Digital sufficiency behaviors to deal with intermittent energy sources in data center

GreenDays2024 @ Toulouse

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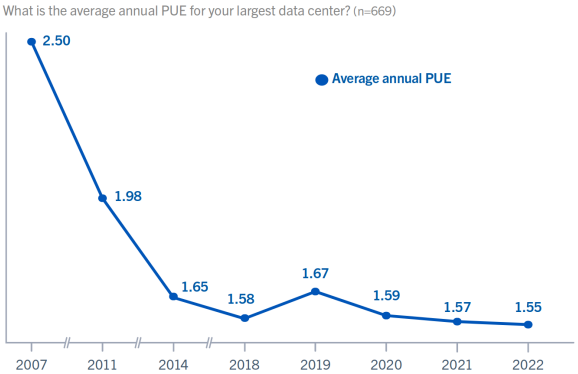
Introduction: rebound effect



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

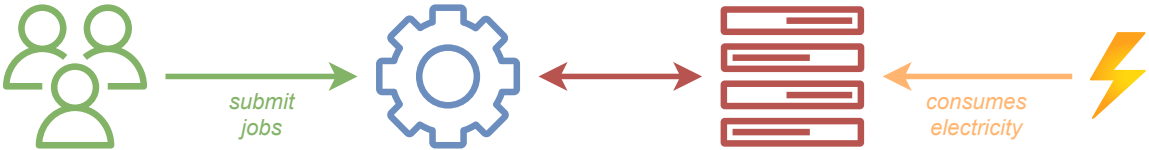
- Efficiency is not enough: **sufficiency**

Sufficiency policies (IPCC, 2022)

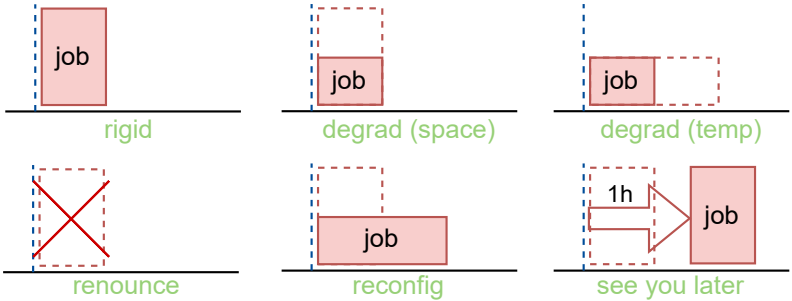
A set of measures and daily practices that **avoid demand** for energy, materials, land and water **while delivering human well-being** for all within planetary boundaries.

- **What would "sufficiency" mean for data centers?**
  $\rightarrow$ voluntary limitation, empower and involve the user

Data center model



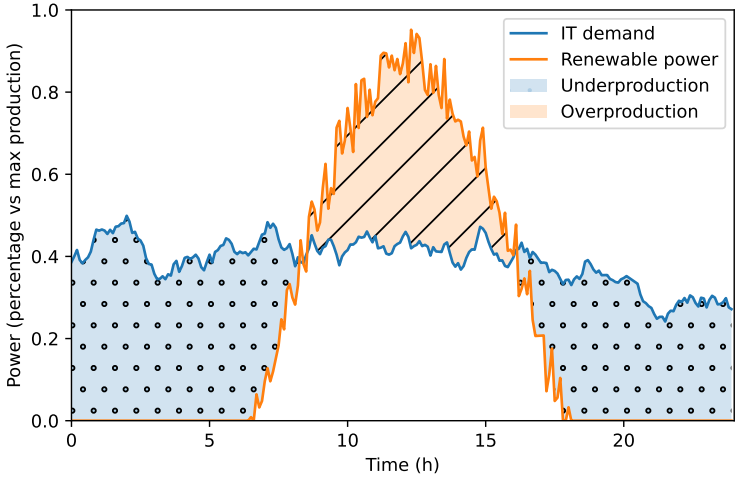
Sufficiency behaviors



- job final state $= n \times see\_you\_later + b$
- $b \in \{$ rigid, degrad (space), degrad (temp), renounce, reconfig $\}$

Renewable energy production

- Solar panels:



3-state energy model

- 3-color state for energy production:
  - green state: everything is fine (production $\geq 100\%$ max conso)
  - yellow state: some disturbance (production $\geq 50\%$ max conso)
  - red state: system critical (production $< 50\%$ max conso).

3-state energy model

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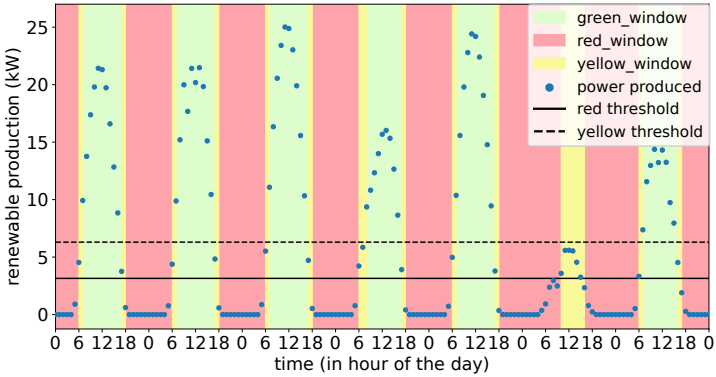
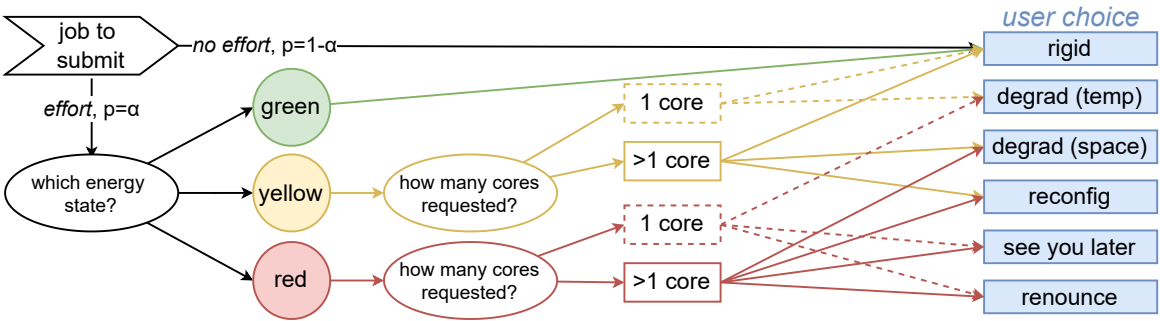
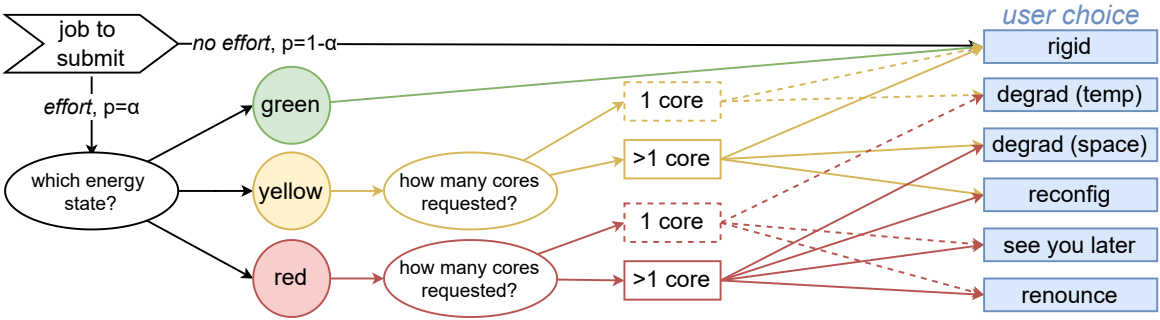


Energy-aware behaviors



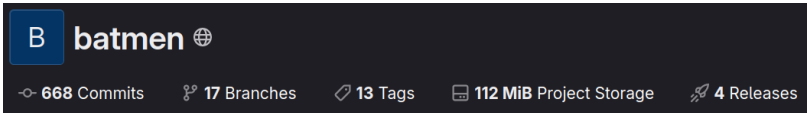
Energy-aware behaviors



- choice of behavior at random depending on the state

Experimental setup

- **Software:** Batsim + Batmen

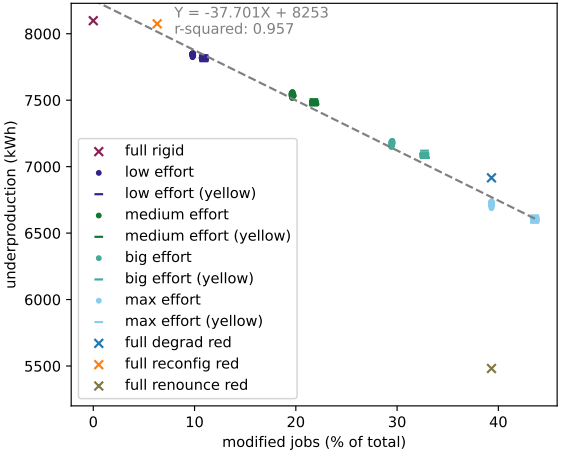


- **IT workload:** filtered version of MetaCentrum from Parallel Workload Archive
  - June 1 to November 11, 2014 (4.5 months)
  - 650000 jobs and 500 users
- **Energy production data:**
  - 145 m^2 solar panels
  - weather data Toulouse 2019 from Renewable Ninja (days aligned with IT)
- **IT platform:**
  - 42 18-core machines
- **Scheduler:** bin-packing scheduler which shutdown machine when idle.

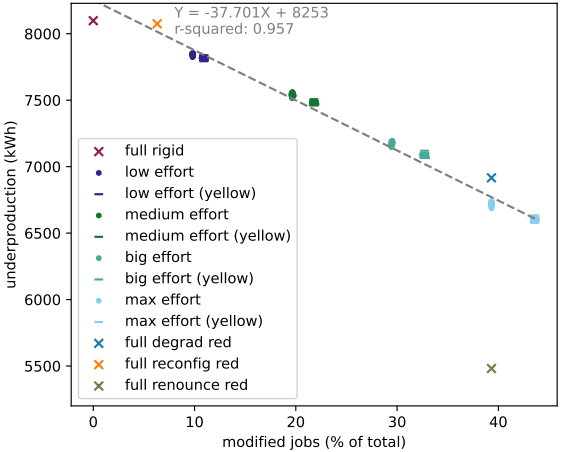
Experimental campaign

- $\alpha =$ probability of modifying a job in red / yellow
- 6 scenari:
  - full rigid ($\alpha = 0$)
  - low effort ($\alpha = .25$)
  - medium effort ($\alpha = .5$)
  - big effort ($\alpha = .75$)
  - max effort ($\alpha = 1$)
  - full renounce/degrad/reconfig in red
- each scenario run 30 times to minimize the effect of randomness

Results

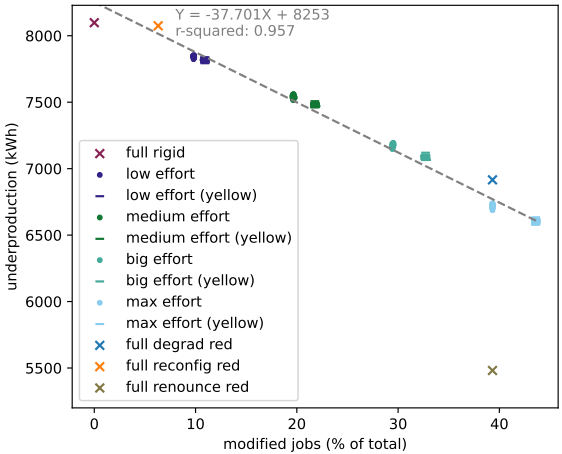

Y = -37.701X + 8253
r-squared: 0.957
underproduction (kWh)
modified jobs (% of total)
8000
7500
7000
6500
6000
5500
0
10
20
30
40
full rigid
low effort
low effort (yellow)
medium effort
medium effort (yellow)
big effort
big effort (yellow)
max effort
max effort (yellow)
full degrad red
full reconfig red
full renounce red

Results



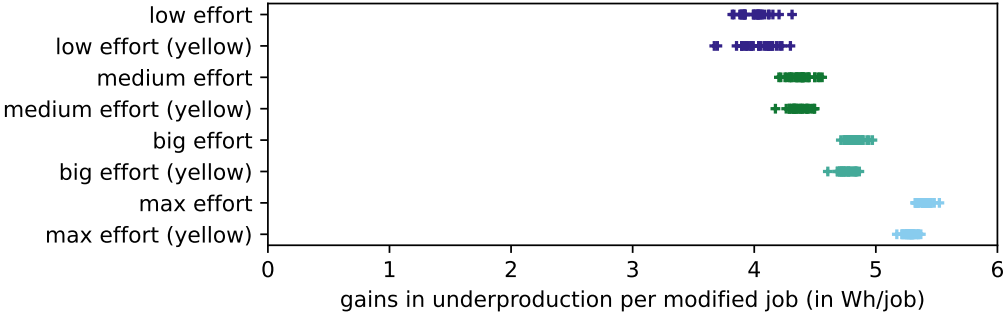
- *How much does user effort impact energy consumption?*
  - → if 50% jobs modified in red/yellow (medium effort), underproduction reduced by 8%
  - → if 100% jobs modified in red/yellow (max effort), underproduction reduced by 18%

Results



- *How much does user effort impact energy consumption?*
  - → if 50% jobs modified in red/yellow (medium effort), underproduction reduced by 8%
  - → if 100% jobs modified in red/yellow (max effort), underproduction reduced by 18%
- Energy savings linear with effort

Results: ratio energy/effort



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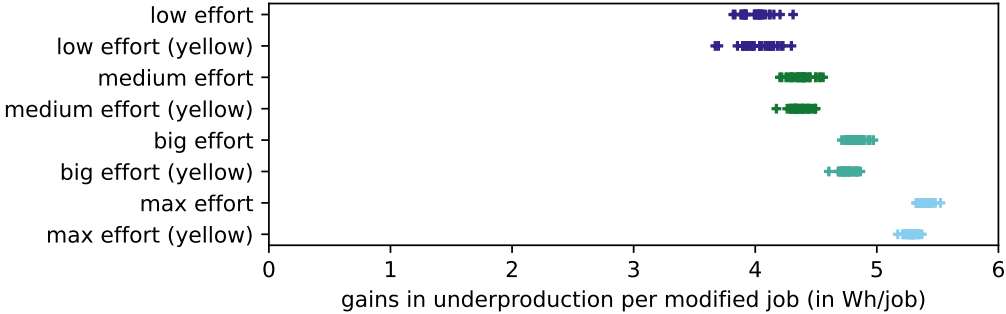

→ marginal gains increase with α: "the more people who make an effort, the greater the impact of a user's additional effort"

→ gains with yellow windows of the same scale than with red

Conclusion

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  - collaboration with the scheduler
  - more realistic replay method
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- First step towards studying **sufficiency** and not **efficiency**
- Simulation campaign **reproducible**
- Article in review:
  - J. Gatt, M. Madon, and G. Da Costa, *"Digital sufficiency behaviors to deal with intermittent energy sources in data center."*

Merci !

- Come to my **PhD defense: April 30, 14:00** (link to come) !!
- Do not hesitate to contact me :-)
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