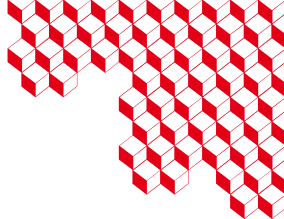




irfu



Computing and sustainability

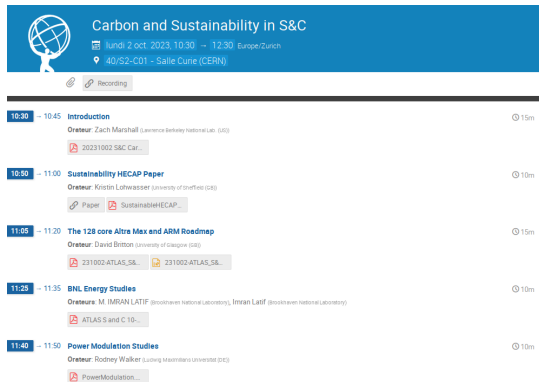
Émilien CHAPON

CAF-users

21 November 2023

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)



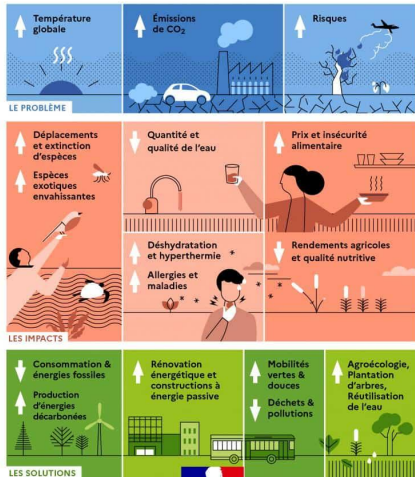
The screenshot shows a video player interface for a session titled "Carbon and Sustainability in S&C". The header bar is blue and contains a globe icon, the session title, the date and time "lundi 2 oct. 2023, 10:30 - 12:30", the location "Europe/Zurich", and the address "40/S2-C01 - Salle Cune (CERN)". Below the header, there is a "Recording" button. The main content area lists several sessions with their start and end times, titles, and speakers. Each session entry includes a play button icon and a duration indicator.

Time	Session Title	Speaker	Duration
10:30 - 10:45	Introduction	Orateur: Zach Marshall (Lawrence Berkeley National Lab. (LBNL))	15m
10:50 - 11:00	Sustainability HECAP Paper	Orateur: Kristin Lohwasser (University of Sheffield (UK))	10m
11:05 - 11:20	The 128 core Atrix Max and ARM Roadmap	Orateur: David Britton (University of Glasgow (UK))	15m
11:25 - 11:35	BNL Energy Studies	Orateurs: M. IMRAN LATIF (Brookhaven National Laboratory), Imran Latif (Brookhaven National Laboratory)	10m
11:40 - 11:50	Power Modulation Studies	Orateur: Rodney Walker (Ludwig-Maximilians-Universität (LMU))	10m

Context

Rapport de synthèse du GIEC

Le changement climatique **aujourd'hui**



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

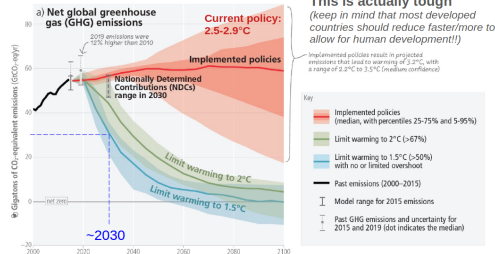
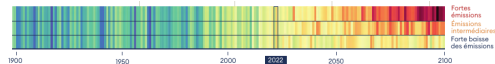
Un rapport des Nations unies et de différents organismes de recherche démontre à quel point les projets des principaux pays producteurs de charbon, de pétrole et de gaz sont en décalage avec les scénarios permettant de limiter le réchauffement à 1,5 °C.

Le Monde

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

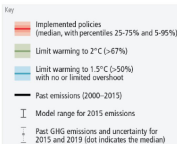
A un peu plus de deux semaines de l'ouverture de la COP28, l'ONU alerte sur l'insuffisance des efforts des Etats pour respecter les objectifs de l'accord de Paris.

Le Monde



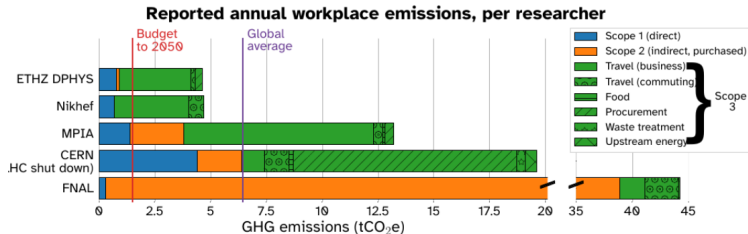
This is actually tough
(keep in mind that most developed countries should reduce faster/more to allow for human development!!)

Implemented policies result in projected emissions that lead to warming of 3.2°C, with a range of 2.2°C to 3.5°C (medium confidence)



Sustainability HECAP paper

- 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).

paper, Kristin Lohwasser's slides

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].

- 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 → lower gCO₂e
- Not intended for “shame”; a reminder that Grid use is relevant to the environment
 - Code optimization and success rate matter

```
Subject: JEDI notification for TaskID:3462852 (18/10 All Succeeded)
From: atlas-odc-panda-no-reply@cern.ch
To: xxx@cern.ch

Summary of TaskID:3462852

Created : 2023-08-30 14:33:06 (UTC)
Ended   : 2023-08-30 15:24:30.687287 (UTC)

Final Status : done

Total Number of Inputs : 10
Succeeded             : 10
Failed                : 0
Cancelled              : 0

Error Dialog : None

In  : mc16_13TeV_363272_MGmCAtNloPy8EC_FKK0gamma.deriv.DAOD_STDM4_e7591_s3126_r9364_p4468
Out : user.xxx.incluy-tree-v03-run6.363272_wc16a.p4468_mvAOD.root/
Out : user.xxx.incluy-tree-v03-run6.363272_wc16a.p4468_hist/
Log : user.xxx.incluy-tree-v03-run6.363272_wc16a.p4468.log/

Parameters : prun --cmfConfig=BE_64-centos7-gcc8-opt --nGRPerJob=MAX --nFilesPerJob=2 --useAthenaPackages --exec="runjob.sh"

PandaFrontURL : http://bopipanda.cern.ch/task/3462852/

Estimated carbon footprint for the task
Succeeded : 6.73 gCO2
Failed    : 0 gCO2
Cancelled : 0 gCO2
Total     : 6.73 gCO2
(More details on estimation: https://panda-wms.readthedocs.io/en/latest/advanced/carbon_footprint.html)

Report Panda problems of any sort to
the mirror for help request
hn-atlas-dist-analysis-help@cern.ch

the JIRA portal for software bug
https://its.cern.ch/jira/browse/ATLASPANDA
```

Example : generating ntuples for full Run 2

Source : ADEME

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

CO ₂ eq (kg)	data15	data16	data17	data18	Run2
succeeded	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

Visualisez facilement une quantité de CO₂e



Power Usage Efficiency (PUE)



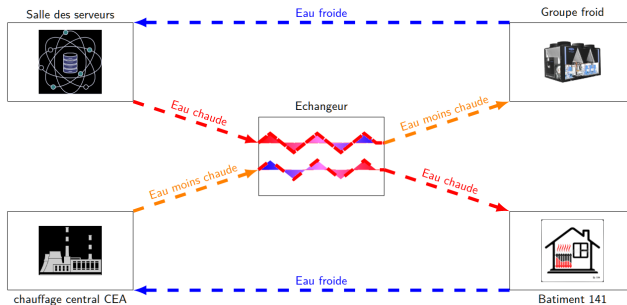
$$\text{PUE} = \frac{\text{Total Facility Energy}}{\text{IT Equipment Energy}} = 1 + \frac{\text{Non IT Facility Energy}}{\text{IT Equipment Energy}}$$

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
 - $(1.6 - 1.1)/1.6 \times 4 \text{ MW}$ datacenter at $0.075 \text{ kg CO}_2\text{e/kWh}$ vs. $10\,000 \text{ m}^2$ at **$8.7 \text{ kg CO}_2\text{e/m}^2$**
→ 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

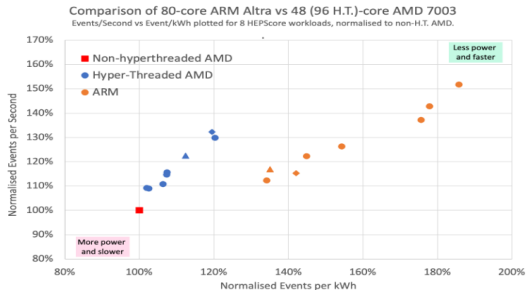
Carrier
Schéma : Étienne Savalle



- 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)

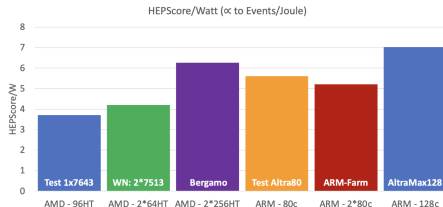
About ARM

- 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

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

- CO₂ / kWh: ~ 80 g
- Coût renouvellement :
 - 33 kgs / thread (DL 365)
 - 220 kgs / thread (Appolo 2000)
 - 27 kgs / cœur (ARM Ampère) (donnée Giga Computing)
- Consommation :
 - 19 kgs / thread (AMD)

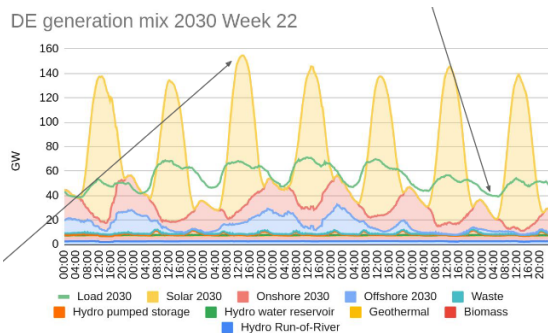


Power modulation

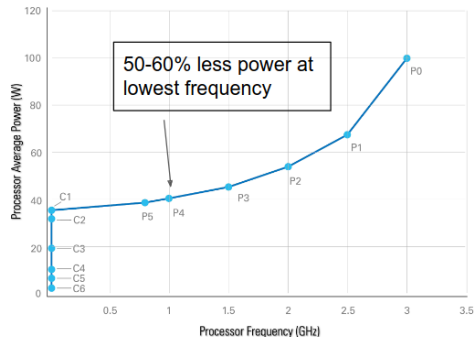
Rod Walker

- 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

DE generation mix 2030 Week 22



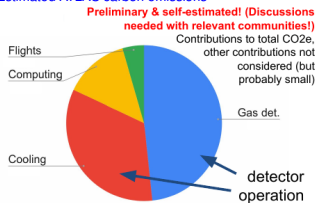
Example Processor Power States



Summary



Estimated ATLAS carbon emissions



CCIN2P3 report



HT. CORES*



SQUARE METERS
for 2 computing rooms



CURRENT MAXIMUM
STORAGE CAPACITY
100 PB of data stored



CARBON*
FOOTPRINT
(Estimated)

- 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