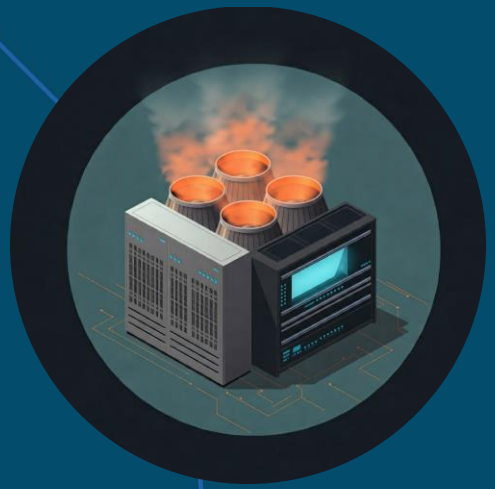
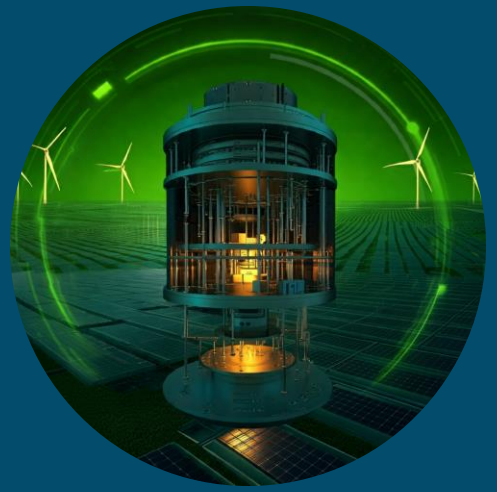
Féidearthachtaí as Cuimse
Infinite Possibilities

The Green Challenge: Sustainable High-Performance and Quantum Computing





Brian Keegan

ECSS: October 25th, 2024

Green ICT and ICT for Green Workshop

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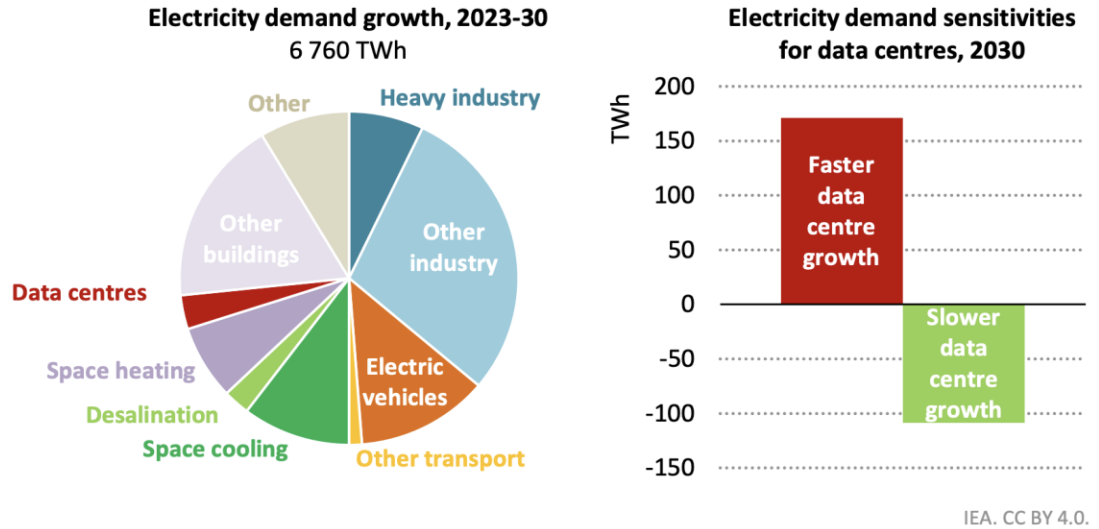
TECHNOLOGICAL UNIVERSITY DUBLIN

Introduction

The Growing Energy Demands of HPC and Quantum Computing

- High-Performance Computing (HPC) drives advancements in scientific research, weather forecasting, financial modelling, and more.
- Quantum computing promises to revolutionize fields like medicine, materials science, and artificial intelligence.
- The Problem: Both HPC and quantum computing are energy-intensive, contributing to rising carbon emissions and environmental concerns.
- Q: Are Sustainability and Competitive Advantage mutually exclusive?

Figure 4.11 ▷ **Electricity demand growth by end-use in the STEPS, 2023-2030, and data centre sensitivity cases**



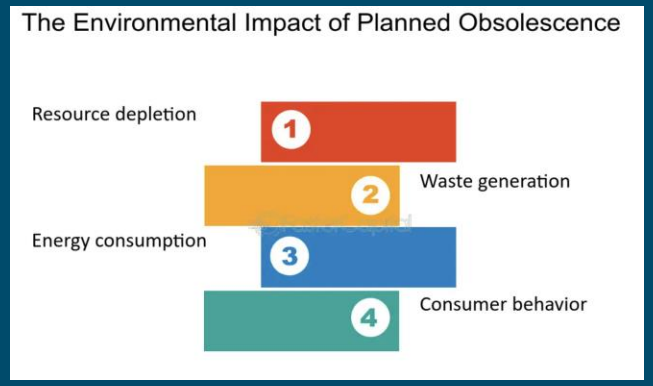
Data centres account for a small share of global electricity demand growth to 2030, and plausible high and low sensitivities do not change the outlook fundamentally

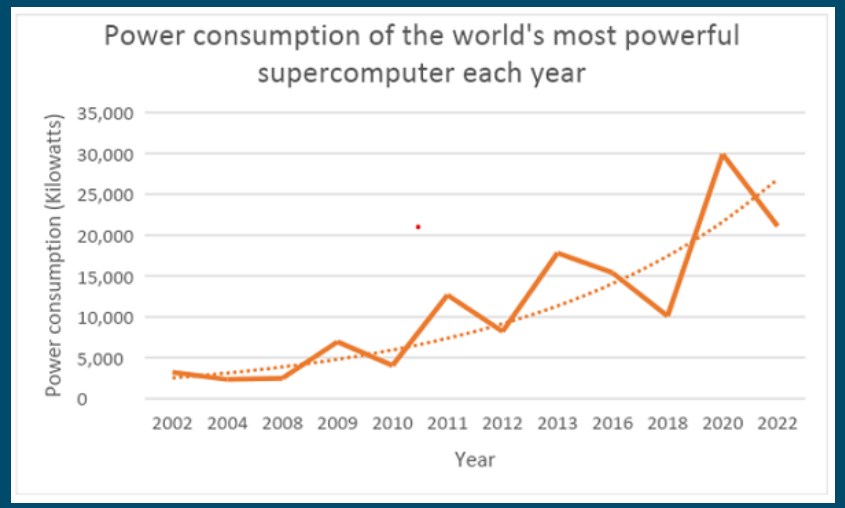
Environmental Impacts of Traditional HPC

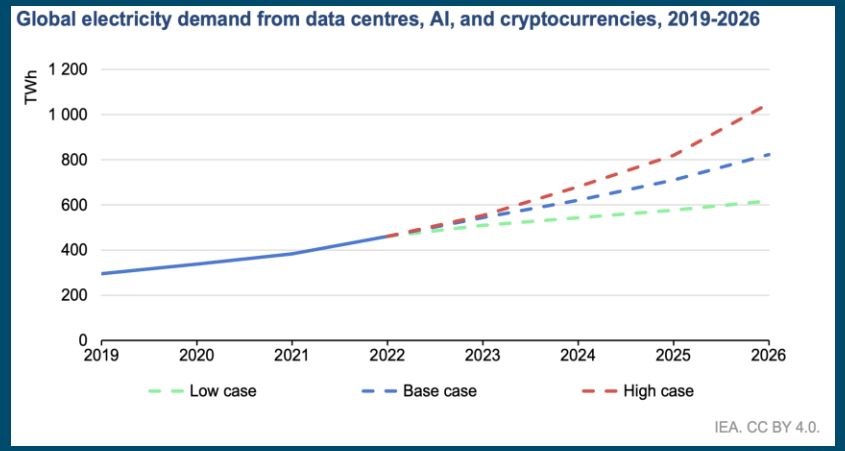
The Carbon Footprint of Classic Supercomputers

Main Issues

- Massive energy consumption for processing and cooling large-scale HPC systems.
- Significant e-waste generation due to the rapid obsolescence of hardware components.
- Resource depletion and environmental impact associated with manufacturing specialized chips and hardware.







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Quantum Computing: A New Set of Challenges

Unique Sustainability Concerns in the Quantum Realm

- Extreme cooling requirements for superconducting qubits, often requiring temperatures near absolute zero (-273.15°C).
- Energy-intensive fabrication processes for quantum processors, involving rare and energy-demanding materials.
- Potential for increased e-waste as quantum technology rapidly evolves and hardware becomes obsolete.

Counter

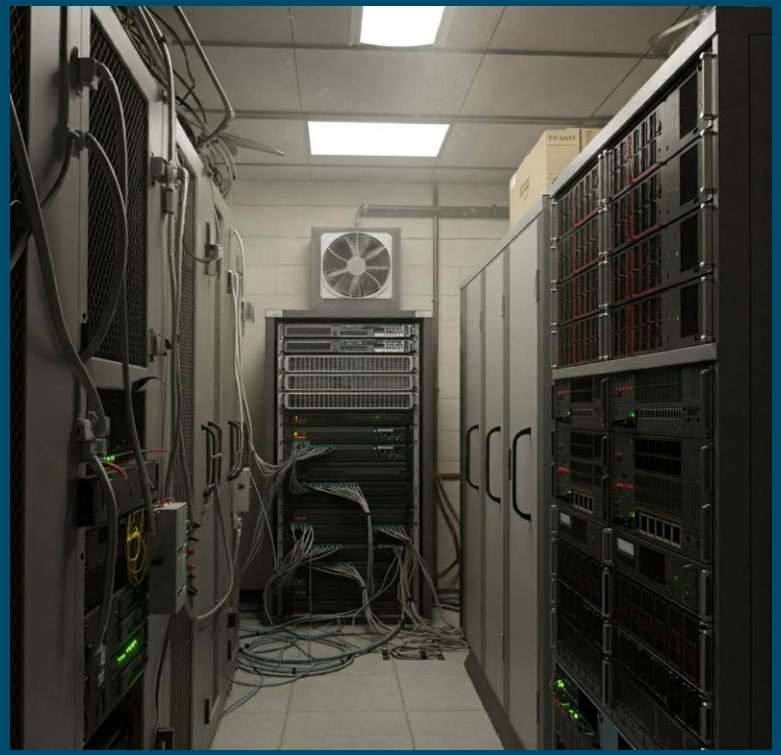
- Q: Does quantum computing power consumption scale directly with the number of qubits?

Real-World Case Study: Bad Practice

Hypothetical Scenario: An Unsustainable HPC Center

A fictional university research lab with an outdated HPC cluster:

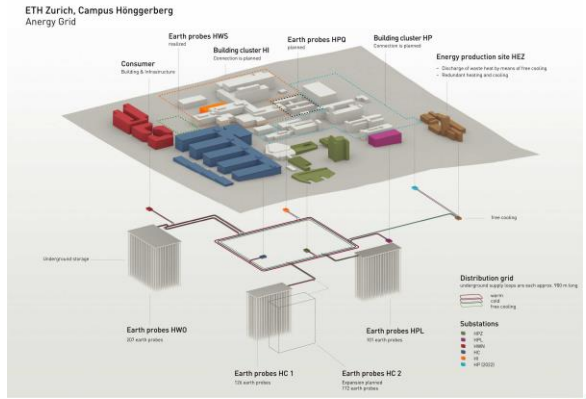
- Inefficient Cooling: Reliance on outdated, energy-intensive cooling systems.
- E-waste Neglect: No program for responsible recycling or disposal of old hardware.
- Lack of Optimization: No strategy for energy-efficient hardware upgrades or software optimization.



Real-World Case Study: Good Practice

Leading the Way: Sustainable HPC at ETH Zurich

- ETH Zurich's approach to green HPC:
- Renewable Energy: Utilizing renewable energy sources (hydropower, solar) to power their data centre.
- Efficient Cooling: Implementing free cooling systems that use outside air and optimizing airflow within the data centre.
- Hardware and Software Optimization: Prioritizing energy-efficient hardware and software to reduce energy consumption.



EU Policies and Guidelines

EU Initiatives for Green HPC and Quantum Computing

Current Policies

- **European Green Deal**: Overarching framework for climate neutrality by 2050, with implications for ICT and research infrastructure.
- **Energy Efficiency Directive (EED)**: Sets energy efficiency targets for data centres and promotes the use of energy-efficient technologies.
- **Ecodesign Directive**: Establishes minimum environmental performance standards for ICT equipment, including servers and storage devices.
- **EuroHPC Joint Undertaking**: Promotes the development of energy-efficient supercomputing infrastructure across Europe.

Challenges for Education and Research

Sustainability in Academia

What are we up against?

- Budget Constraints: Limited funding for investing in energy-efficient infrastructure and sustainable practices.
- Awareness and Training: Need for increased awareness and training on green ICT principles among researchers and students.
- Balancing Needs: Balancing the increasing demand for computational resources with environmental responsibility.

Conclusion and Call to Action

Towards a Greener Future for HPC and Quantum Computing

Go Green:

- Addressing the environmental impact of advanced computing is crucial for a sustainable future.
- Research and development of energy-efficient HPC technologies including quantum are essential.
- Collaboration between academia, industry, and policymakers is needed to promote sustainable practices.
- The change is a complex and nonlinear process that requires sustained effort, collaboration, and perseverance to overcome various barriers and challenges.