

PhD Thesis: Modeling of sustainable ICT and AI sectors with respect to environmental limits

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Title: Modeling of sustainable ICT and AI sectors with respect to environmental limits

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Scientific Research context

The ICT sector is credited to be responsible for about 2 to 4 % of the worldwide Greenhouse Gaz (GHG) emissions [1], a number which is still quickly rising. Such a level is incompatible with Paris agreement to contain global warming below 2°C by 2100. In this context, the question whether the ICT sector should be more regulated is raising in some governmental instances^[1]. If so, which kind of measures could have a real impact? More generally, what could be a sustainable ICT sector in a constrained world?

On the usage side, several studies strive to address this issue through question like: "What is the GHG footprint of X?", with X as "one hour of video streaming", "one email", "storing 100 photos", etc. Because of the non proportionality between such use case units and the underlying physical reality, the answers to those questions is highly misleading and unsuitable to drive user, industry and policymaker choices.

The incredibly rapid raise of AI everywhere is especially concerning. However, in this domain most of current approaches consider only the electricity consumption of the hardware used during the training phase, while ignoring their production, and more importantly, ignoring all systemic concerns [2] such as: unlimited growth, purposes of the end products, rebound-effects, etc. Such blind spots lead to a pure search of power efficiency without any systemic vision of the positive versus negative impacts [3,4].

Work description

Rather than starting from the usages, through this thesis we aim to explore a counter-current approach consisting in starting from worldwide limits to get to the final usages. More precisely, the general goal is to design parametric models quantifying what would be the amount of available ICT resources as a function of several adjustable hypothesis and various environmental constraints (e.g., a GHG budget, resource depletion, energy consumption, etc.). For instance, the kind of questions that will be addressed would be: given a GHG budget for the ICT sector, what infrastructures and terminals can be produced and used? Under which recycling conditions? Once this environmental budget converted to a hardware budget, we can get back to final usages with questions such as: which room for AI? for video streaming? video-conferencing? cloud storage? etc.

Modeling the ICT ecosystem as a whole is an ambitious task whose complexity is exacerbated by feedback loops and by the temporal dimension through technological breakthrough making the system both dynamic and non linear. As a starting point we thus plane to focus on the AI sub-sector targeted towards climate change mitigation and adaptation purposes [4]. The holistic and systemic approach proposed in this thesis is thus complementary to other researches towards frugal AI and will help to question the compatibility of AI with a sustainable world, while providing scenarios for the future of this domain.

Beyond the model itself, through this thesis we will also put an emphasis on its implementation and interface for the exploration of hypotheses and scenarios, for instance taking *multiverse documents* as inspiration [5].

We hope the developed models and tools will help decision making entities to get in line with Paris agreements. We also envision them to be particularly appealing as pedagogical tools to raise awareness and teach about the environmental impact of AI and the ICT sector in general.

Does this subject fits with one of the French PEPR

Not directly, but the proposed subject could contribute to all PEPR for which the question of the environmental footprint of ICT is highly relevant, e.g. : "Intelligence artificielle", "Enseignement et numérique", "Agroécologie et numérique", etc.

Required Knowledge and background

Basic skills in programming and AI, knowledge in the ICT infrastructures, concerned by the environmental crises, curiosity, critical mind.

References

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Duration & start date

36 months, starting October 1st 2022.

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1. See for instance the [REEN](https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000044327272) (<https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000044327272>) law initiated by the French Senate, or the [IPCC AR6 group 3 report](https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_SummaryForPolicymakers.pdf) (https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_SummaryForPolicymakers.pdf): "Digital technology supports decarbonisation only if appropriately governed (high confidence)". ↩