



Digital science to contribute to the ecological transition

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I. The materiality of the immaterial

For nearly five years, more and more studies have made us aware of the materiality of digital technologies and their negative impact on the environment. The carbon footprint of digital technologies is far from negligible and, above all, it is growing exponentially: the larger it is, the faster it grows. The digital sector's share of global GHG emissions is estimated at 2 to 4%, according to studies [Freitag]. There are more terminals on the planet than inhabitants, and a data centre opens every week in the world [CCC]. Most of the GHG emissions are produced during the manufacturing process which also consumes a lot of rare metals, with serious consequences on the depletion of resources and pollution. To complete the picture, it is important to underline the strong inequalities between countries regarding digital technology: while rich countries take full advantages of ICT services, poor countries suffer from the pollution generated by the extraction of mineral resources and by the end of life of equipment. While 86% of the population in France are Internet users, only 35% in Ghana, the final resting place for e-waste from all over the world, and 6% in DRC, the world's leading producer of cobalt. The current development of digital technology is not sustainable in many respects!

Environmental footprint estimates are laden with uncertainty and should be considered as orders of magnitude. Awareness of these orders of magnitude can be sufficient to guide political choices or to take relevant legislative resolutions. It should be noted that this is a young science (just over 10 years old) and that it has made immense progress. Today, a standardized methodology (ISO 14040/44) is available: the Life Cycle Assessment (LCA) [Ligozat, Rasoldier]. It includes the environmental impacts (up to 18 indicators) of a product or service throughout its life cycle, from design to end of life, including production, transport and use.

II. The rebound effect: a stone in the backyard of green growth

This phenomenon was first observed in 1865 by the economist W.S. Jevons: coal consumption in England should have decreased due to the improved performance of steam engines, but instead it increased sharply! The efficiency of digital technologies has steadily improved since they emerged in the middle of the last century, but their carbon footprint has steadily increased. For example, the improved energy efficiency of servers is paradoxically followed by greater energy consumption, because of the growing number of servers and calculations.

According to operators' claims, 5G technologies are expected to divide energy consumption

per gigabit transported by a factor of 10 compared to 4G, once they reach maturity by 2025, and then by a factor of 20 by 2030. However, the number of Gbits transported will not remain constant. According to a study [OpenSignal] conducted in six countries, 5G users consume 2.7 times more data than 4G users. Despite a high degree of uncertainty due to many unknowns (actual deployment by operators, adoption by businesses and consumers), the carbon impact of 5G deployment in France could significantly increase the carbon footprint of digital technologies [HCC].

If the rebound effect is economically attractive, it is dramatic from an environmental point of view: part or even all of the environmental benefits obtained through improved technologies are offset by an increase in use [Combaz]. It is a stone in the backyard of green growth. Rebound effects not only concern energy efficiency. Every time a new technology is expected to save time or money, these savings are used to consume more of the same product (direct rebound effect) or another product (indirect rebound effect). Thus, any technological evolution causes induced effects that are difficult to predict and too often ignored. It is however essential to assess these effects if we want to "contribute to the evolution of digital technology by reducing its environmental impacts" [CCC].

III. Assessing the environmental benefits of a digital solution

Conversely, digital technology is considered as a 'formidable lever for the ecological transition and the fight against climate change' [CCC]. The scientific community has shown great dynamism on this subject in fields as varied as transport, construction, manufacturing, agriculture and energy. But it is essential to better evaluate the net environmental benefit of a solution, without forgetting the environmental impact of the solution itself [The Shift Project]. Some solutions may then show little or no environmental benefits if the energy gains in the use phase are offset by the environmental costs due to the manufacturing stage or end of life.

An LCA assessment is essential to decide whether or not to deploy a technology, possibly to regulate its use, and if so, not to delay alternative actions or research. However, such an evaluation is rarely carried out in scientific studies. For example, in the field of AI, the environmental impact assessment is often limited to energy consumption, neglecting the production and end-of-life of the equipment. According to [Ligozat], among 57 articles proposing applications of AI to fields with a strong potential for climate change adaptation or mitigation, half of them do not include any environmental assessment and none of them take into account the impact of machine learning!

Wherever possible, estimates should also take into account induced effects. Such estimates are difficult to conduct and involve uncertainties, but they are possible and instructive as shown by some recent works (see [Ligozat, Rasoldier]) and studies [IEA]. Research must go on! All stakeholders (universities, companies and governments) have a role to play and must collaborate to successfully complete this task.

IV. Low-tech scientific research

As awareness is growing, the idea of sufficiency is making its way. But at present, it is mostly limited to individual actions: keeping your smartphone as long as possible, limiting your video streaming time, etc. Citizens are faced with contradictory instructions: buy more to keep the economy going, consume less to avoid polluting the planet!

Rebound effects have structural causes: the growth policies of governments and companies, business strategies and social, technical and regulatory standards. These causes must be addressed first. On a global scale, the hoped-for decoupling of economic growth from all critical environmental pressures (green growth) did not happen and is unlikely to happen in the future [EEB, EEA, Parrique]. Technology alone will not allow us to continue the 'business as usual' scenario while preserving the planet's vital resources. But it could help us to implement a just and happy sufficiency: living better with less.

The aim of low-tech approaches is to address the needs of society while limiting reliance on technology [Bihouix]. The term 'low-tech' is used for the techniques, technologies, services and know-hows that follow three main principles: usefulness, accessibility and sustainability. 'They provide the keys to answer our needs, while respecting people and the planet' [Low-techs Lab]. They are eco-designed, resilient, sturdy, repairable, recyclable, agile, and functional. All over the world, initiatives are arising and developing, particularly in the South, where sufficiency is an economic reality. Some 823 projects in 87 countries in 12 areas are referenced in the Low-tech Lab database. Academic research is still hesitating to show interest in low technologies and is mostly limited to eco-design. It could become more involved, in partnership with emerging countries or with the very active "third-places", which contribute to the emergence of a new way of life based on collective intelligence and cooperation. Innovation and sufficiency are compatible!

V. Let's take a step back and develop a new imagination

Sufficiency is not an end in itself, but could be the only way to live within the planetary limits and achieve a radically different model of society based on the principles of sustainability. In order to take an active part in the unavoidable transformation of society, scientific research must also be transformed. Researchers need to take a step back and consider the effects of the technologies to which they contribute: the rebound effects but also the social effects. This requires a broader debate on scientific and technical issues, on the governance of scientific activity and on the relationship between scientific research and society [MakeSEnS].

Siloed research cannot cope with environmental issues, which are global and systemic. A common and collective approach must be developed in order to produce the necessary knowledge and build transdisciplinary communities in the long term. These communities should include not only scientists but also economists, historians, sociologists, philosophers, etc. Such spaces of discussion have emerged recently at a national level in France with the Labos1point5 collective and the GDS EcoInfo, for example, and locally within some universities [La fabrique des questions simples, Plan B]. It is essential to promote these spaces for debate, but they must also interact with society as a whole, in order to develop a new collective imagination, which is essential for society's transformation.

References

Journal and conference papers:

[Freitag] The climate impact of ICT: A review of estimates, trends and regulations - Freitag et al, 2021 - https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8441580/

[Combaz] Le numérique dans l'Anthropocène - Combaz & Bol - https://conf-ng.jres.org/2021/document_revision_1598.html?download

[Ligozat] Unraveling the Hidden Environmental Impacts of AI Solutions for Environment - Ligozat & all - https://arxiv.org/abs/2110.11822
[Rasoldier] How realistic are claims about the benefits of using digital technologies for GHG emissions mitigation? Rasoldier & all - https://computingwithinlimits.org/2022/papers/limits22-final-Rasoldier.pdf

Reports and studies:
[CCC] Accompagner l'évolution du numérique pour réduire ses impacts environnementaux - Convention Citoyenne pour le Climat - https://propositions.conventioncitoyennepourleclimat.fr/pdf/pr/ccc-produireettravailler-accompagner-l-evolution-du-numerique-pour-reduire-ses-impacts-environnementaux.pdf
[OpenSignal] Francesco Rizzato - https://www.opensignal.com/2020/10/21/5g-users-on-average-consume-up-to-27x-more-mobile-data-compared-to-4g-users
[HCC] Controlling the Carbon Impact of 5G - Haut Conseil pour le Climat - https://www.hautconseilclimat.fr/wp-content/uploads/2020/12/hcc_rapports_5g-en.pdf
[EEA] Growth without economic growth - European Environment Agency - https://www.eea.europa.eu/publications/growth-without-economic-growth
[The Shift Project] Implementing digital sufficiency - https://theshiftproject.org/en/article/implementing-digital-sufficiency/
[IEA] Digitalisation and energy - IEA - https://www.iea.org/reports/digitalisation-and-energy
[EEB] Decoupling debunked - Evidence and arguments against green growth as a sole strategy for sustainability – European Environmental Bureau - https://eeb.org/wp-content/uploads/2019/07/Decoupling-Debunked-Executive-Summary.pdf
[MakeSEnS] Sciences, Environnements et Sociétés : Rapport long du groupe de travail MakeSEnS d'Inria - https://inria.hal.science/hal-02340948v1
[Plan B] Anthropocène : Plan B, création de connaissances pour répondre aux enjeux sociétaux de manière soutenable dans les limites planétaires - https://hal.inria.fr/hal-03341576/document

Websites:
[EcoInfo] GDS du CNRS - https://ecoinfo.cnrs.fr/le-gds-ecoinfo/
[Labos1point5] https://labos1point5.org/
[Low-techs Lab] https://lowtechlab.org/en
[France Tiers-lieux] https://francetierslieux.fr/
[La fabrique des questions simples] https://ecoleurbainedelyon.universite-lyon.fr/la-fabrique-des-questions-simples-233379.kjsp

Books:
[Bihouix] L'âge des Low-Techs - Philippe Bihouix
[Laurent] Sortir de la croissance - Éloi Laurent
[Parrique] Ralentir ou périr - Thimothée Parrique