The aims of this session:

To reflect on the potential energy crisis triggered by AI and to consider quantum technology as a solution

Introduction
Motivation (AI)
- *Sustainability ceiling*
- *Smart efficiency*
- *Bottleneck*

Defining technology democratization
- *Definitions and analogies*

Example of technology democratization
- *Data analytics*

Solutions
- *Technology*
- *Education*
- *Policy*

Reflection and conclusion

The Path to Democratizing Quantum Utility

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About

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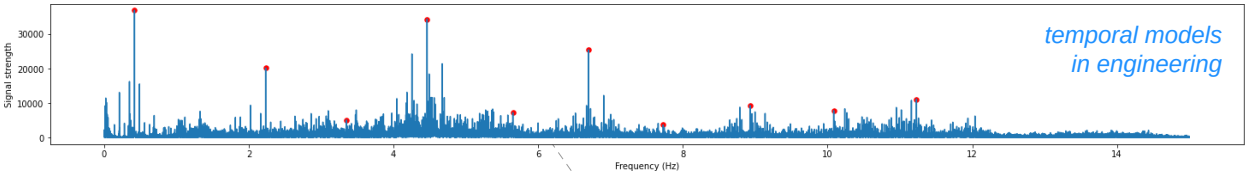

temporal models in engineering

Founder
Researcher
Consultant
at Enquanted

also

Honorary A/Prof
In Quantum Computing
School of IT, SEBE
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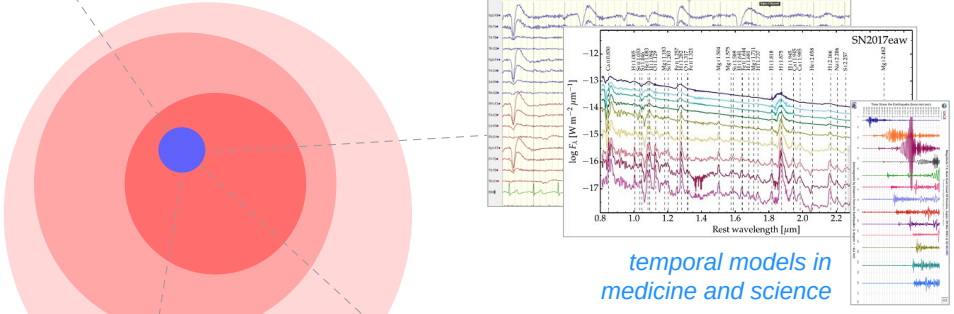
Research

- **Quantum computing**
- **Quantum machine learning**
  - **QML with complex data**
  - **Quantum TS and signal analysis**
  - **Quantum anomaly detection**
- **Classical machine learning**
- **Data visualisation**

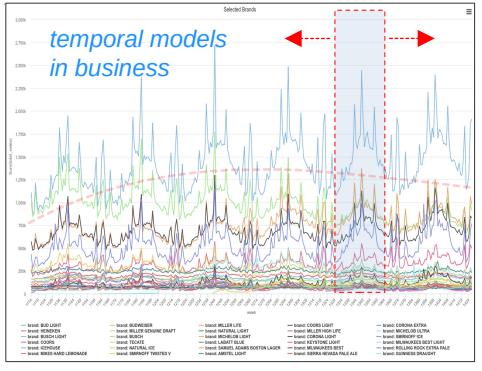
Personal

- **Recreational cycling**
- **Reading science and Sci-Fi**
- **Quantum hackathons**

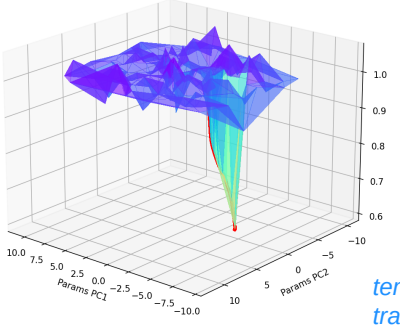
also, supervision of student projects,
supporting quantum internships,
taking part in open science projects,
QC/QML promotion, etc.



temporal models in medicine and science



temporal models in business



investigation of quantum models advantage utility

temporal models training difficulties

Introduction
The AI Energy Wall

- AI becomes an essential part of national infrastructures (IEA, EPRI, S&P)
- Training a single large LLM can take over 1,000 MWh, eqv. 100s of homes / year!
- AI requires data centre services and they require energy, data centres alone:
  - in US use 9% of total energy (2024)
  - in EU use up to 20% of total energy (2024)
- AI workloads requirement for the % of the total data centre power:
  - Currently 15% (2025)
  - Projected 50% (2030)
- Goldman Sachs projects that by 2030, the *US hyperscalers* will control 70% of global data centre capacity, up from ~60% today
- As energy demands rise, access to AI will become the new inequality, hitting both the financial and sustainability ceilings!

Is this an energy crisis?
Is this environmental disaster?

The global computational requirements
growth vs national constraints and solutions

Metric	United States (US)	China (CN)	European Union (EU)
2024 Est. Use	~180–200 TWh	~140 TWh	~70 TWh
2030 Projection	~400–600 TWh	~400 TWh	~115 TWh
Primary Constraint	Transmission Moving power to data centres	Latency Moving data to the east and computing to the western power hubs	Grid Capacity No capacity in FLAP-D hubs, so management by strict regulations
Dominant Player	Private Hyperscalers	State-Owned Enterprises and Tech Giants	Fragmented / US Hyperscalers

US Solution: Small modular reactors / Revived old nuclear plants
tech companies buying new and ageing nuclear reactors to supply power to their data centres

Hyperscalers	Strategy	Partner/Site	Status
Google	**SMR** (500 MW)	Kairos Power	First reactor by 2030
Oracle	**SMR** (1 GW)	Undisclosed (3 units)	"Permits secured"
Amazon	**Mixed** (5 GW)	X-energy (SMR) + Talen (Big)	SMRs in dev; Big plant hit regulatory snag
Microsoft	**Big** (819 MW)	Three Mile Island Undamaged unit 1	Restart in 2028
Meta	**Cancelled**	N/A	Blocked by environ. issues (Bee)

Break time:

Two stories of grand AI development

Capitalists vs public good

- **Amazon** was planning to expand the Susquehanna nuclear plant
- The plan was to connect the data centre directly to the nuclear power plant's busbar bypassing the public transmission grid
- Potential benefit: not paying transmission fees (20-40% of electricity costs) and avoiding years-long queue for the grid connection
- Some utility companies and the Federal Energy Regulatory Commission (FERC) argued that during maintenance and in emergency the plant would still need to access public grid, which would act as a giant battery backup
- Therefore Amazon is a free rider and trying to avoid paying the connection and transmission fees - FERC blocked the plant expansion!

The lesson: Hyperscalers may now be forced to pay their fair share for grid connection and transmission, thus democratizing the costs (socio economic) but slowing down AI development.

Bees vs power

- **Meta** was ready to sign a nuclear deal to power a new AI super-cluster
- The deal would make Meta the first Big Tech company to run an AI super-cluster entirely on nuclear power
- During the mandatory environmental survey of the land adjacent to the nuclear plant (in the belt of many older nuclear reactors), surveyors found a "likely" rare bee species
- Under the ESA, it is illegal to "take" (harm, harass or destroy) the habitat of the protected species
- Proceeding further would require years of biological studies, moving bee habitat, lengthy period of time for public comment and feedback
- The project was cancelled!

- *The lesson: It is not just about having money to access required tech services; it is also about democratization of regulatory and physical constraints of the world (socio political), regardless of money and power.*

Quantum Computing -
Possible part of the solution?

The Quantum Alternative - *Smart Efficiency*

- **Transition**
  - *from* Classical AI (Energy Intensive)
  - *to* Quantum AI/QML (Energy Efficient)
- **Metric:** Total Energy to Solution (TETS)
  - *Classical:* High energy, long duration
    (simulating a molecule could take months)
  - *Quantum:* Low energy, short duration
    (simulating a molecule could take seconds/minutes)
- **Two-Stage Efficiency Advantage**
  - *Stage 1 (Now): Algorithmic Efficiency*
    We save energy by taking fewer / more efficient computational steps
  - *Stage 2 (Future): Thermodynamic Efficiency*
    Leveraging quantum reversible computation (Landauer's Principle)
    to theoretically compute with near-zero heat dissipation
- **Hardware Diversity**
  - *Current (Superconducting):*
    Requires cryogenics (high constant power),
    yet TETS is still lower due to extreme speed
  - *Future (Photonic / Diamond / Neutral-Atom):*
    Potential for room temperature operation, eliminating the cooling energy cost,
    hence creating a double TETS win (faster time + lower power)

We are no longer talking about quantum advantage.
But rather we focus also on quantum utility!

The Bottleneck

- **Realization:**
  - we have the quantum hardware “roadmaps”, but …
  - we lack the quantum technology "drivers"
- **Gap:**
  - quantum machines can save energy, when ….
  - programmed correctly, but …
  - only a fraction of the workforce know how to do this
- **Implication:**
  - to unlock the energy-saving potential of quantum tech, we must decouple the utility of the quantum machine from the complexity of its physics
  - this will lead to quantum technology *Democratization*

… social and technological, not ethical!

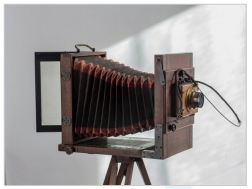
Defining technological democratization

The evolution of need, access and ease of use

Definitions

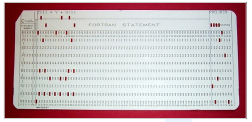
- **Specialization** (vertical)
  - ***Meaning:*** Mastery (e.g., baker)
  - ***Quantum need / availability:*** Exists (e.g., Qiskit programmer)
    Tools for quantum computing experts exist
- **Massification** (horizontal)
  - ***Meaning:*** Ubiquity (e.g., bakery)
  - ***Quantum need / availability:*** Low / Partial
    No need for everybody to use quantum tech
- **Democratization** (tech and cognitive)
  - ***Meaning:*** Utility access (e.g., home cook, bread lover)
  - ***Quantum need / availability:*** High / Non-existent
    No tools for domain experts who may need quantum solutions

The Ladder of Abstraction (hiding complexity)



- **Democratization of Image Capture (photography)**
  - ***From:*** View camera with plate and manual shutter (Manual)
  - ***Through:*** Cameras with light-meter and range-finder (Partial-automation)
  - ***To:*** AI-assisted smartphone cameras (Intent-driven)
  - ***The Lesson:***
    the user focuses on the subject
    the machine handles the optics

- **Democratization of Calculation (Math)**
  - ***From:*** Pen-and-paper, Tables and Slide rules (Manual)
  - ***Through:*** Calculators and later Graphing Calculators (Partial-automation)
  - ***To:*** Wolfram Alpha & Spreadsheets (Intent-driven)
  - ***The Lesson:***
    we stopped being "human computers"
    we become "problem formulators"

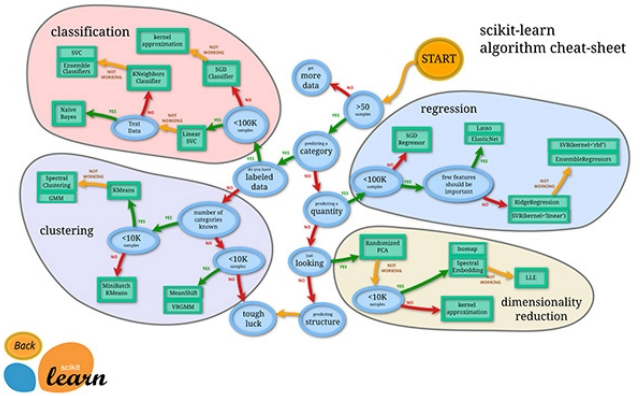


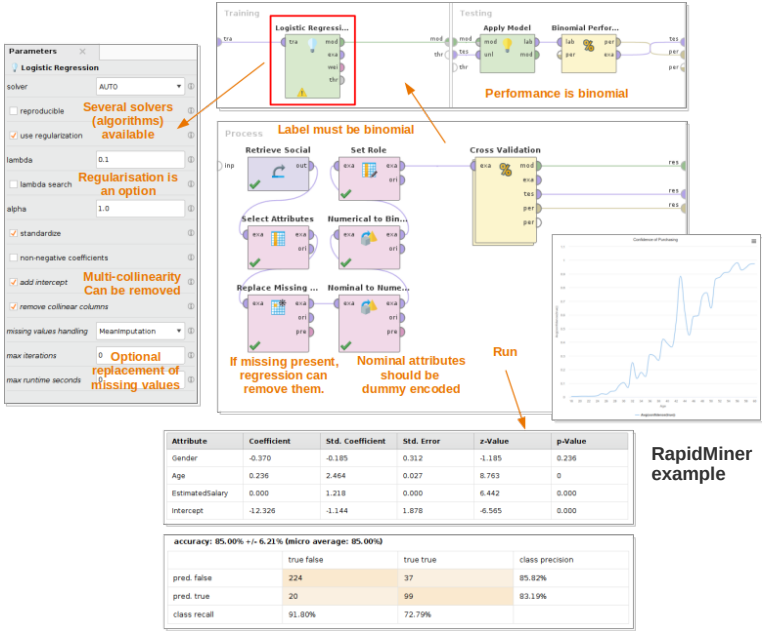
- **Democratization of Logic (Software Engineering)**
  - ***The Historical Trajectory:***
    1) *Coding:* Precise "how" (Assembly, Fortran, Cobol)
    2) *Design & Specification:* Abstract "what" (UML, CASE tools)
    3) *Requirements & Intent:* "why and when" (BPR, business rules engine)
  - ***The Quantum Parallel:***
    1) We are currently stuck at “coding” (Pulse/Gate control)
    2) We need to move to "specification" (Domain-specific objectives)
    3) Ultimately, we need to be at "intent" (Business logic)

Evolution of a solution
Shifts in cognitive load

Cognitive offloading in a key parallel of Data Analytics

- **Stage 1: The Era of Masters (Pre-2005)**
  - ***Start:*** Linear Algebra + Statistics + C++/Fortran
  - ***User:*** A specialized statistician/programmer
  - ***Parallels to QC Today:*** This is exactly where Quantum Computing is now. You need to understand Hamiltonians, circuits and gates, Linear Algebra, and some Quantum Mechanics, to get a result
- **Stage 2: The Era of Librarians (2000-2015)**
  - ***Shift:*** R, SAS, Pandas and Scikit-Learn in Python, TensorFlow, PyTorch
  - ***User:*** Data Scientist
  - ***Change:*** You don't write the matrix multiplication routine; you just import it
  - ***Parallels to QC:*** We are just entering this phase with SDKs, such as like Qiskit with QML library, but their abstraction is still very low (you still need to understand quantum methods and effects)
- **Stage 3: The Era of Strategists (2010-2025)**
  - ***Shift:*** GUI-based tools (SAS Viya, RapidMiner, Tableau, PowerBI)
  - ***User:*** Business Analyst / Marketing Manager
  - ***Change:*** The "Black Box" effect - a user drags a "Logistic Regression" node onto the canvas, does not understand the math, but understand its business value
  - ***The Goal for QC:*** This is the target state, e.g. a logistics manager creates a route optimization workflow and a hybrid quantum-classical algorithm decides which parts execute on what machine
- **Stage 4: The AI-Transformed Polymaths (2020-Near Future)**
  - ***Shift:*** AI-Based tools and AI-Humans teams...





RapidMiner example

Solutions
Hiding quantum, AI, education / innovation

Possible technology approaches to hiding complexity

- **Black-Boxing and Embedding** (inevitable with up-scaling of quantum devices?)
  - ***Concept:*** Moving from "Circuit Composer" to "Problem Solver"
  - ***Mechanism:*** Hiding the quantum circuit entirely behind an API (encapsulation)
  - ***Effect:*** Freeing up the user's mental energy to focus on the why, not the how
- **The Invisible Controller** (differential programming?)
  - ***Concept:*** Controller dispatches computations to co-processors (CPU/GPU/QPU)
  - ***Mechanism:*** The controller decides which program part needs to be compiled for CPU (e.g., data plotting), GPU (e.g., matrix ops), or QPU (e.g., optimization)
  - ***Effect:*** The user may never know they used a quantum computer
- **The Interactive Quantum Computing / QML GUI** (CASE or VLSI like?)
  - ***Concept:*** Interactive GUI for hybrid quantum-classical models
  - ***Mechanism:*** User interactively constructs a visual quantum-classical model → Qiskit / PennyLane code generation → QASM → Hardware Execution
  - ***Effect:*** The problem solution is constructed as a visual model consisting of interlinked, well-understood, domain-specific and reusable components
- **Adding AI Magic** (are we there yet?)
  - ***Concept:*** *Using multimodal AI as a conversational interface*
  - ***Broader Scope:*** *Moving beyond text prompts - an interaction with AI would include multimodal tools to construct and interpret:*
    - *High-level analytic models (e.g., a UML or a financial risk model)*
    - *Audio-visual input (e.g., hand-drawn chemical structure or a video of interaction).*
  - ***Mechanism:*** *User Input (Speech / NL / Diagram / Drawing / Video) → AI Interpretation → QASM → Hardware Execution*
  - ***Effect:*** *Natural expression used as as a domain-specific spec of the problem*

India experience with quantum education and innovation

- **Democratizing Knowledge (Standardization)**

  Problem: Quantum is currently "locked" inside elite Physics departs (IISc, TIFR) and faculty workshops (e.g. MGIT, MTC, JAIN, JIMS)
  - ***Gov. Solution:*** The AICTE B.Tech Minor Degree.
  - ***Policy:*** National Quantum Mission (NQM) collaborated with AICTE on a standardized curriculum for a Minor Degree in Quantum Tech
  - ***Effect:*** Quantum moves from small workshops to a credit-bearing undergrad program in Tier-2 and Tier-3 colleges
  - ***Impact:*** Move from ~2,000 faculty staff trained (via ATAL) to tens of thousands of certified B.Tech graduates by 2026-27
- **Democratizing Access (Infrastructure as a Service)**

  Problem: 99% of Indian colleges cannot afford a quantum machine or device, such access is limited to rich institutes
  - ***Gov. Solution:*** Thematic Hubs (T-Hubs) and "Quantum Clouds"
  - ***Policy:*** The NQM established 4 T-Hubs (like the one at IISc) with a mandate to function as "Hub & Spoke" models
  - ***Specific Examples:***
    - *Chennai Metro Area Quantum Access Network (MAQAN):* to let multiple institutions to "plug in" to a quantum network
    - *Karnataka's Quantum City:* to provide "Quantum Cloud" access to students in remote colleges
  - ***Effect:*** It decouples participation from wealth - eliminates need for hardware acquisition; the government buys it and provides access
- **Democratizing Innovation (Startup Bridge)**

  Problem: Only large defense labs (DRDO) or tech giants could historically afford to build quantum solutions.
  - ***Gov. Solution:*** Non-Equity Funding for Startups.
  - ***Policy:*** Quantum Computing Startup Funding
  - ***Effect:*** The government is providing grants (not loans) to startups, lowering the barrier to entry for young innovators.

Summary
Impact, reflection and conclusion

Are all these inevitable anyway?
Will AI naturally displace IT workforce into Quantum?
(at least for a very short while)

Let us say we have a viable technical solution to achieving democratization of quantum computing. What's next?

Stakeholder Impact

- ***Scientist:*** Accelerates discovery (materials/drugs) without needing a second Ph.D. in physics
- ***Business Leader:*** Accesses "Quantum Advantage" for competitive gain via standard enterprise software (e.g., SAP/Salesforce plugins)
- ***Quantum Workforce:*** Shifts from "Quantum Physicists" to "Quantum-Literate Developers"

Reflection: The Risks of the Black Box

- ***Misinterpretation:*** If you don't understand quantum effects, where choices offered are not definite or conclusive, you might make poor business decisions
- ***Verification:*** Can trust the answers if we can't explain them?

Introduced concepts…

- ***The Abstraction Ladder:***
  The history of technology is the history of hiding complexity
- ***Cognitive Offloading:***
  Shifting focus from process to strategy
- ***Vertical vs. Horizontal Access:***
  Massification (Horizontal) vs. Specialization (Vertical)
- ***Total Energy to Solution (TETS):***
  The proposed metric for computing efficiency

Democratization via education (India experience)

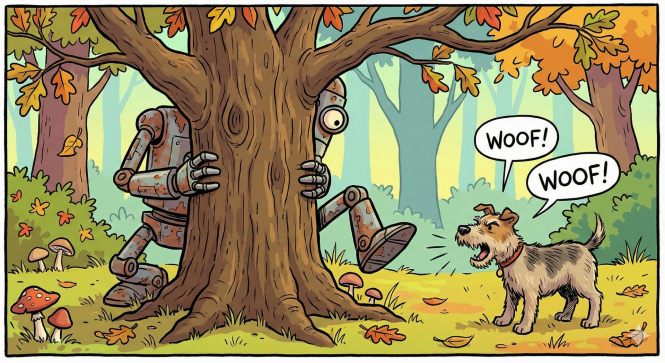
	Phase 1 *(Current Reality)*	**Phase 2** *(Government Aims)*
Education	Faculty workshops (50-person cap)	Formal B.Tech Minor Degrees
Access	Elite labs only (IISc/IITs)	Cloud access for Tier-2/3 Colleges
Hardware	Owned by an institute	Shared utility (Hub & Spoke)
Democratization Level	**Low-Medium** (Compliance limits)	**Medium-High** (Enabled by policy)

Conclusion: The Green Horizon

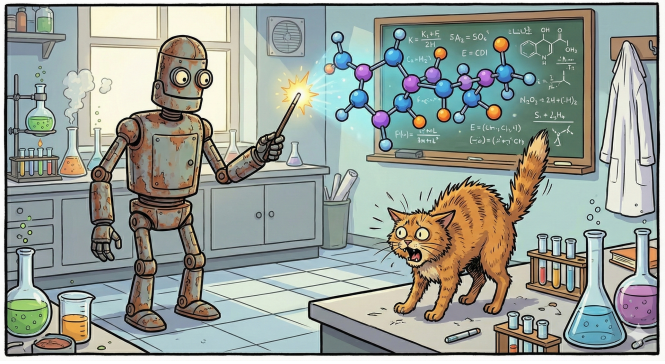
- ***Motivation:*** The unfolding energy crisis of classical AI
- ***Opportunity:*** Quantum technology can be part of the solution
- ***Argument:*** Democratization is the key to unlocking the energy efficiency of Quantum AI. As we make advances in quantum tech, and make its tools accessible physically and cognitively to various stakeholders, we will enable a global shift toward sustainable, high-performance computing, and AI in particular
- ***Closing Remarks:*** Success will be achieved when Quantum Computing becomes an invisible and essential engine of AI progress, as the electricity grid that powers it

Thank you!

Hiding complexity



Adding AI magic



Images from Unsplash, Wikipedia and Nano Banana Pro

Enquanted is being somewhere in-between Enchanted and Entangled

Any questions?

References

Aaronson, S., Childs, A.M., Farhi, E., Harrow, A.W., Sanders, B.C., 2025. Future of Quantum Computing. *ArXiv:2506.19232v1*.

Dessimoz, C., Thomas, P.D., 2024. AI and the democratization of knowledge. *Sci Data 11*, 268.

Gercek, A.A., Seskir, Z.C., 2025. Navigating the Quantum Divide(s). *IEEE Engineering Management Review (Early Access)*, 1–19.

Seskir, Z.C., Umbrello, S., Coenen, C., Vermaas, P.E., 2023. Democratization of quantum technologies. *Quantum Science and Technology 8*.