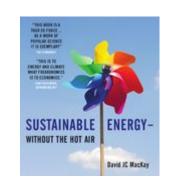
# Datacenter location to minimize CO2 emissions

Rod Walker, LMU

### Introduction

- 100% renewable power grid solves the problem
  - o but too late, ~20yrs? What can we do now?
- "Every BIG helps" (David MacKay: <u>retro html</u>)
  - few % here and there, or even everywhere, does not solve the problem
  - to stop and reverse climate change, need close to 100% reduction in CO2 emissions,
- Free to choose the location with renewable power?
- Compare 1MW of compute in Germany and Sweden
- Effect of interconnected Grids
- Conclusion

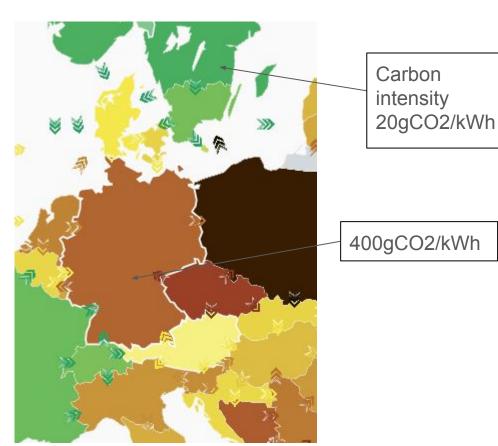


## Are we free to choose a location? Technically.

- Computing Grid lets us locate computing anywhere
  - good connectivity
  - decision to not put everything at CERN finally pays off
- Non-grid user access, e.g. direct batch submission
  - latency not a problem
  - file systems should be local
  - Ixbatch-like



## 1MW Compute (& Storage)



1MW compute consumes 1MW electricity, produces 1MW heat and 1MW\*intensity CO2

Assume same optimizations can be done in both locations, e.g. PUE

#1 mitigation - Waste heat replaces

- natural gas: 200g/kWh heat
- heat pump (SCOP=5), DE: 400/5=80g/kWh heat

## 1MW compute in high or low carbon intensity grid

scenario	Germany kg C02/MWh	Redu ction	Sweden kg CO2/MWh	Reduced CO2 emissions by
	400		20	95%
heat replaces gas (SW too)	400-200=200	50%	20 (20-200=-180)	90% (190%)
Replace heat pump (SW too)	400-80=320	20%	20 (20-20/5=16)	94% (95%)

Get close to 100% reduction of CO2 emission : BIG Heat with heat pumps not Datacenter resistive heating

## Interconnected Grids

If renewable power could be transmitted to datacenter, then location not critical

Spoiler: it can't!

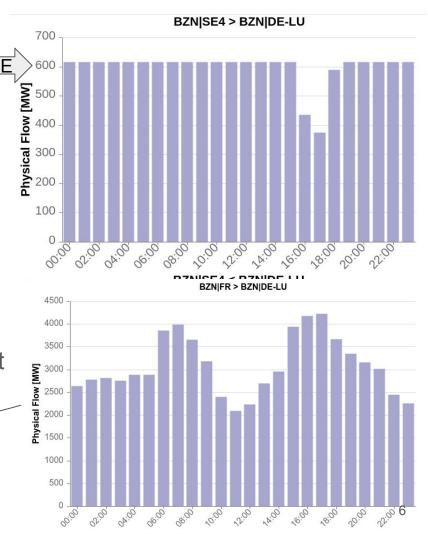
Needs investment and O(10) years

Multiple regions in SE: N-S interconnect 7GB

Valuable capacity for balancing and storage, not base loads.

Reduced load in FR, reduces DE coal generation(potentially)

https://transparency.entsoe.eu



#### Reasons not to

- Financial
  - 'free' stuff: machine room, electricity, manpower, network
    - not actually free, but costs hidden
    - CERN ~3ct/kWh bears no relation to cost of nuclear power plus transmission
- local money for local compute resources
  - Political will, as imposed by national funding bodies
    - already fund HW outside country for good reason, e.g. LHC, exascale HPC
  - dedicated uni resources(local users), control, recognition, training/expertise
    - plugging cables and swapping disks or rather Grid service operation
- Need to disentangle some of these non-physical factors
  - the climate does not care it's the CO2, stupid

#### The Narrative

Pending greening of local electricity grid - production, network, storage, interconnect - O(20) years ...

- Temporarily put new compute and storage at location with plentiful renewable electricity - WLCG investment made this possible!
  - Multiple HW generations(~5 years) before local grid greened, then retire and put locally
  - Easier for compute than steel, chemicals, manufacturing #jobs! Political cover/motivation.
- Funding bodies & universities pool (existing) money
  - Partner site with existing infrastructure. Strong steering committee
  - o largely remote admin team for all services: batch, CE, SE
  - share of WLCG pledge, HS23s, PB allocated to Uni/Country

### Conclusions

- Datacenter has a large and flat power consumption
  - free to locate where power is 100% renewable
- Given current HW location, every few % efficiency improvement is welcome
  - they are just not BIG, and we can do way better, i.e. 95% less CO2
- New compute and storage can and should be located optimally for climate
  - o low CO2 intensity & plentiful electricity, connected, infrastructure, manpower
  - Sweden, Norway, Iceland obviously renewable and not interconnected to central Europe
  - Scotland, northern Germany, France depends on interconnect details. Morocco?
- Challenge to overcome reasons not to
  - acknowledge good reasons: T0 farm, T1 tape for repro
  - o call out bad reasons: fake finance, politics, empire

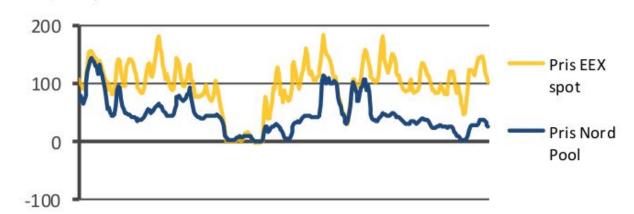
# Backup

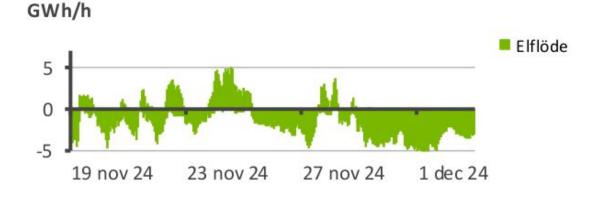
#### From Mattias:

Price difference implies saturation of interconnect, but could be North-South within Nordic countries.

Nordic to/from Germany

EEX och Nord Pool systempris samt det nordiska elflödet till och från Tyskland, källa: EPEX Spot och Nord Pool Pris, EUR/MWh





#### CERN did a lot!

#### 3.15ct/kWh

PV roofs and car parks: ROI>35yrs

10% tertiary power

"PPA is a must towards better management of energy costs ..." - Serge Claudet.

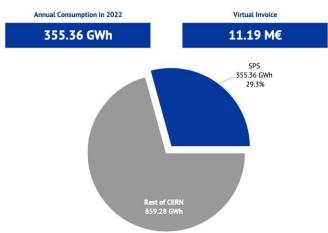




Year 2022

The following consumption figures are extracted from the WebEnergy tool (https://energy.cern.ch).

The invoice price includes energy, transmission, capacity and CEE costs calculated according to CERN's electricity and transmission contracts in force at date.



NOTE: energy counters are located on the high voltage network, therefore it is not possible to achieve perfect granularity in the counting structure. Some approximations are required when defining boundaries between consumers. The counting structure is public and available on the WebEnergy application. For any queries, clarifications or information, please do not hesitate to contact us or consult the website.

Possible discrepancies in energy data of previous years compared to previous invoices are due to recalculations or corrections of the counting structure of WebEnergy.

Issue date: 6/5/2023 https://energy.cern.ch/ Technical contacts

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