Asia-Pacific
Economic Cooperation

Strengthening Collaboration on Standardisation for Quantum Technologies in the APEC Region

Discussion Paper for the APEC Workshop
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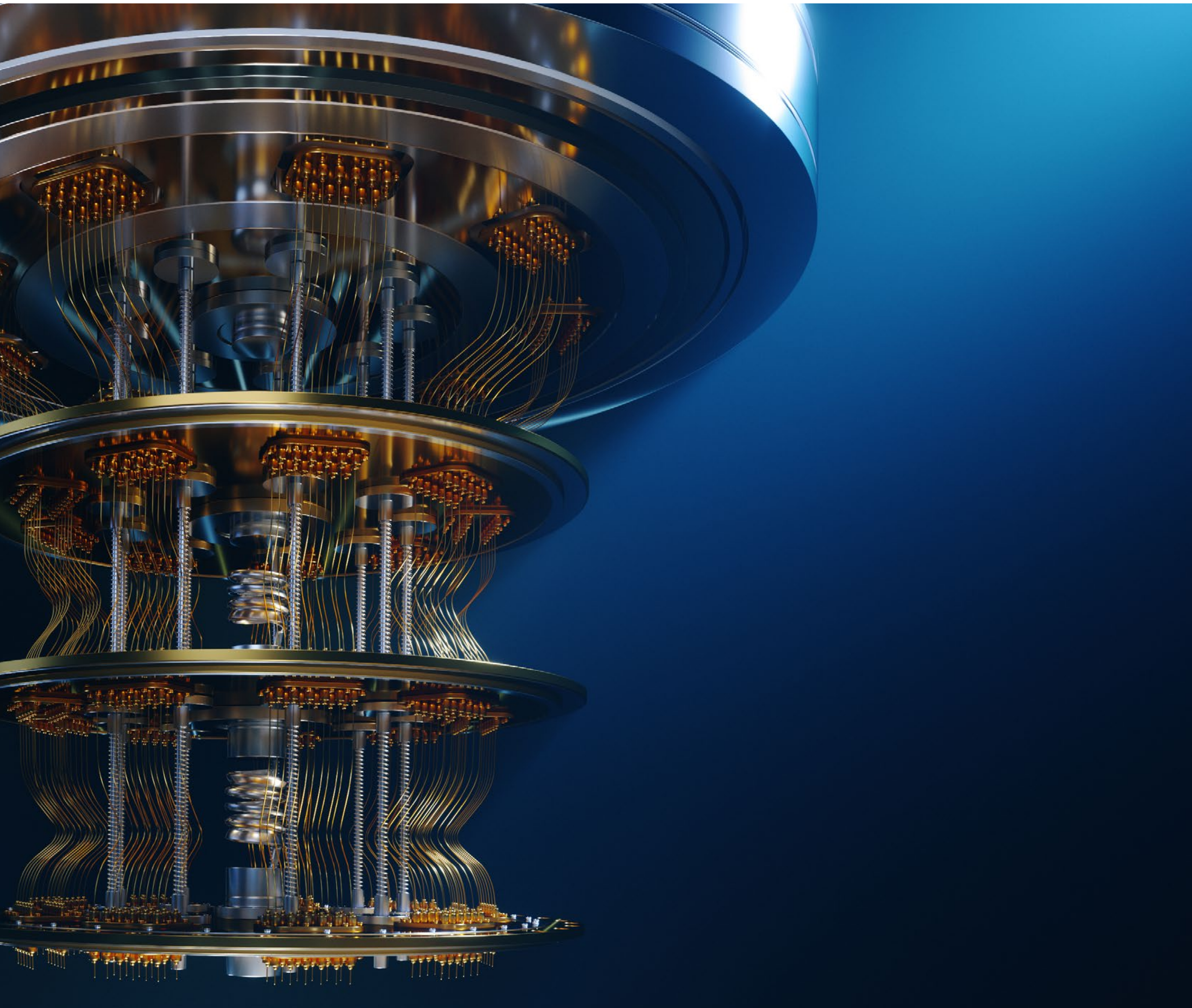

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Abbreviations and Acronyms

APEC	Asia-Pacific Economic Cooperation
ASEAN	Association of Southeast Asian Nations
ETSI	European Telecommunications Standards Institute
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers Standards Association
ISO	International Organization for Standardization
ITU	International Telecommunication Union
JTC	Joint Technical Committee
NIST	National Institute of Standards and Technology
PPPs	Public-Private Partnerships
PQC	Post-Quantum Cryptography
QKD	Quantum Key Distribution
QSC	Quantum-Safe Cryptography
R&D	Research and Development
SCE	Steering Committee on Economic and Technical Cooperation
SDN	Software-Defined Networking
SOM	Senior Officials' Meeting

Executive Summary

We are at the dawn of a new era - the second quantum revolution. Quantum technologies will change the world in ways that we cannot even imagine. As Professor Michael Biercuk, then Director of the Quantum Control Laboratory at the University of Sydney and now Founder of Q-CTRL, puts it: *"Quantum technology… will be as transformational in the 21st century as harnessing electricity was in the 19th."*[1] This revolution represents a strategic frontier in science and innovation, with the potential to revolutionise industries, economies, national security and global competitiveness. Beyond economic impact, quantum technologies offer significant societal benefits across a number of applications, including improved medical imaging for diagnostics and treatment planning, advanced modelling and simulation to accelerate drug discovery, and early detection systems for underground leaks and seismic activity.[2]

According to McKinsey & Company, quantum technologies, including computing, communication and sensing are expected to generate up to $198 billion USD in global revenue by 2040.[3] As advancements in quantum technologies accelerate, both public and private investment and initiatives are rapidly increasing. Quantum start-ups are now going public on major stock exchanges, while government funding commitments have surged into the multi-billion-dollar range.

The APEC region is fast emerging as a quantum hub. While investment levels and strategic approaches vary, there is growing emphasis on national quantum strategies, initiatives, roadmaps and strategic partnerships. This report finds that 15 out of the 21 APEC economies have announced national strategies, roadmaps, initiatives, frameworks or blueprints aimed at advancing their quantum technology capabilities. According to the *Strengthening Collaboration on Standardisation for Quantum Technologies - APEC Survey* (referred to throughout this report as the APEC Quantum Survey) approximately 47% of respondents identified the need for a national strategy or roadmap as an enabler to advance the development and adoption of quantum technologies.

Across the APEC region, member economies such as China, Japan, the United States, the Republic of Korea, Australia, and Singapore are making substantial investments in quantum research and development.[4] China, for example, has committed approximately $15 billion USD and established dedicated hubs such as the Hefei Quantum Centre to translate academic research into commercially viable quantum technologies.[5] These economies are well-positioned to shape the global quantum landscape, particularly in areas like secure communications, advanced materials, and AI powered by quantum computing.

However, the region's diversity presents challenges. While some economies are advancing rapidly, others remain in the early stages of quantum engagement or have

1 Karen Taylor-Brown, "The Quantum Revolution scales up," *Science Meets Business*, October 29, 2020, https://sciencemeetsbusiness.com.au/quantum-revolution-scales-up/.

2 "Quantum Technologies," Australian Government: Department of Industry, Science and Resources, accessed June 22, 2025, https://www.industry.gov.au/publications/list-critical-technologies-national-interest/quantum-technologies.

3 Henning Soller et al., *The Year of Quantum: From concept to reality in 2025*, McKinsey & Company, published June 23, 2025, https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/the-year-of-quantum-from-concept-to-reality-in-2025.

4 "Quantum technology trends in the Asia-Pacific region," Japan Science and Technology Agency, last modified January 30, 2025, https://sj.jst.go.jp/news/202501/n0130-01cac.html.

5 Matt Swayne, "Top Quantum Spenders Based on GDP — List Offers Surprising Changes in Leadership Status," *The Quantum Insider*, April 21, 2024, https://thequantuminsider.com/2023/02/28/top-quantum-spenders-based-on-gdp-list-offers-surprising-changes-in-leadership-status/; Jeffrey Lin and P.W. Singer, "China is opening a new quantum research supercenter," *Popular Science*, May 20, 2021, https://www.popsci.com/chinas-launches-new-quantum-research-supercenter/.

yet to enter the field. According to the APEC Quantum Survey approximately 70% of respondents cited the high cost and technical complexity of quantum technologies as a key challenge, while 57% pointed to limited access to standards, frameworks, guidance, quantum data availability and quality issues as a key concern to developing and deploying quantum technologies in their economies.

To ensure that the benefits of quantum technologies are leveraged by economies across the APEC region, coordinated efforts are essential. Key stakeholders including government, industry, academia, and standards organisations play a critical role in driving regional and global collaboration, international standardisation initiatives and funding for education and research to uplift quantum technology development and adoption.

International standards play a pivotal role in this effort. They establish specifications, frameworks, and requirements that guide the development, testing and deployment of quantum technologies. Standards promote consistency, enable interoperability across borders, and support innovation, trade and competition. More importantly, they strengthen collaboration and build trust among stakeholders, accelerating the integration of quantum technologies across the region.

To fully harness the potential of quantum technologies, APEC economies need to prioritise coordinated policy responses, cross-border collaboration, and the development of international standards. These efforts will be critical in addressing technical, ethical, and interoperability challenges while fostering a resilient and inclusive quantum ecosystem.

This report explores the current state of quantum technology development across the APEC region, with a particular focus on identifying opportunities for collaboration, reducing fragmentation, and promoting interoperability through the adoption of international standards including those developed under IEC/ISO JTC 3. The report is sectioned into four parts covering: definitions for quantum technologies, sectoral overviews across APEC economies, analysis on key barriers to adoption, and opportunities to address and overcome these issues.

The last two sections of the report present an overview of current collaborative efforts across APEC economies regarding the standardisation of quantum technologies, with a particular focus on international initiatives driven by IEC/ISO JTC 3, followed by an overview of initiatives from other international standardisation organisations.

The methodology used in this report is a mixed methods approach combining a literature review, expert surveys and case studies, with data drawn from academic, industry, and government sources to ensure a comprehensive and balanced analysis.

1. What are Quantum Technologies?

Quantum technologies refer to a suite of advanced technologies that harness the principles of quantum mechanics. These principles are the foundational laws of physics that govern the behaviour of matter and energy at the atomic and subatomic scale.[6] Although quantum technologies can be traced back to the early 20th century, the 21st century has been characterised by rapid advancements in both theory and real-world applications.[7] Some quantum principles are already used in everyday technology such as solar panels, LED in light bulbs and sensors that are based on semiconductors.[8]

Quantum technologies exploit the unique properties of quantum mechanics to perform complex tasks and enable new capabilities that are beyond the reach of classical systems. These unique properties include:

- **Superposition**: A quantum particle can be in multiple states at once.
- **Entanglement**: Two particles can be linked, so changing one instantly affects the other, even if they are apart.
- **Interference**: When multiple quantum states interact, creating patterns that either amplify (constructive) or cancel out (destructive) each other.[9]

The field is focused on using unique quantum properties in emerging applications, such as:

- **Quantum computing**: Leverages properties of superposition and entanglement to perform calculations exponentially faster than traditional computers. While classical computers can only address problems one step at a time, quantum computers explore countless possibilities in parallel.
- **Quantum sensing**: Applies principles of quantum mechanics to achieve ultra-precise measurements of physical properties such as time, magnetic fields, and biological or chemical signals.
- **Quantum communication**: Leverages the properties of entanglement to harnesses ultra-secure protocols such as Quantum Key Distribution (QKD), enabling highly secure communication channels within and between quantum computers.[10]

According to McKinsey & Company, by 2040 the total global revenue for quantum technologies could reach **$198 billion USD**[11]. Quantum technology is already becoming increasingly accessible through cloud-based platforms. Companies such as Amazon, Google, IBM and SpinQ offer quantum-as-a-service model allowing organisations to experiment with quantum algorithms and explore potential applications without substantial upfront investment.[12] It is expected that in the next 5 years organisations from finance, pharmaceuticals and logistics will adopt quantum technologies for specific

6 "Quantum Technology," Sydney Quantum Academy, accessed June 20, 2025, https://sydneyquantum.org/discover/quantum-technology/.

7 "Overview of Quantum Technologies: Technology Landscape Report," Dentons, last modified December 6, 2024, https://www.dentons.com/en/insights/articles/2024/december/6/overview-of-quantum-technologies-technology-landscape-report.

8 Tara Fortier, "Demystifying Quantum: It's Here, There and Everywhere," *NIST*, April 10, 2024, https://www.nist.gov/blogs/taking-measure/demystifying-quantum-its-here-there-and-everywhere.

9 "About Quantum and Advanced Technologies," Queensland Government: Department of the Environment, Tourism, Science and innovation, last modified June 13, 2024, https://science.desi.qld.gov.au/industry/quantum/about.

10 Queensland Government, "About Quantum and Advanced Technologies"; "The quantum leap in logistics," DHL Logistics of Things, DHL, last modified June 20, 2025, https://lot.dhl.com/quantum-leap-logistics/.

11 Soller et al., The Year of Quantum.

12 Jacob Roundy, "What is quantum as a service? Definition and top providers," *Informa TechTarget*, April 7, 2025, https://www.techtarget.com/searchcio/definition/quantum-as-a-service.

applications and efficiencies. Table 1 below details the expected and current advances in quantum already being explored across a wide range of fields.

Table 1 – Examples of Quantum Applications and Use Cases Across Industries

Industry	Applications and Use Cases	Example
Defence and Security	Quantum technology has the potential to transform the defence and security sector with applications that leverage its unique secure communication properties, such as quantum cryptography, quantum sensing and detection using quantum radar, magnetometers, and gravimeters, amongst others.	The United States Defense Advanced Research Projects Agency (DARPA) is developing quantum inertial navigation systems to provide highly accurate navigation for military platforms (e.g., submarines, aircraft, and drones) in GPS-denied environments. These systems use quantum sensors like atom interferometers to measure acceleration and rotation with extreme precision, eliminating reliance on vulnerable satellite-based GPS.
Pharmaceuticals	Quantum computing could revolutionise the pharmaceutical industry by accelerating lifesaving drug development.	Pfizer and IBM are working together to integrate generative AI and quantum computing to help make clinical trials faster and more efficient.[13]
Enhancements in AI	Quantum technology can handle the computational challenges of training advanced AI models, processing certain computations exponentially faster than the world's fastest classical computers.[14]	Google's Sycamore processor performed a specific computation in 200 seconds that would take a supercomputer at least 10,000 years.[15]
Finance	Quantum algorithms can be used to find optimisations for risk analysis, portfolios and fraud detection.	JP Morgan Chase, an American multinational investment bank and financial services company, established a quantum engineering team and are developing quantum algorithm systems for AI, financial optimisation and cryptography.[16]
Supply Chain and Logistics	Quantum technologies can be used for route optimisation, network design and predictive maintenance.	Volkswagen have used quantum algorithms to optimise taxi routes in Beijing, using the D-Wave 2000Q™ quantum computer.[17]
Healthcare	Quantum sensors could advance early disease detection, including cancer, infectious diseases and neurological disorders like Alzheimer's disease.[18]	Researchers are developing quantum sensors that can detect the earliest signs of biomarkers associated with cancer.[19]

13 Quantum News, "Quantum Computing Revolutionising Pharma: Speeding Drug Design and Accelerating Clinical Studies," *The Quantum Zeitgeist*, June 3, 2024, https://quantumzeitgeist.com/quantum-computing-revolutionising-pharma-speeding-drug-design-and-accelerating-clinical-studies/.
14 Marin Ivezic, "Google's Sycamore Achieves Quantum Supremacy," *Post Quantum*, October 26, 2019, https://postquantum.com/industry-news/google-sycamore/.
15 Ivezic, "Google's Sycamore Achieves Quantum Supremacy."
16 James Dargan, "11 Global Banks Probing The Wonderful World of Quantum Technologies," *The Quantum Insider*, May 28, 2024, https://thequantuminsider.com/2021/06/23/11-global-banks-probing-the-wonderful-world-of-quantum-technologies/.
17 "How Volkswagen is Using Practical Quantum Computing to Explore Traffic Optimization and More," D-Wave Quantum, accessed June 15, 2025, https://www.dwavequantum.com/media/bbximewp/dwave_vw_case_study_v8.pdf.
18 "Quantum Sensors: The Future of Early Disease Detection," Toxigon Infinite, last modified March 23, 2025, https://toxigon.com/quantum-sensors-for-early-disease-detection.
19 Toxigon Infinite, "Quantum Sensors."

2. Quantum Technologies in the APEC Economies

2.1 Quantum Technology Developments Across APEC Economies

As advancements in quantum technologies unfold and the global race for quantum leadership accelerates, many APEC economies are aligning public initiatives, private investment, research contributions and standardisations efforts to build robust quantum ecosystems and capitalise on the strategic advantages of early investment. This section provides an overview of the current quantum landscape in APEC with a focus on government priorities, industry and investment activities and the research and academic landscape.

2.1.1 APEC Government Priorities

Governments across the APEC region are actively shaping the development of quantum technologies. So far, 15 out of 21 APEC economies (about 71%) have announced a quantum strategy, roadmap or initiative. While national priorities and resources vary, most strategies in advanced economies such as Japan, the United States and Australia focus on boosting economic competitiveness, enhancing national security and positioning their economies at the forefront of global technological leadership.[20]

> *National strategies 'signal serious long-term commitment from government which provides the confidence and certainty required to attract and catalyse innovation translation and incoming industry investment' – Nathan Langford, 2024*[21]

Security is a national priority for several quantum leaders in the APEC region given the unique challenges posed by quantum technologies.[22] Their potential to break classical encryption methods presents a serious risk to critical infrastructure. To address this, economies like Australia, Canada, and the Republic of Korea are prioritising the adoption and implementation of post-quantum cryptography (PQC) and quantum key distribution (QKD) to safeguard sensitive data and communications. Some initiatives include:

- **Australia**: The Australian Cyber Security Centre (ACSC) and Australian Signals Directorate (ASD) have published guidelines planning for a full transition to quantum-resistant cryptography by 2030.[23]
- **Singapore**: In February 2024, the Monetary Authority of Singapore wrote to CEOs of financial organisations with an "Advisory On Addressing The Cybersecurity Risks Associated With Quantum" outlining actions for consideration when dealing with cybersecurity developments in quantum computing.[24]

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20 "National Quantum Strategy," Australian Government: Department of Industry, Science and Resources, published May 3, 2023, https://www.industry.gov.au/publications/national-quantum-strategy; Secretariat of Science, Technology and Innovation Policy, Cabinet Office, *Strategy of Quantum Future Industry Development – Summary* (Government of Japan: Cabinet Office, 2023), https://www8.cao.go.jp/cstp/english/strategy_r08.pdf; "National Quantum Strategy," United States Government, accessed June 26, 2025, https://www.quantum.gov/strategy/.

21 Nathan K Langford and Simon J Devitt, *Quantum Technologies and Standardisation Globally and in Australia* (Standards Australia, 2025), 17, https://www.standards.org.au/documents/quantum-technologies-and-standardisation-globally-and-in-australia.

22 Scott Buchholz et al., "The realist's guide to quantum technology and national security," *Deloitte*, February 6, 2020, https://www.deloitte.com/us/en/insights/industry/government-public-sector-services/the-impact-of-quantum-technology-on-national-security.html.

23 "Post Quantum Government Initiatives by Country and Region," GSMA, accessed June 20, 2025, https://www.gsma.com/newsroom/post-quantum-government-initiatives-by-country-and-region/.

24 "ADVISORY ON ADDRESSING THE CYBERSECURITY RISKS ASSOCIATED WITH QUANTUM", Monetary Authority of Singapore, February 20, 2024, https://www.mas.gov.sg/-/media/mas-media library/regulation/circulars/trpd/mas-quantum-advisory/mas-quantum-advisory.pdf

- **United States**: In 2024, the U.S. Department of Commerce's National Institute of Standards and Technology (NIST) finalised three post-quantum encryption standards, which are designed to secure a wide range of electronic information.[25]
- **Canada**: Canada is reportedly aligning with the NIST standards and planning to introduce standards-based PQC from 2025 to 2026.[26]
- **Republic of Korea**: The Republic of Korea's Quantum Strategy Vision 2035 aims to 'expand the security compliance verification system for quantum cryptography communication equipment.'[27]

Government support across APEC shows a strong commitment to building resilient quantum ecosystems. However, to achieve regional success, it is essential for quantum-leading economies to foster inclusive partnerships with developing members, where government efforts are typically centred on foundational research, capacity building and regional collaboration.

2.1.2 Industry and Investment Activities in the APEC Region

Growing global investment in quantum technologies underscores its shift from a theoretical concept to commercial readiness. In early 2025, over $1.82 billion USD globally was invested in quantum technologies.[28] About 69% of this was invested into quantum computing, double the amount raised from the same period last year.[29] While the total value of quantum investment across the APEC region remains difficult to quantify, recent funding rounds in the region highlight its growing prominence in the global quantum landscape.

In early 2025, several companies based in APEC economies raised funding to support the development and scaling of quantum technologies. Most notably, IonQ, headquartered in the United States, secured over $370 million USD to advance its mission of building and deploying quantum computers.[30] Another US headquartered company, PsiQuantum Pty Ltd, received $312.5 million USD in equity and loans to build the world's first commercial-scale quantum computer in Brisbane[31]. The investment will also enable the establishment of a regional quantum hub, the creation of PhD positions and advancement of research collaborations.[32] D-Wave Systems, originally founded in Canada and now operating out of California, has attracted $150 million USD to support its technical development and business.[33] Other notable investments across the region

25 "NIST Releases First 3 Finalized Post-Quantum Encryption Standards," NIST, Published August 13, 2024, https://www.nist.gov/news-events/news/2024/08/nist-releases-first-3-finalized-post-quantum-encryption-standards.

26 Government of Canada, *Canadian Centre for Cyber Security – How the Canadian Government is Preparing for PQC* (Government of Canada, 2023), https://pkic.org/events/2023/post-quantum-cryptography-conference/pkic-pqcc-how-gc-preparing-for-pqc-melanie-anderson-jonathan-hammell-canadian-government.pdf; GSMA, "Post Quantum Government."

27 Republic of Korea Government: Ministry of Science and ICT, Korea's National Quantum Strategy (Republic of Korea Government: Ministry of Science and ICT, 2023), https://quantuminkorea.org/wp-content/uploads/2024/06/Koreas-National-Quantum-Strategy-2023_c.pdf.

28 Matt Swayne, "Q1 2025 Quantum Technology Investment: What's Driving the Surge in Quantum Investment?" *The Quantum Insider*, May 27, 2025, https://thequantuminsider.com/2025/05/27/q1-2025-quantum-technology-investment-whats-driving-the-surge-in-quantum-investment/.

29 Swayne, "Q1 2025 Quantum Technology Investment."

30 IonQ, "IonQ Raises Over $372 Million Via At-the-Market Equity Offering Program," *IonQ*, March 10, 2025, https://ionq.com/news/ionq-raises-over-usd372-million-via-at-the-market-equity-offering-program.

31 Private Equity Media, "$940m in government funding for quantum computing," *Private Equity Media*, April 30, 2024, https://www.privateequitymedia.com.au/news/investment-activity/940m-in-government-funding-for-quantum-computing/

32 "PsiQuantum," Queensland Government: Queensland Treasury, last modified July 19, 2024, https://www.treasury.qld.gov.au/investment/investment-growth-stories/psiquantum/.

33 D-Wave Quantum, "D-Wave Announces Successful Completion of $150 Million At-the-Market Equity Offering," *D-Wave Quantum*, January 23, 2025, https://www.dwavequantum.com/company/newsroom/press-release/d-wave-announces-successful-completion-of-150-million-at-the-market-equity-offering/.

include Quantum Brilliance based in Australia, which raised $20 million USD, while OptQC, a Japanese company, secured $4.4 million USD earlier this year to support the development of photonic quantum computers.[34]

At present, the biggest investments in quantum technologies have been directed to economies with advanced quantum ecosystems such as the United States and Canada. While emerging quantum economies share a common ambition to build their own quantum capabilities, fostering inclusive growth requires coordinated investment in talent, infrastructure, and cross-regional collaboration.

2.1.3 Research and Academic Landscape in the APEC Region

A strong academic and research base is a critical enabler of national quantum capability. In many leading economies, quantum ecosystems have been underpinned by the outputs of universities and publicly funded research institutions. The academic sector plays a central role in the development of quantum technologies, with many of the most important discoveries in quantum computing originating in university laboratories.[35]

China has emerged as a major leader in quantum research, publishing over 27,000 quantum technology papers between 1990-2021. Australia has published over 4,000 papers during the same period. Singapore and Chinese Taipei are growing their quantum capabilities with 2,399 and 2,116 papers respectively, through government funded programs and partnerships.[36] These global research efforts not only highlight the competitive landscape of quantum technology but also lay the foundation for advancements in scientific discovery, workforce development, and social impact.

Scientific discovery: Universities and research institutes aim to push the boundaries of quantum science, often leading to ground-breaking theoretical research. For example, famous algorithms like Shor's (used for encryption) and Grover's (used to search data faster) were created by researchers. These contributions guide how quantum computers are built and defines its capabilities, setting the stage for practical applications.[37]

Workforce development: Universities are critical to training the future workforce of quantum scientists and engineers.[38] As the quantum industry evolves, there is growing demand from both government and industry for a highly skilled workforce. University-led training programs are central to meeting this demand, supporting regional goals to boost economic competitiveness and reduce dependency on international expertise. Vocational Education and Training (VET) programs in quantum technology are equally important, providing technicians with hands-on skills like operating quantum hardware

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34 Quantum Brilliance, "Quantum Brilliance Raises USD $20 Million in Series A Funding Round," *Quantum Brilliance*, January 15, 2025, https://quantumbrilliance.com/press-release/quantum-brilliance-raises-usd-20-million-in-series-a-funding-round; OptQC, "We are pleased to announce that we have raised a total of 650 million yen in funding," OptQC, January 23, 2025, https://www.optqc.com/en/news/news/press-fundraising-announcement20250123; Quantum Brilliance, "Quantum Brilliance Raises USD $20 Million in Series A Funding Round," *Quantum Brilliance*, January 15, 2025, https://quantumbrilliance.com/press-release/quantum-brilliance-raises-usd-20-million-in-series-a-funding-round; OpTQC, "650 million yen in funding."

35 Gary Fowler, "Importance of the Collaboration Between Academia and Industry for Quantum Computing," GSD Venture Studios, accessed June 22, 2025, https://www.gsdvs.com/post/importance-of-the-collaboration-between-academia-and-industry-for-quantum-computing.

36 Policy and R&D trends of quantum technology in the leading countries of the Asia and Pacific Regions), Japan Science and Technology Agency, March 2023, https://spap.jst.go.jp/investigation/downloads/2022_rr_01_en.pdf; Susan Hill, "Quantum Technology Advancements in Asia-Pacific: A Regional Powerhouse Emerges," Martin Cid Magazine, January 20, 2025, https://www.martincid.com/technology/quantum-technology-advancements-in-asia-pacific-a-regional-powerhouse-emerges/.

37 Fowler, "Importance of the Collaboration."

38 Fowler, "Importance of the Collaboration."

and calibration.[39] These programs empower technicians with practical know-how, improving their job prospects and driving quantum innovation.[40]

Social impact: Academic research also seeks to address global challenges through the development of quantum technologies. Universities are actively exploring real-world applications in areas such as cybersecurity, precision medicine, and climate monitoring. This includes quantum-enhanced drug discovery, secure communication networks and high-sensitivity environmental sensing, demonstrating a strong focus on delivering public value and societal benefit.[41]

The importance of collaboration

Collaboration is also essential to advancing quantum technology in the APEC region. Universities work closely with governments, industries and other academic institutions to share expertise, resources, and infrastructure. Public-Private Partnerships (PPPs), intra-APEC and global academic collaborations, and industry-academia partnerships are prevalent collaborative arrangements in the academic sector. For example, companies collaborate with universities to develop quantum software, test hardware and train talent, bridging the gap between academia and industry.[42] In 2023, IBM announced a 10-year, $100 million USD partnership with the University of Tokyo and the University of Chicago to develop a quantum-centric supercomputer, marking a new era of high-performance computing and underscoring the importance of cross-border collaboration in the region.[43]

39 “The Role of Australia’s VET Sector in the Era of Industry 4.0,” Insources, accessed June 25, 2025, https://insources.com.au/qms/the-role-of-australias-vet-sector-in-the-era-of-industry-4-0/.

40 U.S. Senate Committee on Commerce, Science, & Transportation, “Cantwell, Young, Durbin, Daines Introduce National Quantum Initiative Reauthorization Act,” *U.S. Senate Committee on Commerce, Science, & Transportation*, December 3, 2024, https://www.commerce.senate.gov/2024/12/cantwell-young-durbin-daines-introduce-national-quantum-initiative-reauthorization-act; Franziska Greinert et al., “Advancing quantum technology workforce: industry insights into qualification and training needs,” *EPJ Quantum Technology* 11, no. 82 (2024), https://epjquantumtechnology.springeropen.com/articles/10.1140/epjqt/s40507-024-00294-2.

41 Global Times, “Research breakthrough in China’s quantum direct communication marks potential transition from theory to real-life implication,” *Global Times*, February 23, 2025, https://www.globaltimes.cn/page/202502/1328916.shtml.

42 Betty Zou, “U of T researchers develop new approach using quantum computers to accelerate drug discovery,” University of Toronto: Temetry Faculty of Medicine, January 22, 2025, https://temertymedicine.utoronto.ca/news/u-t-researchers-develop-new-approach-using-quantum-computers-accelerate-drug-discovery.

43 Matt Swayne, “Quantum Sensor Measures Data Securely Over 50 Kilometers Without Entanglement,” *The Quantum Insider*, January 2, 2025, https://thequantuminsider.com/2025/01/02/quantum-sensor-measures-data-securely-over-50-kilometers-without-entanglement/.

2.2 Existing Collaborations on Quantum Technologies in APEC

There have been extensive collaborations on quantum technologies involving APEC members, both within the region and outside of the region. This highlights a dynamic ecosystem of quantum research, development and commercialisation. All member economies are actively engaged in advancing quantum technologies through strategic partnerships, academic exchanges, and international conferences, despite the discrepancy in technical readiness levels within the region. This section provides a high-level overview of **intra-APEC** and **non-APEC collaboration on quantum**.

2.2.1 Intra-APEC Collaboration

Within APEC, collaborations are robust, often driven by shared regional interests and strategic alignments. Examples include:

Quad Initiatives (Australia, Japan, United States, India):

In October 2023, the Quad Investors Network (QUIN) established the Quad Center of Excellence for Quantum Information Science, convened the Quad Investment and Technology Dialogue at the White House, and announced a strategic partnership with Australian firm Q-CTRL to deliver quantum technology training programs.[44]

ASEAN Quantum Initiatives:

Malaysia, Thailand, and the Philippines are developing regional quantum ecosystems. SDT Inc a quantum computing company headquartered in Republic of Korea collaborates with the Malaysian Institute of Microelectronic Systems (MIMOS) on quantum communication, while Thailand hosts the Siam Quantum Science and Technology Conference in 2024.[45] Additionally, QISTCon.ph 2025 in the Philippines, the SEA Quantathon 2025 in Thailand, and Malaysia's ASEAN Quantum Summit 2025 are key regional initiatives aimed at fostering collaboration and advancing quantum innovation across Southeast Asia.[46]

2.2.2 Non-APEC Collaboration

APEC economies have also established partnerships with non-APEC economies to drive quantum technology development and foster a global network of innovation. The United States has formed collaborative alliances with European nations, including Switzerland and the Netherlands, to drive innovation and cooperation in quantum information science and technology.[47] Canada complements these efforts by collaborating with France , the United States (U.S), and the United Kingdom (UK) to advance quantum

44 Jennifer Jackett, "Delivering the Quad's tech agenda," *APSI: The Strategist*, March 8, 2024, https://www.aspistrategist.org.au/delivering-the-quads-tech-agenda/.

45 Cierra Choucair, "Malaysia's First Quantum Computing Centre Launched Through SDT Inc. and MIMOS Partnership," *The Quantum Insider*, November 13, 2024, https://thequantuminsider.com/2024/11/13/malaysias-first-quantum-computing-centre-launched-through-sdt-inc-and-mimos-partnership/; "Thailand's First International Quantum Conference Hosted by PSU," PSU: Faculty of Science, published December 2, 2024, https://www.sci.psu.ac.th/en/news/2024/12/sqst2024-opening-ceremony-en/.

46 World Quantum Day, "The Southeast Asia World Quantum Day Initiatives," *World Quantum Day*, June 18, 2025, https://worldquantumday.org/news/the-southeast-asia-world-quantum-day-initiatives.

47 "National Quantum Initiative," United States Government, accessed June 26, 2025, https://www.quantum.gov/; "Joint Statement of the United States of America and the Netherlands on Cooperation in Quantum Information Science and Technology," U.S. Department of State, published February 16, 2023, https://2021-2025.state.gov/joint-statement-of-the-united-states-of-america-and-the-netherlands-on-cooperation-in-quantum-information-science-and-technology/; "The United States and Switzerland Sign Joint Statement to Strengthen Collaboration on Quantum," United States Government: National Quantum Initiative, published October 19, 2022, https://www.quantum.gov/the-united-states-and-switzerland-sign-joint-statement-to-strengthen-collaboration-on-quantum/.

research and development.[48] In Australia, companies like Quantum Brilliance have led collaborative efforts with the United Kingdom (UK) and Germany, focusing on pioneering diamond-based quantum computers.[49] Quantum Brilliance has also established offices in Singapore and Japan, signalling potential future collaborations in the region.[50]

Other APEC economies including New Zealand, the Philippines and Mexico, are also expanding their quantum capabilities through collaborations with non-APEC economies. These diverse partnerships strengthen global innovation in quantum communication, research, and workforce development. Through these strategic alliances and strong industry-academic ties, APEC economies are positioning themselves at the forefront of transformative advancements in quantum science and technology.[51]

48 Cierra Choucair, "Canada Invests over $52 Million in 107 Quantum Research Projects in Computing, Communications, and Beyond," *The Quantum Insider*, January 21, 2025, https://thequantuminsider.com/2025/01/21/canada-invests-over-52-million-in-107-quantum-research-projects-in-computing-communications-and-beyond/; "£6.5m boost for innovative quantum projects in UK and Canada," UKRI, published January 27, 2025, https://www.ukri.org/news/6-5m-boost-for-innovative-quantum-projects-in-uk-and-canada/.

49 Johannes Kostka and Michael Quin, "New hub to make diamond-based quantum computers," RMIT University, published April 21, 2022, https://www.rmit.edu.au/news/all-news/2022/apr/diamond-quantum-computing-hub.

50 "Germany Awards Contract to Quantum Brilliance and ParityQC to Build World's First Mobile Quantum Computer by 2025," *Quantum Brilliance*, published September 18, 2024, https://quantumbrilliance.com/press-release/germany-awards-contract-to-quantum-brilliance-and-parityqc; "Quantum Brilliance Partners with STFC Hartree Centre to Make Quantum Tech More Scalable," *Quantum Brilliance*, published November 1, 2023, https://quantumbrilliance.com/press-release/quantum-brilliance-partners-with-stfc-hartree-centre-to-make-quantum-tech-more-scalable; "Quantum Brilliance establish a subsidiary in Japan," *Quantum Brilliance*, accessed June 25, 2025, https://quantumbrilliance.com/press-release/quantum-brilliance-establish-a-subsidiary-in-japan-en.

51 "Quantum Technology Roadmap," PCIEERD, accessed June 20, 2025, https://pcieerd.dost.gov.ph/images/pdf/2021/roadmaps/sectoral_roadmaps_division/etdd/Quantum-Technology-RD-Roadmap.pdf; "One Quantum Philippines," *OneQuantum Philippines*, accessed June 23, 2025, https://www.onequantum.ph/; "The European Quantum Communication Infrastructure (EuroQCI) Initiative," European Commission, accessed June 21, 2025, https://digital-strategy.ec.europa.eu/en/policies/european-quantum-communication-infrastructure-euroqci; BRICS is an intergovernmental organised formed by 11 countries, including: Brazil, Russia, India, China, South Africa, Saudi Arabia, Egypt, United Arab Emirates, Ethiopia, Indonesia and Iran; "About the BRICS," BRICS, published January 20, 2025, https://brics.br/en/about-the-brics.

2.3. Challenges & Opportunities for Quantum Technologies in the APEC Region

To understand the challenges and opportunities for developing and scaling quantum technologies across the APEC region, Standards Australia with support from the APEC Sub-Committee on Standards and Conformance (SCSC) Secretariat, undertook an APEC-wide survey on *Strengthening Collaboration on Standardisation for Quantum Technologies*.[52]

This section provides an analysis of survey responses to two key questions:

- What challenges are limiting the ability to develop and scale quantum technologies in the future?
- What are the opportunities to support the development and adoption of quantum technologies?

To support these survey findings, an in-depth review of relevant literature, policy documents and reports was conducted to provide additional context and highlight areas for regional collaboration and action.

2.3.1 Barriers to Developing and Scaling Quantum in the APEC Region

The *Quantum Economy Blueprint* (2024), published by the World Economic Forum, outlines several challenges associated with the development and adoption of quantum technologies. One of the most prominent challenges is the emergence of a global *'quantum divide'*, where certain economies risk falling behind due to limited access to quantum technologies. This disparity not only has the potential to deepen regional inequalities, but also creates significant security vulnerabilities, as economies with less advanced quantum capabilities may be ill-equipped to protect against quantum-enabled cyber threats, thereby putting their national security at risk.[53]

To gain a greater understanding of the barriers faced by APEC economies and how they might be addressed, Standards Australia undertook an APEC-wide survey to evaluate the challenges and opportunities for quantum development and co-ordination across the region.

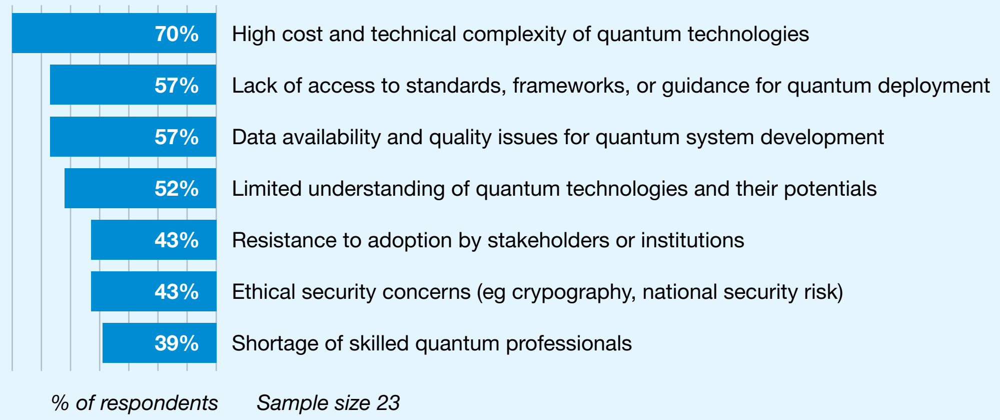
The survey received strong participation, with over 37 responses from a range of APEC member economies. When asked about the main challenges limiting the future development and scaling of quantum technologies in the APEC region at scale (where multiple answers were allowable), several key themes emerged.

The most frequently cited challenge amongst participants was the high cost and technical complexity of quantum technologies (70%). This was followed by concerns about limited access to standards, frameworks, or guidance for quantum development (57%), data availability and quality issues for quantum system development (57%). Other notable challenges included a limited understanding of quantum technologies and their potentials (52%), resistance to adoption by stakeholders or institutions (43%), and ethical and security concerns (43%), See Figure 1 for the complete breakdown of the responses.

52 Standards Australia, *Strengthening Collaboration on Standardisation for Quantum Technologies - APEC Survey* (external survey, publicly unavailable, June 2025).

53 Kelly Richdale, Arunima Sarkar, and Mira Wolf-Bauwens, Quantum Economy Blueprint – Insights Report (World Economic Forum, 2024), https://www3.weforum.org/docs/WEF_Quantum_Economy_Blueprint_2024.pdf.

Figure 1 – Challenges Limiting the Development and Scaling of Quantum Technologies in the APEC region



Source: Strengthening Collaboration on Standardisation for Quantum Technologies - APEC Quantum Survey, 2025.

These regional findings reflect challenges seen globally. According to the Quantum Readiness 2025 report by QuEra which surveyed 770 quantum experts, researchers, and decision-makers worldwide, nearly half of the respondents surveyed cited the high cost of implementing hardware, software, or consulting services as the biggest barrier to adopting quantum computing.[54] The report also highlighted concerns around regulation and compliance, including uncertainty about the legal and regulatory implications of implementing quantum technologies. Finally, it emphasised the need for more affordable access and expanded quantum education to accelerate quantum awareness and adoption across the globe.

These challenges closely mirror those identified through the APEC Quantum Survey, where 52% of respondents noted concerns about the limited understanding of quantum technologies and their potential, and 39% noted a shortage of skilled quantum professionals as a key barrier to the development and scaling of quantum technologies.

> *"Developing the necessary expertise and workforce to support the quantum industry will be crucial in the US." – Survey Respondent from the United States, APEC Quantum Survey*

> *"…resistance to adoption by stakeholders or institutions, driven by a lack of awareness, uncertainty about ROI, or risk aversion, could delay the integration of quantum solutions in strategic industries." – Survey Respondent from Malaysia, APEC Quantum Survey*

The equitable and inclusive growth of a holistic and robust regional quantum ecosystem requires an effective response to the risks and challenges that could hinder their development. These challenges are captured in Figure 1 above and expanded upon in Table 2 below.

54 Quera, Survey Report: Quantum Readiness (Quera, 2025), https://cdn.prod.website-files.com/643b94c382e84463a9e52264/679026cb4e2b6e7fa8ec2882_QuEra%20Quantum%20Readiness%20survey%20Jan%2025.pdf.

Table 2 – Challenges Limiting the Development and Scaling of Quantum in APEC Economies

Key Challenges Limiting the Development and Scaling of Quantum in APEC Economies	
Uneven Funding in Quantum Technology Advancement	Although quantum technologies offer significant potential, their nascency presents notable financial risks for private investors. While the promise of substantial future returns continues to attract interest, maintaining long-term investment can be difficult due to the extended timelines required for these technologies to reach commercial viability.[55]
Lack of Standards and Benchmarking Frameworks	The absence of unified regulatory frameworks and benchmarking standards across APEC economies is a major barrier to quantum technology development. According to the survey, respondents identified the lack of standards and benchmarking frameworks as one of the most significant challenges facing quantum development across APEC economies, highlighting a critical gap in the region's quantum development infrastructure.
Talent Shortage: Uneven Access to Quantum-Ready Skilled Workforce	The rapid growth of the global quantum industry has exposed a widening talent gap across APEC economies, driven by fragmentation and a lack of alignment between academic programs and industry needs, highlighting the urgent need for coordinated efforts to build a skilled and inclusive workforce.[56] Focusing on expanding domestic talent pipelines while preserving strong international recruitment capabilities can help build a robust and globally competitive quantum workforce.[57]
Quantum Supply Chain Challenges	The quantum supply chain can make access and availability of key resources more difficult, posing challenges for consistent supply and development.[58] For instance, Australia's quantum industry depends on intricate global supply chains for essential materials and components which are susceptible to disruptions, leading to uncertain availability and fluctuating costs.[59]
Fragmented Quantum Ecosystems Across APEC Economies	While economies have developed their own approaches to quantum governance, they share a common challenge in balancing the promotion of innovation with the need to address security concerns. This has led to the rise of hybrid governance models that aim to manage both priorities effectively.[60] Businesses can face potential barriers entering regional markets due to incompatible infrastructure and regulatory uncertainty, weakening the potential for a unified APEC quantum ecosystem.
Exposure to Emerging Cybersecurity Threats	Quantum technologies in APEC are advancing rapidly, introducing new cybersecurity risks. Quantum systems, such as QKD and quantum sensors, are vulnerable to implementation flaws, side-channel attacks, and spoofing.[61] These threats are compounded by the lack of mature, quantum-specific security protocols and standards across the region.
No Consistent Approach to Quantum Development	Companies are pursuing various approaches across quantum technologies. For example, some quantum computing companies are utilising superconducting qubit technology, whereas other are adopting techniques involving suspended electrons using lasers at room temperatures.[62] There is limited consensus on the most suitable technical pathway, and whether or how to harmonise these efforts. As a result of this fragmentation, standardisation may be viewed as a potential impediment to innovation.

55 "A quantum technologies policy primer," OECD, last modified January 28, 2025, https://www.oecd.org/en/publications/a-quantum-technologies-policy-primer_fd1153c3-en.html.

56 Jonathan Ruane et al., The Quantum Index Report 2025, MIT Initiative on the Digital Economy (Massachusetts Institute of Technology, 2025), https://www.yumpu.com/en/document/read/70553845/2025-mit-quantum-index-report.

57 Ruane et al., *The Quantum Index Report 2025*.

58 Richdale, Sarkar, and Wolf-Bauwens, *Quantum Economy Blueprint*.

59 Richdale, Sarkar, and Wolf-Bauwens, *Quantum Economy Blueprint*.

60 Ruane et al., *The Quantum Index Report 2025*.

61 Adrien Green et al., "Quantum Key Distribution for Critical Infrastructures: Towards Cyber-Physical Security for Hydropower and Dams," *Sensors* 23, 9818 (2023): 1-24, https://pmc.ncbi.nlm.nih.gov/articles/PMC10748243/pdf/sensors-23-09818.pdf.

62 Craig S. Smith, "Top 10 Quantum Computing Companies Making Change," *Forbes*, December 11, 2023, https://www.forbes.com/sites/technology/article/top-quantum-computing-companies/.

2.3.2 Opportunities for the Development and Adoption of Quantum Technologies in the APEC Region

The global quantum technology ecosystem is undergoing a fast expansion, driven by significant government investments, international collaborations and the need for standardisation.[63] APEC economies are uniquely positioned to harness the global momentum in quantum technologies by aligning national strategies, shaping international standards, cultivating a skilled workforce, strengthening sovereign capabilities and deepening regional collaboration.

> *"By aligning with APEC-wide standards on quantum-safe cryptography, quantum communications, and performance benchmarks, Malaysia can improve the credibility and market readiness of its locally developed quantum solutions." - Survey Respondent from Malaysia, APEC Quantum Survey*

This section outlines the major opportunities for the development and adoption of quantum technologies. Opportunities identified from the research and APEC Quantum survey results are summarised in Table 3 below. These responses highlight a diverse range of opportunities that APEC economies can leverage to support the adoption and advancement of quantum technologies. Recurring themes across the APEC Quantum survey responses include the critical role of government-led policies, regional and global collaboration, international standardisation initiatives, and funding for education on quantum technology development and adoption. National roadmaps and industry support are also seen as key support mechanisms to guide quantum development efforts.

Table 3 – Opportunities for the Development and Adoption of Quantum Technologies in the APEC Region

Key Opportunities for Quantum Technology Development and Adoption	
Standardisation Activities	Participation in national and international standards development can help support interoperability, market access, and regulatory alignment across jurisdictions, in addition to guiding the direction of enterprises, startups, and research institutions.
International and Regional Collaboration	Cross-border partnerships, including through APEC, multilateral forums, and global initiatives enables shared access to infrastructure, knowledge exchange, and joint research and development. Resource sharing can also reduce costs.
National Policies and Roadmaps	National policy measures, such as tax incentives, targeted grants, and funding programs for education, research and industry can support the growth of startups and quantum enterprises. Aligning public investment with priority areas such as secure finance and quantum education can also enhance the region's overall competitiveness.
Education and Talent Upskilling	Training initiatives, such as quantum bootcamps and partnerships with platforms like IBM Quantum and Amazon Braket can help bridge critical talent gaps in quantum technologies. Stakeholder education and outreach aligned with national quantum roadmaps can further build awareness and public support, both of which are essential for long-term capacity-building. Integrating quantum science into tertiary education, postgraduate training, and international exchange programs will be vital to addressing skills shortages and developing a future-ready quantum workforce.
Sector-Specific Use Cases	Quantum-safe encryption for banking and simulations for pharmaceuticals and logistics offer great optimisation potential in efficiency and security. Successful use cases can demonstrate practical applications, attract investment and raise awareness.

Source: APEC Quantum Survey, 2025.

63 Langford and Devitt, *Quantum Technologies and Standardisation Globally and in Australia*.

With economies at different stages of development, a potential strength for the region lies in collaboration, especially through shared infrastructure, well concerted policy development, and inclusive capacity-building. As one survey respondent from the Philippines noted, *“Capacity building with standardisation focus includes facilitating knowledge sharing, supporting research collaboration, and funding training programs to develop a skilled workforce.”*[64] This perspective reflects a broader regional consensus on the importance of coordinated efforts to uplift all member economies. The development of harmonised quantum standards, notably through IEC/ISO JTC 3, is seen by respondents as essential to ensuring interoperability and preventing fragmentation. The role of standards in enabling quantum collaboration is explored in more detail in the next section.

64 Standards Australia, *Strengthening Collaboration on Standardisation for Quantum Technologies - APEC Survey*.

3. Role of Standards in Fostering Quantum Development and Collaboration

3.1 What Are Quantum Technology Standards

ISO standards are internationally recognised and adopted guidelines developed by the International Standardisation Organisation (ISO) to ensure quality, safety, efficiency, and interoperability across global industries and technologies. The IEC/ISO Joint Technical Committees (JTCs) are collaborative groups formed by the International Electrotechnical Commission (IEC) and ISO to develop unified standards in areas of mutual interest, such as quantum technologies and information technology. These joint committees bring together global experts to harmonise standards, reduce duplication and promote international consensus on critical emerging technologies.

Progress in quantum technologies has prompted standardisation activities to ensure compatibility and interoperability among diverse systems. As organisations and researchers strive to transition from theoretical models to practical applications, establishing robust standards becomes crucial for fostering innovation, enhancing competition and facilitating efficient supply chains in this nascent sector. In January 2024, the IEC and ISO created a joint technical committee: IEC/ISO JTC 3, Quantum Technologies, tasked with developing international standards on quantum technologies.[65]

IEC/ISO JTC 3 – Quantum Technologies

IEC/ISO JTC 3 provides a global forum for the development of international standards aimed at promoting interoperability, reliability, and broader market adoption of quantum technologies. Its scope encompasses areas such as performance metrics for quantum computing, communication protocols, metrological standards, and harmonised terminology.

Quantum technology standards are formal specifications, guidelines and frameworks to support the advancement, interoperability and responsible deployment of quantum technologies, including quantum computing, sensing and communications. These standards aim to ensure consistency, reliability and compatibility across quantum systems and applications, addressing technical requirements, performance metrics, ethical governance, and workforce needs. They are also expected to support innovation, trade, and industry development, and to promote international cooperation. This will be achieved by providing a clear and structured foundation for research, commercialisation, and adoption, while also helping countries navigate the fast-changing landscape of quantum technologies and diverse technical systems.[66]

3.2 Standards Development Efforts in APEC Economies

The APEC region is an important player in the global standardisation of quantum technologies, particularly through IEC/ISO JTC 3.

65 "IEC and ISO launch new joint technical committee on quantum technologies," ISO, published January 11, 2024, https://www.iso.org/news/new-joint-committee-quantum-technologies.
66 Langford and Devitt, *Quantum Technologies and Standardisation Globally and in Australia*, 3-4; 8-12.

A number of APEC member economies are actively engaged in IEC/ISO JTC 3, leveraging their technological capabilities with national quantum strategies in the region to influence global standards. The Republic of Korea holds the Chair position of IEC/ISO JTC 3, reflecting its advanced quantum ecosystem and strategic commitment to global standardisation. Meanwhile, the United States coordinates a U.S. National Committee Technical Advisory Group, administered by NIST, to lead U.S. working groups and provide technical input.[67] Other participating members from APEC economies include Australia, Canada, China, Japan and Russia. The full list of APEC economies that are participating and observing members of IEC/ISO JTC 3 can be found in Appendix 2.

IEC/ISO JTC 3's work helps contribute to harmonising quantum ecosystems, identifying technology readiness levels in the region and globally, and facilitating commercialisation across APEC's diverse economies.[68] Contributions from APEC in IEC/ISO JTC 3 span multiple quantum sectors, leveraging the region's research, industry, and policy strengths to develop standards that deliver technical, commercial and social benefits.

While advanced economies continue to lead the development of quantum technologies, emerging APEC economies have meaningful opportunities to contribute to standardisation efforts through a range of initiatives. Sponsored by the APEC Policy Partnership on Science, Technology and Innovation (PPSTI), the APEC Quantum Science and Technology Forum plays an important role in supporting regional preparedness for quantum technologies by providing a platform for partnership dialogue, technical cooperation, and capacity building among member economies.[69] Additional pathways for engagement include participation in APEC-hosted workshops, involvement in joint quantum research initiatives, and contributions to standardisation discussions through platforms such as the APEC Sub-Committee on Standards and Conformance (SCSC).[70]

Though limited by resources, the region-wide forums and initiatives highlighted above demonstrate APEC's largely inclusive approach to quantum standardisation. These efforts support the strategic focus of APEC economies in creating interoperable, secure and scalable quantum standards, with both advanced and emerging economies collaborating in technical development and building capacity.[71]

67 "New IEC/ISO Joint Technical Committee on Quantum Technologies—Inviting Participants for the U.S. National Committee Technical Advisory Group," NIST, Published February 9, 2024, https://www.nist.gov/news-events/news/2024/02/new-ieciso-joint-technical-committee-quantum-technologies-inviting.

68 ISO, "IEC and ISO launch new joint technical."

69 https://www.apec.org/groups/som-steering-committee-on-economic-and-technical-cooperation "Project Title: APEC Quantum Science and Technology Forum," APEC Project Database, APEC, last modified June 27, 2025, https://aimp2.apec.org/sites/PDB/Lists/Proposals/DispForm.aspx?ID=3811.

70 "Project Title: Strengthening Collaboration on Standardisation for Quantum Technologies," APEC Project Database, APEC, last modified March 18, 2025, https://aimp2.apec.org/sites/PDB/Lists/Proposals/DispForm.aspx?ID=3730; APEC, "Project Title: APEC Quantum."

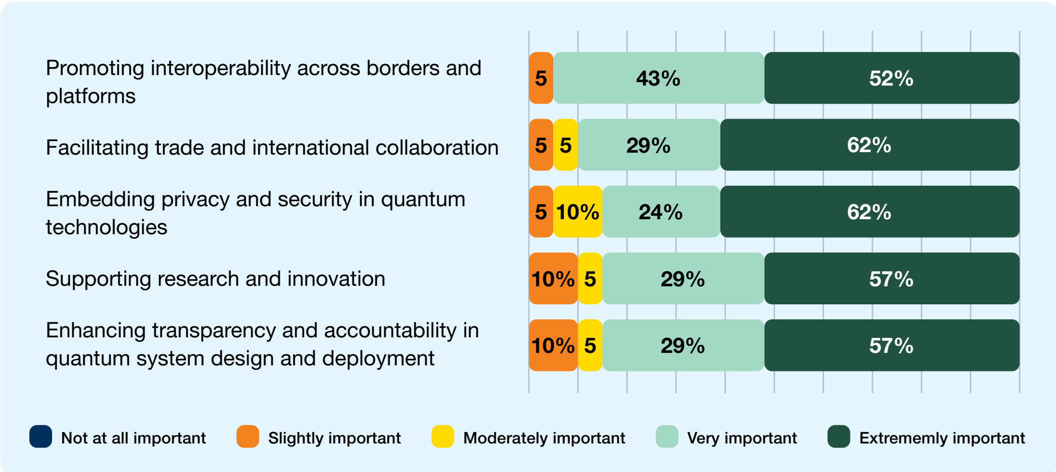
71 APEC, "Project Title: Strengthening Collaboration"; APEC, "Project Title: APEC Quantum."

3.3 Benefits of Standards for Quantum Technologies

As part of the APEC Quantum survey, respondents were asked to evaluate the importance of standards in supporting quantum technologies across the following aspects:

- Promoting interoperability across borders and platforms.
- Facilitating trade and international collaboration.
- Embedding privacy and security in quantum technologies.
- Supporting research and innovation.
- Enhancing transparency and accountability in quantum system design and deployment.[72]

Figure 2 – Importance of Standards in Supporting Quantum Technologies



Source: APEC Quantum Survey, 2025.

Among the 21 responses to this question, the survey found several key areas where standards are perceived as playing an important role in supporting quantum technologies, including:[73]

1. **Facilitating trade and international collaboration** was rated as highly important by 91% of respondents, underscoring the need for harmonised standards to enable cross-border cooperation and market integration. This reflects a shared recognition that quantum technologies must be interoperable to support global innovation and economic growth.
2. **Embedding privacy and security in the design and deployment of quantum technologies** was identified as very or extremely important by 86% of participants. This highlights growing concerns around data protection and the need for robust frameworks to ensure trust and resilience in quantum systems.
3. **Supporting research and innovation** also received strong support, with 86% of respondents rating it as very or extremely important. Standards are seen as foundational to guiding research efforts, enabling reproducibility, and accelerating the transition from discovery to application.

72 Standards Australia, *Strengthening Collaboration on Standardisation for Quantum Technologies - APEC Survey* (external survey, publicly unavailable, June 2025).
73 Standards Australia, *Strengthening Collaboration on Standardisation for Quantum Technologies - APEC Survey*.

Together, these findings suggest a strong consensus among APEC stakeholders that standards are seen not merely as technical specifications but as strategic tools for advancing social collaboration and economic growth.

3.3.1 International Standards Support Collaboration

Standards development presents an opportunity for capacity building, particularly through participation in international standards fora such as IEC/ISO JTC 3, which allows economies to develop local expertise, contribute national perspectives, and remain aligned with evolving global trends.

Research from the Research AND Development Corporation (RAND) identifies standard setting as one of five critical policy areas essential for international quantum cooperation, alongside talent mobility and supply chain coordination.[74] Standards setting frameworks can help economies avoid duplication of effort, share infrastructure, and co-develop solutions that are interoperable across jurisdictions.

Within the APEC context, standards development offers a strategic platform for economies at varying stages of quantum readiness to engage constructively. Emerging economies can build capacity and increase their visibility on the global stage, while more advanced economies can influence global norms and accelerate technology deployment.

The role of IEC/ISO JTC 3 is particularly relevant in facilitating coordinated regional engagement. As a centralised body, IEC/ISO JTC 3 provides a structure through which diverse economic and technical inputs can be harmonised into globally applicable standards. Regional workshops involving experts from diverse APEC economies could potentially encourage knowledge exchange under IEC/ISO JTC 3's guidance.[75] Partnerships with regional education providers and industry consortia (e.g., APEC's Sub-Committee on Standards and Conformance, SOM (Senior Officials' Meeting) Steering Committee on Economic and Technical Cooperation (SCE)) and coordinated via IEC/ISO JTC 3 subgroups, can also potentially enhance quantum literacy, aligning standards with workforce needs in economies where understanding of quantum technologies may be limited.

Overall, international standards can serve as vital enablers of collaboration, developing trust and ensuring that quantum technologies develop in an inclusive, interoperable, and globally coordinated manner.[76]

3.3.2 International Standards Support Trade

International standards establish clear, globally recognised guidelines for performance, measurement, and system compatibility, significantly easing market entry for businesses by reducing complex technical and regulatory barriers. This facilitates smoother trade and technology transfer, enabling companies to scale their quantum innovations and products across international borders. As noted by a number of survey respondents:

> *"By adopting and contributing to international standards, our country can enhance its readiness for quantum technologies and facilitate global collaboration and trade in the quantum era." – Survey Respondent from Peru, APEC Quantum Survey*

74 Edward Parker, "Promoting Strong International Collaboration in Quantum Technology Research and Development," *RAND*, February 22, 2023, https://www.rand.org/pubs/perspectives/PEA1874-1.html.

75 "Quantum technology: Standards, innovation and partnerships in the quantum era," IEC, accessed June 25, 2025, https://www.iec.ch/academy/webinars/standards-innovation-and-partnerships-quantum-era.

76 ISO, "IEC and ISO launch new joint technical."

> *"Standardization led by APEC can reduce technical trade barriers and enhance interoperability, allowing Malaysian research institutions, startups, and industries to integrate quantum technologies more seamlessly into global supply chains." – Survey Respondent from Malaysia, APEC Quantum Survey*

By ensuring that quantum technologies are designed, tested, and deployed with consistency, standards promote mutual recognition of certifications and compliance across economies, eliminating the need for repetitive, costly testing or redundant certification processes. This streamlining of supply chains reduces operational costs, accelerates market access, and strengthens integrated global markets, allowing quantum goods and services to flow seamlessly across regions.[77] As one survey respondent from the Philippines noted: *"Standards facilitate interoperability with existing computing media and serve as a base for utility-based R&D,"*[78] underscoring how standards ensure quantum technologies are compatible with existing systems, making them more marketable and trade-friendly. This alignment fosters economic competitiveness and encourages cross-border collaboration, as businesses can confidently engage in markets knowing their technologies adhere to shared standards.

Furthermore, standards enable economies to leverage regional strengths to create tradeable quantum solutions that meet international demand. By encouraging interoperability and reducing trade barriers, international standards not only enhance market efficiency but also position APEC economies as leaders in the global quantum trade ecosystem, driving equitable economic growth.

3.3.3 International Standards Enhance Security in Quantum Technologies

International standards are essential for embedding privacy and security into the design, development, and deployment of quantum technologies. As quantum computing and quantum communications evolve, they introduce both transformative capabilities and new risks, particularly in relation to data protection, cryptographic integrity, and system resilience.[79] International standards provide a globally consistent framework that can address these challenges by defining technical requirements, risk management practices, and security controls tailored to quantum-specific contexts.[80]

For example, standards can support the secure design of quantum communication protocols, such as quantum key distribution (QKD), and define methods to assess their robustness against potential vulnerabilities. In quantum computing, they can provide guidance on securing quantum-classical interfaces, managing access control, and ensuring integrity in quantum software execution. Additionally, standards can help benchmark methods to objectively validate the performance of competing quantum sensors against their respective performance claims, possibly improving end user

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77 Patrick McDill, "The Importance of Standards in Today's Global Market," *Roqqett Blog*, June 11, 2024, https://www.roqqett.com/blog/the-importance-of-standards-in-today-s-global-market.

78 Standards Australia, *Strengthening Collaboration on Standardisation for Quantum Technologies - APEC Survey*.

79 Michele Mosca and Donna Dodson, "Here's why it's important to build long-term cryptographic resilience," *World Economic Forum*, December 20, 2024, https://www.weforum.org/stories/2024/12/cryptographic-resilience-build-cybersecurity-nist/. Henning Soller et al., "Quantum communication growth drivers: Cybersecurity and quantum computing," *McKinsey Digital*, February 21, 2025, https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/quantum-communication-growth-drivers-cybersecurity-and-quantum-computing.

80 Vita Santa Barletta et al., "Enabling Quantum Privacy and Security by Design: Imperatives for Contemporary State-of-the-Art in Quantum Software Engineering," *Journal of Software: Evolution and Process* 37, no. 2 (2025): 1-35, https://onlinelibrary.wiley.com/doi/pdf/10.1002/smr.70005.

confidence and potentially leading to greater technological adoption and commercial development.[81]

In the APEC region, where digital infrastructure maturity varies across economies, internationally harmonised standards can help level the playing field by providing all stakeholders with access to best-practice security frameworks. They can also promote interoperability of security solutions and support mutual trust, which is critical for regional cooperation and secure cross-border data exchange.[82] Furthermore, standards enable conformity assessment and certification processes that give assurance to regulators, developers, and end-users that quantum systems are secure, reliable, and privacy-respecting.[83]

As quantum technology advances and poses new risks to traditional encryption, international standards will be key in helping economies shift to quantum-secure systems.[84] They will help guide global efforts to manage risks, protect privacy, and create reliable quantum infrastructure across the APEC region.[85]

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81 Quantum Economic Development Consortium (QED-C), *Quantum Sensing for Position, Navigation, and Timing Use Cases* (SRI International, 2024), 13, https://quantumconsortium.org/mp-files/quantum-sensing-for-position-navigation-and-timing-use-cases.pdf/.

82 Francesca Casalini et al., *Fostering Cross-border Data Flows with Trust* (OECD, 2022), https://www.oecd.org/content/dam/oecd/en/publications/reports/2022/12/fostering-cross-border-data-flows-with-trust_617f8e3f/139b32ad-en.pdf; Lisa Robinson, Kosuke Kizawa and Elettra Ronchi, Interoperability of privacy and data protection frameworks (OECD, 2021), https://goingdigital.oecd.org/data/notes/No21_ToolkitNote_PrivacyDataInteroperability.pdf.

83 McDill, "The Importance of Standards in Today's Global Market."

84 Marin Ivezic, "NIST Unveils Post-Quantum Cryptography (PQC) Standards," *Post Quantum*, August 13, 2024, https://postquantum.com/industry-news/nist-pqc-standards/.

85 Langford and Devitt, *Quantum Technologies and Standardisation Globally and in Australia*.

4. Other Standards for Quantum Technologies

Table 4 – Number of Standards, Under Development and Published, by Leading Global Standards Development Organisations

Standards Development Organisation	IEEE	ITU	CEN/CENELEC	ETSI
Number of Standards Under Development	7	27	5	0
Number of Published Standards	0	42	11	31

Source: Standards Australia esearch, June 2025.

4.1 The Institute of Electrical and Electronics Engineers Standards Association (IEEE)

The Institute of Electrical and Electronics Engineers Standards Association (IEEE) is a US-based globally recognised standards development organisation with contributing experts from more than 160 countries.[86] It endeavours to advance global technologies and technological innovation by driving standardisation to facilitate the functionality, capabilities and interoperability of a wide range of products and services.[87] IEEE also participates in global quantum standardisation, acting as a liaison for IEC/ISO JTC 3.[88] At the time of this report, there are no quantum standards published by the IEEE. However, there are seven standards currently under development which cover various aspects of quantum technologies including quantum definitions, quantum computing and quantum cybersecurity. Please see Table 7 in Appendix 1 for more details on these standards. Across the IEEE standards activities, there are four committees involved in quantum standardisation. The details of these committees have been listed in Table 8 of Appendix 1.

4.2 International Telecommunication Union (ITU)

The International Telecommunication Union (ITU) is an agency of the United Nations dedicated to digital technologies, with a membership of 194 member states and over 1000 companies, universities, and international and regional organisations.[89] The ITU aims to enable international connectivity in communication networks by facilitating international agreements and standardisation, knowledge sharing, capacity building, and equitable access to technology globally.[90]

The ITU's Telecommunication Standardisation Sector (ITU-T) is dedicated to developing international standards relevant to information and communication technologies, including quantum communication. ITU-T standards, also known as ITU-T Recommendations, are developed by an assembly of experts from around the world through 'Study Groups.'[91] It is worth noting that ITU-T also acts as a liaison for IEC/ISO JTC 3.[92]

86 "About IEEE Standards Association," IEEE SA, accessed June 25, 2025, https://standards.ieee.org/about/.
87 IEEE SA, "About IEEE Standards Association."
88 "IEC/ISO JTC 3 – Quantum technologies: Structure: Membership," IEC, accessed June 27, 2025, https://www.iec.ch/dyn/www/f?p=103:29:210277032327374::::FSP_ORG_ID,FSP_LANG_ID:49854,25.
89 "About International Telecommunication Union (ITU)," ITU, accessed June 28, 2025, https://www.itu.int/en/about/Pages/default.aspx.
90 ITU, "About International Telecommunication Union (ITU)."
91 "ITU-T in brief," ITU, accessed June 28, 2025, https://www.itu.int/en/ITU-T/about/Pages/default.aspx.
92 "IEC/ISO JTC 3 – Quantum technologies: Structure: Membership," IEC, accessed June 28, 2025, https://www.iec.ch/dyn/www/f?p=103:29:210277032327374::::FSP_ORG_ID,FSP_LANG_ID:49854,25.

At the time of this report, ITU-T have published approximately 42 standards relevant to quantum technologies, particularly relating to quantum communication and quantum sensing. The majority of these standards are focused on quantum key distribution networks, along with one standard relating to quantum-safe algorithms and another relating to quantum noise random number generator. Please see Table 9 in Appendix 1 for five examples of ITU-T quantum standards. Across the 42 ITU-T standards, there are three study groups involved in the quantum standardisation space. The details of these committees have been listed in Table 10 in Appendix 1. In 2024, ITU announced that its relevant study groups will also explore standardisation around post-quantum cryptography.[93]

4.3 CEN/CENELEC

European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC) are officially recognised by the European Union and the European Free Trade Association (EFTA) as responsible for developing and defining voluntary standards at a European level.[94]

Both CEN and CENELEC are collaborating to develop quantum technology standards through the CEN and CENELEC Joint Technical Committee 22 - CEN-CLC/JTC 22, Quantum Technologies. The committee's focus areas for standards development include, but are not limited to, quantum enabling technologies, quantum metrology, quantum communication and quantum computing.[95]

At the time of this report, no standards have been published by the CEN/CENELEC joint technical committee. However, 11 standards are currently under development. Please see Table 11 in Appendix 1 for examples of standards currently under development by this committee.

4.4 The European Telecommunications Standards Institute (ETSI)

The European Telecommunications Standards Institute (ETSI) develops, ratifies and tests globally applicable standards for ICT-enabled systems, applications and services.[96] Like CEN and CENELEC, ETSI is officially recognised by the European Union and the European Free Trade Association (EFTA) as being responsible for regional standardisation at a European level.[97]

ETSI has two committees that is involved in the standardisation of quantum technologies. Table 12 in Appendix 1 identifies these committees and their scope of work. At the time of this report, ETSI has published 31 standards, of which all are specifically related to quantum communication. From the 31 standards, ESTI's Industry Specification Group on Quantum Key Distribution (ISG QKD) have published 12 standards focused on quantum key distribution, while ETSI's Technical Committee on Cyber Security (TC CYBER) have published 19 standards across areas including quantum-safe cryptography, signatures, key exchanges and algorithms, among others. Please see Table 13 and Table 14 in Appendix 1 for two standards from each committee.

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93 Tomas Lamanauskas, "Quantum: No longer 20 years away?" *ITU*, November 26, 2024, https://www.itu.int/hub/2024/11/quantum-no-longer-20-years-away/.
94 "About CENELEC," CEN-CENELEC, accessed June 28, 2025, https://www.cencenelec.eu/about-cenelec/.
95 "Quantum Technologies," CEN-CENELEC, accessed June 28, 2025, https://www.cencenelec.eu/areas-of-work/cen-cenelec-topics/quantum-technologies/.
96 "About ETSI," ETSI, accessed June 28, 2025, https://www.etsi.org/about?jjj=1751245699204.
97 CEN-CENELEC, "About CENELEC."

5.0 Conclusion

Quantum technologies are poised to redefine the global technology landscape, offering transformative capabilities across critical sectors including finance, healthcare, logistics and national security. As the second quantum revolution gains momentum, APEC economies are presented with a strategic opportunity to position themselves at the forefront of this technological paradigm shift.

This report has examined the current state of quantum technology development across the APEC region, identifying key challenges and opportunities, and underscoring the pivotal role of international standards in fostering inclusive, secure, and scalable quantum ecosystems. While disparities in readiness and resources persist, APEC's strength lies in its diversity and capacity for collaboration through technical leadership, capability building, and collaborative engagement.

Findings from the APEC Quantum survey affirm a broad consensus that standards are not merely technical instruments but strategic enablers of innovation, trade, trust and security. International standards, particularly those developed under IEC/ISO JTC 3, provide a coherent framework to guide the responsible development, deployment, and governance of quantum technologies. They support interoperability, ethical design and workforce development, thereby ensuring that quantum advancements are accessible and beneficial to all member economies.

To fully realise the potential of quantum technologies, APEC economies must prioritise inclusive standardisation processes, coordinated policy responses, and targeted capacity-building initiatives. Proposed mechanisms identified in this report, such as participation in international standardisation activities, national strategies and cross-border partnerships represent practical avenues to strengthen regional capabilities and global influence.

As the world celebrates the International Year of Quantum Science and Technology in 2025, APEC has a unique opportunity to lead by example in advancing a trusted, ethical, and inclusive quantum ecosystem that delivers enduring value across the region and contributes meaningfully to the global quantum future.

Appendices

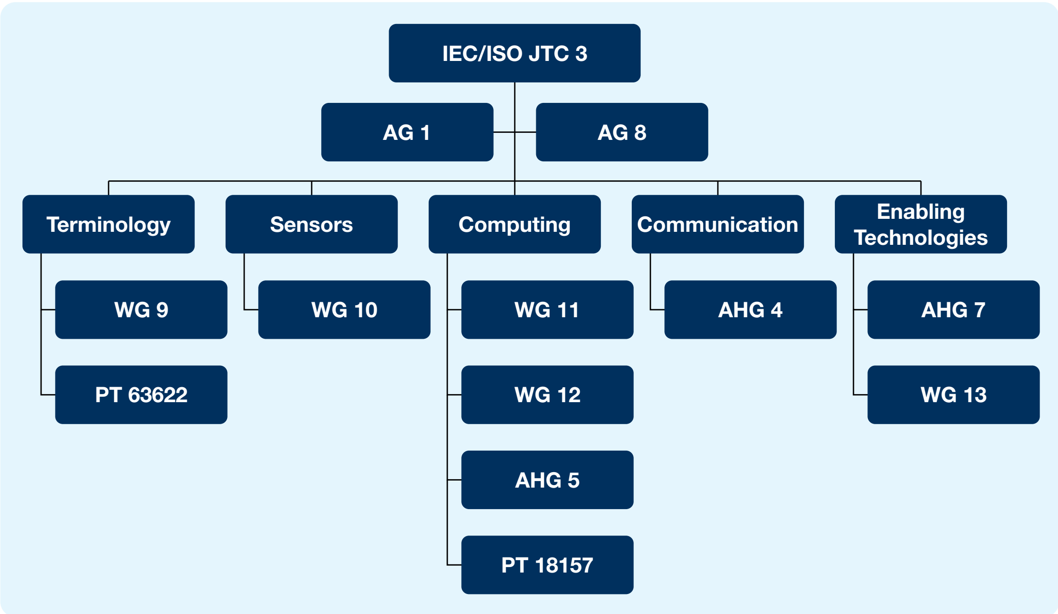
Appendix 1: Standards Mapping

Table 5 – IEC/ISO JTC 3 Quantum Standards Activity

IEC/ISO JTC 3 Quantum Standards Activity		
Focus Area	**Standard Title**	**Status**
Quantum Computing	**ISO/IEC 4879:2024, *Information technology — Quantum computing — Vocabulary*** This document defines terms commonly used in the field of quantum computing.	Published
Quantum Computing	**ISO/IEC AWI TR 18157, *Information technology — Introduction to quantum computing*** (Abstract Unavailable)	Under Development
Quantum Computing	**ISO/IEC 63607 ED1, *Quantum technologies – Terminology and quantities – General quantities*** (Abstract Unavailable)	Under Development
Quantum Computing	**IEC/ISO 63622 ED1, *Quantum Photonics Vocabulary*** (Abstract Unavailable)	Under Development
Quantum Computing	**IEC/ISO 63655 ED1, *Quantum technologies – Terminology and quantities – General vocabulary*** (Abstract Unavailable)	Under Development

Figure 3 – IEC/ISO JTC 3 Quantum Standards Committee and Working Group Structure

(Tentative), June 2025



Source: Standards Australia

Table 6 – IEC/ISO JTC 3 Working Groups involved in Quantum Standards Activity[98]

Working Groups under IEC/ISO JTC 3	
Working Group Code	**Working Group Title**
WG 9	Working Group 9 – Terminology and quantities
WG 10	Working Group 10 – Quantum sensors
WG 11	Working Group 11 – Quantum computing supply chain
WG 12	Working Group 12 – Quantum computing benchmarking
WG 13	Working Group 13 – Quantum random number generators
AG 1	Advisory Group 1 – Strategic planning
AG 8	Advisory Group 8 – Chair's Advisory Group
AHG 4	Ad-Hoc Group – Quantum Communication
AHG 5	Ad-Hoc Group – Quantum Computing and Simulation
AHG 7	Ad-Hoc Group – Quantum enabling technologies

Table 7 – IEEE Quantum Standards Activity

IEEE Quantum Standards Activity		
Focus Area	**Standard Title**	**Status**
Quantum Computing; Quantum; Communication; Quantum Sensing	**IEEE P7130, *Standard for Quantum Technologies Definitions*** Addresses quantum technologies specific terminology and establishes definitions necessary to facilitate clarity of understanding to enable compatibility and interoperability.	Under Development
Quantum Computing	**IEEE P3185, *Standard for Hybrid Quantum-Classical Computing*** Defines the hardware and software architecture of hybrid quantum-classical computing environments.	Under Development
Quantum Computing	**IEEE P3329, *Standard for Quantum Computing Energy Efficiency*** Defines energy efficiency metrics for quantum computing (gate-based, quantum annealing, quantum simulation). It compares the performance of the computation to its energy consumption.	Under Development
Quantum Communication	**IEEE P1943, *Standard for Post-Quantum Network Security*** Defines a method to implement optimised post-quantum version of existing network security protocols. It is based on a multi-layer protocols approach and allows data packets and/or data encapsulated to be quantum resistant to future cryptographically relevant quantum computers (CRQCs).	Under Development
Quantum Communication	**IEEE P2995, *Trial-Use Standard for a Quantum Algorithm Design and Development*** Defines a standardised method for the design of quantum algorithms. The defined methods apply to any type of algorithm that can be assimilated into quantum primitives and/or quantum applications.	Under Development

98 "IEC/ISO JTC 3 – Quantum technologies: Structure: Subgroups," IEC, accessed June 28, 2025, https://www.iec.ch/ords/f?p=103:29:11909904048435::::FSP_ORG_ID,FSP_LANG_ID:49854,25#1.

IEEE Quantum Standards Activity (continued)		
Quantum Communication	**IEEE P3172, *Recommended Practice for Post-Quantum Cryptography Migration*** This recommended practice describes multi-step processes that can be used to implement hybrid mechanisms (combinations of classical quantum-vulnerable and quantum-resistant public-key algorithms). Existing post-quantum cryptography (PQC) systems are described.	Under Development
Quantum Communication	**IEEE P1947, *Standard for Quantum Cybersecurity Framework*** This standard describes a Quantum Cybersecurity Framework composed of two categories: 1) threat vectors to information processing (data) security including new vectors due to quantum computing, and 2) defense mechanisms of advanced technologies tailored to the threat vectors.	Under Development

Table 8 – IEEE Committees involved in Quantum Standards Activity

Committee Title (Code)	Committee Scope
IEEE Computer Society Standards Activities Board Standards Committee (C/SABSC)	Standards development that supports theory, design, practice, and application relating to computer and information processing science and technology, including quantum computing.[99]
IEEE Virtualised and Software Defined Networks, and Services Standards Committee (COM/NetSoft-SC)	Standards development that relates to operations, administration, management, services, softwarisation, virtualisation of communication networks, including quantum communication.[100]
IEEE Software & Systems Engineering Standards Committee (C/S2ESC)	Standardisation of notations, nomenclatures, methods, processes, products, resources, solution, and techniques for the engineering of software and systems dependent on software, including a standardised method for the design of quantum algorithms.[101]
IEEE Cybersecurity & Privacy Standards Committee (C/CPSC)	Development and maintenance of cybersecurity and privacy standards including information security management systems, network security, cryptographic techniques and post-quantum cryptography among others.[102]

99 "IEEE Computer Society Standards Activities Board Standards Committee," IEEE SA, accessed June 25, 2025, https://sagroups.ieee.org/csabsc/; "About the IEEE Computer Society," IEEE Computer Society, accessed June 25, 2025, https://www.computer.org/about.
100 "NetSoft," IEEE SA, accessed June 25, 2025, https://sagroups.ieee.org/netsoft/.
101 "Software & Systems Engineering Standards Committee," IEEE Computer Society, accessed June 25, 2025, https://www.computer.org/volunteering/boards-and-committees/standards-activities/committees/s2esc.
102 "Cybersecurity & Privacy Standards Committee," IEEE Computer Society, accessed June 25, 2025, https://www.computer.org/volunteering/boards-and-committees/standards-activities/committees/cybersecurity-privacy.

Table 9 – Examples of ITU-T Quantum Standards Activity

Examples of ITU-T Quantum Standards Activity		
Focus Area	**Standard Title**	**Status**
Quantum Communication	**ITU-T Y.3804 (04/2025), *Quantum key distribution networks – Control and management*** Specifies functions and procedures for quantum key distribution network (QKDN) control and management to realise secure, stable, efficient, and robust operations of and services by a quantum key distribution (QKD) network as well as to manage a QKDN as a whole and support user network management.	Published
Quantum Communication	**ITU-T Y.3818 (09/2024), *Quantum key distribution network interworking – Architecture*** Specifies functional architecture models for quantum key distribution network interworking (QKDNi), i.e., functional architectures with gateway and interworking nodes.	Published
Quantum Communication	**ITU-T Q.4160 (12/2023), *Quantum key distribution networks – Protocol framework*** Specifies a framework for signalling and protocols for quantum key distribution network (QKDN).	Published
Quantum Communication	**ITU-T X.1811 (04/2021), *Security guidelines for applying quantum-safe algorithms in IMT-2020 systems*** Identifies threats raised by quantum computing to International Mobile Telecommunications-2020 (IMT-2020) systems through assessing the security strength of currently used cryptographic algorithms. This Recommendation briefly reviews quantum safe algorithms, including both symmetric and asymmetric types, and provides guidelines for applying quantum safe algorithms in IMT-2020 systems.	Published
Quantum Sensing	**ITU-T X.1702 (11/2019), *Quantum noise random number generator architecture*** Defines a generic functional architecture of a quantum entropy source, a common method to estimate and validate the entropy of a noise source under evaluation, and a common method to specify randomness extractors when they are part of the implemented system.	Published

Table 10 – ITU-T Study Groups involved in Quantum Standards Activity

Study Group Title (Code)	Study Group Scope
Study Group 11: Signalling requirements, protocols, test specifications and combating counterfeit telecommunication/ICT devices **(ITU-T SG11)**	ITU-T SG11 is responsible for developing standards that define how telephone calls and other ICT services are handled in the network, as well as on the security of signalling protocols and global interoperability testing specifications.[103] ITU-T SG11 have developed standards on the protocol aspects for quantum key distribution networks.
Study Group 13: Future networks and emerging network technologies **(ITU-T SG13)**	ITU-T SG13 is responsible for developing standards related to information-centric networking (ICN), intersecting with various critical and emerging technologies such as artificial intelligence, cloud computing, as well as quantum networks and their related technologies including networking aspects of quantum key distribution networks (QKDN).[104]
Study Group 17: Security **(ITU-T SG17)**	ITU-T SG17 is responsible for developing standards that enhances confidence, security and trust in the use of telecommunications/ICTs, including areas around cybersecurity and data protection among others, as well as quantum-based security, including quantum key distribution (QKD) and post-quantum cryptography algorithms.

Table 11 – Examples of CEN-CLC/JTC 22 Quantum Standards Activity

Examples of CEN-CLC/JTC 22's Quantum Standards Activity		
Focus Area	**Standard Title**	**Status**
Quantum Computing	**FprCEN/CLC/TR 18202, *Layer model of Quantum Computing*** This document defines a layer model that covers the entire stack of universal gate-based quantum computers. The scope of this Technical Report is restricted to a universal gate-based quantum-computing model, also known as a digital or circuit quantum-computing model, on multiple physical systems such as transmon, spin-qubit, ion-trap, neutral-atom, and others.	Under Development
Quantum Communication	**JT022003, *Gap analysis of current quantum communication and quantum cryptography standards*** This document provides a comprehensive comparative analysis of current quantum communication and quantum cryptography standards.	Under Development
Quantum Communication	**JT022011, *Standardisation needs for satellite based QKD*** The "Standardisation needs for satellite-based QKD" work item will provide insights that will influence future standardisation efforts.	Under Development
Quantum Communication	**JT022002, *QKD and PQC – An equitable analysis and comparison of both technologies*** This document provides an equitable analysis of how the Quantum Key Distribution (QKD) and Post-quantum Cryptography (PQC) technologies relate to each other.	Under Development
Quantum Computing	**JT022006, *Hybridisation of Quantum Computing*** The scope of this project is to develop a technical report that defines requirements, interfacing protocols and software for hybridisation of quantum computing, i.e., integrating quantum computers within the classical high-performance computing (HPC) infrastructure.	Under Development

103 "About SG11 (2022-2024)," ITU, accessed June 25, 2025, https://www.itu.int/en/ITU-T/about/groups/2022-2024/Pages/sg11.aspx.
104 "About Study Group 13," ITU, accessed June 25, 2025, https://www.itu.int/en/ITU-T/about/groups/2025-2028/Pages/sg13.aspx.

Table 12 – ETSI Committees involved in Quantum Standards Activity

Committee Title (Code)	Committee Scope
Industry Specification Group on Quantum Key Distribution (ISG QKD)	Standardisation around quantum key distribution system interfaces, implementation security requirements and optical characterisation of Quantum key distribution systems and their components - to support quality and safe deployment of Quantum key distribution.[105]
Technical Committee on Cyber Security (TC CYBER)	TC Cyber encompasses the Quantum-Safe Cryptography working group, dedicated to the standardisation of cryptographic algorithms (QSC) to "mitigate the potentially disruptive technology of quantum computing."[106]

Table 13 – Examples of ETSI Quantum Standards Activity: Industry Specification Group on Quantum Key Distribution

Examples of ETSI Quantum Standards Activity: Industry Specification Group on Quantum Key Distribution		
Focus Area	**Standard Title**	**Status**
Quantum Communication	**ETSI GS QKD 012 V1.1.1, *Quantum Key Distribution (QKD); Device and Communication Channel Parameters for QKD Deployment*** Describes the main communication resources involved in a QKD system and the possible architectures that can be adopted when performing a QKD deployment over an optical network infrastructure. The scope of the present document is restricted to QKD deployments over fibre optical networks.	Published
Quantum Communication	**ETSI GS QKD 015 V2.1.1, *Quantum Key Distribution (QKD); Control Interface for Software Defined Networks*** Provides a definition of management interfaces for the integration of QKD in disaggregated network control plane architectures, in particular with Software-Defined Networking (SDN). It defines abstraction models and workflows between an SDN-enabled QKD node and the SDN controller, including resource discovery, capabilities dissemination and system configuration operations.	Published

Table 14 – Examples of ETSI Quantum Standards Activity: Technical Committee on Cyber Security

Examples of ETSI Quantum Standards Activity: Technical Committee on Cyber Security		
Focus Area	**Standard Title**	**Status**
Quantum Communication	**ETSI TR 103 965 V1.1.1, *CYBER; Quantum-Safe Cryptography (QSC); Impact of Quantum Computing on Cryptographic Security Proofs*** The present document is intended to provide an overview of the impact of quantum computing on the security proofs of several cryptographic protocols.	Published
Quantum Communication	**ETSI GR QSC 006 V1.1.1, *Quantum-Safe Cryptography (QSC); Limits to Quantum Computing applied to symmetric key sizes*** The present document gives information on the long-term suitability of symmetric cryptographic primitives in the face of quantum computing.	Published

105 "Quantum Key Distribution (QKD)," ETSI, accessed June 26, 2025, https://www.etsi.org/technologies/quantum-key-distribution.
106 "TC CYBER Roadmap," ESTI, accessed June 27, 2025, https://www.etsi.org/cyber-security/tc-cyber-roadmap.

Appendix 2: APEC Member Economies Involved in IEC/ISO JTC 3, As of June 2025

Table 15 – List of APEC Member Economies and Their Involvement in IEC/ISO JTC 3

Economy	IEC/ISO JTC 3 Membership
Australia	P Member
Canada	P Member
People's Republic of China	P Member
Indonesia	O Member
Japan	P Member
Republic of Korea	P Member
Mexico	O Member
The Republic of the Philippines	O Member
The Russian Federation	P Member
Singapore	O Member
Thailand	O Member
United States of America	P Member

Legend: P = Participating Member, O = Observing Member