reduce emissions in their own sectors and will no longer be able to account for the gains made thanks to digital technologies.

Direct impact - The direct carbon footprint of digital technologies in Belgium is estimated by the authors of the report to fall by between 4% and 16% by 2030, despite the sharp increase in electricity consumption associated with these technologies. Surprisingly, **these levels of reduction in the direct carbon footprint for 2030 are well below the sectoral target set** at -45% between 2015 and 2030. These targets are proposed by the Science Based Target initiative (SBTi), and supported by the ITU, GSMA and GeSI.[123]

After pointing out that estimates of the future of digital technologies are highly uncertain, the reader is left short of explanations and referred to the appendices for information on the variables and assumptions behind the estimates of direct impact. **There, it is impossible to know how the impact on the quantity of emissions is calculated, or even how the variables involved are combined and weighted to obtain the result**. Quite surprisingly, and without any documentation, we discover, for example, that the impact of end-use and demand for IoT is expected to fall, without any explanation of how this will happen in a context of increasing adoption of digital technologies.

Limitations - The report explains a series of limitations linked to the choices made, which contribute to its methodological transparency. Apart from the fact that **no margin of error is ever mentioned** in the study, other limitations - more inherent to the methodologies chosen - are not mentioned.



In order to model the indirect benefits of digital technology, the assessment is based on an approach based on pre-selected use cases, rather than on an approach based on all the technologies in a sector.[124] A use case is defined as a practical application of one or more digital technologies enabling GHG emissions to be reduced in a particular sector or process.[125] The justification put forward is the possibility of calculating the impact of these technologies where they are already established, and therefore benefiting from real, existing figures. The effect of 15 use cases is therefore calculated.

The choice of technologies and sectors concerned is justified by their weight in the main CO_2 emitters in Belgium.[126] The rationale behind the report's selection is to focus on the most promising technologies in terms of reducing carbon emissions. According to the authors, this approach is particularly conservative to the extent that other current or future technologies are just as promising, and could have been selected to further reduce the carbon footprint associated with their deployment. The virtue of this approach is that it can be based on past data and figures collected as part of practical experiments.

However, it has one major drawback, namely that it does not take into account the development of other technologies in the sectors targeted and in other sectors, whose overall impact is likely to have a negative impact on the total footprint. In other words, **this approach requires extreme caution in terms of the conclusions that can be drawn, given that the technological spectrum covered is limited and selective**.

Finally, all the sectors chosen are not independent of each other: they interact with each other. So, to assess overall gains by adding up the gains of each sector individually is to run **the risk of potentially counting the same gain several times** in the overall result.

3.2.2.4 What are the conclusions and recommendations for *Digital4Climate*?

Do the conclusions accurately reflect the work as a whole?

Are the recommendations directly linked to the conclusions?

When it comes to drawing lessons from such an exercise, it is, in light of the above, nuance and caution that are called for. The shortcut that leads to the association of accelerated digital transition and ecological transition, as highlighted by Agoria in its communication and in the introduction to the report, raises questions: "In short, the greater the degree of digitalisation, the greater the reduction in CO_2 emissions. Agoria is firmly convinced that digital technologies can help provide an answer to the climate challenge. The digital transition and the green transition can reinforce each other, ensure sustainable growth and contribute to Belgium's economic and social prosperity". **In no way does the report lead to such conclusions.** This caricature of the overall message may give rise to fears of commercial conclusions that are divorced from the limitations and detail of the analytical approach presented in the report. The widespread call for more digitisation does not derive in any way from reading the report. At most, it allows an attempt at generalisation based on the technologies assessed.

The report goes on to make a series of recommendations to companies and governments. Firstly, it is important to pay close attention to the process used: **the recommendations** made by Agoria (the sponsor) **lack nuance and a direct link with the study carried out**. The recommendations are based solely on separate interviews with 20 Belgian companies. There are no additional details of these interviews: we do not know who was interviewed or what was said. Secondly, while there are a few proposals that are directly linked to the content of *Digital4Climate* (e.g., the call to adopt the technologies examined in the report), most of the proposals are very indirectly linked to the content of the report (e.g., the call to improve connectivity through the deployment of 5G). With regard to the latter, it should be noted that the recommendation does not in any way include the ecological impact in the equation, despite the fact that, as discussed elsewhere,[127] all possible questions can be asked on this subject.[128,129]

It should be noted that other studies, with a broader environmental scope, make recommendations that are much more nuanced than those of *Digital4Climate*. For example, in the Walloon report "Environmental and climatic impacts of digital tools",[130] Digital Wallonia and the Walloon Digital Agency - in line with the conclusions of GreenIT.fr - recommend, among other things, sobriety in digital use.

Finally, let's take a look at the world that these recommendations, taken together, will bring about. If the scenarios we have outlined are to become reality, we will need to live in *smart houses*, significantly increase the use of teleworking and go further in the development of *smart cities*. Alternatives exist in these areas, and other mobility, energy and urban development policies can also be mobilised. These proposals therefore constitute a possible policy option, one society among others that can be envisaged in terms of environmental concerns, as mentioned earlier in the section on policy.

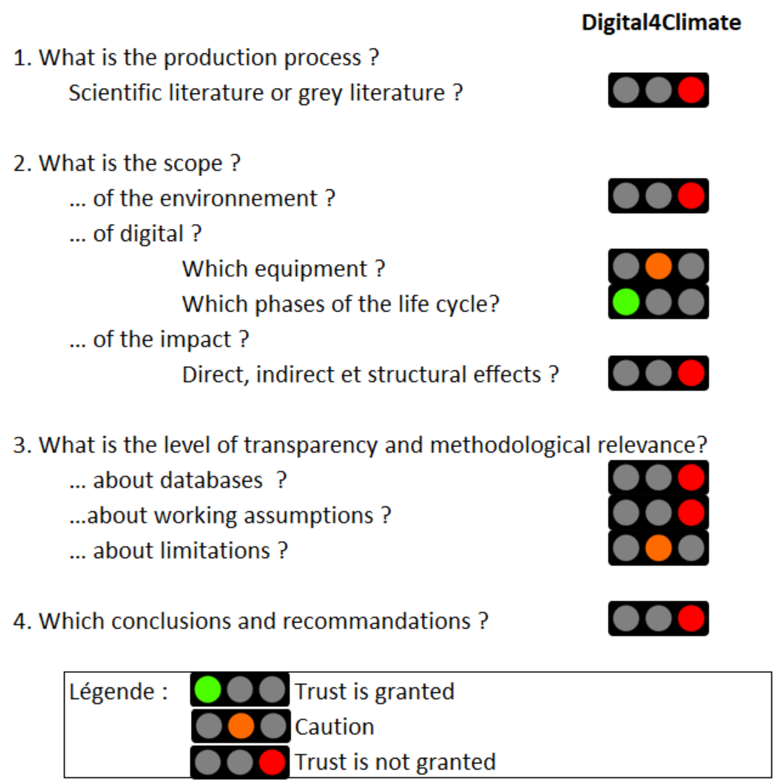
3.3. From a reading grid to a citizen's perspective

There are a number of positive points in the report, such as the fact that the entire lifecycle of digital technologies is taken into account, and the sectoral approach based on case studies, which gives a clearer picture of technologies with interesting potential. Similarly, a specific page is devoted to the limitations of the study, pointing out the uncertainties relating to the *baseline* and adoption rates, the limitations of the life cycle calculation where certain phases have not been considered, and the failure to take account of the rebound effect.

At the same time, the report contains a number of weaknesses and gaps that call for caution with regard to the figures put forward:

1. The environment is only considered from a climate perspective.
2. The adoption rates are poorly documented and the methods used to calculate the potential impact of indirect impacts are not explained.
3. There is no evidence to support the orders of magnitude given for direct impacts.
4. The rebound effect, although recognised as having a significant impact, is not accounted for.
5. The conclusions reflect very little of the study as a whole, and the recommendations are only loosely linked to it.

The table opposite provides a rational illustration of the summary of this analysis using a qualitative reliability/confidence indicator.



3.4. Are other studies of this kind more reliable?

As can be seen from the above, a quick read through, in light of a few key criteria, enables this type of report to be accepted, its qualities and limitations to be weighed up, and a distanced and critical interpretation to be made of the communication elements that are ultimately disseminated in the public arena. Researcher Gauthier Roussilhe has examined, in detail, studies comparable to *Digital4Climate* produced by representatives of companies in the sector, whose main approach is to extrapolate from specific cases of use and highlight the effects of activation that reduce emissions, while ignoring those that increase them. He notes a number of methodological gaps, poorly supported hypotheses and a tendency to play down the rebound effect. The researcher concludes: **"A study of the claims of positive impacts of digital technology on the climate leads to the conclusion that they cannot be used to inform political decisions or research. They are based on extremely patchy data and assumptions that are too optimistic to extrapolate global estimates. (...) this analysis suggests that, today, the digital sector does not offer any guarantees on the environmental issue".**[131] Similar observations can be made elsewhere: the papers provide too little information on the assumptions and scenarios formulated, the rebound effect is often unduly discounted, and extrapolations from case studies are forced.[132,133] These considerations are not just intellectual nitpicking: without sound methodologies, transfers of environmental impacts are very real.

It is important to make a clear distinction between what are real methodological difficulties, avoidable flaws and political assertions that clearly go beyond what can be stated in an isolated study. Assessing the effects of digital technology on the climate in particular - and the environment in general - is a complex exercise based on a number of assumptions. Assessing the environmental impact of digital technology suffers from a number of difficulties, as Roussilhe observes: the cross-cutting nature of digital technology (a sector in its own right and scattered across other sectors), the focus on energy and GHG emissions while neglecting the material impact (which is difficult to calculate), leading to an underestimation of the impact of manufacturing, the absence of benchmark data from the Asian ecosystem, the omission of new trends influencing the growth of the sector (IoT, Blockchain, etc.), the difficulty of assessing the impact of digital technology on the environment, and so on.), the difficulty of obtaining data from manufacturers, and the fact that decisive impact factors, such as the consumption of scarce resources or water, are not included. In its latest publication,[134] it identifies and summarises all the gaps (in knowledge and methodology) concerning the direct and indirect effects of digital technology on the environment.

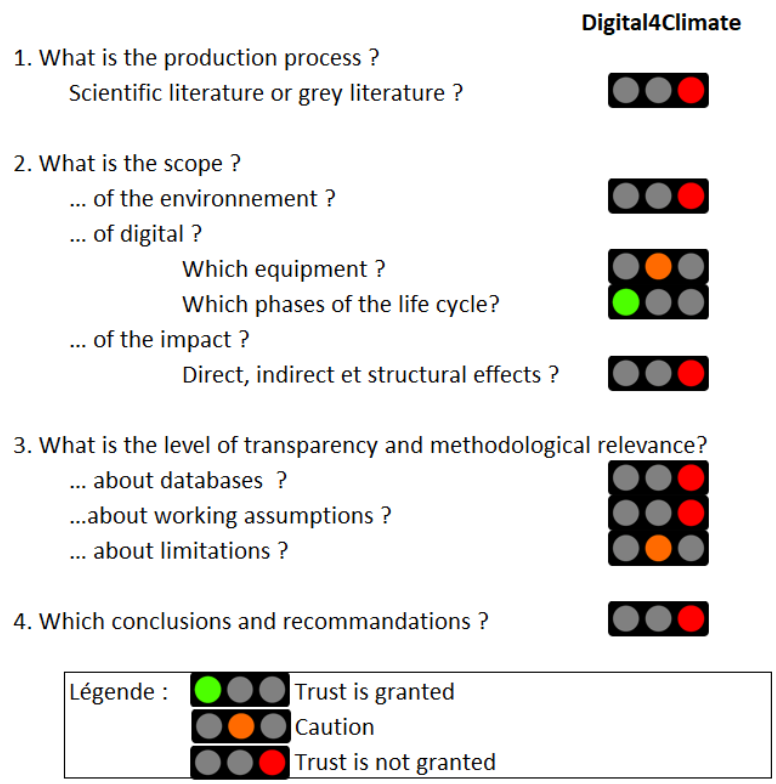
It also highlights the lack of a common methodology for existing studies, making comparisons between reports a thorny issue: "The obstacles to the application of certain benchmarks (multicriteria in particular) lie in the complexity of their implementation. The methods have been developed, but the tools needed to apply them (databases, for example) do not exist.[135] There are, however, avenues for convergence, such as the existence of common methodological standards for life cycle assessments (ISO 14040[136] and 14044[137]). The convergence of approaches towards common standards is likely to increase the capitalisation of knowledge, reinforce existing knowledge and facilitate its practical use.

The citizen perspective, in a nutshell

Taking a citizen's view of a publication on the environmental impact of the digital sector can be complex and even confusing. How much trust should be placed in studies on the subject? What assessment criteria should be applied? How do you distinguish between alarmist conclusions and those encouraging more and more digital technology?

This document provides the general public with a framework for reading the various reports published in a critical way. This reading grid is based on **four main axes**, through which the flaws and intrinsic qualities of a publication are revealed. These assessment axes lead to **nine confidence indicators** (green/orange/red) producing a dashboard that can be consulted at a glance, as illustrated opposite.

By way of illustration, the latest *Digital4Climate* study by a Belgian lobby was scrutinised. Our analysis reveals a single positive indicator encouraging confidence, two mixed indicators and six indicators encouraging distrust. **This assessment suggests that the use of the *Digital4Climate* report in a political decision-making context would be inappropriate, or even counter-productive for the environment.**



Conclusion and recommendations

Do the ecological transition and the digital transition reinforce or contradict each other? Are they compatible? Can they coexist, and if so, how?

The expert perspective, which objectively reviews the state of knowledge, leads to the conclusion that these two transitions are indeed linked, but that their relationship is subject to debate - leaving us to wonder about the impact of digital technology on the environment. It is therefore unfounded to assert that these two transitions naturally reinforce each other. The scarcity of existing studies and the fact that they are so recent mean that we need to be cautious and use precaution before concluding that digitisation is necessary at every level.

The political perspective invites us to broaden our field of vision: there are several possible scenarios for this dual transition, each embodying a certain political imagination and a certain way of life. Each discourse must therefore be analysed in the light of the imagination it conveys and the lifestyles it underpins.

The citizen perspective provides a framework for critically reading the various studies published on the impact of digital technology on the environment - and for taking a stand on the issue. The latest '*Digital4Climate*' report by a Belgian lobby (used as a case study in this analytical framework), has a number of significant pitfalls that call for the utmost caution when its conclusions are taken up in the public and political spheres.

In light of these conclusions, the following recommendations can be made:

1. Adopt the three-perspective reflection (expert, politician, citizen) as soon as new knowledge is produced.

We can only be astonished at the way new knowledge is treated by certain politicians, particularly when it is produced by industrial interest groups.
Indeed, the application of the three perspectives to the latest Belgian study (*Digital4Climate)* suggests that the use of this study in a political decision-making context would be inappropriate, and even counter-productive for the environment.
Yet ministers[138] have used the study as a reference.

2. When in doubt, use precaution.

Given the difficulty of determining whether or not the rise of digitisation is leading to a net reduction in the global ecological footprint, and given the increasingly urgent need to reduce it, the simple application of the precautionary principle would lead to the following conclusion: every economic sector must work to reduce its ecological footprint, with no exception being made for digital technology.

Annexe 1 - Summary of the 4 ADEME scenarios

SOCIETY IN 2050

ADEME

	 S1 FRUGAL GENERATION	 S2 REGIONAL COOPERATION	 S3 GREEN TECHNOLOGIES	 S4 RESTORATION GAMBLE	
LIFESTYLES – Society	• Search for meaning • **Frugality chosen but also imposed** • Preference for local sourcing • Nature protected	• Sustainable changes in lifestyles • **Sharing economy** • Fairness • Preservation of nature enshrined in law	• **New technologies rather than reduced consumption** • "Green" consumerism for the benefit of well-off populations, connected society • Services provided by Nature are optimised	• **Mass consumption** lifestyles safeguarded • Nature is a resource to be exploited • Confidence in the ability to repair damage to ecosystems	Society
Food	• Meat consumption reduced by a factor of 3 • **Share of organic: 70%**	• **Meat consumption halved** • Share of organic: 50%	• 30% reduction in meat consumption • **Share of organic: 30%**	• Meat consumption almost stable (10% decrease), supplemented by **alternative synthetic or plant proteins**	Food
Housing	• Massive and rapid renovation • **Strong limits on new construction** (conversion of vacant housing and second homes into primary residences)	• Massive renovation, **gradual but profound changes in lifestyle** (growth in cohabitation and the size of housing adapted to household size)	• **Large-scale demolition and rebuilding** of housing • All homes renovated but not efficiently: only half undergo deep renovation	• New construction **maintained** • Only half of the housing stock renovated. When renovated, houses undergo deep renovation • **Appliances multiply**, combining technological innovation and energy efficiency	Housing
Personal mobility	• **Strong reduction in mobility** • Distance travelled per person reduced by one-third • Half of all journeys on foot or by bicycle	• **Managed mobility** • Distance travelled per person reduced by 17% • Nearly half of all journeys on foot or by bicycle	• Mobility managed with State support: infrastructure, widespread teleworking, car-pooling • **+13% in distance travelled per person** • 30% of journeys on foot or by bicycle	• Strong increase in mobility • +28% in distance travelled per person • People prioritise **speed** • 20% of journeys on foot or by bicycle	Personal mobility **LIFESTYLES**
Technical Relationship to progress, digital, R&D	• Organisational and technical innovation • **Prevalence of low-tech**, reuse and repair • Digital collaboration • **Stable data centre consumption** due to stabilisation of flows	• Massive investment (energy efficiency, renewable energy and infrastructure) • Digital technology in support of regional development • **Stable data centre consumption** due to stabilisation of flows	• Targeting of the most **competitive technologies to decarbonise** • Digital technology in support of optimisation • Data centres consume 10 times more energy than in 2020	• Innovation on all fronts • Capture, storage or use of captured carbon essential • Pervasive presence of the Internet of Things and Artificial Intelligence: data **centres consume 15 times more energy** than in 2020	Technical Relationship to progress, digital, R&D
Governance Decision-making ladders, international cooperation	• **Local decision-making**, little international cooperation • Regulation, prohibition and rationing via quotas	• Shared governance • **Environmental taxation** and redistribution • National decisions and European cooperation	• Minimum **regulatory framework** for the private sector • Government as planner • Targeted carbon tax	• Supply-side support • Strong and targeted international cooperation in a few key sectors • **Centralised planning of the energy system**	Governance Decision-making ladders, international cooperation
Region Rural-urban mix – land degradation	• Important role for the region in terms of resources and taking action • **"De-urbanisation"** in favour of medium-sized cities and rural areas	• **Demographic recovery of medium-sized cities** • Cooperation between regions • Regional energy planning and land policies	• **Urbanisation**, competition between regions, functional cities	• Low involvement by regions, **urban sprawl**, intensive agriculture	Region Rural-urban mix – land degradation
ECONOMY – Macro-economy	• **New prosperity indicators** (income gaps, quality of life, etc.) • Contraction in international trade	• Qualitative growth , **"re-industrialisation"** of key sectors in conjunction with the regions • Regulated international trade	• **Green growth**, innovation driven by technology • Regional specialisation • International competition and globalisation of trade	• **Carbon-based economic growth** • Minimal and targeted carbon tax • Globalisation of the economy	Macro-economy
Industry	• **Production as close as possible to needs** • 70% of steel, aluminium, glass, paper, carboard and plastic sourced from recycled materials	• Production of value rather than volume • **Dynamic local markets** • 80% of steel, aluminium, glass, paper, carboard and plastic sourced from recycled materials	• **Energy decarbonisation** • 60% of steel, aluminium, glass, paper, carboard and plastic sourced from recycled materials	• Decarbonisation of industry relying on **carbon capture and storage** • 45% of steel, aluminium, glass, paper, carboard and plastic sourced from recycled materials	Industry **ECONOMY**

Annexe 2 - Annotated summary of the hypotheses used in the "Digital4Climate" report to assess the indirect impact of digital technology

Construction: GHG emissions can be reduced by between 8.3% and 10.8%. The starting point considered is the WEM scenario.

Smart Homes BMS	**Adoption of technology:** The adoption of a Building Management System (BMS) to control electrical and mechanical equipment, as well as the integration of cameras, motion sensors and automatic doors for private homes.	61 to 86% in 2030 (17% in 2020)
	Impact on emissions: Energy savings	11% reduction in emissions
	Our comments: The forecast for the highest adoption rate is based on the assumption that Belgium will become one of Europe's best performers in this area, joining Great Britain. The source of the estimate is not known.	
Smart Homes Smart meters	**Technology adoption:** The expected impact of smart meters. It is assumed that the installation of these meters will influence individual behaviour through the transparency they allow. The indicator is the % of homes equipped.	78 to 100% by 2030 (3% in 2020)
	Impact on emissions: Energy savings generated by more conscious behaviour.	3% reduction in emissions
	Our comment: The criterion of the number of homes equipped is not totally linked to changes in behaviour. Assuming that 100% of homes equipped corresponds to 100% change in behaviour tends to overestimate the rate of adoption and, therefore, the rate of reduction in emissions.	
Smart Commerces BMS	**Adoption of technology:** The adoption of a Building Management System (BMS) designed to control electrical and mechanical equipment (lighting, ventilation, etc.) for commercial premises.	54 to 60% by 2030 (20% in 2020)
	Impact on emissions: Energy savings.	28% reduction in emissions
	Our comment: The adoption rate forecast is based on the growth rate of commercial BMS in Europe. The source is not known.	
Smart Construction BIM	**Adoption of technology:** The adoption of software enabling architects to optimise their operations (waste, time and transport savings, etc.).	81% to 89% in 2030 (40% in 2020)
	Impact on emissions: Reduction in waste, increase in renovations and savings in transport and operating time.	7% reduction in emissions
	Our comments: The highest adoption rate forecast is based on the assumption that Belgium will become one of Europe's best performers in this area. The source of the estimate is not known.	

<u>Mobility and logistics:</u> GHG emissions can be reduced by between 10.6% and 14.2%. The starting point considered is the WEM scenario.

Virtualisation of work	**Technology adoption:** Share of frequent teleworkers (2 days a week or more).	42 to 49% in 2030 (12% in 2020)
	Impact on emissions: Reduction in emissions linked to the use of transport to get to work.	16% reduction in emissions
	Our comment: The 42% increase in the teleworking population is the result of Accenture research. The highest rate of adoption corresponds to the level of teleworking during the peak of the Covid period.	
Smart traffic light & signals	**Technology adoption:** Proportion of "smart intersections" in Antwerp and Brussels. The weighted situation in Antwerp and Brussels is used as a proxy for all Belgian cities.	100 to 112%. (35% in 2020).
	Impact on emissions: Traffic optimisation.	16% reduction in emissions
	Our comment: Considering the situation of Antwerp and Brussels as proxies for all Belgian cities is likely to overestimate the adoption rate. 112% corresponds to an extension of these systems to rural areas. Here again, there is reason to doubt that such widespread adoption will take place in small towns, particularly in view of the cost to public finances.	
Smart Logistics (Route & freight optimization)	**Technology adoption:** Proportion of transport companies connected. The German situation has been considered as a proxy.	25 to 37%. (9% in 2020).
	Impact on emissions:	37% reduction in emissions
	Our comments: German data has been used as a proxy. The source of the estimate is not known.	
Smart Logistics (Rail freight modal substitution & digitalisation)	**Technology adoption:** The proportion of automated freight operating on the Belgian market has been taken into account.	74 to 90%
	Impact on emissions: Substitution effect and increased efficiency in terms of emissions.	8%
	Our comments: The sources are not known.	
Smart Logistics (Inland navigation modal substitution & automation)	**Technology adoption:** Proportion of autonomous vehicles operating on the Belgian market.	57 to 74%
	Impact on emissions: Substitution effect and increased efficiency in terms of emissions.	6%
	Our comments: The source is not known.	

Industry: GHG emissions can be reduced by between 10% and 12.3%. The starting point considered is the WEM scenario.

Digital Design & Production (Process simulation)	**Technology adoption:** Penetration rate of simulation modelling applications in the process industries. It is considered that the life sciences industries are a good indicator for the process industries.	51 to 62% in 2030 (6% in 2020)
	Impact on emissions: Reduction in emissions linked to the deployment of simulation modelling applications in the process industries.	9% reduction in emissions
	Our comments: The life sciences sector was considered for the process industries. This choice was not explained. The sources are not known.	
Digital Design & Production (Virtual Prototyping and Twinning)	**Technology adoption:** Penetration rate of virtual prototyping applications in the product industries. It is considered that CPG industries are a good indicator for product industries.	56 to 67%. (2% in 2020).
	Impact on emissions: Reduction in emissions linked to the deployment of virtual prototyping applications in the product industries.	9% reduction in emissions
	Our comments: The consumer packaged goods sector was considered for the process industries. This choice has not been explained. The sources are not known.	
Smart Manufacturing (Manufacturing automation)	**Technology adoption:** Penetration rate of intelligent automation in production in Belgium.	95 to 100%. (53% in 2020).
	Impact on emissions: Reduction in emissions thanks to energy savings from the deployment of manufacturing automation in the Belgian manufacturing sector.	25% reduction in emissions
	Our comments: The sources are not known.	
Smart Manufacturing (Scheduled maintenance)	**Technology adoption:** Proportion of companies adopting predictive maintenance in the Belgian manufacturing sector.	60 to 80%. (15% by 2020).
	Impact on emissions: Reduction in emissions thanks to energy savings resulting from the deployment of predictive maintenance in the Belgian manufacturing sector.	9% reduction in emissions
	Our comments: The sources are not known.	

Energy: GHG emissions can be reduced by between 12% and 14.5%. The starting point considered is the WEM scenario.

Digital efficiency	**Technology adoption:** Proportion of renewable energy plants with ICT technologies. Expert contribution: 80% to 100% of new renewable energy plants should be equipped with digital technologies.	61 to 74% in 2030 (0% in 2020)
	Impact on emissions: Reduction in emissions thanks to increased efficiency and production of renewable energy using digital technologies (mainly digital twins and predictive maintenance).	7% reduction in emissions
	Our comments: ELIA's forecasts have been used to estimate the 2030 baseline without additional measures.	
Flexible networks	**Technology adoption:** Proportion of DSRs and storage centres that can meet full flexibility criteria. Accelerated scenarios consider aggressive adoption of Vehicle-to-grid (V2G) storage.	70 to 79%. (27% in 2020).
	Impact on emissions: Reduction in emissions due to fewer plant interruptions, thanks to effective DSR and the use of storage solutions.	18% reduction in emissions
	Our comments: ELIA's forecasts have been used to estimate the 2030 baseline without additional measures.	

Glossary

AR (Augmented Reality): technology that superimposes an image on the user's vision of their environment.

Edge Computing: a form of computing carried out on site, or close to a specific data source, reducing the need to process data in a remote datacentre.

GHGs (greenhouse gases): Greenhouse gases are the gases naturally present in the atmosphere. By absorbing part of the sunlight and heat emitted by the Earth, they guarantee the conditions for life on our planet. The greenhouse effect they cause is therefore a natural phenomenon. Unfortunately, human activity has generated huge quantities of certain gases, as well as the accumulation of new substances, amplifying the natural greenhouse effect and causing unprecedented disruption.

GeSI (Global enabling Sustainability Initiative): a cross-industry initiative that aims to create and implement sustainable digital solutions. In 2023, its board of directors will include telecoms giants such as Verizon, AT&T, T-mobile US, Taiwan Mobile Foundation, Deutsch Telekom, TDC NET, Telstra, ETNO and Huawei.

IPCC (Intergovernmental Panel on Climate Change): an expert body that summarises the state of knowledge on climate change and the role of human activity, the IPCC publishes scientific reports that are used by governments to reach agreements in the fight against global warming.

GSMA (Global System for Mobile Communications): international association representing the interests of more than 750 mobile operators and manufacturers from 220 countries around the world, plus 400 other companies from the wider mobile telephony sphere who are associate members.

AI (Artificial Intelligence): a set of theories and techniques used to create machines capable of simulating human intelligence.

TIC / ICT (Information and Communication Technologies): computer, audiovisual, multimedia, Internet and telecommunications techniques.

IIoT (Industrial Internet of Things): integration of machine learning, big data technology, sensor analysis and automation of machine-to-machine communication. This is being done in the knowledge that the Internet of Things will be scaled up and driven by businesses. The idea is that smart machines can capture and communicate data more accurately to help businesses find problems faster and increase overall efficiency.

IoT (Internet of Things): a network of objects (such as sensors and actuators) that can autonomously capture data and intelligently self-configure in response to physical events in the world, enabling these systems to become active participants in a variety of public, commercial, scientific and personal processes.

Metaverse: The metaverse corresponds to a virtual world, the contraction of "meta" and "universe".

Open Data: refers to a movement, originating in Great Britain and the United States, to open up and make available the data produced and collected by public services (administrations, local authorities, etc.).

VR (Virtual Reality): technology that immerses people in a digitally created artificial world.

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[3] Olivier Vidal, CNRS "Matières premières et énergie à l'échelle mondiale dans la transition énergétique" (2019)

[4] *> Le rapport Digital4Climate a été présentée devant la ministre Tinne Van der Straeten d'après les déclarations d'Agoria*
> La réponse de Willy Borsu à propos de Digital4Climate au Parlement de Wallonie, le 09/06/22 https://www.parlement-wallonie.be/pwpages?p=interp-questions-voir&type=28&iddoc=112180

[5] www.consilium.europa.eu/fr/policies/climate-change/

[6] www.harris-interactive.fr/opinion_polls/developpement-du-numerique-et-enjeux-environnementaux-une-possible-cohabitation

[7] Olivier Vidal, CNRS "Matières premières et énergie à l'échelle mondiale dans la transition énergétique" (2019)

[8] GreenIT.fr (2019), Empreinte environnementale du numérique mondial : « In 2019, the digital universe will consist of 34 billion devices for 4.1 billion users, or 8 devices per user. In 2019, the mass of this digital universe will reach 223 million tonnes, or the equivalent of 179 million cars weighing 1.3 tonnes (5 times the French car fleet).» (Deepl Translation)

[9] The study includes the results published - and frequently cited - by the teams of Jens Malmodin at Ericsson, Anders Andrae at Huawei and Lofti Belkhir at McMaster University. The studies published by these three research teams generally proceed by: (1) drawing up a list of the devices under consideration; (2) agreeing, for each device, the quantity of greenhouse gases emitted during its production, transport and use; (3) estimating the number of devices produced and their lifespan

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[17] Malmodin et al. (2018) The Energy and Carbon Footprint of the Global ICT and E&M Sectors 2010–2015

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[22] The World Bank and ITU (2023), Measuring the Emissions & Energy Footprint of the ICT Sector: Implications for Climate Action.

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[38] Bieser, Kalte, Hilty (2022), Auswirkungen digitaler Produkte auf den Klimaschutz

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https://www2.deloitte.com/content/dam/Deloitte/uk/Documents/technology-media-telecommunications/deloitte-uk-tech-for-impact.pdf

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[42] “CO_2 emissions in Belgium in 2019, the year before the coronavirus pandemic, amounted to 116.5 megatons. By 2030, by deploying digital solutions in the four most CO_2-intensive Belgian sectors, these CO_2 emissions will be reduced by 10.4 to 13.3 megatons or roughly ten percent of total Belgian emissions.” https://www.agoria.be/en/themes/about-us/agoria-news/federal/fifteen-digital-technologies-are-set-to-reduce-c02-by-5-times-than-the-total-digital-emissions-by-2030

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[46] Commission européenne (2021), Une boussole numérique pour 2030 : l'Europe balise la décennie numérique

[47] Commission européenne (2020), Shaping Europe’s digital future : “*Yet it is also clear that the ICT sector also needs to undergo its own green transformation. The environmental footprint of the sector is significant, estimated at 5-9% of the world's total electricity use and more than 2% of all emissions. Data centres and telecommunications will need to become more energy efficient, reuse waste energy, and use more renewable energy sources. They can and should become climate neutral by 2030. How ICT equipment is designed, bought, consumed and recycled also matters. Beyond the energy efficiency requirements of Ecodesign, ICT equipment must become fully circular - designed to last longer, to be properly maintained, to contain recycled material and to be easily dismantled and recycled.”*

[48] Commission européenne (2022), Questions and answers on the 2022 Strategic Foresight Report : “*(1) The energy consumption could increase if digital technologies do not become more energy-efficient. ICTs are responsible for 5%-9% of global electricity use. This could grow as the use of blockchain, internet of things, platforms, search engines, and virtual reality applications increase. (2) The greater use of digital technologies could increase electronic waste and its environmental impact. It could reach 75 million tons by 2030. (3) The green and digital transitions will require more raw materials. For example, the use of lithium in the EU, mainly in batteries, is projected to raise by 3500% by 2050. However, their extraction, mining and processing can also be damaging for the environment and water security. This can also raise ethical concerns. This being said, the EU and its Member States already have a good legislative framework in place to ensure that mining takes place under environmentally and socially sound conditions.*"

[49] Pathak M, Slade R, Shukla P, Skea J, Pichs-Madruga R, Urge- Vorsatz (2022), Technical summary, Climate Change 2022 :
“At present, the understanding of both the direct and indirect impacts of digitalisation on energy use, carbon emissions and potential mitigation is limited”

[50] Pirson et Bol (2021), Assessing the embodied carbon footprint of IoT edge devices with a bottom-up life-cycle approach :

“*Several papers agree on the current absolute ICT carbon footprint which is evaluated at about 1000–2000 $MtCO_2$-eq or equivalently 2%–4% of the world greenhouse gas (GHG) emissions (Freitag et al., 2021). A significant part of this footprint is attributed to the ICT production, estimated between 281 and 543 $MtCO_2$-eq (Freitag et al., 2021) in 2020. However, there is no consensus on future trends. As IoT is a growing part of ICT, it should also be subject to analyses regarding environmental impacts and sustainability (Stead et al., 2019, Nižetić et al., 2020, Belkhir and Elmeligi, 2018). This is supported by existing LCA of ICT devices (Ercan et al., 2016) showing that the production of electronic components accounts for a major part of the environmental impacts, especially for battery-powered devices. For instance, the embodied carbon footprint of smartphones accounts for more than 70% of the overall footprint (Louis-Philippe et al., 2020). Unfortunately, far less research has been conducted on the direct impacts generated by the massive production and deployment of the IoT.*”

[51] Roussilhe, Ligozat et Quinton (2023), A review of the state of knowledge of the environmental effects of digitization : *"To the best of our knowledge, no scientific publication so far has provided an assessment of the global (current or potential) enabling effects of digitization for GHG emission mitigation."*

[52] Digitalization for Sustainability (D4S) lead by TU Berlin (2022): Digital Reset - Redirecting Technologies for the Deep Sustainability Transformation.

[53] Agence du Numérique & Digital Wallonia (2022) : Impacts environnementaux et climatiques des outils numériques

[54] Le Soir (11/03/2021), La 5G déchire les experts belges

[55] RTBF (16/02/2021), Rapport sur la 5G en Wallonie : les experts expriment leurs divergences

[56] AlterNumeris (2021), La 5G - au-delà du 'pour ou contre'

[57] ADEME (2022), Prospective - Transitions 2050 : "*The richness of the scenarios constructed, aiming for carbon neutrality in 2050, can obviously only be appreciated by reading the Agency's complete work. Depending on the choices made, the energy mix will differ. While the climate issue is predominant in the exercise, it should not obscure other major issues such as biodiversity or the pressure on natural resources (irrigation water, construction materials), the content of which varies from one scenario to another.*" (Deepl Translation)

[58] This scenario halves final energy consumption to 790 TWh per year (1,772 TWh in 2015). It mobilises only biological carbon sinks and achieves -42 million tonnes of carbon equivalent per year (401 $MtCO_2eq$ in 2015).

[59] Final energy consumption is reduced to 833 TWh and emissions to -28 $MtCO_2eq$.

[60] Rey, F., Dutoit, T., Côte, F. & Lescourret, F. (2015). L'ingénierie écologique au service de l'aménagement du territoire. *Sciences Eaux & Territoires*, 16, 2-3 : " *Ecological engineering can be defined as a field of action by and for the living, i.e. it corresponds to the use by practitioners of ecological knowledge, concepts and theories, for ecological and/or social purposes that are often more or less closely intertwined (ecotechnologies, agro-ecology, agro-forestry, ecological rehabilitation, etc.). (...) Ecological engineering is often equated with projects for the ecological restoration of natural or semi-natural, terrestrial or aquatic environments. Finally, ecological engineering aims to create new ecosystems that benefit both man and the biosphere (green roofs, mesocosms, etc.).*"(Deepl Translation)

[61] Final energy consumption is set to fall to 1,074 TWh per year and emissions to -9 Mt CO_2eq.

[62] ADEME (2022), Prospective - Transitions 2050 : « *The supply of energy must meet the demand for goods and services, particularly digital ones, which consume large amounts of energy, as well as the need for mobility. To achieve this, biomass is used extensively, in particular waste for methanisation and wood for energy. Thanks to the resources available, pyrogasification plays an important role in this scenario.* » (Deepl Translation)

[63] ADEME (2022), Prospective - Transitions 2050

[64] Final energy consumption is expected to rise to 1,360 TWh and emissions to 1 Mt CO_2eq.

[65] For the first scenario, the radical changes in behaviour may pose a risk to its social acceptance; for the second, the technologies that make it viable (in terms of CO_2 capture and storage) are not at a stage of development that would allow them to be deployed in the short term.

[66] The Shift Project (2020), Déployer la sobriété numérique

[67] Ibidem

[68] Villalba, B. (2016). Sobriété : ce que les pauvres ont à nous dire. Revue Projet, 350, 39-49.

[69] Semal, L., Szuba, M. & Villalba, B. (2014). « Sobriétés » (2010-2013) : une recherche interdisciplinaire sur l'institutionnalisation de politiques locales de sobriété énergétique. Natures Sciences Sociétés, 22, 351-358.

[70] Villalba, B. (2016). Sobriété : ce que les pauvres ont à nous dire. Revue Projet, 350, 39-49.

[71] See the abundant literature in Policy Studies and, more particularly, the Anglo-Saxon and Francophone variants on public policy instruments. See, for example, Hood and Margetts (2007).

[72] Proposition de loi visant à réduire l'empreinte environnementale du numérique n° 2021-1485 du 15 novembre 2021), parue au JO n° 266 du 16 novembre 2021 http://www.senat.fr/dossier-legislatif/ppl20-027.html

[73] J. Laïnae et N. Alep (2020), «Contre l'alternumerisme : pourquoi nous ne vous proposerons pas d'écogestes numériques ni de solutions pour penser une démocratie numérique »

[74] ARCEP (2020), Pour un numérique soutenable

[75] EcoInfo CNRS par F. Berthoud (2019), Eco-conception https://ecoinfo.cnrs.fr/2019/02/19/eco-conception/

[76] G. Roussilhe (2022), Explications sur l'empreinte carbone du streaming et du transfert de données

[77] JP Nicolaï, L. Peragin (2022), Revue de l'OFCE, 176 : Les certificats de sobriété numérique comme instrument de régulation de la pollution numérique

[78] Bordage, F., de Montenay, L., Benqassem, S., Delmas Orgelet, J., Domon, F., Prunel, D., Vateau, C. et Lees Perasso, E. GreenIT.fr. (2021). Au-delà des chiffres : Comprendre les impacts environnementaux du numérique et agir

[79] Chemins de transition (2022). Comment faire converger la transition numérique et la transition écologique au Québec dans un horizon de 20 ans ? Rapport final du défi numérique

[80] Petit, V. (2017). Transition écologique et numérique. Vers des territoires communs? Revue d'Économie Régionale & Urbaine, 797-818

[81] E. Caccamo, https://polemos-decroissance.org/ (2020), Société post-croissance et technologies numériques

[82] N. Alep, extraite du n°1 de la revue Permanences critiques : Quelques pistes de réflexion pour une décroissance numérique

[83] L'Echo (03/05/2022) : Le numérique pourrait réduire les émissions belges de CO2 de 10%, selon Agoria

[84] RTBF (03/05/2022) : Au moins 10% de baisse des émissions CO2 en 2030 grâce au digital, selon une étude d'Agoria

[85] Joachim Schöpfel (2015), « Littérature « grise » : de l'ombre à la lumière »

[86] Association Française pour l'Information Scientifique (2014), Comprendre le système de publication scientifique

[87] Journal Nice-Matin, (06/11/2021), L'aéroport de Nice peut-il être neutre en carbone? : "*De fait, un aéroport pollue. Parce qu'il y a du trafic aérien, des activités aéroportuaires et des activités mobiles. Mais la plupart des groupes aéroportuaires ne prennent pas toutes ces sources en compte quand ils font l'inventaire de leurs émissions*"

[88] Pirson et Bol (2021), Assessing the embodied carbon footprint of IoT edge devices with a bottom-up life-cycle approach

[89] Commission européenne (2013), 2013/179/UE : Recommandation de la commission du 9 avril 2013 relative à l'utilisation de méthodes communes pour mesurer et indiquer la performance environnementale des produits et des organisations sur l'ensemble du cycle de vie

[90] In 2009, an international team of 17 researchers defined 9 planetary limits: these are the thresholds that humanity should not exceed in order not to compromise the favourable conditions in which it has been able to develop and to be able to live sustainably in a safe ecosystem. At present, 6 of the 9 limits have already been crossed.

[91] Bordage, F., de Montenay, L., Benqassem, S., Delmas-Orgelet, J., Domon, F., Prunel, D., Vateau, C. and Lees Perasso, E. GreenIT.fr. (2021), Digital technologies in Europe: an environmental life cycle approach.

[92] Ibidem, p10 : "*We observe an inversion of "trends" between the most impactful environmental indicators for ICT, climate change and resource use (minerals and metals). This shows that climate change cannot be effectively mitigated without at the same time addressing the other environmental issues related to an activity such as ICT. This is to be understood in the light of technology resource dependency: each specific non-renewable resource used can become a separate issue in its own right in the case of a flow shortage or if a material becomes scarce*"

[93] Hilty, L. M. (2008). Environmental impact of ICT-A conceptual framework and some strategic recommendations. OECD workshop on ICT and environmental challenges Copenhagen; Hilty, L. M., & Aebischer, B. (2015). Ict for sustainability: An emerging research field. In ICT Innovations for Sustainability (pp. 3-36). Springer International Publishing.

[94] Agence du Numérique & Digital Wallonia (2022) : Impacts environnementaux et climatiques des outils numériques

[95] EcoInfo CNRS (2016), Effets rebond du numérique

[96] Ibid.

[97] Ibid. : « *For example, in the case of teleshopping, teleworking and teleconferencing, a significant proportion of the travel savings are cancelled out by the increase in non-work trips to do the shopping or accompany family members on leisure trips. Falch (2012) shows, for example, that Denmark has the highest rebound effect from teleworking (73%). In this country, teleworking has reduced motorised home-work journeys by 105 km per week. At the same time, however, it has resulted in 77 km of personal travel, which partly cancels out the kilometres saved by teleworking, giving a rebound effect of 73% (77 km/105 km).* » (Deepl Translation)

[98] Gossart (2016), Rebound effects and ICT : a review of the literature : "*Indirect rebound effects have also been observed for ICT services aimed at reducing transport. For example, in the case of teleshopping, teleworking and teleconferencing, 'a substantial part of the transport savings is cancelled out by increased transport for other purposes such as shopping and increased transport by other family members' (...) In the field of e-learning, Herring and Roy studied the environmental impacts of three higher education systems [39]. They concluded that 'e-learning does not lead to a reduction in energy or CO_2 emissions compared to paper-based distance learning, due to rebound effects such as computer use and home heating'. (ibid., p. 525) As for Caird et al, their study of 30 higher education courses in on-campus and distance learning systems at 15 UK institutions revealed that, despite rebound effects, online teaching led to dematerialisation*"(Deepl Translation)

[99] EcoInfo CNRS (2016), Effets rebond du numérique

[100] Agence du Numérique & Digital Wallonia (2022), p16, Impacts environnementaux et climatiques des outils numériques

[101] La Libre Belgique (03/05/2022), Relever le défi de la neutralité carbone grâce au digital, est-ce réaliste ? "On n'échappera pas à une forme de sobriété digitale... et elle n'arrivera pas spontanément"

[102] Accenture also contributed to the GeSI SMARTer2020 and 2030 reports, as well as https://5gclimate.ctia.org/ This may explain why all these reports point in the same direction: they are produced by the same people, using the same methodology and the same data..

[103] Agoria (2023), "D'ici 2030, 15 technologies numériques réduiront les émissions de CO2 de 5 fois le total des émissions du numérique"

[104] Ibid.

[105] Ibid.

[106] D. Meadows, D. Meadows, J. Randers, W. Behrens III (MIT) (1972), Les Limites à la croissance (The Limits to Growth)

[107] Registre de Transparence Européen : https://ec.europa.eu/transparencyregister/public/consultation/search.do

[108] Les études sont disponibles en libre accès sur le site web des commanditaires référencés.

[109] Status d'Agoria : https://www.agoria.be/system/files/documents/2021-01/status-et-reglement-d-ordre-interieur.pdf

[110] Agoria (2022), *Digital4Climate* - Study about the contribution of digital technologies to reduce carbon emissions in Belgium

"*The central intention of the study is to answer the question of whether digital technologies, in addition to other key levers, can make a relevant contribution to achieving the Belgian cli-mate goals by 2030. To this end, a quantitative model of the incremental carbon abatement of digital technologies by 2030 was contrasted with the projected carbon emissions of digital technologies in 2030*". (p.9)

[111] Ibid. : "*The objective of this report is to derive meaningful insights and recommendations for a broad range of stakeholders related to the contribution of digital technologies in view of GHG emissions. Additional environmental impacts, related to water use, waste generation, resource depletion, etc., have been left out of the analysis to reduce the complexity and associated uncertainty of the forecasting model. Recent endeavours to consider impacts across the whole range of planetary boundaries, as done by Benqassem et al. (2021), are for sure much needed and future forecasting should consider multi-criteria analysis to the fullest extent*" (p. 61)

[112] Ibid. : "*The calculation methodology takes into consideration the end user & IoT devices, the networks and the data centres in their whole life cycle*" (p. 16)

[113] Ibid. : "*End user and IoT devices covered in this study focus on ICT- and IoT-related devices, and hence exclude entertainment devices, such as TVs and gaming consoles*" (p.16)

[114] Ibid. : "*The overall calculation approach builds on the data provided by the recent study by Benqassem et al. (2021). The reason for this is twofold: first, it is a comprehensive study and encompasses all life cycle stages and granular data on a wide range of devices, networks and data centres. Second, for the purpose of this report, its focus on the European Union is considered more relevant than related studies at the global level. This report, therefore, leverages the Benqassem et al. (2021) study to derive the GHG footprint of a subset of digital technologies in Belgium for 2019, as the basis for the subsequent forecasting until 2030*". (p.75)

[115] Ibid. : "*There is no quantification of the rebound effects based on the study results, as the literature base is very heterogeneous, and no reliable calculation was possible for each application*" (p.74).

[116] Ibid. "*This methodology is based on the widely recognised GeSI studies (e.g. Smarter 2030). Estimations of all values were based on secondary research from generally recognised sources (+200 sources) and validated by at least three independent experts for each sector*" (p.11).

[117] Scenario in which no or very few measures are taken to reduce greenhouse gas emissions.

[118] Ibibid. "*For buildings, manufacturing and mobility & logistics, 2019 baselines were projected to 2030 based on the appropriate WEM scenarios of the National Energy and Climate Plan (NECP). For energy, 2030 emissions were based on Elia forecasts for electricity demand and carbon intensity, adjusted recently with new commitments by the Belgian Government around nuclear and offshore wind*" (p.13).

[119] Ibid. "*The estimated 2030 emissions that can be addressed by a use case lever will be calculated from the 2019"*

European Environment Agency (EEA) data which is projected to 2030 based on the industry forecasts or the With Existing Measures (WEM) scenario of the National Energy and Climate Plan (NECP)" (p.11).

[120] Ibid. "*It is important to note that the baseline emissions used in the quantitative model are higher than the volumes that will be achieved in 2030 if the measures in the NECP are effectively implemented. As the WEM scenario includes less carbon reducing efforts than the With Applied Measures (WAM, also from the NECP) scenario, it is a better basis for estimating the carbon reduction effect of digital technologies. Specifically, this avoids double counting the reduction effect of digital as much as possible, as the additional carbon reduction efforts in the WAM scenario implicitly include some digital impact. As such, not all new reduction measures for direct emissions were included in the 2030 scenario (e.g. use of renewable energy)*" (p.13)

[121] "Estimations of all values were based on secondary research from generally recognised sources (+200 sources) and validated by at least three independent experts for each sector" (p.11).

[122] A proxy is a kind of indirect indicator. It is a variable which is not directly relevant but which replaces a variable which is not observable or for which no data is available.

[123] www.itu.int/en/mediacentre/Pages/PR04-2020-ICT-industry-to-reduce-greenhouse-gas-emissions-by-45-percent-by-2030.aspx; www.itu.int/ITU-T/recommendations/rec.aspx?rec=14084; www.itu.int/en/action/environment-and-climate-change/Documents/20200227-Guidance-ICT-companies-report.PDF; www.gsma.com/betterfuture/climate-company-guidance

[124] Ibid. : "*In this study, the carbon abatement effect of digital technologies is calculated from a use case perspective, rather than a technology perspective*". (p.10).

[125] Ibid. : "*In this context, a use case is defined as a practical application of one or more digital technologies that enables a reduction in CO_2e emissions in a particular business or process (e.g. smart homes)*" (p.10).

[126] Ibid. "*The use cases that served as the basis for carbon abatement calculations were selected from four key sectors: manufacturing, mobility & logistics, energy and buildings*". (p.11).

[127] AlterNumeris (2021), La 5G Au-delà du 'Pour ou Contre' - www.alternumeris.org/la-5g-au-dela-du-pour-ou-contre/

[128] Miguel Coma (2021) , 5G La Nouvelle Utopie

[129] The Shift Project (2021), Impact Environnemental du Numérique : Tendances à 5 Ans et Gouvernance de la 5G

[130] Agence du Numérique & Digital Wallonia (2022) : Impacts environnementaux et climatiques des outils numériques

[131] G. Roussilhe (2021), Que peut le numérique pour la transition écologique ? État des lieux de l'empreinte écologique du numérique et étude de ses impacts positifs annoncés pour la transition

[132] Rasoldier, A., Combaz, J., Girault, A., Marquet, K., Quinton, S. (2022), How realistic are claims about the benefits of using digital technologies for GHG emissions mitigation?

[133] Vlad C Coroamă, Pernilla Bergmark, Mattias Höjer and Jens Malmodin (2020), A Methodology for Assessing the Environmental Effects Induced by ICT Services – Part I: Single Services.

[134] Roussilhe, Ligozat et Quinton (2023), A review of the state of knowledge of the environmental effects of digitization

[135] Auteurs : Yasmine Aiouch (Deloitte), Augustin Chanoine (Deloitte), Léo Corbet (Deloitte), Pierrick Drapeau (Deloitte), Louis Ollion (Deloitte), Valentine Vigneron (Deloitte), avec les contributions de Caroline Vateau (APL-datacenter), Etienne Lees Perasso (Bureau Veritas), Julie Orgelet (DDemain), Frédéric Bordage (GreenIT.fr) et Prune Esquerre (IDATE) (2022), Évaluation de l'impact environnemental du numérique en France et analyse prospective, Etat des lieux et pistes d'actions.

[136] ISO 14040: standard specifying the principles and framework for carrying out life cycle analyses.

[137] ISO 14044: standard specifying the requirements and providing guidelines for carrying out life cycle assessments.

[138] *> Le rapport Digital4Climate a été présentée devant la ministre Tinne Van der Straeten d'après les déclarations d'Agoria*
> La réponse de Willy Borsu à propos de Digital4Climate au Parlement de Wallonie, le 09/06/22 https://www.parlement-wallonie.be/pwpages?p=interp-questions-voir&type=28&iddoc=112180