Engineers for Canada's Quantum Workforce

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ABOUT THE AUTHOR

Tina Dekker is an intellectual property lawyer at Borden Ladner Gervais, LLP in Ottawa. Tina graduated from the University of Waterloo with an honours degree in Nanotechnology Engineering and specialized in nanoelectronics, semiconductors, and microfabrication. She continued her studies as a Master's student with the Quantum Materials and Devices Lab at the Institute for Quantum Computing in Waterloo. Her work included fabricating quantum devices to examine the optical and electronic properties of materials with reduced dimensionality for applications in quantum information technology. Tina completed her Juris Doctor at the University of Ottawa, where she researched, published, and presented on the legal and ethical implications of quantum technologies as a research fellow with the Centre for Law, Technology and Society.

ABSTRACT

Quantum technologies have become the next hyped technology, and the unique capabilities that quantum technologies bring are expected to disrupt many industries. In view of a rapidly evolving global quantum ecosystem, the Canadian federal government recently released Canada's National Quantum Strategy, which is investing $360 million dollars into Canada's quantum ecosystem to support the three pillars of Research, Talent, and Commercialization. Canada needs diverse talent to establish a robust quantum workforce that can support its growing quantum ecosystem. Much of this talent can be sourced from Canada's existing professionals, but transitioning into the quantum field can be difficult due to the field's unique concepts and jargon. This two-part paper series introduces core concepts of quantum technologies and provides an outlook of the role engineers will have in contributing to quantum technology development.

INTRODUCTION

With the advancement of quantum technology (QT) research and development, nations strive to leverage the potential benefits of quantum technologies at a commercial scale. As a result, many nations are implementing national initiatives to enrich their quantum ecosystems [1]. Canada released its National Quantum Strategy (NQS) in January 2023, involving a seven-year plan to invest at least $360 million into Canada's quantum ecosystem [2].

Canada has a strong foundation in quantum research and is an early investor in QT, but establishing a robust quantum ecosystem requires a sustained commercialization effort [3], [4], which Canada's engineering community is well-equipped to support. Quantum industry is also facing a talent crisis, and engineers who upskill or apply their existing expertise can expect to find exciting opportunities in this growing field.

The first part of this two-part white paper series provided a high-level introduction to QT [5]. This second part of the series describes the role engineers are well-suited for in contributing to QT development in Canada.

1. Growing Canada's Quantum Industry

Canada's NQS is a mission-oriented funding plan to enrich Canada's national quantum ecosystem, focusing on three core pillars: Research, Talent, and Commercialization. Under the Talent pillar, the government recognizes the need for a cross-disciplinary workforce to meet the growing needs of quantum industry. This need also relates to the Commercialization pillar, which is directed to the growth of existing and new quantum companies as well as identifying use cases of QT in other sectors [2].

Private funding is also critical to the commercialization effort. The Quantum Insider's 2022 Investment Update reported an increasing trend in private investment in the global quantum industry, with more than $700 million invested into quantum companies in Canada [6]. These ongoing investments increase the demand for a quantum-ready workforce. A quantum-ready workforce needs not only quantum experts for core R&D, but also non-quantum experts who leverage skills and knowledge in areas such as systems design, software, user experience, and manufacturing, as well as in business and management. Engineers will play a critical role in fulfilling these adjacent needs.

2. The Role of Engineers in Quantum Industry

Engineers can contribute to the quantum industry in both quantum roles (i.e., requiring quantum skills) and non-quantum roles, for example, to solve problems in QT development and discover QT applications in other industries. Many engineers are already deeply involved in quantum industry. Notably, the Institute of Electrical and Electronics Engineers (IEEE) has had a dedicated quantum initiative since 2019, IEEE Quantum [7], and hosts annually one of the largest international quantum research and industry conferences, IEEE Quantum Week [8].

Additionally, engineers are often highly skilled at connecting and translating technical concepts to both real world applications and business objectives. QT development and commercialization is expected to impact both society and the planet [9]–[11]. These impacts suggest that professional engineers,

In the context of this white paper series, the term "engineer" is used in its informal context to include not just professional engineers, but also students or graduates of engineering programs and adjacent fields like computer science.

engineering graduates, and engineering consultants will have an increasing role in ensuring quantum technologies are deployed responsibly and efficiently, taking into consideration factors like public safety, environmental impact, and project management. These considerations will also be situated in the evolving quantum regulatory landscape, both in Canada and globally [12]–[14]. This includes, for example, the development and implementation of technical standards, a domain familiar to many engineers.

a. Engineers who Acquire Quantum Skills

In their global quantum workforce analysis, Kaur and Venegas-Gomez identify the near-term importance of upskilling the existing workforce to meet industry needs [15]. Dr. Shohini Ghose similarly explained that "even if every physics major in Canada were to choose a career in quantum computing, it would probably not meet the future workforce needs of the sector" and noted the intersection of quantum computing with several disciplines outside of physics, including engineering [16, Sec. 15:30 (Dr. Shohini Ghose)].

Kaur and Venegas-Gomez also identified the degree requirements for quantum industry job vacancies in their analysis of the global quantum workforce needs. While PhD graduates in quantum studies are still favoured, the study further notes that bachelor's graduates from STEM fields that acquire quantum industry experience increase their value in the quantum industry employment market [15].

Figure 1

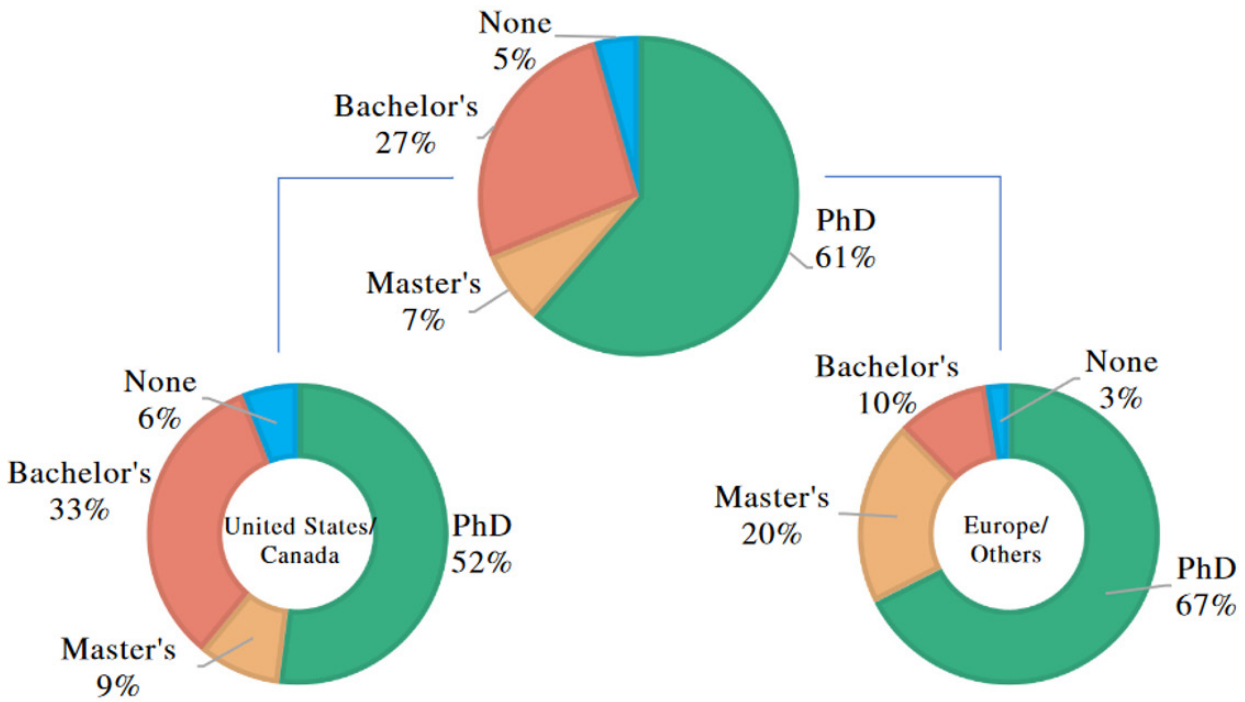

Figure 1: Degree requirements for job vacancies in quantum industry (a) globally; (b) in the United States and Canada; and (c) in Europe and the rest of the world, according to job postings on the Quantum Computing Report in 2022 [15], [17]. Source: reproduced from [15].

Despite the current focus on academic credentials, established engineering professionals can also develop core quantum skills, and push quantum industry to further recognize interdisciplinary expertise. Currently, upskilling usually requires engaging with external resources and learning opportunities, some examples of which are provided below. In the long-term, industries and larger organizations may eventually provide internal upskilling programs in conjunction with quantum R&D initiatives.

Engineering students and recent graduates are also well-positioned to continue their education with a quantum focus through summer schools, internships, as well as graduate programs with quantum specializations. The availability of such quantum education programming continues to grow in Canada.

b. Engineers who Apply Existing Expertise

Engineers will also find opportunities to apply their existing expertise to the quantum industry without a need to learn core quantum skills. In a survey of job type hiring needs for a group of quantum companies in the United States, only 7 out of 19 identified job types require quantum-specific skills. Only one of the identified engineering job types, the Photonics/Optics Engineer/Scientist, requires in-depth quantum knowledge. The broad application space of quantum technologies in areas such as sensing, optimization, simulation, communication, and materials science is an opportunity for engineers from any discipline to engage with QT to discover useful applications of QT or advance QT product development.

Figure 2

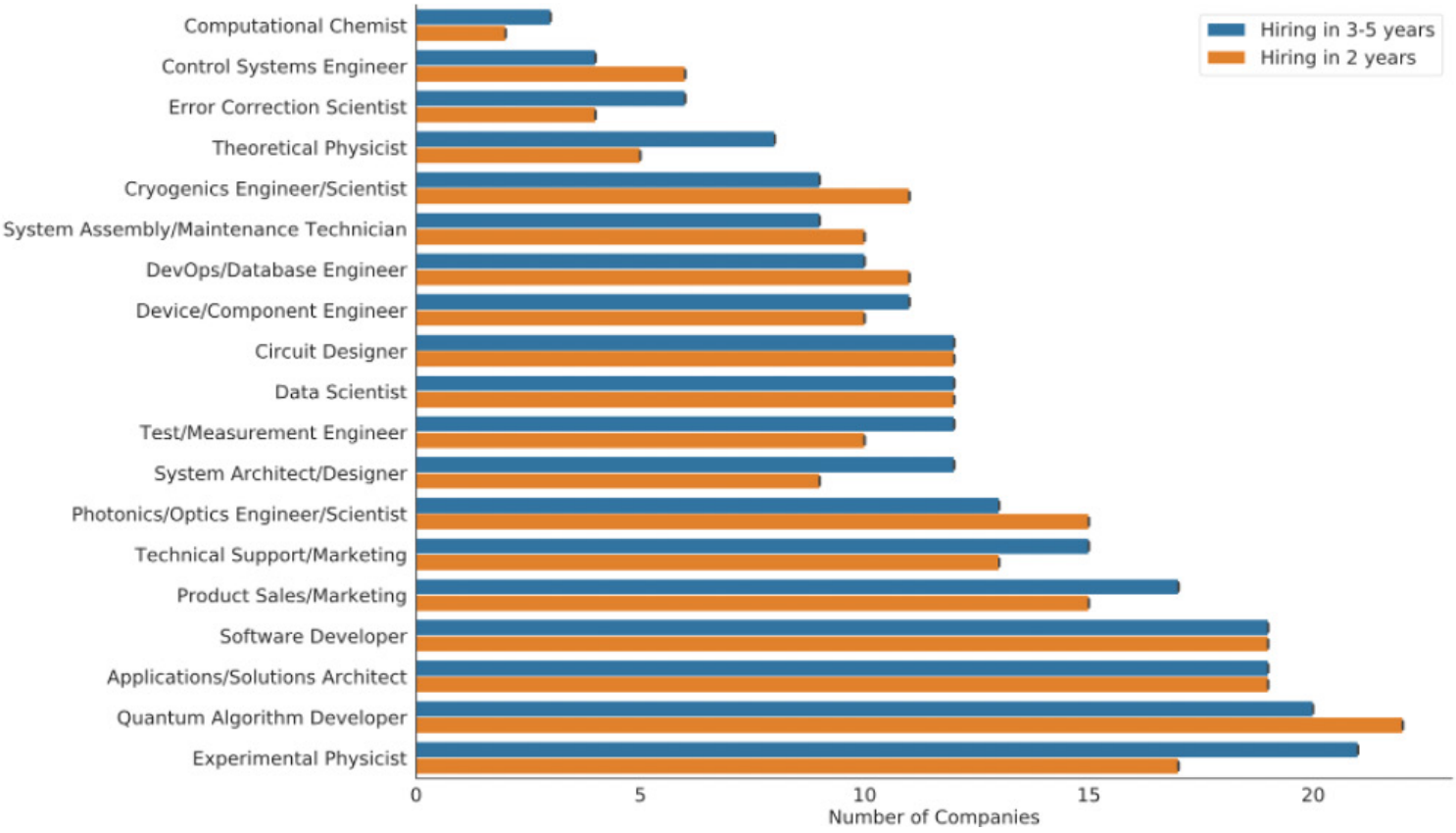

Figure 2: Number of United States quantum companies (out of 57 surveyed) indicating they would hire a particular job type. The authors identified only seven job-types that require quantum skills: Photonics/Optics Engineer/Scientist, Quantum Algorithm Developer, Computational Chemist, Theoretical Physicist, Experimental Physicist, Applications/Solutions Architect, and Error Correction Scientist. Source: reproduced from [18].

Engineers with experience in management and business who adapt their skills to the unique attributes of the quantum industry offer significant value in the practical aspects of commercializing QT. Notwithstanding the influx of funding, QT development is often very expensive to account for materials and equipment, namely in hardware development. Small to medium enterprises with limited resources will benefit greatly from experienced leadership to maximize funding allocation in the competitive and unique market. This need will only grow as quantum companies try to scale their products.

Similarly, engineers with experience in regulatory and standards compliance can offer guidance in the evolving regulatory landscape for QT. As quantum industry matures and more companies enter the competitive market, there will be an increasing need to define the environmental, social, and governance (ESG) standards for organizations in quantum industry. This includes, for example, the development and implementation of technical standards (e.g., in cybersecurity [19]), and the corresponding compliance and enforcement frameworks.

3. How Engineers Can Get Involved in Quantum Industry

As noted above, some engineers may be interested in developing core quantum skills to contribute to QT development, while others may only need to be quantum-aware to apply their expertise. Many resources exist to support the spectrum of learning goals. QURECA (Quantum Resources and Careers) provides a helpful overview of some available quantum learning resources [15], [20]. Engineers in business and management may also be interested in services offered by Canadian quantum consultants [21]–[23]. Students and graduates can research program offerings at Canadian universities and quantum research institutes [24]–[29].

Whether a student or professional, engineers who are interested in quantum industry can attend a conference to connect with quantum companies and the quantum community. Canada boasts a well-connected quantum community with established quantum ecosystems in Waterloo, Sherbrooke, Calgary, and Vancouver. Notable annual Canadian quantum conferences include Quantum Days [30], Inside Quantum Technology Canada [31], and Quantum Connections [32]. A list of global quantum conferences (not limited to industry) each year is also available [33]. Engineers seeking job opportunities in quantum industry may also consult quantum-focused job boards [20], [34]–[36].

4. Engineering the Future of Quantum

Working in quantum industry is an opportunity to work with cutting-edge technology, challenge "classical" ways of thinking, and solve tough problems with potentially far-reaching impact. Quantum is for everyone, and myriad resources exist to teach quantum concepts to individuals at all levels of education. Engineers have an opportunity to engage with the quantum industry in both quantum roles through upskilling and non-quantum roles by leveraging existing expertise. Engineers can highlight their knowledge and skills to the industry, and the quantum companies that recognize the value in engineers' skills will position themselves as leaders in the industry by capturing and retaining this talent.

BIBLIOGRAPHY

[1] J. Kung and M. Fancy, 'A Quantum Revolution: Report on Global Policies for Quantum Technology', Canada Institute for Advanced Research, Apr. 2021. [Online]. Available: https://cifar.ca/cifarnews/2021/04/07/a-quantum-revolution-report-on-global-policies-for-quantum-technology/

[2] 'Canada's National Quantum Strategy', Innovation, Science and Economic Development Canada, Jan. 2023. [Online]. Available: https://ised-isde.canada.ca/site/national-quantum-strategy/en/canadas-national-quantum-strategy

[3] B. Sussman, P. Corkum, A. Blais, D. Cory, and A. Damascelli, 'Quantum Canada', Quantum Sci. Technol., vol. 4, no. 2, p. 020503, Feb. 2019, doi: 10.1088/2058-9565/ab029d.

[4] J. Berg, 'The Canadian Quantum Ecosystem Report 2023', Quantum Algorithms Institute (QAI). Accessed: Jun. 26, 2023. [Online]. Available: https://quantumalgorithms.ca/reports/the-canadian-quantum-ecosystem-report-2023/

[5] T. Dekker, 'Quantum Technology: A Brief Introduction', Ontario Society of Professional Engineers, Jul. 2023. [Online]. Available: https://ospe.on.ca/wp-content/uploads/2023/07/Quantum-Technology-July-2023.pdf

[6] 'Quantum Technology Investment Update 2022 Review', The Quantum Insider. [Online]. Available: https://thequantuminsider.com/wp-content/uploads/2023/02/Quantum-Technology-Investor-Update_vFF.pdf

[7] 'Home - IEEE Quantum'. Accessed: Jul. 07, 2023. [Online]. Available: https://quantum.ieee.org/

[8] 'QCE23 Home: IEEE Quantum Week', IEEE Quantum Week. [Online]. Available: https://qce.quantum.ieee.org/2023/

[9] E. Perrier, 'Ethical Quantum Computing: A Roadmap'. arXiv, Apr. 20, 2022. doi: 10.48550/arXiv.2102.00759.

[10] M. Kop et al., 'Towards Responsible Quantum Technology'. Rochester, NY, Mar. 17, 2023. doi: 10.2139/ssrn.4393248.

[11] T. Roberson, 'Talking About Responsible Quantum: "Awareness Is the Absolute Minimum that … We Need to Do"', NanoEthics, vol. 17, no. 1, p. 2, Mar. 2023, doi: 10.1007/s11569-023-00437-2.

[12] T. Dekker and F. Martin-Bariteau, 'Regulating Uncertain States: A Risk-Based Policy Agenda for Quantum Technologies', Canadian Journal of Law and Technology, vol. 20, no. 2, p. 179, 2022, doi: 10.2139/ssrn.4203758.

[13] E. de Jong, 'Own the Unknown: An Anticipatory Approach to Prepare Society for the Quantum Age', Digit. Soc., vol. 1, no. 2, 2022, doi: 10.1007/s44206-022-00020-4.

[14] E. Perrier, 'The Quantum Governance Stack: Models of Governance for Quantum Information Technologies', Digit. Soc., vol. 1, no. 3, p. 22, Oct. 2022, doi: 10.1007/s44206-022-00019-x.

[15] M. Kaur and A. Venegas-Gomez, 'Defining the quantum workforce landscape: a review of global quantum education initiatives', Opt. Eng., vol. 61, no. 8, p. 081806, May 2022, doi: 10.1117/1.OE.61.8.081806.

[16] 'House of Commons, Standing Committee on Industry and Technology, Evidence, 44-1, No 16'. [Online]. Available: https://www.ourcommons.ca/DocumentViewer/en/44-1/INDU/meeting-16/evidence#Int-11615817

[17] D. Finke, 'Quantum Computing Report', Quantum Computing Report. [Online]. Available: https://quantumcomputingreport.com/

[18] C. Hughes, D. Finke, D.-A. German, C. Merzbacher, P. M. Vora, and H. J. Lewandowski, 'Assessing the Needs of the Quantum Industry', IEEE Trans. Educ., vol. 65, no. 4, pp. 592–601, Nov. 2022, doi: 10.1109/TE.2022.3153841.

[19] 'Post-Quantum Cryptography Standardization', National Institute of Standards and Technologies. [Online]. Available: https://csrc.nist.gov/Projects/Post-Quantum-Cryptography/Post-Quantum-Cryptography-Standardization

[20] 'QURECA', Qureca. [Online]. Available: https://qureca.com/

[21] 'Enterprise Quantum', Enterprise Quantum. [Online]. Available: https://www.enterprisequantum.ca/

[22] 'Qubo Consulting Corp.', Qubo Consulting Corp. [Online]. Available: https://www.quboquantum.com

[23] 'Quantum Strategy Institute', Quantum Strategy Institute. [Online]. Available: https://quantumstrategyinstitute.com/

[24] 'Institute for Quantum Computing', University of Waterloo. [Online]. Available: https://uwaterloo.ca/institute-for-quantum-computing/

[25] 'Quantum Horizons Alberta', Quantum Horizons Alberta. [Online]. Available: https://www.quantumhorizonsab.ca

[26] 'Quantum City', University of Calgary. [Online]. Available: https://research.ucalgary.ca/quantum-city

[27] 'Nexus for Quantum Technologies Institute'. [Online]. Available: https://nexqt.ca/about-us/

[28] 'Institut quantique', Université de Sherbrooke. [Online]. Available: https://www.usherbrooke.ca/iq/

[29] 'Industrial Engagement and Consultancy', Canadian Quantum Research Center. [Online]. Available: https://candqrc.ca/consultancy.html

[30] 'Quantum Days', Quantum Days. [Online]. Available: https://quantumdays.ca/

[31] 'IQT Canada: Canada's Quantum Computing Event', Inside Quantum Technology Conference. Accessed: Jul. 27, 2023. [Online]. Available: https://iqtevent.com/canada/

[32] 'Quantum Connections'. [Online]. Available: https://uwaterloo.ca/institute-for-quantum-computing/quantum-connections-conference

[33] ‘2023 Conferences’, Quantum Technology Lab. [Online]. Available: https://quantum.info/conf/index.html

[34] ‘Quantum Jobs’, The Quantum Insider. [Online]. Available: https://thequantuminsider.com/quantum-jobs/

[35] D. Finke, ‘U.S. / Canada Quantum Computing Jobs’, Quantum Computing Report. [Online]. Available: https://quantumcomputingreport.com/jobs-u-s-canada/

[36] ‘Quantum Jobs’, QED-C. [Online]. Available: https://quantumconsortium.org/quantum-jobs/

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