

# The evolution of HPC for a sustainable world

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# Sustainable HPC

- Legislation & Reporting
- The Energy Mix
- Embedded Carbon
- Green Washing (or not) ?
- Procuring and Running an Efficient HPC Service
- Sustainability and the Cost of HPC



# Legislation & Reporting

# Environmental, Societal and Governance Reporting

## ⬡ UK Climate-related Financial Disclosure (CFD) Regulations

- Mandatory climate disclosures for largest companies from 6th April, 2022

## ⬡ EU Corporate Sustainability Reporting Directive (CSRD)

- From 5<sup>th</sup> Jan 2023, large/listed companies to disclose information on the risks and opportunities arising from social and environmental issues, and the impact of their activities on people and the environment.



# Carbon Accounting

## Carbon emission scopes for carbon (GHG) accounting

- Scope 1: direct emissions under the control of an organization
- Scope 2: emissions from purchased electricity, direct heating or cooling
- Scope 3: emissions not under the control of the organization

## In relation to HPC:

- Scope 1 might relate to oil that you use for a backup generator
- Scope 2 emissions generally relate to the energy mix of the supplied electricity and the efficiency of the data centre (eg. PUE); emissions may also be offset (eg. by re-using waste heat)
- Scope 3 generally relates to embedded carbon in the building of data centres, data centre equipment, and IT equipment; emissions may be reduced through



# Carbon Pricing

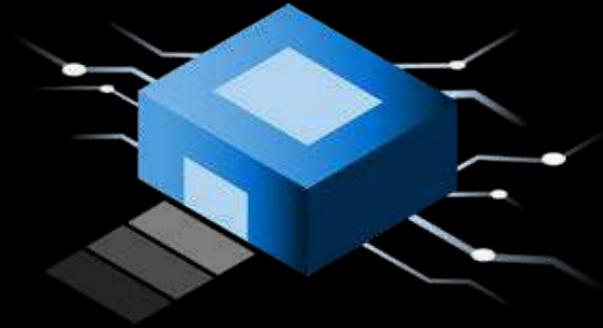
- Carbon pricing tries to capture the 'societal' costs of emissions
  - Carbon prices can be set and used by governments to define taxes
  - Internal prices are also used by organizations to help them hold operating divisions financially responsible for reducing their carbon emissions
  - There is a huge variation in pricing (the full societal cost is estimated as \$100s to \$1000s per tCO<sub>2</sub>e; Microsoft uses \$15; a third of governments put it under \$10; only Sweden and Switzerland >\$100)



- Increasingly, organizations set an internal carbon price against which any HPC resources will be measured
- Although not currently in scope, future Carbon Taxes may lead to direct costs for HPC.....

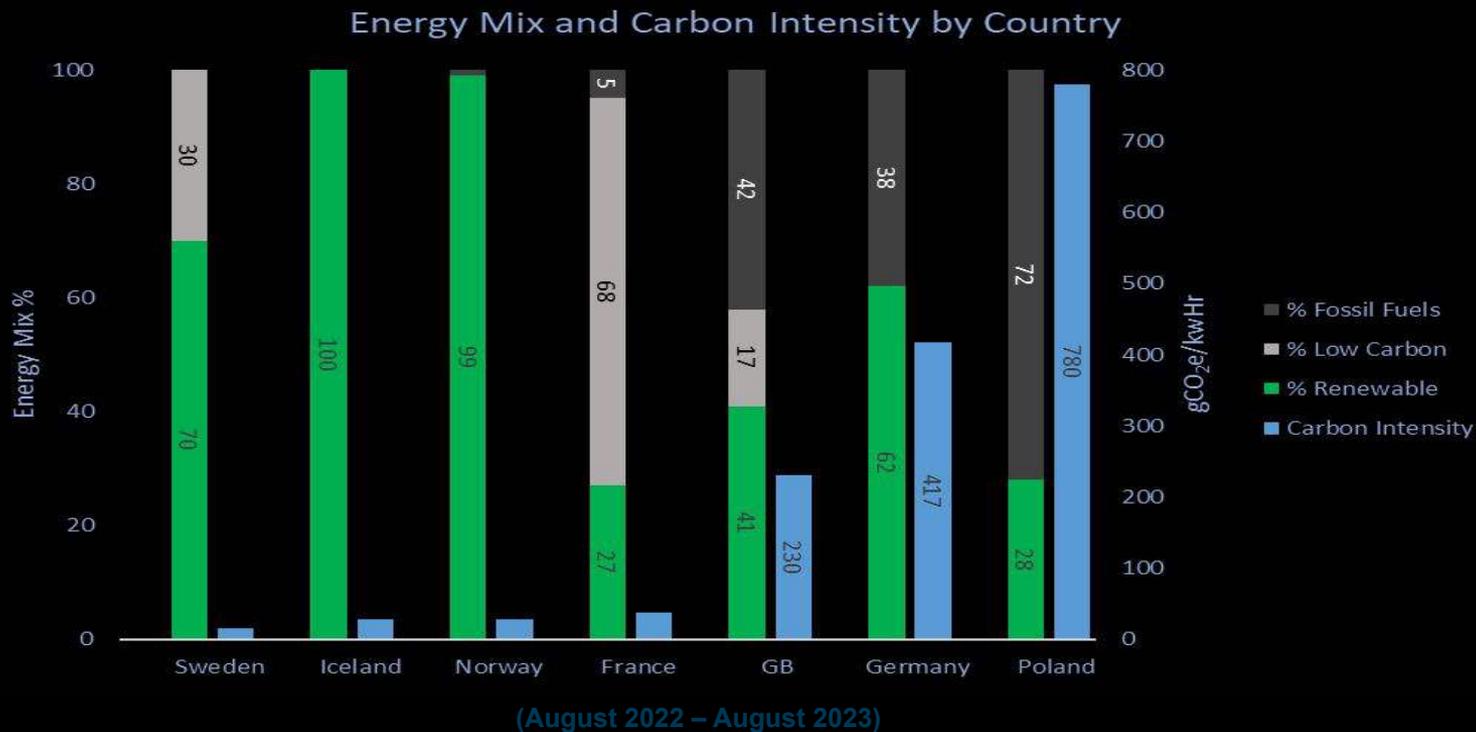
# New Data Centre Legislation (examples..)

- EU European Energy Efficiency Directive (EED) will apply to data centres from March 2024
  - Reporting of energy use & metrics such as PUE, heat re-use and “IT equipment utilization indicators”
  - Expectation that parts the EU Code of Conduct for Data Centres will be enforced in coming years (eg. PUE < 1.2 & minimum heat re-use)
- German Bundestag to pass law so that new data centres:
  - Have a PUE<1.2 from 2026
  - Re-use at least 10% of heat from 2026 and 20% from 2028

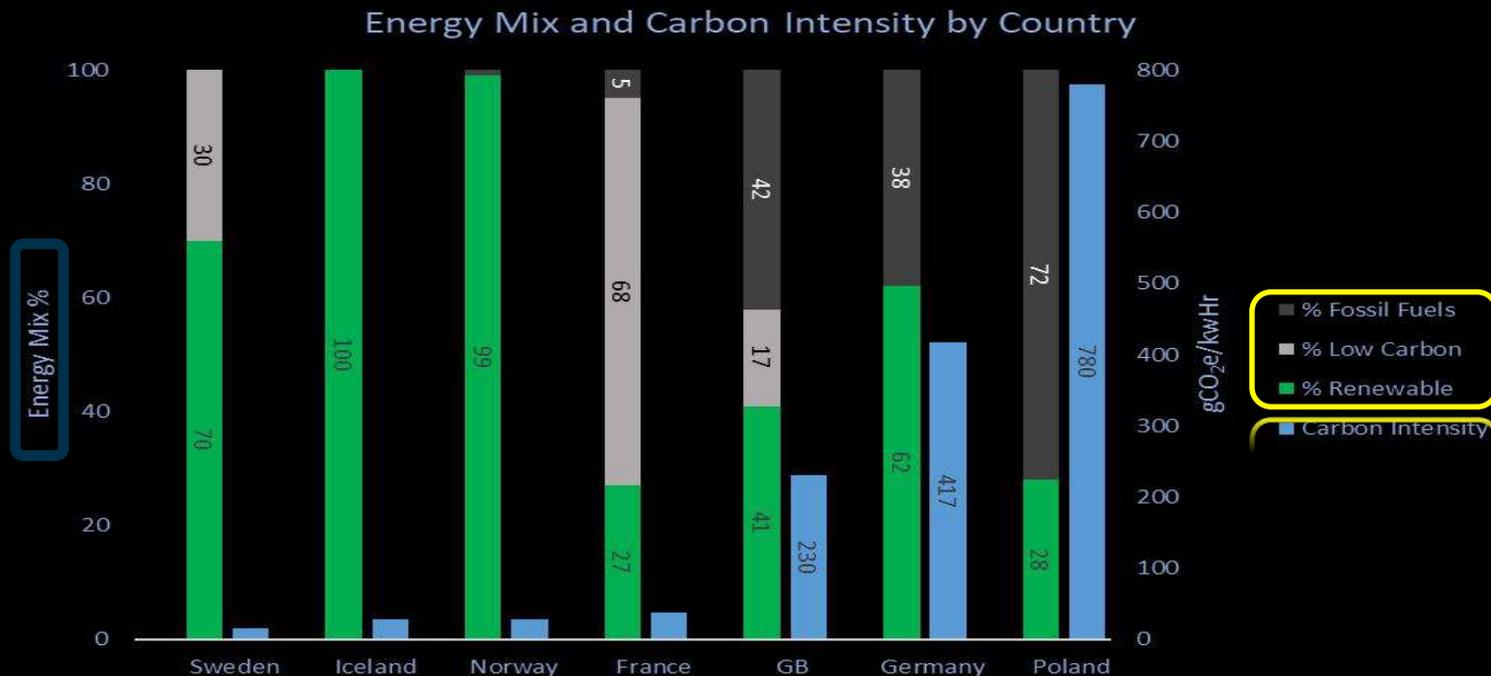


# The Energy Mix

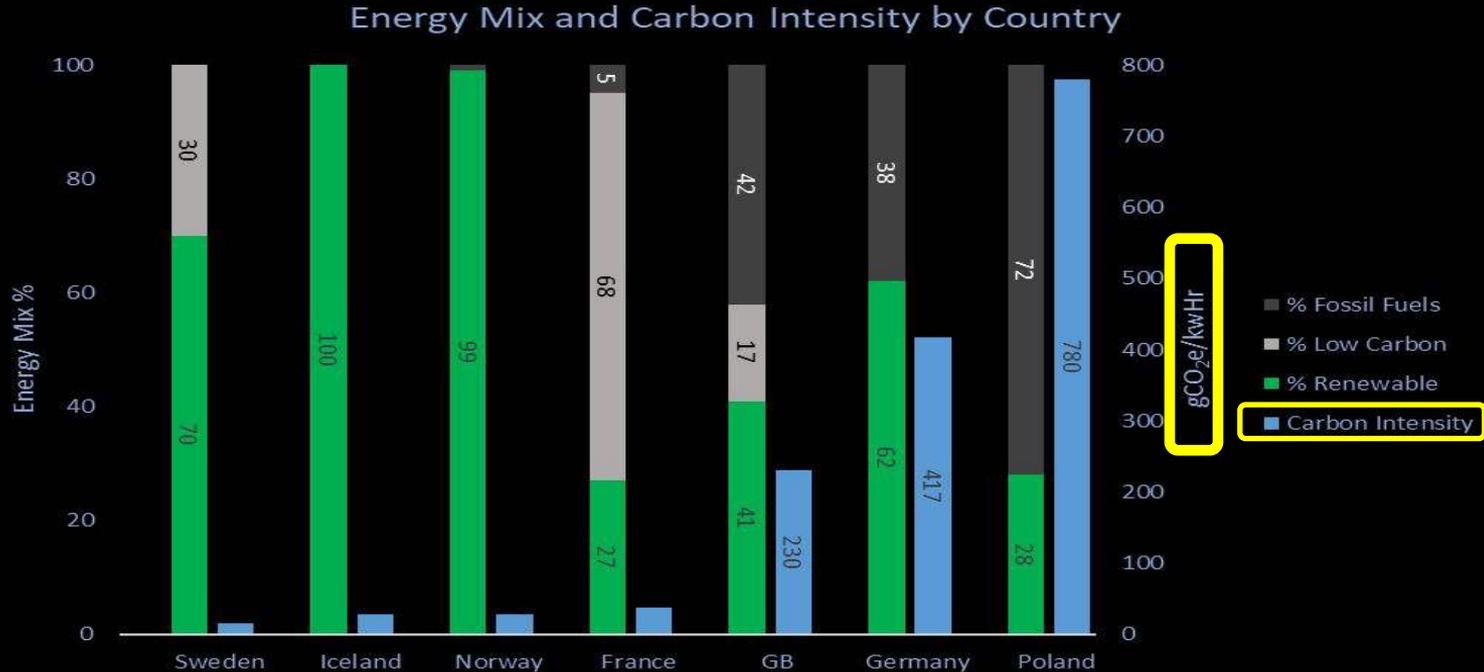
# Electricity generation and renewables



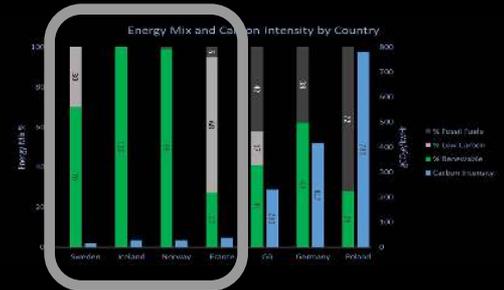
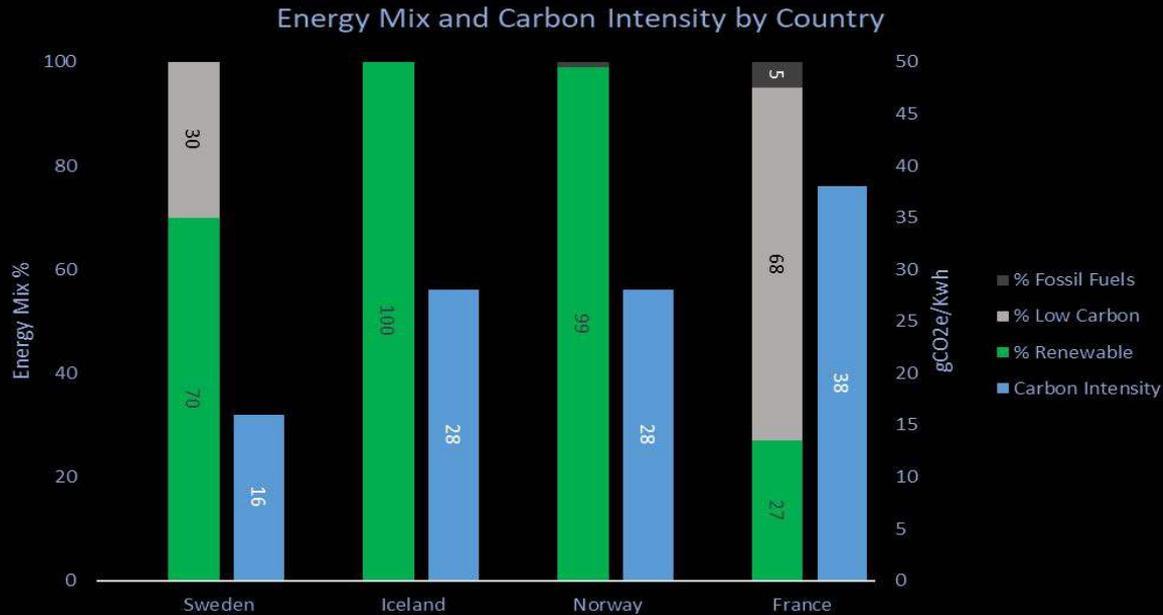
# Electricity generation and renewables



# Electricity generation and renewables



# Electricity generation and renewables



# Embedded Carbon

# Embedded Carbon (Scope 3) – HPC hardware

Companies such as Dell and HPE now publish data on embedded carbon equivalents in their server and storage products, detailing:

- Manufacturing: generally, well over 90%
- Shipping to customer: often negligible
- EOL: often a small (1-3%) positive or negative %
- Significant variation in estimates !

Note:

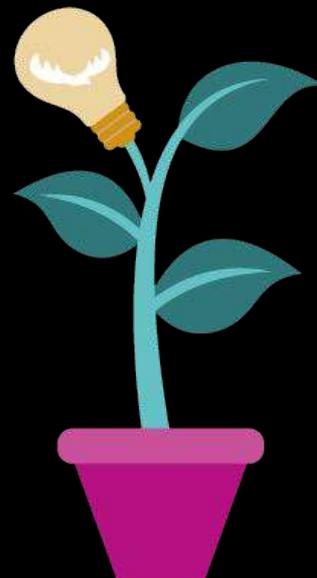
- “SSDs dominate in terms of impact in manufacturing phase. They contribute between 48% and 62%, depending on the product” – Dell PowerEdge 6525 with 2 x AMD EPYC 7452 and 2 x 4TB drives



# Green-Washing (or not)?

# Holistic carbon accounting is not straightforward

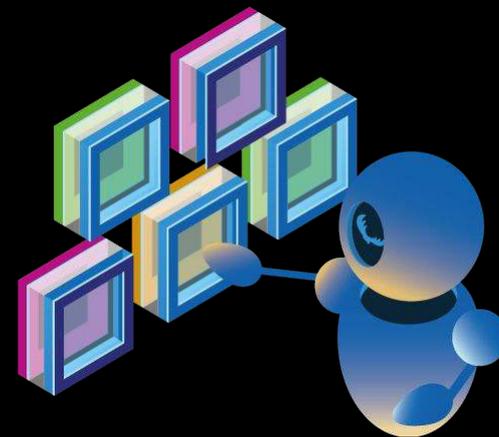
- Is signing up to 100% renewable energy in the UK 'green' ?
  - To what extent does it merely shift the problem elsewhere
  - ..... or does it actually encourage change?
- Does carbon offsetting help or hinder?
- Scope 2 vs. Scope 3:
  - Estimates on embedded carbon are not always easy to find and its relative importance depends significantly on the Scope 2 energy mix
  - Choices as to how embedded carbon is 'depreciated' ?



# Procuring & Running an Efficient HPC Service

# Procuring for cost and sustainability

- On-premise vs. co-located vs. Cloud – or a balanced mix?
  - What is the (real and environmental) cost of energy?
  - How efficient is your current data centre vs. a co-location site?
  - What are the direct/indirect costs and embedded carbon for a new data centre or a data centre re-fit ?
- Map requirements & application mix to hardware and lifetime costs
  - AMD vs. ARM vs. Intel vs Nvidia...
  - Is there a role for older hardware in an HPC service?



# Maximizing 'science per gCO<sub>2</sub>e'

- Maximize system reliability
- Minimize idle cycles; drive user adoption & minimize user errors
- Optimize system throughput
  - Application optimization and benchmarking
  - Match applications to specific hardware resources
  - Ensure that applications can scale to the resources demanded



# Sustainability & the cost of HPC

# What if we compared the costs of.....

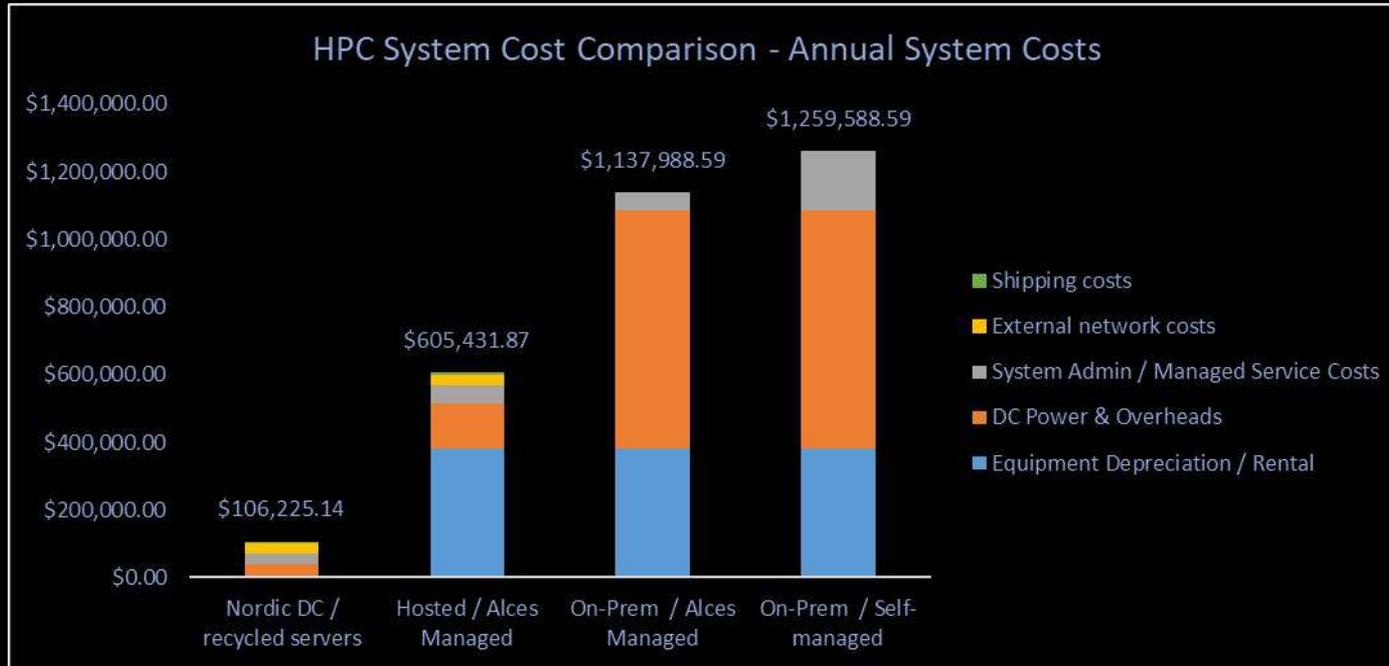
- A new HPC system hosted in the UK
  - Written off over 5 years
  - In a data centre with PUE of 1.5
  - Electricity @ 37p per kWh
  - With DC overheads (staff costs, equipment depreciation & maintenance, etc) of £30,000 p.a



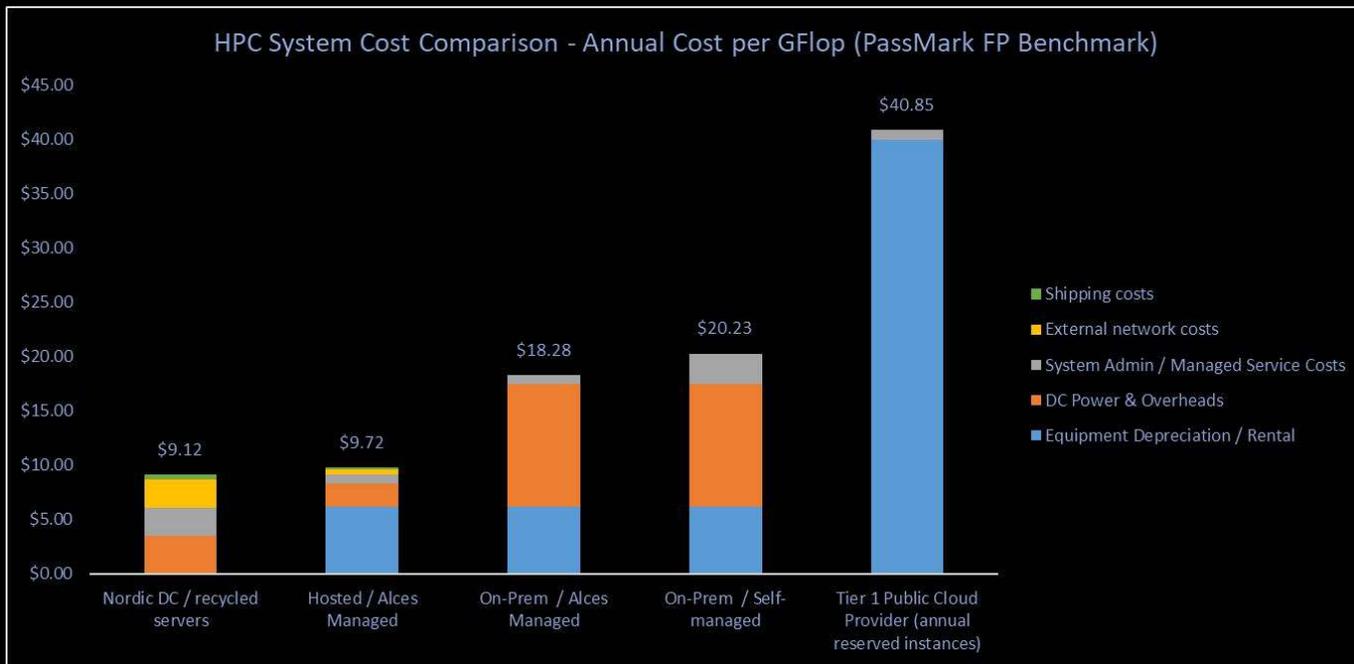
- The same HPC system hosted in a Nordic data centre

- A previous-generation HPC system given a new lease of life in a Nordic data centre

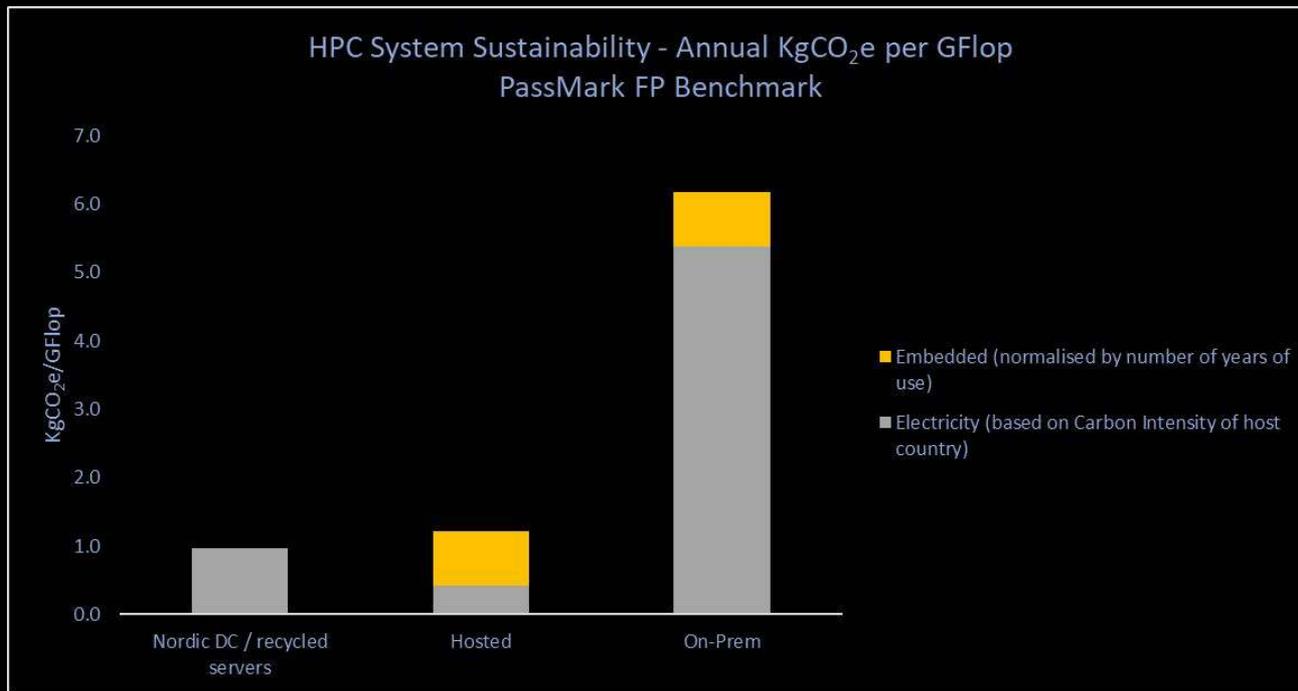
# Annual System Costs



# Annual Costs per GFlop



# Annual Carbon Footprint per GFlop



**And as for  
the future...**