INSIDE QUANTUM TECHNOLOGY
IQT NORDICS
OSLO, NORWAY

the energetic challenges of FTQC

#QEI
the quantum energy initiative

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IQT Nordics, Oslo, June 22nd, 2026

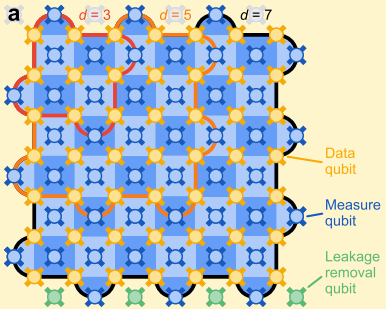
why drives FTQC costs?

fault tolerance quantum computing (FTQC)

- support logical gates on a universal gate set.
- avoid error propagation and amplification.
- fault-tolerant results readout.

error correction on logical qubits (QEC)

tens to thousands physical qubits per logical qubits



error rate $\approx 10^{-4}$ to $\approx 10^{-18}$

- qubit connectivity.
- physical qubit operations fidelities (>99.9%).
- error correction codes.
- cost of deterministic or heralded photon generation (for photon qubits).
- logical gates implementation.
- error syndrome detection.

looming energetic challenge

New Scientist

Technology

Some quantum computers might need more power than supercomputers

A preliminary analysis suggests that industrially useful quantum computers designs come with a broad spectrum of energy footprints, including some larger than the most powerful existing supercomputers

By Karmela Padavic-Callaghan

8 January 2026

https://www.newscientist.com/article/2509492-some-quantum-computers-might-need-more-power-than-supercomputers/

PT PHYSICS TODAY

NEWS / ARTICLE

How much electricity does a quantum computer need?

JUN 15, 2026

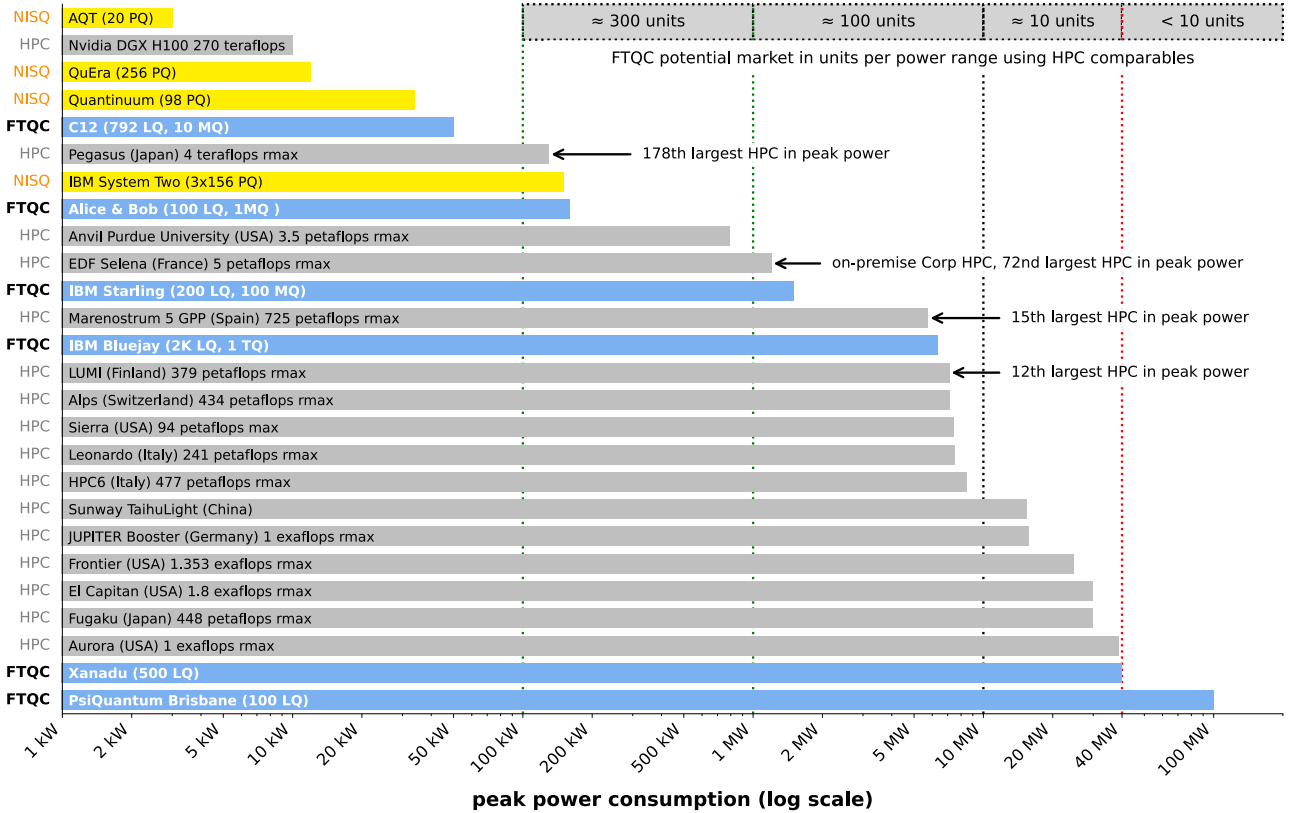
The question is attracting attention amid rising energy use by classical computing data centers.

DOI: 10.1063/pt.41fbb5d95c

Jenessa Duncombe

https://physicstoday.aip.org/news/how-much-electricity-does-a-quantum-computer-need

first FTQC vs HPC power estimates



needs

- benchmarking using standard workloads.
- account for computing time.
- account for hardware cost.
- more vendors publishing peak FTQC power estimates, including cold atoms, ions and silicon qubit.

source: Olivier Ezratty, June 2026

estimate base power for various FTQCs and actual for existing largest HPCs WW and NISQ QCs. HPC source: https://www.top500.org/lists/top500/2025/11/ and Nvidia. FTQC sources: vendor data or data reconciliation.

#QEI

the quantum energy initiative

quantum-energy-initiative.org/

QEI 2025 (Grenoble) and 2026 (Barcelona)

why

- ICT energy consumption is growing fast.
- most quantum technologies will add an incremental energetic cost to existing ICT.
- it is time to work on this as quantum technologies and applications are designed.
- ethical and responsible innovation imperative.

what

- build **new** science and engineering.
- create full-stack methodologies and standards to evaluate, optimize, and benchmark quantum technologies energy consumption.
- change the rules of the game.

how

- QEI scientific board (8).
- QEI community (>700 participants from 81 countries).
- QEI workshops (2023 in Singapore, 2025 in Grenoble, 2026 in Barcelona, 2027 in Lisbon).
- QEI IEEE standards WG.
- ≈30 industry partners including IBM, Quandela, etc.

#QEI
the quantum energy initiative

pillars

science and engineering

- quantum thermodynamics and energetics.
- classical information thermodynamics.
- solid-state physics, quantum optics, quantum control, and quantum interfaces.
- quantum information theory and protocols: communications, algorithms, QEC/FTQC fundamentals.
- quantum metrology and sensing.

- QEC/FTQC full-stack implementation.
- quantum devices manufacturing.
- enabling technologies scaling.
- quantum network and QPU interconnect infrastructure.
- quantum software engineering and FTQC-HPC integration.
- quantum sensors.

non-exhaustive inventory

interdisciplinarity
hardware + software
resource estimates

- IEEE QEI standard.
- benchmarking standards.
- economic impact analysis.
- help projects funding.
- ethics and sustainability.
- policy makers outreach.

ecosystem

the initial call

Perspective

PRX QUANTUM **3,** 020101 (2022)

Quantum Technologies Need a Quantum Energy Initiative

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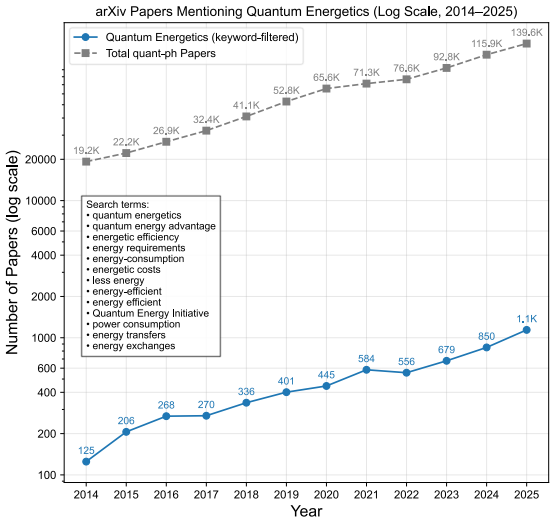
(Received 18 November 2021; revised 11 April 2022; published 1 June 2022)

prxquantum 3.020101

a nascent academic field



a first full-stack methodology

PRX QUANTUM **4,** 040319 (2023)

Optimizing Resource Efficiencies for Scalable Full-Stack Quantum Computers

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expanding work on FTQC

The energetic challenges of fault-tolerant quantum computing

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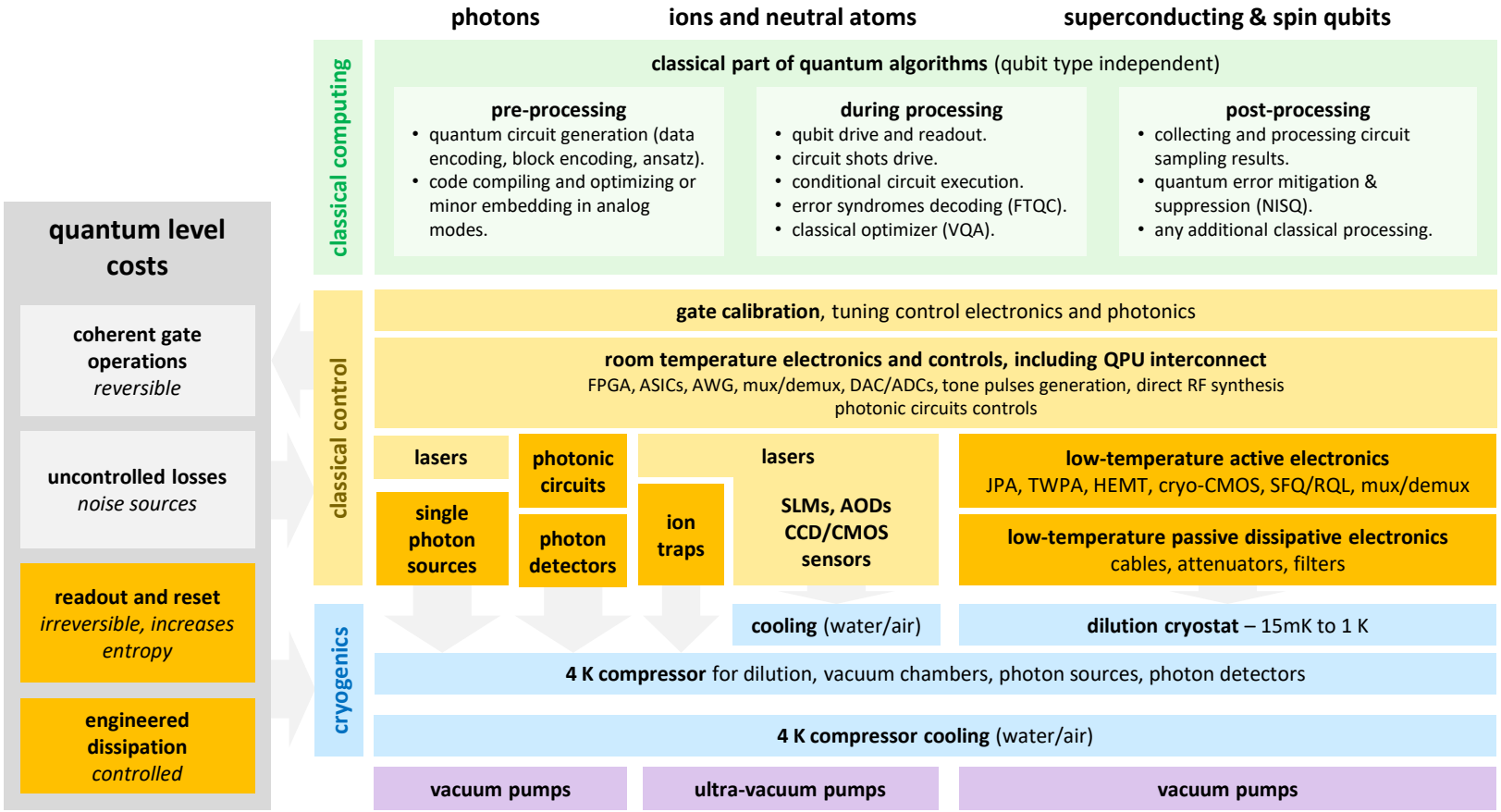
in preparation

standardization

https://sagroups.ieee.org/qei/

more to come…

accounting for all energetic costs



counter intuitive facts

cryogenics

- all qubit types rely on cryogenics.
- it's usually a variable cost vs physical qubit #.
- cryogenics won't be the dominant energetic cost in most cases.

electronics and photonics

- control electronics and photonics may become the dominant energetic cost in solid state platforms.

error correction

- error syndrome detection may dominate energetic costs for some qubit modalities.

science vs engineering

- still room for progress at the fundamental level.
- enabling technologies key role.
- lots of interdependencies between stack components.

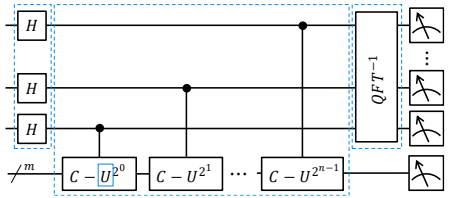
classical computing

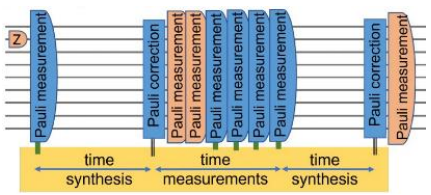
- classical energetic costs must be considered before, during and after a quantum circuit run.
- compilation is a variable cost vs the problem data.

economics

- energy can represent >30% of an FTQC total cost of ownership.
- FTQC cost could double the energetic bill of HPC centers.

classical computing costs to consider





problem structure
problem data

classical bits

value of interest
- ground state
- excited state
- index value

classical computing tasks

quantum circuit generation
- problem reformulation
- includes data encoding in an input vector or an oracle

circuit compiling
- transpiling and optimization
- error correction and fault tolerance conversion (FTQC)
- circuit partitioning

real time error detection (FTQC)

batch manager
- controls multiple circuit execution
- distributed workloads

circuit shots post-processing

calibration

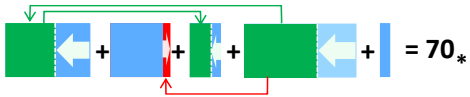
from baseline estimates to optimizations

more powerful optimizations

holistic optimizations

reductionist optimizations

- interdependent optimizations.
- typically, introduce trade-offs between spending less energy and introducing more noise.



examples:

- moving control electronics at cryogenic temperatures.
- multiplexing control signals.
- moving atoms to implement two-qubit gates and QEC.
- changing qubit temperature.

baseline resources

- include all active components.
- using existing state of the art technologies.
- sum-up the energy and power contribution of each component.

- optimize the consumption of individual components in the stack, without introducing more noise on the processor.

examples:

- improve cryogenic efficiency.
- reduce cable heat conduction.
- reduce the algorithmic cost without degrading its accuracy.

* % of baseline power or energy, for the sake of demonstration

key takeaways

- **quantum computing energetics** is a nascent field.
- **FTQC power consumption** may become significant, depending on the qubit type.
- **joint academic-industry-users work needed**, from assessments to optimizations.
- **standardization** needed as well on the basics of energy/power evaluations.
- **energy as the first step** towards full environmental footprint analysis.

discussion

get the slides

now