Welcome! You’re joining us for

When Quantum Gets Real: Use Cases, Risks & Responsibility

As you’re waiting, introduce yourself in the chat:

- name, pronouns
- where you’re from
- why are you here?

When Quantum Gets Real: Use Cases, Risks & Responsibility

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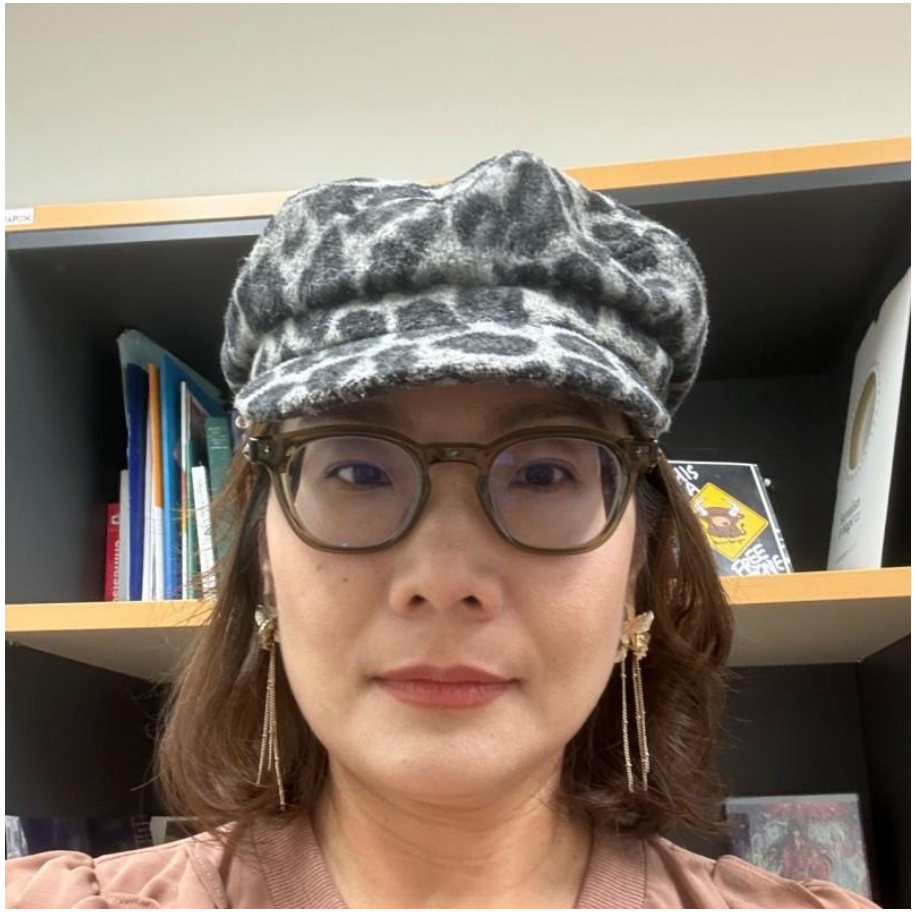
Centre for Quantum Technologies, National University of Singapore

25 June 2025

Clara Yun Fontaine

Clara (they/them) is a PhD candidate at the **Centre for Quantum Technologies in Singapore**. As an experimental physicist and engineer, they build **superconducting quantum devices** to enable robust quantum computing and explore quantum simulations of nature. In the broader quantum ecosystem, they actively engage in **education and outreach (QCamp), community-building (QYRA), and responsible technology initiatives (ResQT)** in the Singapore and Indo-Pacific ecosystems. They are dedicated to shaping the course of science and technology to **dismantle systems of oppression**, and **build a gentler, sustainable world in its place where every human lives with dignity**.

Clarissa Ai Ling Lee



Clarissa (they/them) is a Malaysian researcher whose work focuses on the **ethical and societal dimensions of emerging technologies**, particularly responsible innovation in quantum technologies. With a background bridging **physics, digital media, and innovation/creative studies, she examines how quantum research intersects with issues of governance, equity, and global policy**, drawing on her previous work on nuclear technologies in developing economies. Her interdisciplinary approach integrates speculative design, participatory design, policy studies, and critical theory to explore **how quantum technologies can be developed ethically and inclusively**, especially within the context of Southeast Asia and emerging markets.

What is responsible quantum technology? Tell us your thoughts!

slido.com – 2638042

Responsibility means thinking about…

How will this technology impact our world, both in its development and deployment?

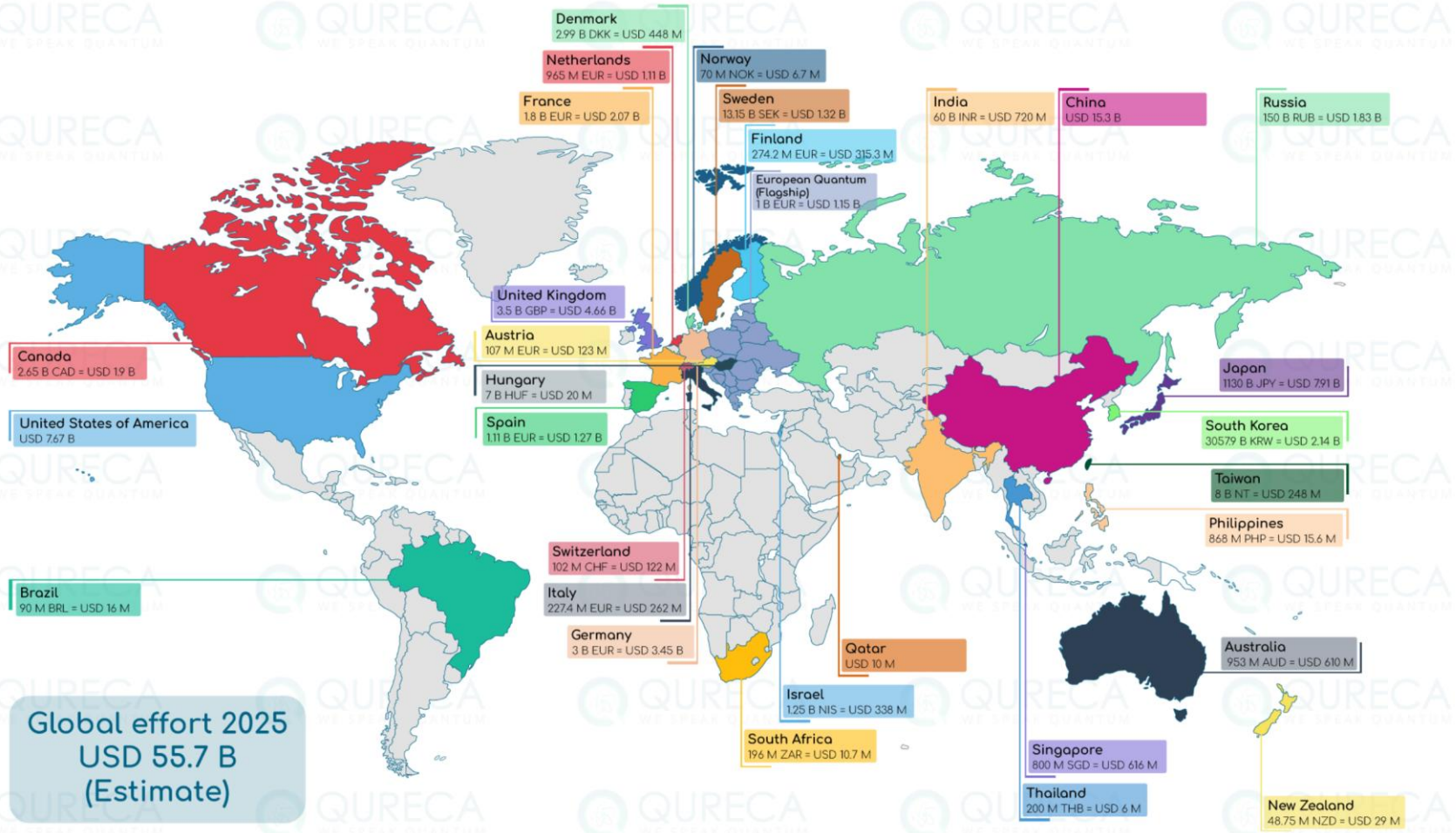
- Who or what benefits?
- Who or what is harmed?
- How are existing structures disrupted or perpetuated?

What can be done to shape its impacts, and who is responsible for doing so?

- Power distribution?
- Resource distribution?
- Timeline?

Why do we care about responsibility in quantum?

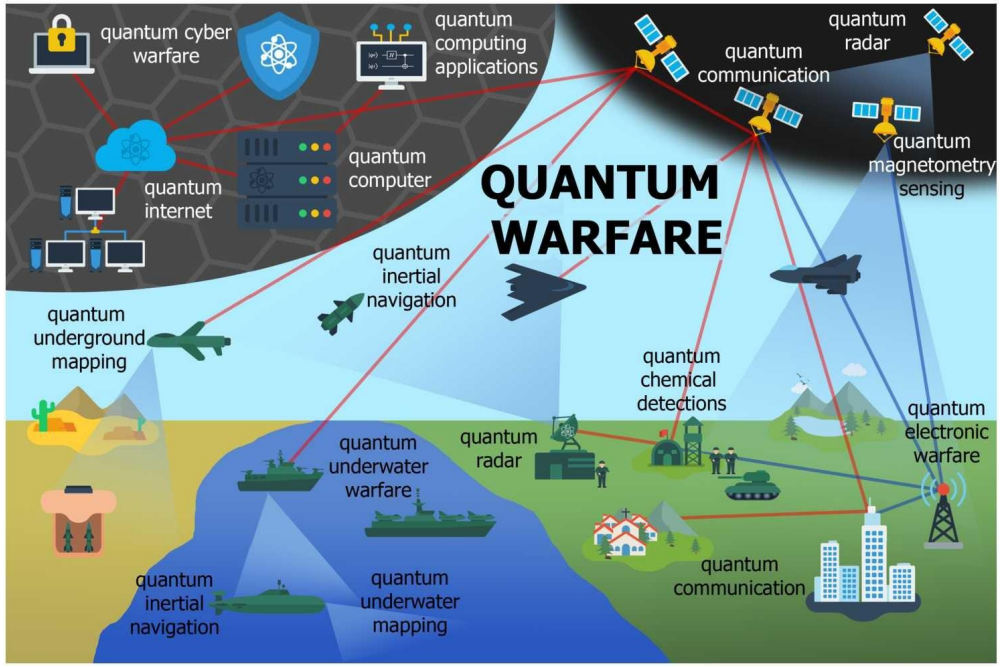
Massive global investment = massive stakes



https://www.qureca.com/quantum-initiatives-worldwide/

Potentially transformative use-cases, both for harm and good

quantum technology to “keep the fight unfair”



Krelina, M. Quantum technology for military applications. *EPJ Quantum Technol.* **8**, 24 (2021)

Sustainability: Theme 9 of the Quantum Economy Blueprint

(McKinsey, 2022)

Exhibit 1

Quantum computing could bring about step changes throughout the economy that would have a huge impact on carbon abatement and carbon removal.

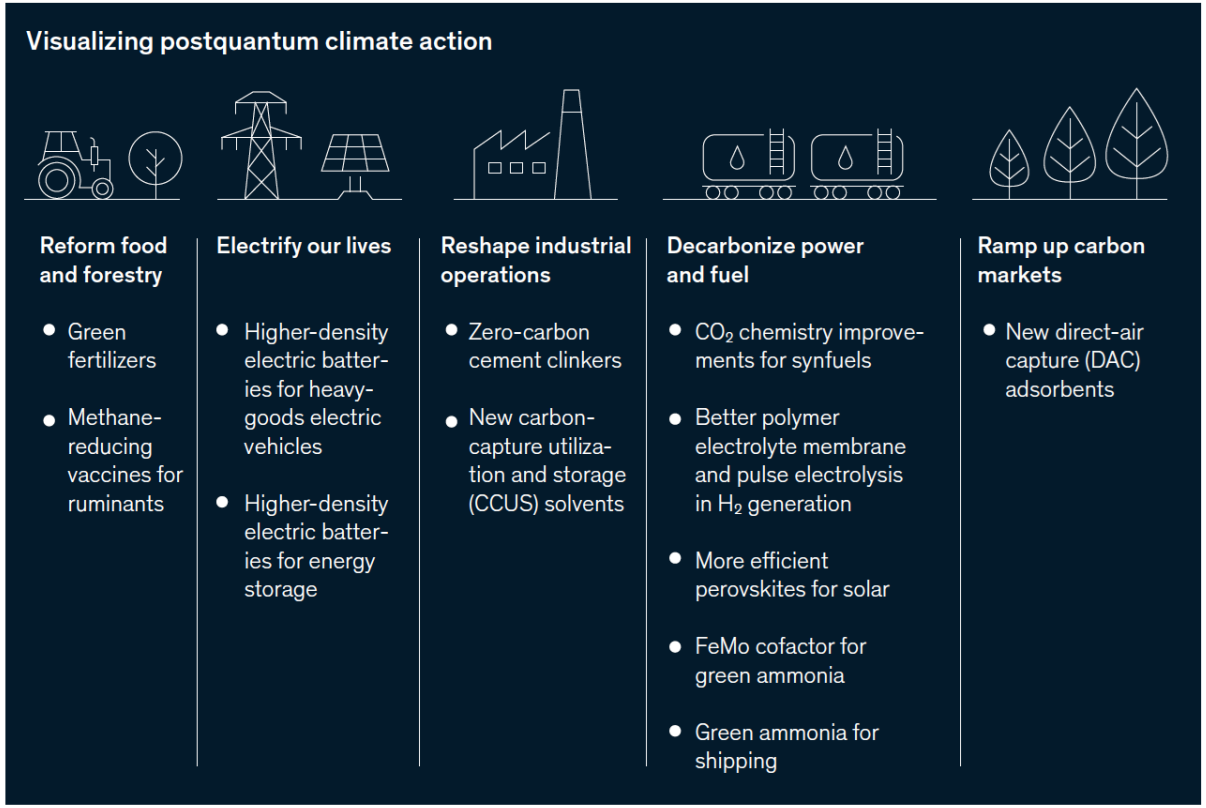
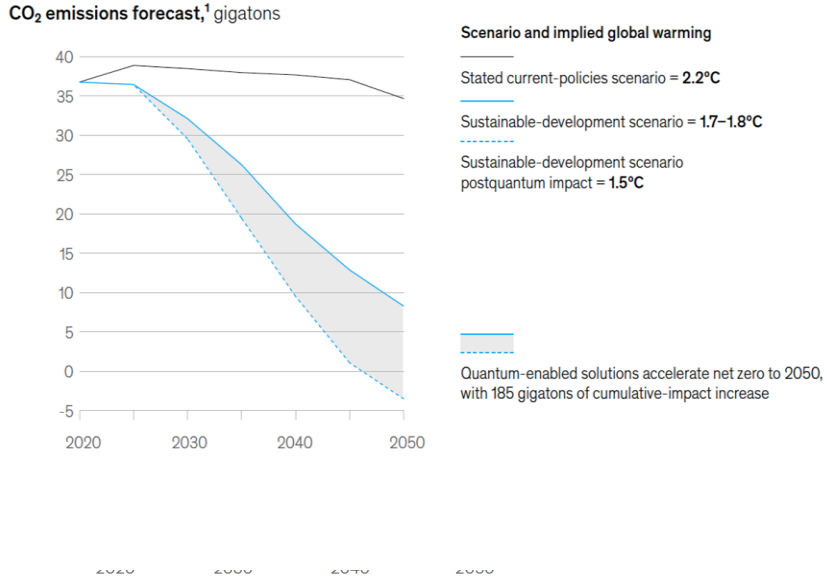
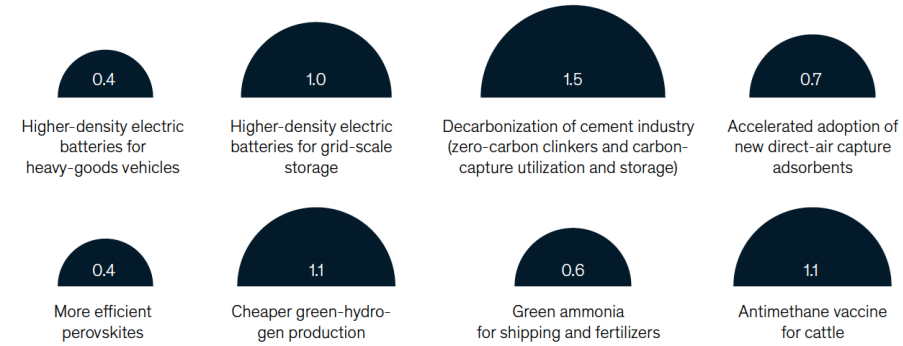


Exhibit 5

Quantum-enabled technologies could put the world back on track to becoming net-zero before 2050.



Annual additional CO_2 quantum impact abatement potential, gigatons



Source: International Energy Agency; McKinsey analysis

The Building Blocks of Sustainability - Energy, Climate Change, and Environment

9.1: **Strategies for sustainable quantum technologies** - development of low-energy consumption QTs that do not require scarce materials.

9.2 **Strategies for energy consumption benchmarks** - different applications of quantum technologies can be implemented in various ways or with different hardware. Benchmarks are developed.

9.3 **Incentivization strategies for sustainability use cases** - identification of use cases that could contribute to global sustainability, focusing on global sustainability and climate change.

9.4 **Focus areas for positive impact on environment** - establishing detailed research plans for areas in material science, chemistry, and environmental monitoring.

Risks of perpetuating existing harms in world full of injustices

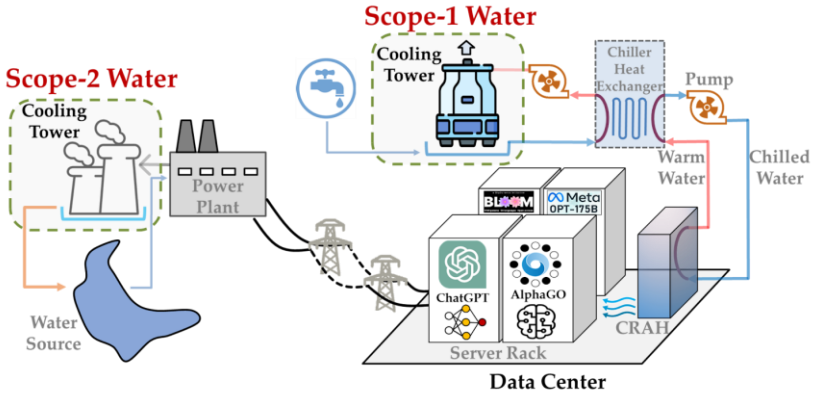
The Mountain that Eats Men
Cerro Rico, Bolivia

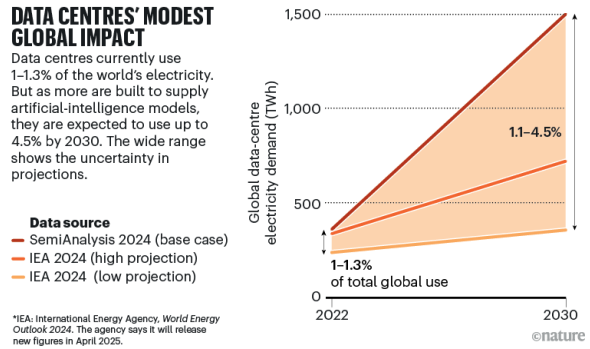
Mining for materials used to build technology: indium, silver, zinc, lead

https://www.npr.org/2012/09/25/161752820/bolivias-cerro-rico-the-mountain-that-eats-men

High physical resource cost in an accelerating climate crisis

https://oecd.ai/en/wonk/how-much-water-does-ai-consume





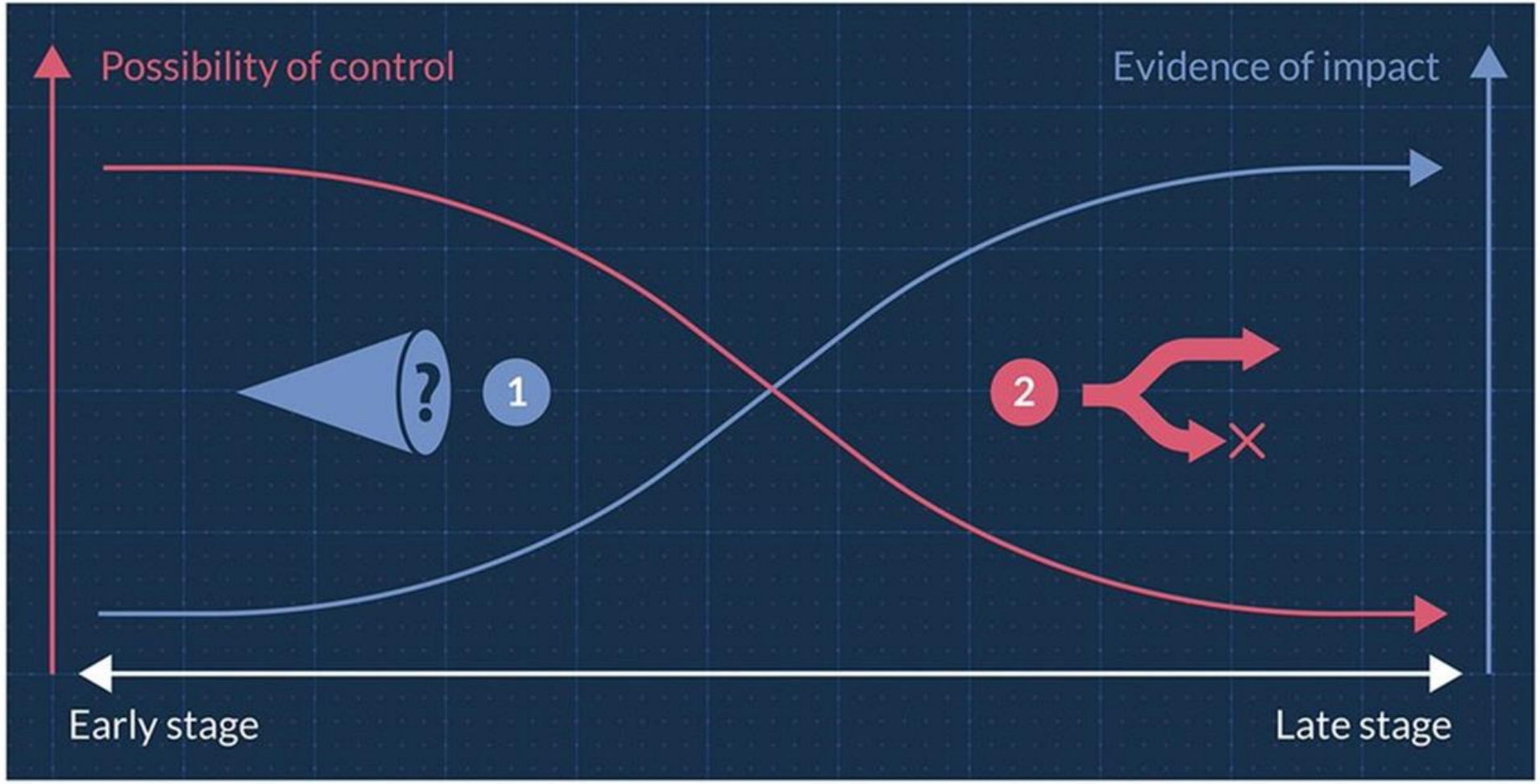
Global AI's Scope 1 & 2 Water Withdrawal in 2027

Est. 4.2~6.6 Billion Cubic Meters

AI ≈

4~6x Annual Water Withdrawal of Denmark

Collingridge dilemma: the time is now

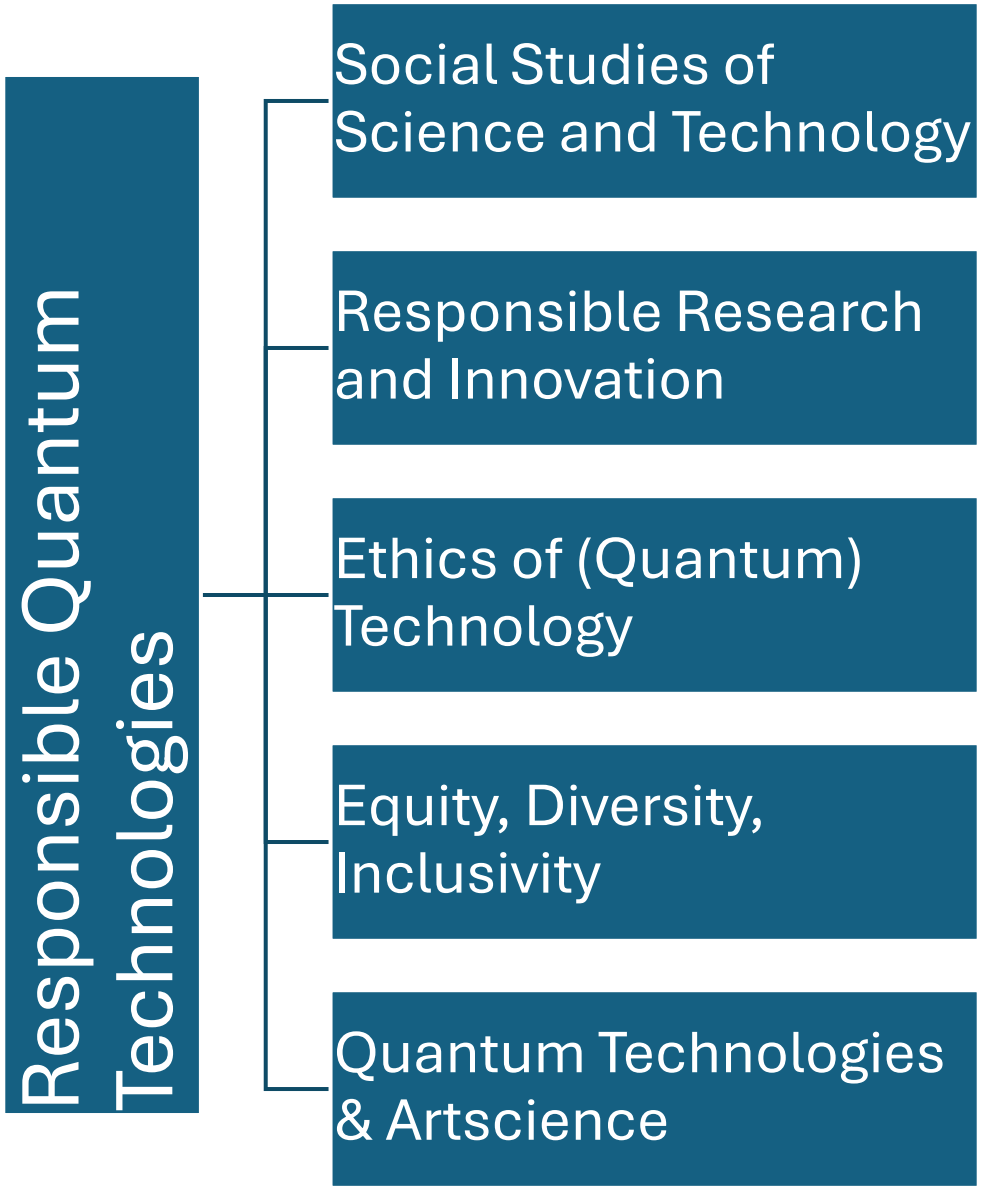


1
- Easy to control
- Hard to know the impact

2
- High evidence of impact
- Hard to control

Credit: Zeki Seskir

Getting Started in Thinking Critically and Responsibly: Some Theories


Responsible Quantum Technologies
Social Studies of Science and Technology
Responsible Research and Innovation
Ethics of (Quantum) Technology
Equity, Diversity, Inclusivity
Quantum Technologies & Artscience

1. Place of Quantum Technologies in the Social Studies of Science and Technology

- Philosophical, historical and sociological dimensions across quantum 1.0 and 2.0.
  - In philosophy, the focus is on the foundational nature of quantum physics leading to particular forms of technologization, and ethics governing technologization.
  - In history, the focus involves the history of quantum physics (quantum mechanics), history of (quantum) technology, and socio-political-cultural histories.
  - The sociological overlaps with the anthropological.

2. Responsible Research and Innovation

- Newly emerging science and technology.
- Social signifiers and impact potential.
- Techno-visionary futures.
- Responsibility as ethics.
- Consequences of decision-making.
- Ethical, legal, social and economic implications.

3. Ethics of (Quantum) Technology

Pacing — anticipate speed of development to introduce governance for minimizing harm.

Timeliness — maintaining ethical principles with technological development to support non-harmful societal transition.

Risk — potential unwanted events and outcomes that may result from applications of the new technology.

4. Equity, Diversity, Inclusivity (EDI) – Why Does That Matter?

Technology is always social - how you choose to design technology impacts users.

Technologies designed to fit with other technologies - augmentation of certain values.

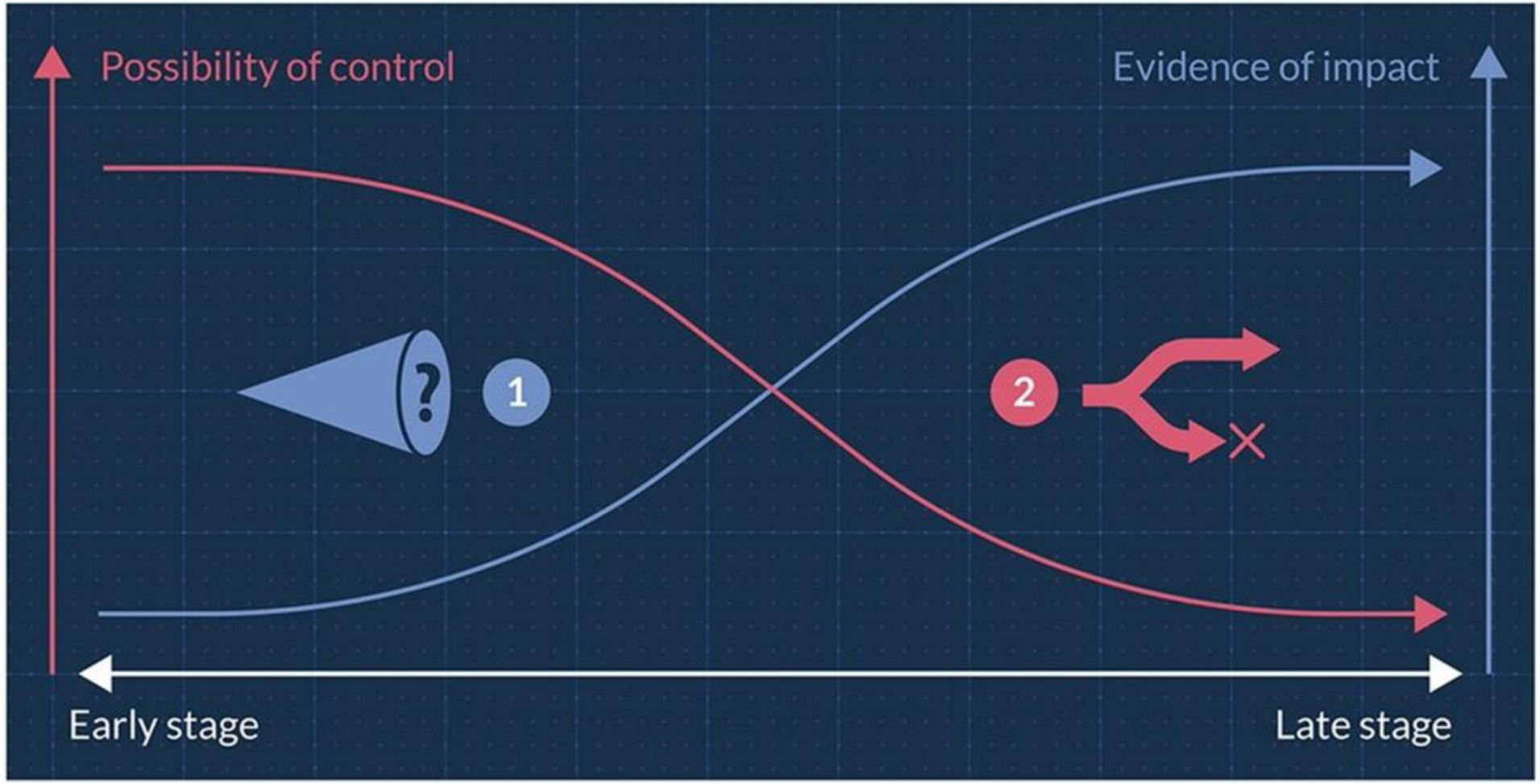
Principle of Symmetry – similar standards could be applied to explain why a use case could both be successful or unsuccessful.

5. Quantum Technologies & Artscience

Science Communication	Art becomes the medium for illuminating and demonstrating the aesthetic and intuitive aspect of quantum technoscience.
Art installation or Performance	The science becomes the building block for the art.
Creative Multimodal Technologies	The art and science match and complement each other to produce quantum-inspired/quantum inflected creative technologies.
Gamification	Concepts, theories, and technologies gamified for the purpose of education & learning, as well as exploratory and discovery type research.
Quantum artscience	Highest attainment not yet accomplished.

Zooming into Southeast Asia: How can we be responsible?

Technology and the Collingridge dilemma



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Credit: Zeki Seskir

The SEA of Responsible Quantum Technologies for SEA

Safeguarding	Engaging	Advancing
Safeguarding against risks – historically began with nuclear technologies.	Engaging stakeholders in innovation – could this encourage co-creation cultures?	Advancing quantum technologies – work in progress

Technological Assessment: ASEAN Framework

- In the ASEAN Plan of Action on Science, Technology, and Innovation, for 2016-2025, there is no technological assessment thrust.
- Lack of frameworks for assessing the technologies acquired, developed, and/or commercialized.
- National S&T agenda primarily focuses almost primarily on cultivating technical skills, leading to a positivistic and unreflective technoscientific culture.

What are the forces impacting responsibility in the broader ecosystem?

Responsibility compels us to engage with
the forces that shape the world.

Quantum is situated within broader power structures.

capitalism >

few rich elite own production
workers sell labour to earn money
rich elite accumulate surplus created by workers
demands endless growth in a finite world

imperialism >

rich countries dominate poor for land, labour, resources
control is military, political, and/or economic
benefits for rich core; harms for periphery

Capitalism is fortified and expanded through imperialism.

Capitalism and imperialism are upheld through a web of systems.

> the military

> the criminal justice system

> property laws

> financial systems

> education

> media and cultural institutions

> global organisations

In some critical ways, **these systems help the rich and powerful accumulate wealth**.

It’s unavoidable that
capitalism and imperialism
shape how quantum tech is and will be
developed, governed, and used.

Let’s go over some examples.

Capitalism rewards those who already have capital.

capital >	money, land, raw materials, intellectual property, financial assets
those with capital >	invest and extract more value higher access to loans, grants, and investments lower risk of debt political power: lobbying, government contracts

QUANTUM IMPACT >

Entities with wealth have more power to shape quantum.

imperial core v. peripheries

Global North v. Global South

tech giants v. startups

Capitalism rewards private ownership and control of quantum.

power of ownership and control >

charge others for use
control or prohibit use
profit from labour and innovation
reinforce unequal dependencies

QUANTUM IMPACT >

Wealthy private owners end up in control of quantum.

fruits of public research → corporations or military

Decision-making isn’t democratic.

controlled by elites > few private, wealthy owners of tech governments, corporations

driven by profit, not public need > accountable to shareholders

framed as “too technical” for the public > discourages public participation

secrecy around geopolitics > closed-door discussions
export controls
knowledge security

QUANTUM IMPACT >

The dominant use-cases will benefit the elites.

financial modeling, supply chain dominance, market monopolisation, military, surveillance, and policing

War use-cases will prevail.

imperialism demands militarization for wealth accumulation >

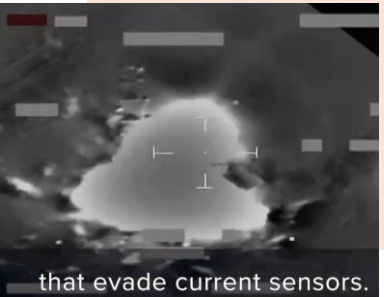
seize land, labour and resources
suppress resistance
protect corporate interests
establish political and economic control

militarization is profitable >

defence industry is lucrative
weapons, sensors, cybersecurity, surveillance
surveillance

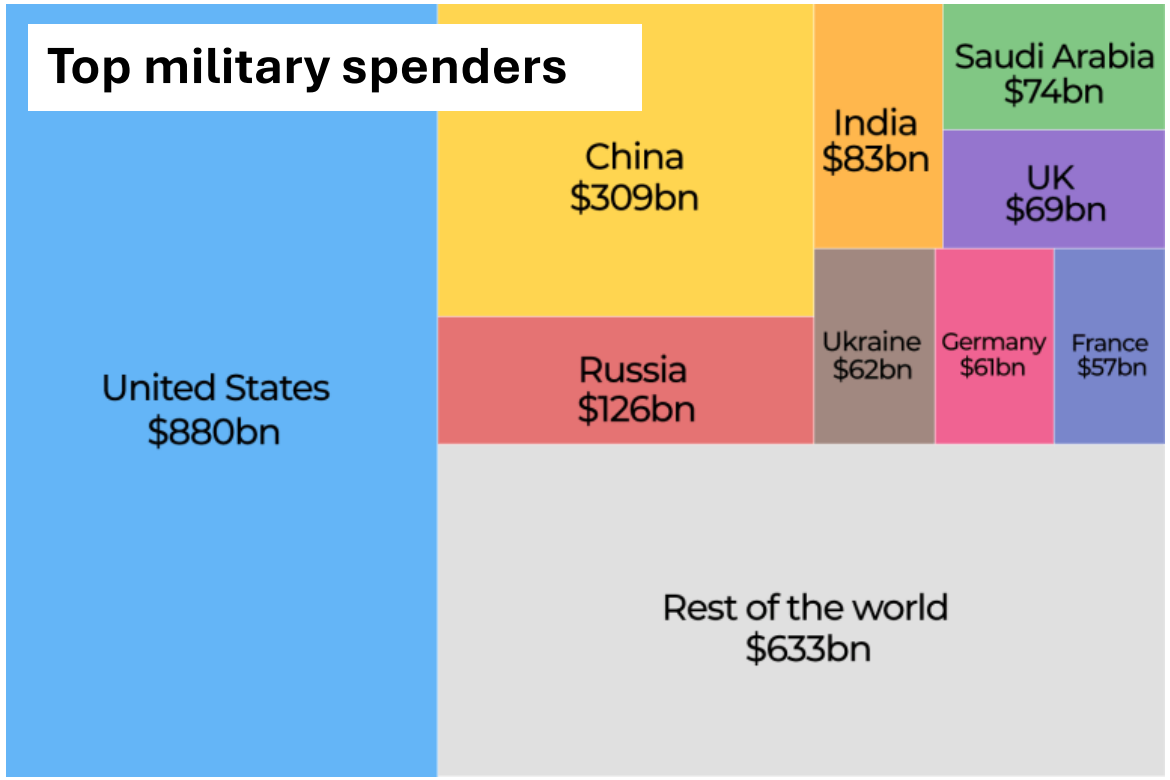
profit strengthens imperialism >

money means power

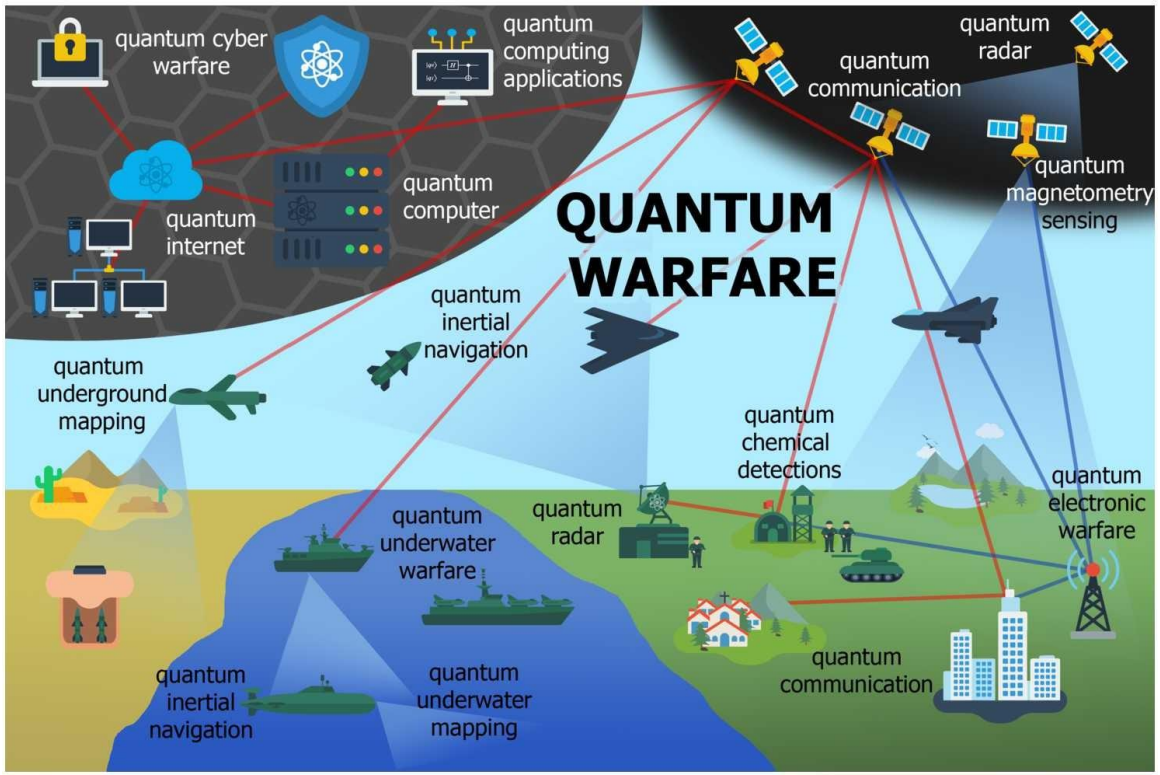


QUANTUM IMPACT >
The military and state heavily fund war applications of quantum.

War use-cases will prevail.



https://www.aljazeera.com/news/2025/2/17/which-countries-are-the-top-military-spenders-and-where-does-europe-rank



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Lockheed Martin and Google Cloud Announce Collaboration to Advance Generative AI For National Security

Intel to spend $25bn expanding its Israel chip plant

US Army Reserve swears in tech leaders from Palantir, Meta, OpenAI, and Thinking Machines

GOOGLE IS HELPING THE TRUMP ADMINISTRATION DEPLOY AI ALONG THE MEXICAN BORDER

Google is part of a Customs and Border Protection plan to use machine learning for surveillance, documents reviewed by The Intercept reveal.

The Hidden Ties Between Google and Amazon's Project Nimbus and Israel's Military

Trump Taps Palantir to Compile Data on Americans

Google drops pledge not to use AI for weapons or surveillance

OpenAI wins $200m contract with US military for 'warfighting'

TECHNOLOGY

Big Tech in the military-industrial complex

The top five contracts between major technology companies and United States military and intelligence agencies between 2019 and 2022 had contract ceilings worth at least $53bn, according to a report by the Costs of War Project at Brown University's Watson Institute for International and Public Affairs.

VENDOR	BUYER	CONTRACT CEILING	AWARD/DURATIONS
Integrated Visual Augmentation System (IVAS)			
Microsoft	U.S. ARMY	$22bn	March 2021 / 10yrs
"Wild and Stormy"			
a		$10bn	July 2021 / 5yrs
Commerical cloud enterprise			
a Microsoft G IBM ORACLE	CIA	"Tens of billions"	November 2020 / 15yrs
Joint Warfare Cloud Capability (JWCC)			
a Microsoft G ORACLE		$9bn	December 2022 / 5yrs
Enterprise Services			
Microsoft		$1.76bn	January 2019 / 5yrs

Source: Watson Institute for International & Public Affairs (Brown University) April 18, 2024

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Knowledge and resources restricted to protect capital and preserve dominance.

incentivized restrictions >

monopolize markets
patent and control its use
gain economic, military and political control

National knowledge security guidelines

Secure international collaboration

QUANTUM IMPACT >

export controls, economic sanctions, knowledge security regulations, limiting scientific collaboration, classification as national security technologies, visa restrictions

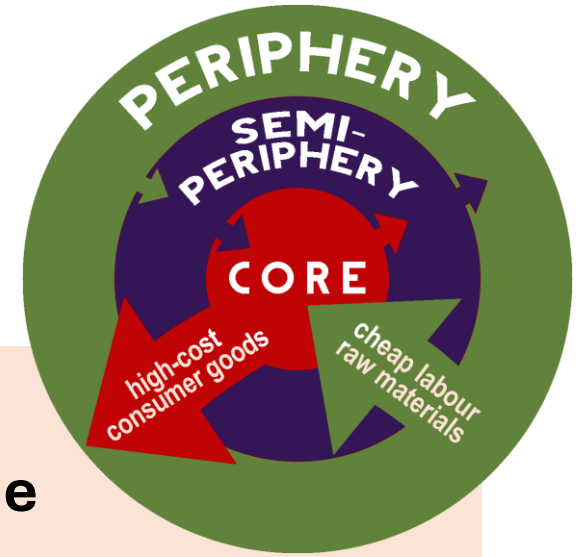
On a global scale, capitalism and imperialism create extractive relationships.

flow from periphery to core >

knowledge, talent, raw materials, goods
financial investments

little investment into regional autonomy >

forces a dependency



QUANTUM IMPACT >

The development of the imperial core through the underdevelopment of the Global South periphery.

mining conflict minerals, Global South doesn't have resources or knowledge to build their own quantum technology, students studying abroad cannot return due to lack of opportunity

Dissent and noncompliance will be repressed.

economic coercion >	essential goods privatized fear of poverty, homelessness, unemployment work or starve
criminalisation >	illegalized protests, strikes, speech labelling dissent as “terrorism”
surveillance >	digital footprint artificial intelligence
ideology >	meritocracy and individualism “if you suffer, it’s your fault” “change is unrealistic”

QUANTUM IMPACT >

Workers and students will be surveilled and violently repressed by elites to ensure control over use-cases and profits.

Dissent and noncompliance will be repressed.

https://www.aljazeera.com/gallery/2025/1/20/aerial-photos-show-scale-of-israeli-destruction-in-gaza

https://www.theonlinecitizen.com/2025/03/09/students-condemn-police-raids-over-gaza-memorial-as-intimidation-spf-says-actions-were-lawful-and-necessary/

https://www.theguardian.com/us-news/2025/apr/26/university-student-protesters-discipline

https://www.lemonde.fr/en/international/article/2025/05/16/council-of-europe-accuses-israel-of-deliberate-starvation-in-gaza_6741353_4.html

Google has fired 50 employees after protests over Israel cloud deal,

Microsoft workers fired over Gaza vigil say company 'crumbled under pressure'

Mahmoud Khalil: US judge denies release of detained Palestinian activist

https://www.commondreams.org/news/college-campus-protests-gaza

Germany wants to deport four pro-Palestine activists: What you should know

Capitalism puts profit over planet.

treating the planet as free >	violent extraction of resources ecological devastation climate crisis: point of no return
greenwashed climate "solutions" >	only if it makes a profit protect image and profits
frontline communities bear the costs >	poor, migrants, displaced, disabled, Indigenous

QUANTUM IMPACT >

Use-cases will prioritize profit for the elite over sustainability of the planet.

ignoring physical resource cost, devastating material extraction, fossil fuel use-cases, risk modeling to profit from climate chaos

Selective responsibility to justify violence: how words are twisted to gain public support for imperialism

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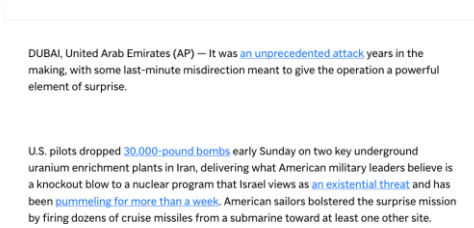
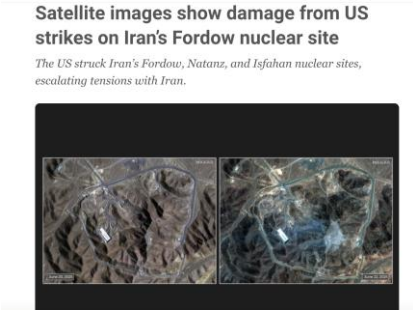


Strikes on Nuclear Facilities



We need disruptive interventions and alternative structures for responsible quantum.

Existing power structures shape who benefits from new technologies and who bears the cost. Without intentional responsible engagement, we risk quantum development and technologies that perpetuate the violences of capitalism to privilege the elite at the cost of our collective wellbeing and the planet.

A few ideas on responsible interventions for democratic quantum technology

public funding >	accountability to the public, not to a few shareholders
collective ownership >	cooperative models (e.g. worker-owned startups)
democratic governance of the problems and solutions that matter	quantum to meet the needs of people: health and wellbeing, climate, economic planning

…

Breakout Groups!
Reflecting on impacts of quantum use-cases

Questions to Ask When Designing Use Cases

1. What are the constituent parts (including facts)?
2. Who are the persons involved in making the technology?
3. Who will be using the technology?
4. Which parts of the technology are more impactful?

More questions to ask

- What were the previous systems and iterations of the technology?
- What kind of design choices influenced the architecture of the technology?
- How could the technological design influence behaviours?
- What is the path dependency of the technology?
- What are the knowledge expectations involved?
- What kind of exclusion could such expectations produce?

Some quantum use-cases to consider

1. Improving fertilizers to enhance crop productivity
2. Magnetocardiography with quantum sensors and AI for heart disease diagnosis
3. Ultra-secure quantum communication with QKD
4. Quantum sensors and clocks for GPS-free navigation
5. Decrypting RSA encryption with quantum algorithms on a quantum computer
6. Quantum optimization for planning supply chain and distribution as an alternative to free-market

Discussion questions

1. What are the potential benefits of this use-case?
2. What are the potential harms of this use-case?
3. Who would benefit, and who would be harmed?
4. What are some second-order consequences from the benefits and harms?

Document your discussions

1. Open the Day 1 folder
2. Open the Google Slides titled **Day 1 Collaborative Brainstorming**
3. Make a copy of the 2-slide template and populate with your discussion outcomes