Maël Madon's Research Statement

I am a researcher in computer science with a strong interest in understanding, modeling and addressing the **environmental impact of Information and Communication Technologies (ICT)** and in particular of **data centers**. My research mixes methods from the field of distributed systems (software development, simulations, statistical analysis) with methods from qualitative research (interviews, thematic analysis) and environmental sciences (Life Cycle Assessment (LCA)). My passion in this field started during my postgraduate studies at Ecole Polytechnique (Paris, France) as I was learning more about the climate crisis and its associated challenges. This challenged my view on ICT: are they part of the problem, or of the solution? From that point on, I directed my academic path into the simultaneously emerging field of ICT and sustainability.

Past research. My first research experience was during my master degree when I joined Jean-Marc Pierson's lab (Toulouse, France) for an internship in the [Datazero](#) project in 2019. I developed a Python simulation and Mixed Integer Linear Programming formulation of the electric and thermal components of a data center. Thereby, I investigated the potential of pre-cooling the infrastructure in anticipation of a shortage in renewable energy supply [1].
In 2021, I conducted my master's thesis research with Pernilla Bergmark and Jens Malmodin from the company Ericsson (Stockholm, Sweden), one of the first institutions to publish studies on environmental impacts of digital technologies. I built a parametrized tool based on LCA results to streamline the carbon footprint assessment of telecommunication base stations [2]. My tool was the first of its kind and successfully adopted by the company as well as generating strong interest among industrials and academics.

Thesis work. In 2021, I was awarded a full PhD scholarship from Ecole Polytechnique and returned to Toulouse to work with Georges Da Costa and Jean-Marc Pierson. My knowledge of the field allowed me to arrive at the conclusion that improvements in *efficiency* of a digital technology (like data centers) are followed in most cases by a growth in usage, canceling out any potential savings. As a result, I focused my PhD on *sufficiency* [3], which measures environmental impacts in absolute rather than in relative terms. This led me to explore the practical use of data centers, and therefore their users. Digital sufficiency is a rather new concept, and my dissertation constitutes the first consideration of data centers' environmental impacts through that angle. Three remarkable outcomes of my PhD work comprise:

1. The development of the software [Batmen](#) (license GNU LGPLv3), allowing the simulation of users of large-scale distributed systems. Batmen is a plugin to the scientific simulator [Batsim](#) and was used for all the simulation work of my thesis [4-6].
2. An in-depth study of how to correctly model users' behaviors when evaluating the performance of distributed systems [5]. My PhD jury praised its novelty and potential to fundamentally change the way research is conducted in the field.
3. A multidisciplinary contribution, using methods from the social sciences (group interviews, transcriptions and thematic analysis) to explore the concept of digital sufficiency among indirect users of distributed systems (in this case, cloud users) [7]. This work was carried out during a research visit at Vrije Universiteit Amsterdam in Patricia Lago's team.

Latest works. After my PhD and before taking a gap year for traveling and volunteering in South America, I was involved in several projects, still unpublished.

1. A large experimental campaign on a research cluster to study MPI malleability in a realistic scenario, with a software brick simulating user behavior (in collaboration with the Barcelona Supercomputing Center).
2. Work on the middleware and input data in the project Datazero2 (PI: Jean-Marc Pierson).
3. Coordination of the Labo1point5 "Cœur de métier - Informatique" working group: series of interviews exploring what ICT research should focus on in a more sustainable world.

References

[1] Madon, M, & Pierson, J. M. (2020) Integrating Pre-Cooling of Data Center Operated with Renewable Energies. In: 2020 IEEE Green Computing and Communications (GreenCom).

[2] Madon, M. (2021) Developing a Parameterized Embodied Emissions Calculator for telecommunication networks equipment (PEEC) (Master's thesis). KTH Royal Institute of Technology, Stockholm.

[3] Santarius, T., Bieser, J.C.T., Frick, V. *et al.* (2023) Digital sufficiency: conceptual considerations for ICTs on a finite planet. *Ann. Telecommun.*

[4] Madon, M., Da Costa, G., & Pierson, J. M. (2022). Characterization of different user behaviors for demand response in data centers. In *European Conference on Parallel Processing*.

[5] Madon, M., Da Costa, G., & Pierson, J. M. (2024). Replay with Feedback: How does the performance of HPC system impact user submission behavior? In *Future Generation Computer Systems*.

[6] Gatt, J., Madon, M., & Da Costa, G. (2024). Digital sufficiency behaviors to deal with intermittent energy sources in a data center. In *2024 International Conference on ICT for Sustainability (ICT4S)*

[7] Madon, M., & Lago, P. (2023) "We are Always on, is That Really Necessary?" Exploring the Path to Digital Sufficiency in Flexible Work. In *2023 International Conference on ICT for Sustainability (ICT4S)*