Computing and sustainability

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CAF-users

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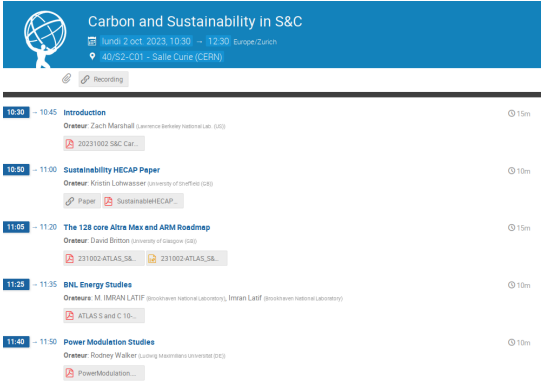
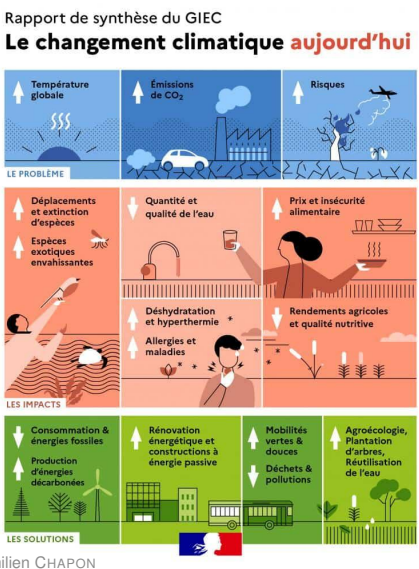
Introduction

- Mostly a summary of the “Carbon and Sustainability” session at the last Software&Computing week (October 2023) and of some discussions at recent LCG France meetings
- Also other sources (e.g. CHEP : Tier 2 footprint, IRISCAST, datacenter refurbishment, WLCG energy)



Context



Haut Conseil pour le Climat, IPCC (GIEC) latest executive summary

Lutte contre le déréglement climatique : les Etats prévoient de produire deux fois trop de combustibles fossiles en 2030

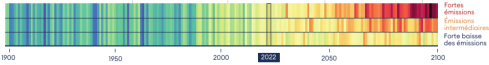
Un rapport des Nations unies et de différents organismes de recherche démontre à quel point les projets des principaux pays producteurs de charbon, de pétrole et de gaz sont en décalage avec les scénarios permettant de limiter le réchauffement à 1,5 °C.

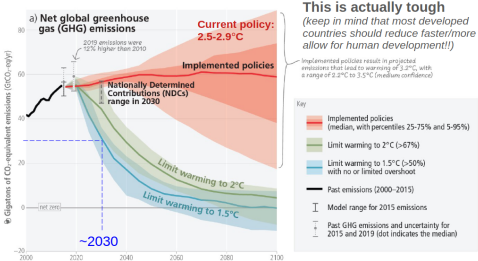
Le Monde

Les engagements des Etats ne sont pas à la hauteur pour limiter le réchauffement climatique

A un peu plus de deux semaines de l'ouverture de la COP28, l'ONU alerte sur l'insuffisance des efforts des Etats pour respecter les objectifs de l'accord de Paris.

Le Monde

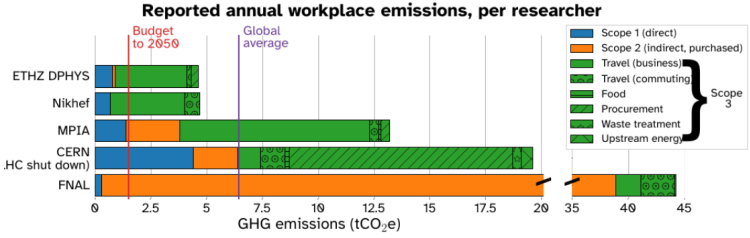




Sustainability HECAP paper

paper, Kristin Lohwasser's slides

- Community paper about sustainability in HEP, astrophysics, cosmology, and related fields
- Covers computing, energy, food, mobility, research infrastructures and technology, resources and waste
- Discussion includes best practice examples and recommendations



2019 data, save MPIA (2018), and ETHZ business travel (average 2016-2018).

Recommendations — Computing

Individual actions:

- Make sustainable personal computing choices by considering the necessity of hardware upgrades, the repurposing of hardware, and the environmental credentials of suppliers and their products.
- Assess and improve the efficiency and portability of codes by considering, e.g., the required resolutions and accuracy.
- Assess and optimise data transmission and storage needs.
- Follow best practice in open-access data publishing, prioritising reproducibility and limiting repeat processing.
- Read the section on E-waste (Section 7).

Further group actions:

- Right-size IT requirements and optimise hardware lifecycles.
- Schedule queueing systems with environmental sustainability in mind, so as to maximise the use of renewables, accounting for the geographical location of servers/data centres.

Further institutional actions:

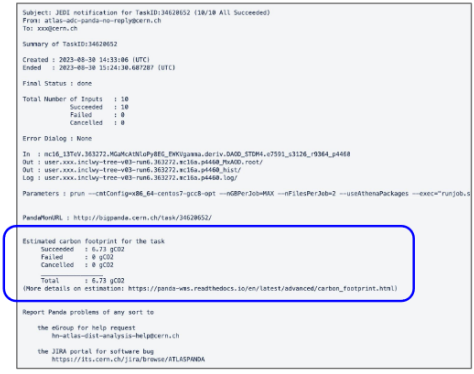
- Ensure that environmental sustainability is a core consideration when designing and choosing sites for large computing infrastructure, such as data centres, including, e.g., the availability of renewables, the efficiency of cooling systems and the reuse of waste heat.
- Proceduralise the repair, upgrade and repurposing of existing computing, the de-inventorising of personal equipment for leaving personnel or for donation, and the responsible recycling of retired hardware.
- Select cloud computing services for their carbon emission mitigation policies.

Some of the above recommendations are based on those made by Jan Rybizki [34].

PANDA

Zach Marshall

- JEDI sends a summary when a user's grid job finishes
- New feature : an average carbon estimate
  - Links to a page explaining that number
  - Along with some background and some equivalents for comparison
- Averaged for several reasons
  - Inaccuracy of and missing site-specific data
  - Pledged CPU doesn't sit idle
  - Users pushing on a single site could cause other problems
  - Faster code $\rightarrow$ lower gCO_2e
- Not intended for "shame" ; a reminder that Grid use is relevant to the environment
  - Code optimization and success rate matter

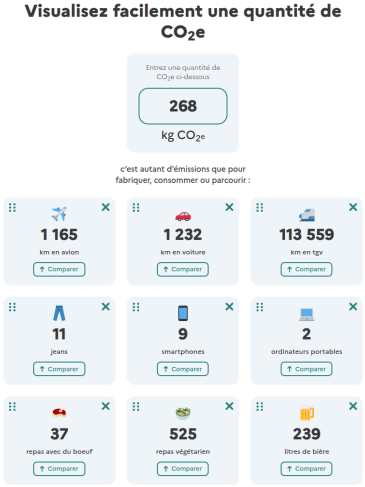


Example : generating ntuples for full Run 2

I recently processed the full Run 2 data (AOD_PHYS) to produce analysis ntuples. (Software / jobs / ntuple content could / should probably be optimised...)

CO2eq (kg)	data15	data16	data17	data18	Run2
suceeded	13.61	52.48	53.09	123.1	242.28
failed	2.83	3.07	8.13	12.38	26.41
cancelled	0	0	0	0	0
Njobs total	19639	91528	113757	104692	329616
Total	16.44	55.55	61.22	135.48	**268.69**

Source : ADEME



Power Usage Efficiency (PUE)

Wikipedia

$$\text{PUE} = \frac{\text{Total Facility Energy}}{\text{IT Equipment Energy}} = 1 + \frac{\text{Non IT Facility Energy}}{\text{IT Equipment Energy}}$$

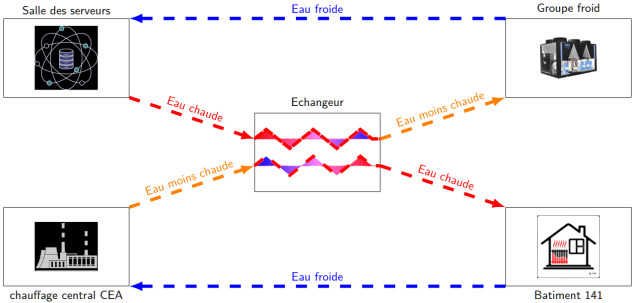
Examples :

- CC IN2P3 : 1.47 (ref) thanks to the new room (2019)
- CERN Meyrin centre : 1.44
- Future PCC (Prévessin Computing Centre, to start operations soon) : 1.1
  - Includes heat recovery of up to 3 MW out of the first 4 MW
  - $(1.6 - 1.1)/1.6 \times 4$ MW datacenter at 0.075 kg CO_2e/kWh vs. 10 000 m^2 at 8.7 kg CO_2e/m^2 $\rightarrow$ worth it in 2 months ! (ignoring equipment...)
- RAL : $\approx$ 1.2, NERSC (Berkeley) : 1.06
- World average (not only WLCG) : 1.55

Ongoing project : heat recovery at Irfu

Carrier

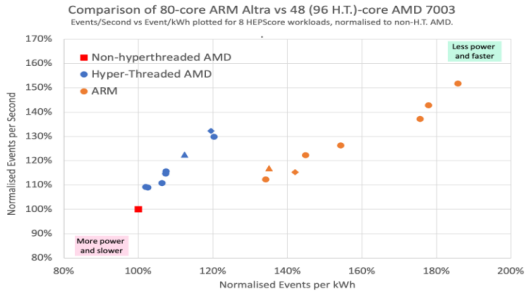
Schéma : Étienne Savalle



- One of the cooling units for the Irfu computing room needs to be replaced next year
- Planning to reinject the heat into the building's heating system
  - NB : building renovated 2 years ago with much improved insulation
- Hoping to be able to cover $\approx$ 100% the building's heating needs (560 MWh)

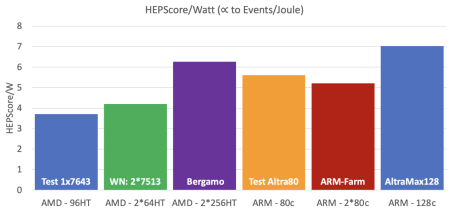
About ARM

- ARM vs AMD architecture :
  - ⊖ Porting HEP software on non-X86 arch. non trivial
  - ⊕ Recent huge increase in performance of mobile devices over last 10 years
  - ⊕ LHC experiments have software releases for ARM (used in some HPC) and have done some (but not all) physics validation
- According to a study from GridPP (UK), ARM is much more energy efficient and generally faster than Hyper-Threaded AMD, depending on workload



ARM : studies presented at the S&C week

- Study from GridPP ranking Ampere's 128-core ALTRA-Max (ARM) as the most energy efficient CPU (HEPScore/W)
  - AMD's Bergamo (512 threads) also very efficient



- BNL compared ARM Ampere Altra Max (128 cores) and Ampere Altra (64 cores) with Intel Xeon (x86_64, 48 cores, 96 threads) :

	ARM 128 core	ARM 64 core	x86_64 Xeon
HEPscore / Watt	5.49	4.13	2.13
Watts / 1000 HS23 (% of Xeon)	182.3 (39%)	241.9 (51%)	470.3 (100%)
Rel. purchase cost	0.89	0.61	1

Enjeux financiers

Enjeu financier

- Coût électrique :
  - 0,18 / Kw.h (2022)
  - 0,38 / Kw.h (2023)
- Coût renouvellement :
  - 70 €/threads (DL 365)
  - 66 €/threads (Appolo 2000)
  - 117 €/cœurs (ARM Ampère) (prix public ??)
- Consommation :
  - 2,8 W/threads (24 KW.h/an) (AMD)
  - 10 €/threads/an

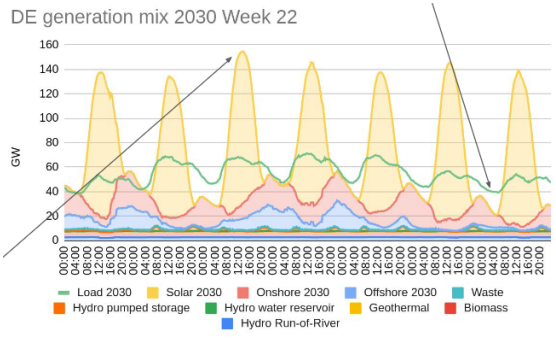
Enjeu environnemental

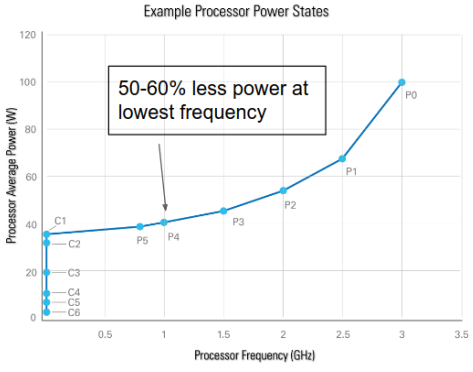
- CO_2 / kWh: ~ 80 g
- Coût renouvellement :
  - 33 kgs / thread (DL 365)
  - 220 kgs / thread (Appolo 2000)
  - 27 kgs / coeur (ARM Ampère) (donnée Giga Computing)
- Consommation :
  - 19 kgs / thread (AMD)

Power modulation

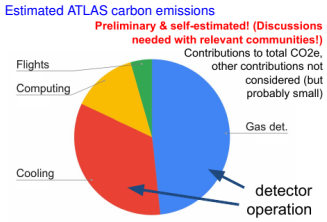
Rod Walker

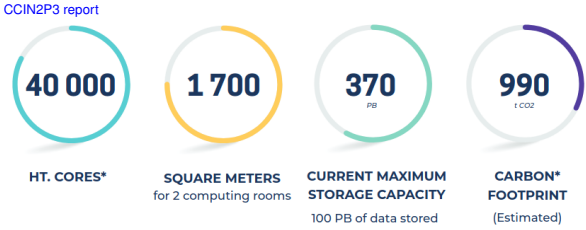
- More renewables in electricity mix in the future → larger dependance of produced power
- Likely to reflect in electricity costs
- Those unable or unwilling to modulate will pay more





Summary





- Computing has a large share in HEP's carbon budget
  - Even before the HL-LHC needs
- Increasing effort in greener computing
  - More efficient computing centres
  - Reduce "embedded carbon" (hardware lifecycle)
  - More efficient architectures (ARM...)
  - More efficient usage and software