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Institut de Recherche en Informatique de Toulouse





Digital Sufficiency in Data Centers

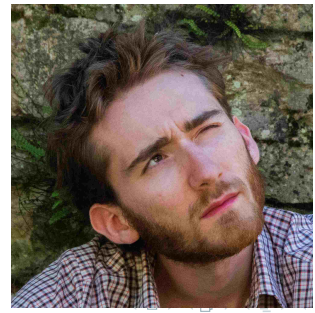
Maël Madon

ROADEF'24 @ Amiens

March 7, 2024

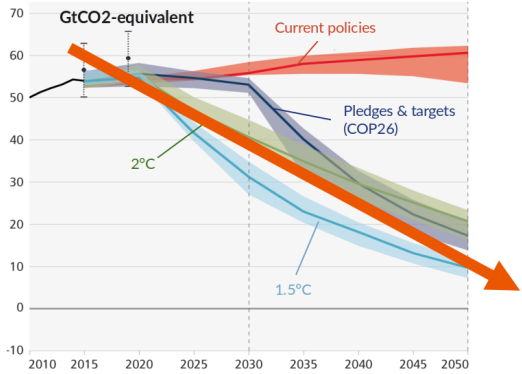
About me

- Maël Madon, 2nd year PhD student
- SEPIA team at IRIT (Toulouse)
- Supervisors: Georges Da Costa and Jean-Marc Pierson



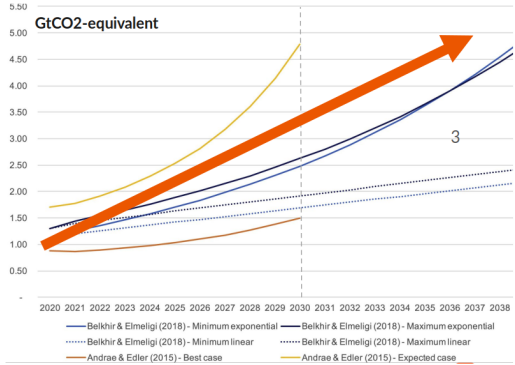
Context: growing greenhouse gases emissions

What we need to do:



Source: Valérie Masson-Delmotte, data from IPCC

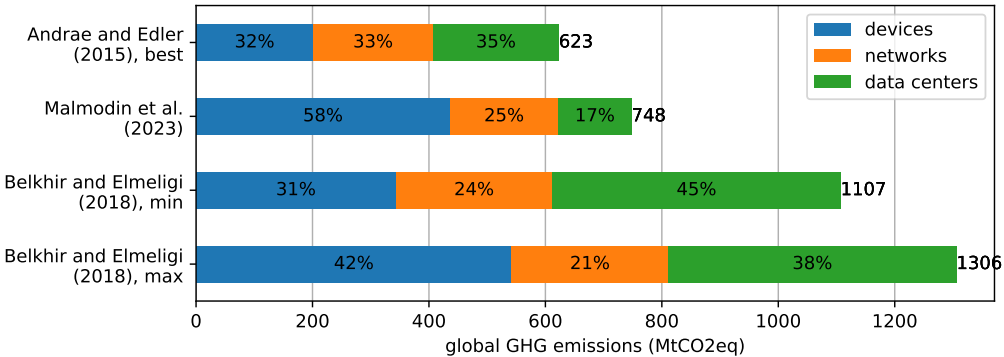
ICT industry =
2–4% global emissions



Source: Freitag et al. 2021

Where do ICT emissions come from?

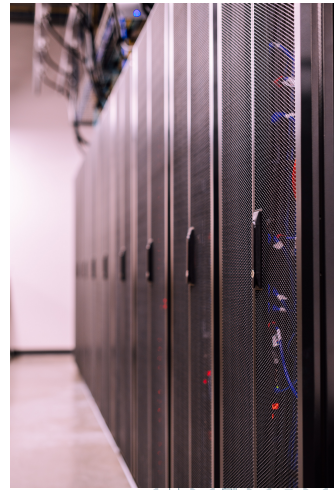
Global GHG emission estimates for ICT industry in 2020:



Footprint reduction in data center

Traditional techniques:

- **Energy efficiency** (virtualization, workload consolidation, DVFS...)
- **Use of renewable energies** (workload adaptation to power envelope, geographic load shifting, ...)
- **Data center environment** (cooling management, waste heat utilization, use of batteries)



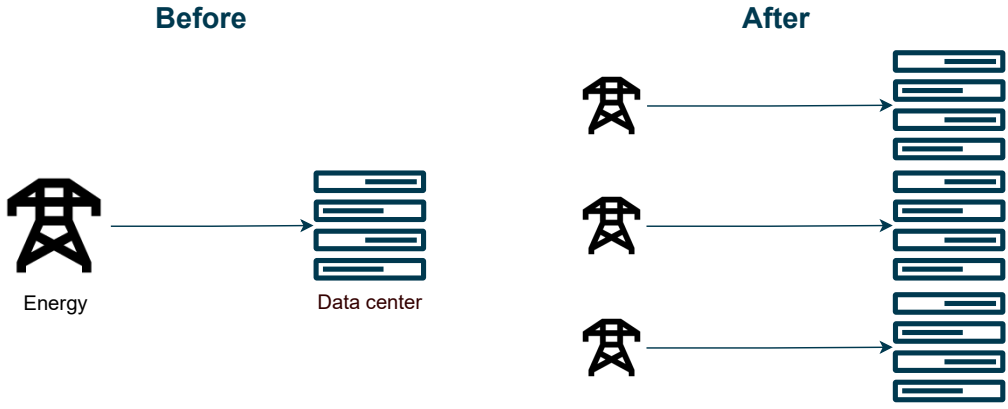
www.pexels.com

Efficiency techniques

Before

After

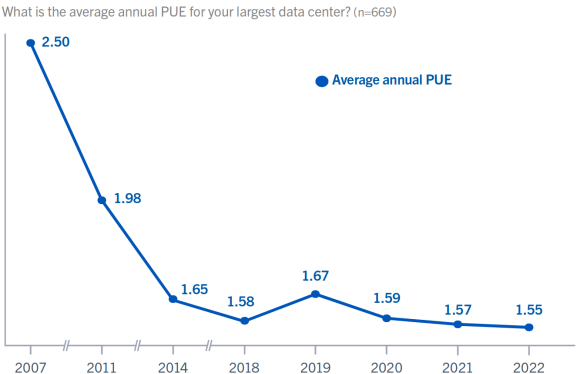
Rebound effect?



Data center = 1
Energy = 2

Data center = 3
Energy = 3

Rebound effect



Source: Uptime Institute Global Data Center Survey 2022

Global trends in digital and energy indicators, 2015-2022

	2015	2022	Change
Internet users	3 billion	5.3 billion	+78%
Internet traffic	0.6 ZB	4.4 ZB	+600%
Data centre workloads	180 million	800 million	+340%
Data centre energy use (excluding crypto)	200 TWh	240-340 TWh	+20-70%
Crypto mining energy use	4 TWh	100-150 TWh	+2300-3500%
Data transmission network energy use	220 TWh	260-360 TWh	+18-64%

Source: International Energy Agency

Sufficiency

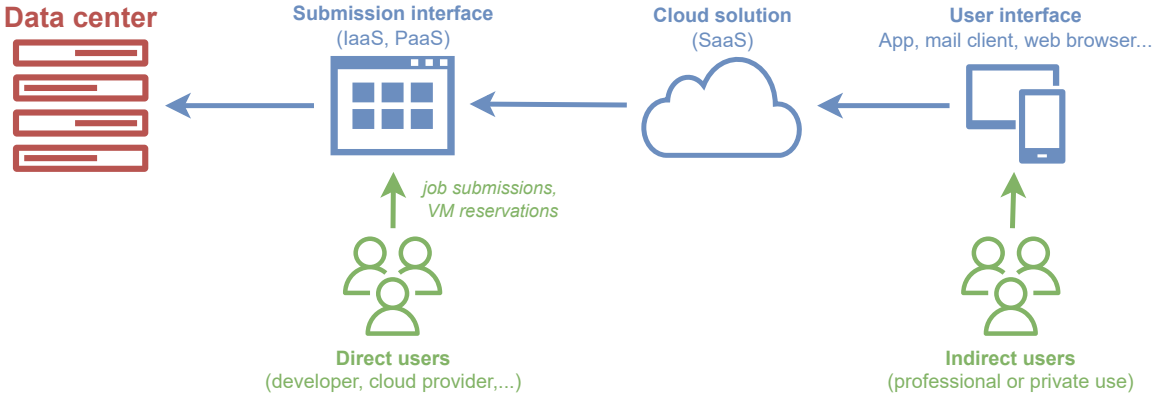
- Efficiency is not enough: **sufficiency**

Sufficiency policies (IPCC, 2022)

A set of measures and daily practices that **avoid demand** for energy, materials, land and water **while delivering human well-being** for all within planetary boundaries.

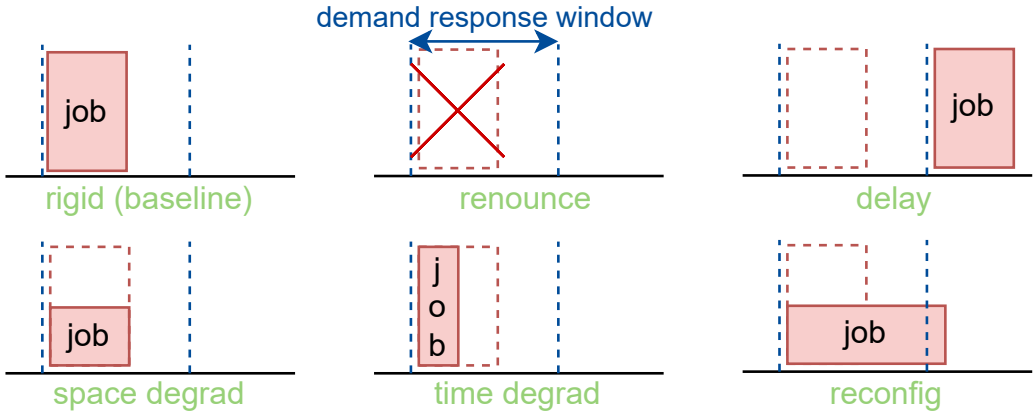
- **What would "sufficiency" mean for data centers?**
  => voluntary limitation, empower and involve the user

Data center user?



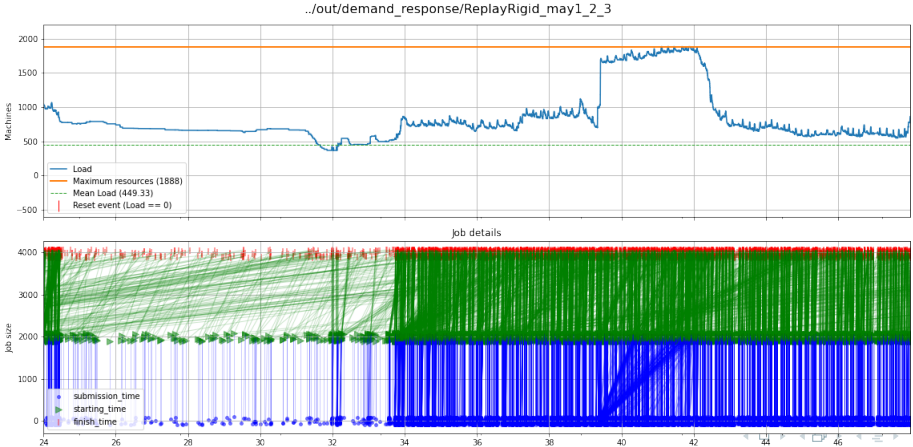
(cloud context)

“Sufficiency behaviors” for direct data center users



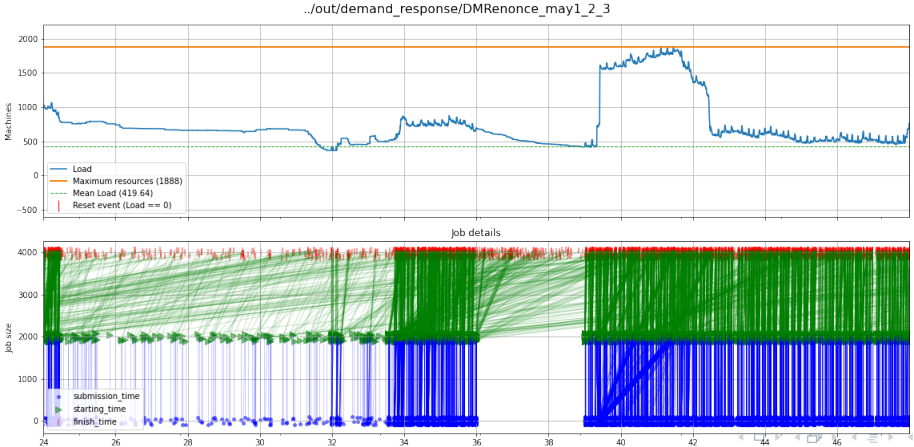
Output

- Behavior during demand response window: **rigid**



Output

- Behavior during demand response window: **renounce**



Output

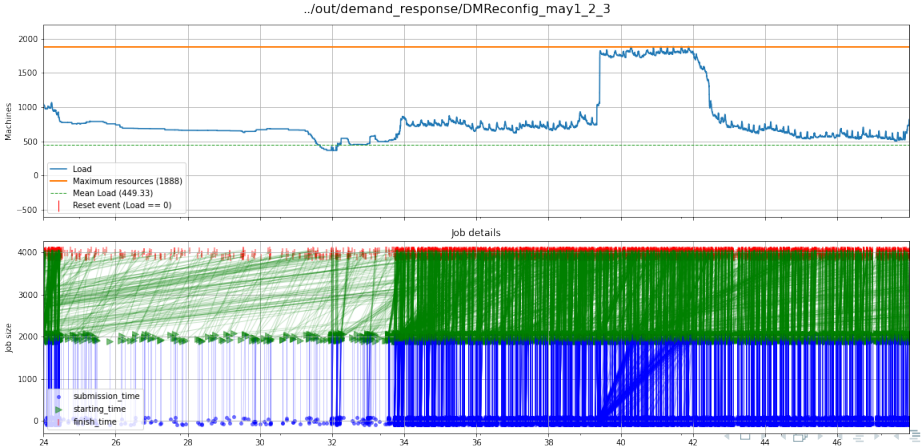
- Behavior during demand response window: **delay**

Output

- Behavior during demand response window: **degrad**

Output

- Behavior during demand response window: **reconfig**



Results

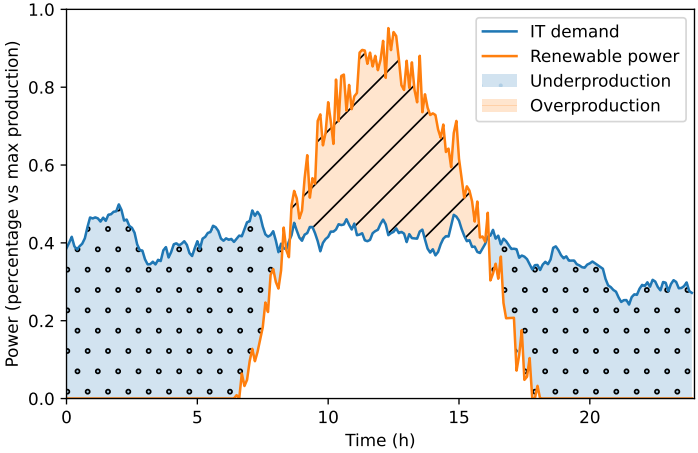
- Pros and cons of each behavior:

behavior	energy in	energy overall	sched. metrics	"acceptability"
renounce	1st	1st	1st	5th
delay	1st	5th	5th	2nd
space degrad	3rd	3rd	2nd	3rd
reconfig	3rd	4th	4th	1st
time degrad	5th	2nd	2nd	3rd

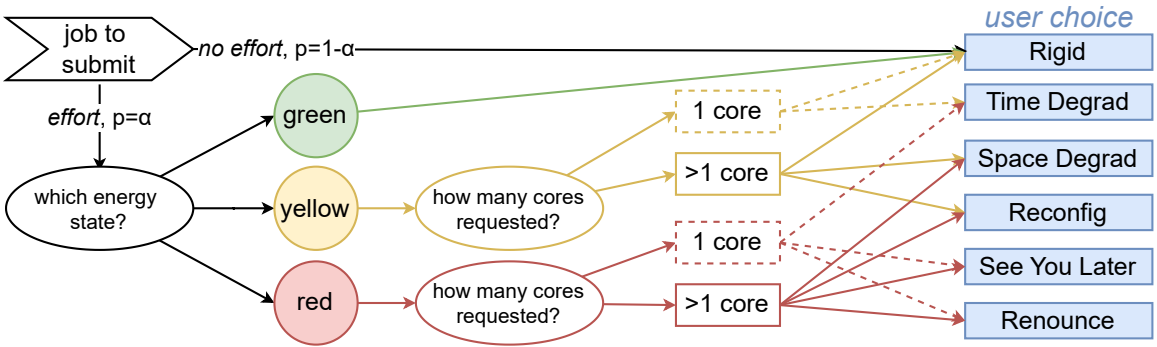
- All the details in the article[1]
- Open-source software and reproducible experiments: gitlab.irit.fr/sepia-pub/open-science/demand-response-user

[1] M. Madon, G. Da Costa, and J.-M. Pierson, "*Characterization of Different User Behaviors for Demand Response in Data Centers*," in Euro-Par 2022, doi: 10.1007/978-3-031-12597-3_4

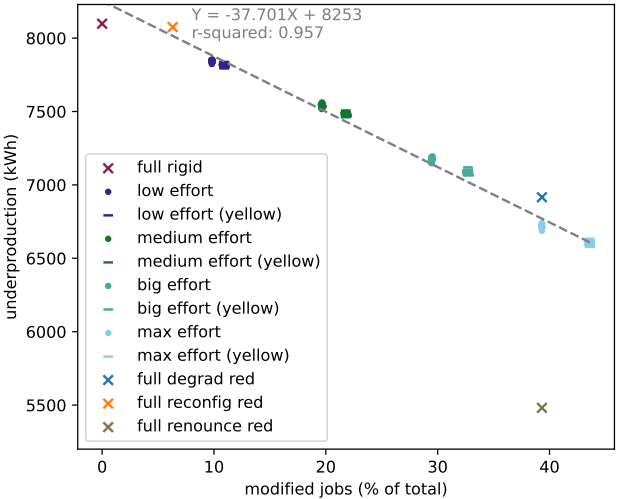
Sufficiency behaviors in a renewable context



Sufficiency behaviors in a renewable context

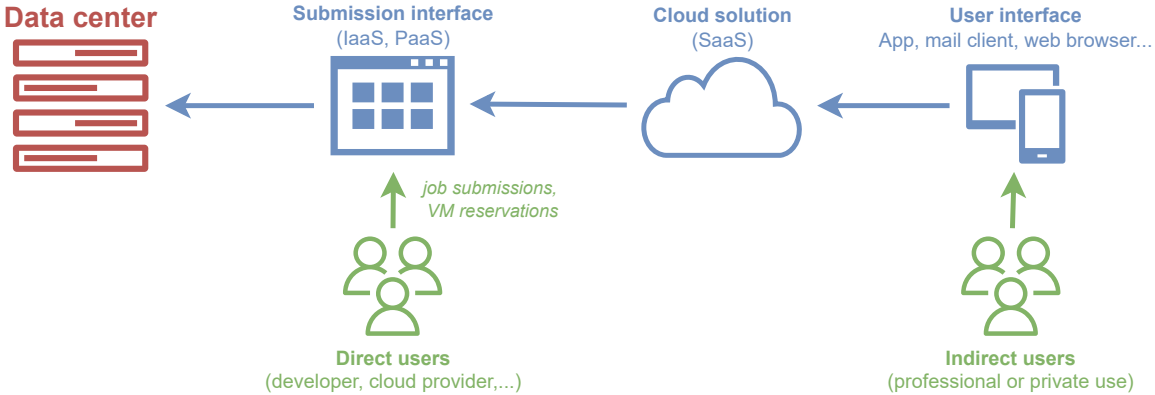


Results



- Article in review:
  J. Gatt, M. Madon, and G. Da Costa,
  "Digital sufficiency behaviors to deal with intermittent energy sources in data center."

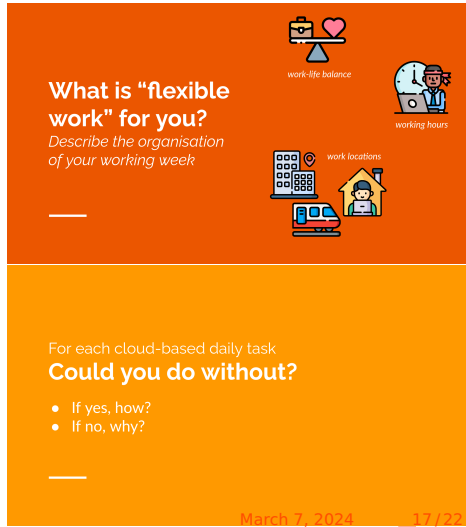
Data center user?



(cloud context)

Digital Sufficiency in Flexible Work

- **Study goal:** Re-design the use of cloud services for flexible working towards sufficiency
- How much digital interventions are *necessary* and how much is *superfluous*?
- **Method:** Focus groups within companies



Qualitative research method

- **Data collection:**
  - 3 focus groups (Netherlands)
  - 2 companies (small IT company / large consulting firm)
  - 11 participants (consultants, developers, HR, ...)

- **Data analysis:**

Video-recording (5h)

↓

Transcripts (67 pages)

↓

Open coding (248 codes)

↓

Thematic analysis (12 main themes)

↓

Codebook

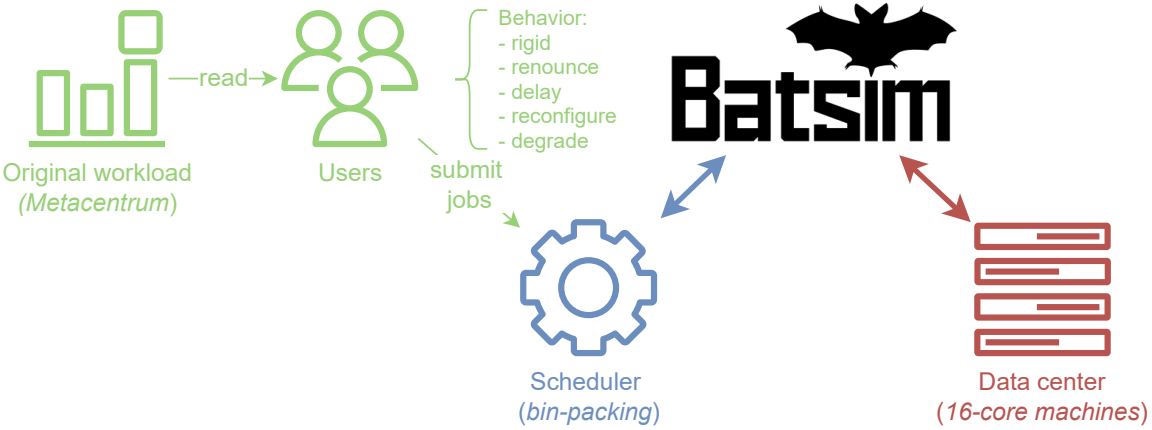
Conclusion

- Going beyond *efficiency*, investigating *sufficiency* for data centers
  - through **simulation** and **qualitative research** methods
- the link between the two works is quite distant
  - simulation: user HPC, direct actor
  - qualitative study: user SaaS, does she have the *agency*?

- Come to my **PhD defense: April 30, 14:00** !!
- Do not hesitate to contact me :-):
  - www.irit.fr/~Mael.Madon
  - mael.madon@irit.fr

Extra slides

The simulated system



Fluid and residual mass