

Polytechnique Montréal's Institutional Research Plan presents our institution's strategic orientations and actionable priorities in terms of research to our external collaborators. This plan specifically meets the requirements of the Canada Research Chairs (CRC) Program, federal and provincial granting agencies, and the Canada Foundation for Innovation (CFI).

1. INTRODUCTION

Polytechnique Montréal is an engineering university founded in 1873, located on the *Université de Montréal* campus. Our mission is to: i) educate engineers and top-level scientists to meet the challenges of an evolving world and make them key agents of change; ii) conduct research that addresses major societal issues; iii) influence its environment intellectually, economically and socially.

Polytechnique offers its 9,600 students (including 24% at the graduate level) one of Canada's largest ranges of engineering training programs, with 12 undergraduate programs (aerospace, biomedical, chemical, civil, electrical, geological, industrial, computer, software, mechanical, mining, and engineering physics). Add to the latter, master's and doctoral level programs in most of the aforementioned disciplines, as well as graduate programs in energy, nuclear, metallurgical, and mineral engineering, sustainable development, and engineering mathematics. Since its establishment, Polytechnique has trained nearly 60,000 engineers, scientists, and researchers.

2. RESEARCH PHILOSOPHY

To celebrate its 150th birthday in 2023, Polytechnique Montréal aspires to become a technological university recognized internationally for its leadership, boldness and entrepreneurship. Polytechnique will also seek to be a source of inspiration, a reference in its field and a model of diversity and inclusion – firmly convinced that these values foster creativity and constitute an undeniable catalyst for excellence in educational activities as well as research.

In keeping with its historical role in the economic development of society, Polytechnique wishes to meet the major challenges of the future by training highly qualified personnel, by pursuing interdisciplinary research work in synergy with its milieu, and by relying on its community as a developmental engine. To accomplish this, Polytechnique advocates pursuing multidisciplinary research and development (R&D) activities with numerous partners using a collaborative and synergistic approach. These collaborations maximize intellectual, economic, environmental, and societal impact; Polytechnique integrates the above into all of its R&D activities, and its spheres of excellence reflect this vision.

3. RESEARCH AND ENTREPRENEURIAL TRAINING

In response to the challenges posed by an ever-changing world, Polytechnique trains highly qualified personnel through appealing training programs that anticipate society's needs. To enrich students' training and education, our institution favours interdisciplinary training programs, and the integration of internationally-minded multidisciplinary training projects. This enables Polytechnique students to flourish through immersion in domains of societal importance outside their field of study. To further enrich student training, Polytechnique promotes experiential learning through internships, assorted projects, involvement in technical societies and student committees, entrepreneurship, and international exchanges.

At the graduate level, Polytechnique also promotes the pursuit of research projects that take into consideration social, political, environmental, and economic elements. From the initial stages of research project development, Polytechnique encourages its graduate students to integrate every stakeholder - including the end users of the technologies developed by researchers. The latter permits our institution to maximize its impact by i) training highly qualified personnel who occupy strategic positions in Québec, Canada, and internationally; and by ii) conducting innovative projects that meet society's needs.

Congruent with its desire to maximize its impact on its milieu, Polytechnique also commits significant resources to training engineer-entrepreneurs. The institution seeks to create Canadian-based high value added start-ups, so that this path will become a more frequent and viable employment option for its students.

4. SPHERES OF EXCELLENCE

In order to meet the [global sustainable development goals](#) and the [14 major engineering challenges](#) set out by the National Academy of Engineering (2008), both of which endeavour to have a significant impact on our society, Polytechnique has structured all research activities around **8 spheres of excellence**, grouped into three categories. These areas are associated with each other and describe areas of research in which Polytechnique has a critical mass of researchers.

The **i) Energy, Water, and Resources in a Transitional World, ii) Human Health, iii) Future Industries and Digital Society, iv) Sustainable Transport and Infrastructures** spheres of excellence are related to societal challenges Polytechnique wishes to contribute to. Then, there are three critical technological spheres, **i) Modeling and Artificial Intelligence, ii) Innovative Materials, iii) New Frontiers in Information and Communication Technologies** - each of which represents transversal research themes which appear in many of Polytechnique's research activities. At the very heart of all the 8 spheres of excellence is the **Environment, Economy, and Society** sphere of excellence, associated with the assessment, management, and consideration of the environmental, economic, and societal impact of activities; the latter sphere Polytechnique wishes to see influencing all other spheres.

	Research institutes, centres and groups	Canada Research Chairs (CRC)	Other Research Chairs	Number of CFI-Qc-partners projects	Total value	Polytechnique's share
Energy, Water, and Resources in a Transitional World	12	4	6	22	36 310 506 \$	27 331 365 \$
Environment, Economy, and	10	1	2	2	1 171 221 \$	807 872 \$
Future Industries and Digital Society	1	0	0	7	28 487 998 \$	13 470 382 \$
Innovative Materials	8	5	6	49	182 427 300 \$	103 815 644 \$
Modeling and Artificial Intelligence	5	1	5 + 1 CERC	7	49 914 554 \$	15 779 718 \$
New Frontiers in Information and Communication Technologies	10	3	2	17	33 314 342 \$	32 593 043 \$
Human Health	3	3	6	32	95 969 911 \$	69 198 352 \$
Sustainable Transport and Infrastructures	7	4	4	16	75 558 990 \$	48 682 862 \$
TOTAL	56	21 + 3 not allocated	31 + 1 CERC	151	503 154 822 \$	311 679 238 \$

5. RESEARCH ORGANIZATION

5.1 Research institutes, centres, and groups

Our researchers are organized into major research institutes, centres, and groups that are equipped with cutting-edge technological infrastructure, a diversified range of equipment, and highly-specialized human resources. The table below presents a summary of our primary research units.¹

Sphere of Excellence	Research unit names
Energy, Water, and Resources in a Transitional World	<ul style="list-style-type: none"> Research Institute on Mines and the Environment (RIME) UQAT-Polytechnique* Trottier Energy Institute (IET)* Canadian International Resources and Development Institute (CIRDI)* Research, Development and Validation Centre for Water-Treatment Technologies and Processes (CREDEAU)* Interdisciplinary Research Centre on Sustainable Development Operationalization (CIRODD)* Centre for Green Chemistry and Catalysis (CGCC)* Québec Water Research Centre (CentrEau)* Research Centre on the Dynamics of Earth Systems (GEOTOP)* Experimental and Numerical Engineering Water Flow Group (GENIE EAU) Geothermal and Hydrogeology Research Group (G2H) Québec Ecotoxicology Network (EcotoQ)* Research Centre in Industrial Flow Processes (URPEI)
	<ul style="list-style-type: none"> Institute for Sustainable Engineering and Net Zero Economy (IIDEC)* International Observatory on the Societal Impacts of AI and Digital Technology (OBVIA)*

¹ Given their large number, lab-type research units do not appear in this table. The latter units may have nevertheless received CFI/Government of Québec research funding, and play an important role in Polytechnique's ecosystem.

Environment, Economy, and Society	<ul style="list-style-type: none"> • International Reference Centre for the Life Cycle of Products, Processes and Services (CIRAIG)* • Québec Intersectorial Network on Floods (RIISQ)* • Centre for Interuniversity Research and Analysis on Organizations (CIRANO)* • Centre for Risk & Performance (CRP) • Interuniversity Research Centre on Science and Technology (CIRST)* • Research Group in Technology Management and Globalisation (GMT) • Partnership for the Organization of Innovation and New Technologies (4POINT0)* • Cities Regions World Research Network*
Future Industries and Digital Society	<ul style="list-style-type: none"> • Product Development and Manufacturing Research Group (GRDFP)
Innovative Materials	<ul style="list-style-type: none"> • Centre for Applied Research on Polymers and Composites (CREPEC)* • Aluminum Research Centre (REGAL)* • Centre for Characterization and Microscopy of Materials (CM²) • Centre for Research in Computational Thermochemistry (CRCT) • Thin-Film Physics and Technology Research Group (GCM)* • Québec Advanced Materials Research Cluster (RQMP)* • Green Surface Engineering for Advanced Manufacturing Network (Green-SEAM)* • Green Electronics Network (GreEN)*
Modeling and Artificial Intelligence	<ul style="list-style-type: none"> • Institute for Data Valorization (IVADO)* • Québec Artificial Intelligence Institute (MILA)* • Research Group in Decision Analysis (GÉRAD)* • Québec Research Network on Neuroscience and Artificial Intelligence (UNIQUE)* • Calcul Québec*
New Frontiers in Information and Communication Technologies	<ul style="list-style-type: none"> • Transdisciplinary Institute of Quantum Information (INTRIQ)* • Centre for Systems, Technologies and Applications for Radiofrequency and Communications (STAR@com)* • Advanced Research Centre in Microwaves and Space Electronics (POLY-GRAMES) • Computer Research Institute of Montréal (CRIM)* • Centre for Optics, Photonics and Lasers (COPL)* • Microelectronics and Microsystems Research Group (GR2M) • Mobile Computing and Networking Research Group (GRIM) • Software Engineering Research Group (PolyMORSE) • Québec Microelectronics Strategic Cluster (RESMIQ)* • Centre Studying Distributed Intelligent Shared Environments (REPARTI)*
Human Health	<ul style="list-style-type: none"> • TransMedTech Institute (iTMT)* • Institute for Biomedical Engineering • Biomedical Science and Technologies Research Centre (GRSTB)
Sustainable Transport and Infrastructures	<ul style="list-style-type: none"> • Institute of Innovation and Design in Aerospace of Polytechnique (IICAP) • Centre for Interuniversity Studies on structures under extreme loads (CEISCE)* • Interuniversity Research Centre on Enterprise Networks, Logistics and Transportation (CIRRELT)* • Concrete Infrastructure Research Centre (CRIB)* • Structural Engineering Research Group (GRS) • Geotechnical Research Group (GRG) • Road Safety Research Network (RRSR)*

*Inter-university research units

5.2 Research Chairs

Canada Research Chairs (CRC): Polytechnique has 24 CRCs, established according to its institutional research priorities. Since its inception, the CRC program has had a major impact on Polytechnique in terms of both attracting and retaining high-calibre researchers.

Industrial Chairs: With a view to conduct relevant, high-level research that takes into account industry and societal needs, Polytechnique promotes long-term collaborations with its industrial partners. Industrial Chairs enable the university to maximize the impact of university-business collaborations, and to facilitate the transfer of research into society. Polytechnique has 16 industrial/private Research Chairs (8 of which are NSERC research chairs), three (3) Philanthropic Chairs, one (1) FRQ/IVADO Research Chair, five (5) TransMedTech Chairs, three (3) CIFAI-AI Chairs, two (2) UNESCO Chair, one (1) Scale-AI Chair and one (1) MEI Chair.

Canada Excellence Research Chair (CERC): Since 2018, Polytechnique has been host to one of 20 extremely prestigious CERC chairs, held in universities across Canada. The institution's CERC in Data Science for Real-Time Decision-Making is based on considerable expertise in the field of operations research and data science, and close collaborations with an extensive network of academic and industrial experts who make today's Montréal a global center of expertise in the field.

Spheres of Excellence Chair Titles and Chair Holders	
Energy, Water, and Resources in a Transitional World	<ul style="list-style-type: none"> • Tier-1 CRC in High-Temperature High-Pressure Heterogeneous Catalysis (G. Patience) • Tier 2 CRC in Decentralized and Small-Scale Water Treatment (D. Claveau-Mallet) • Tier 2 CRC in Computational Hydrosystems (A. Shakibaenia) • Tier-2 CRC in Intensified Mechano-Chemical Processes for Sustainable Biomass Conversion (D. Boffito) • NSERC Industrial Chair in Drinking Water Treatment (M. Prévost, B. Barbeau, S. Dorner) • NSERC / General Electric Industrial Chair in Two-Phase Flow (S. Étienne) • NSERC/Hydro-Québec/RTE/EDF/Opal-RT Industrial Chair on the Multi Time-Frame Simulation of Transients for Large Scale Power Systems (J. Mashedjan) • NSERC Industrial Chair in Geothermal Energy for Geothermal Standing Column Wells in Industrial Buildings (P. Pasquier) • TOTAL Industrial Chair in Hydrodynamic Modeling of Multiphase Processes Under Extreme Conditions (J. Chaouki) • UNESCO Chair in Sustainable Engineering: Applied Solar Technologies (O. Savadogo)
Environment, Economy, and Society	<ul style="list-style-type: none"> • Tier-1 CRC in Creation, Development and Innovation Commercialization (C. Beaudry) • UNESCO Chair in Green and Sustainable Electronics (C. Santato) • Chair in residual materials recovery (R. Legros, R. Samson, G. Majeau-Bettez)
Innovative Materials	<ul style="list-style-type: none"> • Tier-1 CRC in Computational Thermodynamics for High Temperature Sustainable Processes (P. Chartrand) • Tier-1 CRC in Sustainable Organic Electronics: Materials, Processes and Devices (C. Santato) • Tier-2 CRC in Nanoscale and Quantum Semiconductors (O. Moutanabbir) • Tier-2 CRC in Fatigue Damage of Advanced Metallic Materials (M. Brochu) • Tier-2 CRC in Hybrid and Molecular Photonics (S. Kéna-Cohen) • NSERC/Prolamina Industrial Research Chair on Safe, Smart and Sustainable Packaging (A. Ajji) • NSERC Multisectorial Industrial Research Chair on Coatings and Surface Engineering (L. Martinu) • Safran Industrial Research Chair on Additive Manufacturing of Organic Matrix Composites (AMOMC) (D. Therriault) • Philanthropic Chair in Materials Engineering and Additive Manufacturing (E. Martin) • Philanthropic Chair in Materials Engineering for Metal Recycling (J.P. Harvey) • MEI Chair in Quantum Photonics (S. Francoeur)
Modeling and Artificial Intelligence	<ul style="list-style-type: none"> • CERC in Data Science for Real-Time Decision-Making (A. Lodi) • Tier-1 CRC in Healthcare Analytics and Logistics (L.M. Rousseau) • Jarislowsky/SNC-Lavalin Research Chair in International Project Management (R. Pellerin) • CIFAI Chair in Artificial Intelligence (S. Chandar) • CIFAI Chair in Artificial Intelligence (C. Pal) • CIFAI Chair in Artificial Intelligence (F. Khomh) • Scale-AI Chair in Data-Driven Supply Chains (T. Vidal)
New Frontiers in Information and Communication Technologies	<ul style="list-style-type: none"> • Tier-1 CRC in Ubiquitous Terahertz Photonics (M. Skorobogatiy) • Tier-2 CRC in Ultrafast and Quantum Photonics (D. Seletskiy) • Tier-2 CRC in User Experience Design of Data-Driven Systems (J. Cheng) • NSERC Industrial Research Chair (IRC) for High Speed and Programmable Packet Processing (Y. Savaria) • FRQ-IVADO Chair on Software Quality Assurance For Machine Learning Applications (F. Khomh)
Human Health	<ul style="list-style-type: none"> • Tier-1 CRC in Vascular Optical Imaging (F. Lesage) • Tier-2 CRC in Intelligent Image Guided Interventions (S. Kadoury) • Tier-2 CRC in Quantitative Magnetic Resonance Imaging (J. Cohen-Adad) • NSERC/Medtronic Industrial Research Chair in Spine Biomechanics (C. E. Aubin) • TransMedTech Research Chair in Assistive and Rehabilitation Technologies (A. Mohebbi) • TransMedTech Research Chair in Diagnostic and Therapeutic Technologies (G. Merle) • TransMedTech Research Chair in Plasma Medicine (S. Reuter) • TransMedTech Research Chair in Pediatric Neuroimaging (B. De Leener) • TransMedTech Research Chair in Bioanalytical Systems (R. Trouillon)
Sustainable Transport and Infrastructures	<ul style="list-style-type: none"> • Tier 1 CRC on the Modelling and Control of Unsteady Aircraft Aerodynamics (E. Laurendeau) • Tier-1 CRC in Modeling and Simulation in Earthquake Engineering (N. Bouaanani) • Tier-1 CRC on Personal Mobility (C. Morency) • Tier-2 CRC in Design and Optimization of Non-Regular Mechanical Systems (A. Batailly) • NSERC / CRIAQ / Bombardier Industrial Research Chair on Aerothermodynamic Interdisciplinary Analysis and Design Methods for Transport Aircraft (É. Laurendeau) • Research Chair on Evaluation and Implementation of Sustainability in Transportation (C. Morency) • Chair in Transport Transformation (C. Morency, N. Mousseau, M. Trépanier) • Safran Industrial Chair on Multifunctional Passive Acoustic Treatments for Turbofan Composite Structures (A. Ross)

5.3 Inter-institutional Groups

To advance its collective research capacities, Polytechnique relies on inter-institutional groups with its partner universities and colleges. This approach is based on the strategic groups program espoused by the *Fonds de recherche du Québec – Nature et technologies* (FRQNT); the *Fonds de recherche du Québec – Santé* (FRQS) centres program, and on NSERC's Canadian strategic networks. Polytechnique leads several strategic groups funded by the FRQNT (e.g. CEISCE, CREPEC and RESMIQ), and is also a stakeholder in many FRQNT strategic groups (e.g. Calcul Québec, CIRODD, COPL, CRIB CIRRELT, CIRST, CREPEC, CentrEau, CCVC, EcotoQ, GEOTOP, GERAD, INTER, REGAL, REPARTI, RQMP, STARaCom, UNIQUE, and VRM).

Further, Polytechnique is a member of several NSERC networks, such as the Green Surface Engineering for Advanced Manufacturing Network (Green-Seam), the Canadian NSERC Green Electronics Network (GreEN), and numerous Networks of Centres of Excellence Canada (ex. RdIN, SERENE-RISC).

5.4 Industry Clusters and Sectoral Industrial Consortia

Polytechnique's research activities are also aligned with federal and provincial government priorities. As such, Polytechnique is a stakeholder in major industry clusters where it possesses expertise (e.g. Aéro Montréal in the aerospace sector, Numana in the ITC sector, Montréal InVivo in life sciences / health technologies sector, ScaleAI in the artificial intelligence sector, and Écotech in the environmental sector.) Moreover, Polytechnique actively participates in a collaborative innovation ecosystem via Regroupements sectoriels de recherche industrielle (RSRI) research consortiums, namely the Centre québécois de recherche et de développement de l'aluminium (CQRDA), the Consortium for Research and Innovation in Aerospace in Québec (CRIAQ), the Québec Consortium for industrial bioprocess research and innovation (CRIBIQ), the Biopharmaceutical Research Consortium (CQDM), the **Metal Transformation Research and Innovation Consortium** (CRITM), Innovation en énergie électrique (InnovÉÉ), the Industrial Consortium for Research and Innovation in Medical Technologies (MEDTEQ), the Advanced Materials Research and Innovation Hub (PRIMA Québec), and Prompt Québec in the ICT sector. Polytechnique's participation in these industry clusters and RSRI research consortiums enables our institution to cultivate strong connections, and to maximize its impact on local industry.

6. MAJOR RESEARCH INITIATIVES

Thanks to its close collaboration with established academic and industrial partners, in recent years our institution has positioned itself as a world-class player in several fields.

TransMedTech Institute (iTMT): Led by Polytechnique, this transdisciplinary and translational initiative of nearly \$100 million, is based on an integrated university-hospital infrastructure and cutting-edge equipment, as well as on strategic partnerships and recognized innovative research partnerships in the fields of biomedical engineering and medical technologies. The iTMT features a "living lab" approach, wherein engineers, biomedical scientists, clinicians, patients, caregivers, and students, as well as health care system stakeholders and decision-makers, are at the very heart of an open innovation ecosystem.

IVADO Institute: A joint initiative of more than \$240 million between the *Université de Montreal*, HEC, Polytechnique and several other partners, the IVADO Institute, seeks to harness the full potential of big data. The research activities performed by its researchers bring to life great potential for new discoveries, technologies, processes, and products that will propel humanity towards a truly knowledge-based society. IVADO's approach builds on the unique combination of machine learning / deep learning and operations research - the science of optimization.

CONCLUSION

In recent years, the research environment in which Polytechnique operates has significantly changed. Our institution has played a leading role in several major initiatives that have enabled us to position ourselves as an international player - particularly in biomedical engineering and data science. These accomplishments are based on the top-tier research work of Polytechnique's professors, research staff, and students. To achieve the ambitious goals that we have set for ourselves and to meet anticipated developments in each of our spheres of excellence, over the past 30 months, Polytechnique has hired 60 new professors - of which more than 35% are women - bringing to 330 the number of faculty. Polytechnique also believes that we can continue to increase the number of graduate and postdoctoral students, research professionals and technicians, in order to meet the goals that we have set for ourselves, and to have a significant, enduring impact on society.