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MEMORANDUM

ATTENTION	Senate	**DATE**	June 20, 2023
FROM	Kevin Oldknow, Senior Advisor and Acting Chair, SCUP on behalf of Wade Parkhouse, Provost and Vice-President Academic *pro tem*	**PAGES**	1/188
RE:	Full Program Proposal for a Master of Engineering in Sustainable Energy Engineering (SCUP 23-18)		

At its meeting on April 12, 2023, SCUP reviewed and approved the Full Program Proposal for a Master of Engineering in Sustainable Energy Engineering.

Motion: That Senate approve and recommend to the Board of Governors the full program proposal for a Master of Engineering in Sustainable Energy Engineering from the Faculty of Applied Sciences effective **Fall 2024.**

For Information:
Included in the full program proposal and approved by SGSC subject to the approval of Senate:
1. New calendar entry: Master of Engineering in Sustainable Energy Engineering
2. New Courses:
   - SEE 770 Water, Energy and Food Nexus
   - SEE 771 Sustainable Energy Systems I
   - SEE 772 Sustainable Energy Systems II
   - SEE 773 Sustainable Energy Policy
   - SEE 799 Capstone Project

C: Colin Copeland, Associate Professor and Graduate Program Chair, School of Sustainable Engineering

SFU GRADUATE AND POSTDOCTORAL STUDIES

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MEMORANDUM

ATTENTION Senate Committee on University Priorities (SCUP)

DATE March 30, 2023

FROM Jeff Derksen,
Chair of Senate Graduate Studies Committee (SGSC)

RE: Full program proposal: Sustainable Energy Engineering MEng.

For approval:

At its meeting on February 7, 2023, SGSC approved the full program proposal for a Master of Engineering in Sustainable Energy Engineering from the Faculty of Applied Sciences. SGSC is recommending it to SCUP for approval, effective **Fall 2024**

Motion:

That SCUP approve and recommend to Senate the full program proposal for a Master of Engineering in Sustainable Energy Engineering from the Faculty of Applied Sciences effective **Fall 2024**.

For Information:

Included in the full program proposal and approved by SGSC subject to the approval of Senate:

New calendar entry: Master of Engineering in Sustainable Energy Engineering

New Courses:

- SEE 770 Water, Energy and Food Nexus
- SEE 771 Sustainable Energy Systems I
- SEE 772 Sustainable Energy Systems II
- SEE 773 Sustainable Energy Policy
- SEE 799 Capstone Project

OFFICE OF THE DEAN
Faculty of Applied Sciences
Simon Fraser University

MEMORANDUM

Attention Dr. Jeff Derksen
Dean, Graduate Studies

Date: Jan 17, 2023

From Dr. Parvaneh Saeed, psaeedi@sfu.ca
Faculty of Applied Science, Graduate Studies Committee

Re: FAS-SEE New Master of Engineering in Sustainable Energy Engineering- Full Program Submission

The faculty of Applied Sciences Graduate Studies Committee would like to submit the proposal for the Master of Engineering (MEng) program in Sustainable Energy Engineering by the School of Sustainable Energy Engineering – a course-based Masters degree.

The attached full program details the plan and all related details important to the offering of the MEng program to deliver an interdisciplinary engineering degree that equips graduates with the conceptual knowledge of the sustainable energy domain and the skills required to succeed in a competitive work setting. We would like to offer this program starting Fall 2024.

Regards,

Parvaneh Saeedi

Associate Dean, Research and Graduate Studies
Faculty of Applied Sciences

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MEMORANDUM

ATTENTION	Associate Dean Research and Grad Studies, Faculty of Applied Sciences	**DATE**	09 Aug 2022
FROM	Dr. Colin Copeland, Graduate Program Chair, School of Sustainable Energy Engineering	**PAGES**	1
RE:	Submission of the Full Program Proposal for an MEng in Sustainable Energy Engineering		

This memo is to accompany the full program proposal for the creation of a Master of Engineering (MEng) in Sustainable Energy Engineering.

This is anticipated that the program could be launched in Fall 2024 subject to approvals.

The rational for this proposal is to broaden the graduate programs offered by the School of Sustainable Energy Engineering to include a course-based Masters degree.

SEE Graduate Program Committee Chair

SFU SIMON FRASER UNIVERSITY
ENGAGING THE WORLD

Master of Engineering (MEng)

Full Program Proposal

November 2022

School of Sustainable Energy Engineering

Faculty of Applied Science

SUMMARY

1) Proposed credential to be awarded

Master of Engineering (MEng) in Sustainable Energy Engineering

2) Location of program

The School of Sustainable Energy Engineering's (SEE) proposed MEng program will be hosted in the purpose-built SRYE facility (opened September 2019) located on the SFU Surrey Campus.

3) Academic unit(s) offering proposed program

This program will be offered by the School of Sustainable Energy Engineering in the Faculty of Applied Sciences.

4) Anticipated program start date

Fall 2024

5) Anticipated completion time

The proposed MEng in Sustainable Energy Engineering program is anticipated to be completed in four terms of full-time study (1.33 years).

6) Contact information

Colin Copeland, Associate Professor, 236-808-3456, ccopelan@sfu.ca

PROGRAM DETAILS

7) Aims, goals and/or objectives of the proposed program

The proposed MEng in Sustainable Energy Engineering aims to deliver an interdisciplinary engineering degree that equips its graduates with conceptual knowledge of the sustainable energy domain, an ability to understand and design technological solutions, and the skill set needed to succeed in a competitive work setting. The graduates from this program will be able to undertake advanced technical roles in British Columbia's (BC) clean-tech economy, filling a current gap in the market, and the advanced interdisciplinary training will ensure that they are also ready to assume leadership roles in the industry.

The proposed full-time program is designed to facilitate interdisciplinary scholarly research and will connect with multiple academic domains at SFU – notably, public policy, political science, and environmental management – in order to develop a unique knowledgebase of sustainability and the policy-relevant dimensions of sustainable energy engineering. The program will be specifically focused on the following objectives:

i. Impart interdisciplinary sustainable energy engineering education that instills systems thinking, understanding of the financial and economic landscape, and knowledge of policy-domain interactions.
ii. Develop an integrated and holistic skill set that includes technical skills complemented with a mastery of teamwork, collaborative problem solving, and effective communications and outreach.
iii. Identify and foster partnerships with a range of potential employers and technology leaders in relevant domains.

Engage and collaborate with other academic units at SFU to enrich the student experience and build a truly interdisciplinary curriculum.

The following are the program-level learning outcomes for the MEng program:

i. Develop an in-depth understanding of engineering design, problem-solving, and technological deployment of sustainable energy solutions across a wide array of economic sectors.
ii. Demonstrate the application of sustainability principles to the energy engineering field, as well as closely related fields of water, food, and environmental security, in order to develop optimized solutions for energy challenges.
iii. Develop a systems approach towards assessment of energy applications while understanding pertinent interactions, tradeoffs, and contradictions.
iv. Identify and anticipate the impacts of governmental policy and regulations on sustainable energy and clean-tech projects and inform engineering practices accordingly.
v. Effectively communicate to a range of audiences, using various formats (e.g., written, spoken, social media), the nuances and trade-offs inherent in sustainable energy engineering.
vi. Understand and apply effective team-based problem solving and project management strategies.

The curriculum will achieve these objectives through two pedagogic approaches. First, a solid conceptual basis for an interdisciplinary approach toward sustainable energy engineering will be developed through a mix of courses customized for the MEng in

Sustainable Energy Engineering program. Targeted SEE graduate courses and selected courses offered by other SFU academic units will also be utilized. Key technical skills will include the application of: (a) an in-depth understanding of sustainable energy engineering design and technological deployment, (b) sustainable principles to optimize energy solutions, (c) systems-based thinking to capture interactions and tradeoffs, and (d) a knowledge of policy and regulation pertaining to sustainable energy sectors or projects. Second, a series of non-technical skills will be integrated into the curriculum, particularly those related to teamwork, creative thinking, strong communications, ethics and responsibility, and business planning and entrepreneurship. These non-technical skills will be reinforced through a team-based capstone project completed in a student's final semester, which will showcase the combined skill sets gained and strengthened throughout the program. The students will complete this project over an eight-month period at the end of their program. The project will involve a group of three or four students working directly with an external partner on a multi-disciplinary problem.

8) How does the proposed program fit within the mandate of the institution?

The mandate letter addressed to the board members of Simon Fraser University on behalf of Premier Horgan and the Executive Council dated June 1, 2021 describes five foundational principles to inform SFU policies and programs. Of these five, the two that are highly relevant to the proposed MEng in Sustainable Energy Engineering program are "A better future through fighting climate change" and "A strong, sustainable economy that works for everyone".[1]

- **A better future through fighting climate change**: The mandate letter points to the announcement of the CleanBC climate action plan and the responsibility of institutions to chart a path toward a cleaner and better future by supporting the clean-tech economy, protecting clean air, land, and water, and supporting communities to prepare for climate impacts. The proposed MEng in Sustainable Energy Engineering will help SFU deliver on their commitment to "engage in global challenges"[2] including "enabling and valuing interdisciplinary scholarship notably in community-centred climate innovation".[2] The proposed multi-disciplinary MEng in Sustainable Energy Engineering degree will complement SEE's existing undergraduate and thesis-based graduate (MASc and PhD)

[1] SFU Mandate Letter: https://www2.gov.bc.ca/assets/gov/education/post-secondary-education/institution-resources-administration/mandate-letters/docs/mandate-simon-fraser-university.pdf

[2] SFU Strategic Plan: https://www.sfu.ca/content/dam/sfu/main/about/strategicplan/files/SFU%20What's%20Next%20Strategy%202023.pdf

programs to meet these commitments. In partnership with industry collaborators across BC, the proposed program is positioned to strengthen ties with the local and regional communities to "reinforce our role as the university for BC, using our capacity for social and economic change to strengthen the province".[2] With a strong interdisciplinary foundation, this program aims to bring together a diverse set of expertise and, thus, act as a hub for "enlightenment and dialogue on key public issues"**Error! Bookmark not defined.** of which the issue of sustainability is most pressing. SFU's strategic vision also notes the opportunity to "expand experiential education to improve student outcomes and accelerate regional impact and innovation".[2] Indeed, the proposed MEng degree will include a final capstone project where students will apply the multidisciplinary curriculum to solve unique, real-world problems facing an external sponsor from the community, as described later in this document (see question 31).

- **A strong, sustainable economy that works for everyone**: The mandate letter calls for support for economic recovery by helping businesses to build a clean and innovative economy that will carry BC forward. To this end, the university's vision is to *transform student experience* such that we are "preparing students for an uncertain and complex world".[2] Faced with the challenges caused by a changing climate, the field of engineering has had to make significant and rapid changes to many sectors of the economy, from transportation and manufacturing to the built environment and power generation. These changes have led to many opportunities in the clean-tech sector and the requirement for larger firms to rapidly pivot to remain competitive. The proposed MEng in Sustainable Energy Engineering is, therefore, designed to equip students with the knowledge and skills to navigate the interplay of policy, economic, and engineering domains that are required for technology leaders in the present environment. Graduates from traditional undergraduate engineering backgrounds will find a curriculum that enhances and broadens their technical knowledge in a way that provides them an edge as employers seek sustainable-savvy recruits. Finally, it is worth noting the underlying principles of the SFU vision include a strong commitment to sustainability. The proposed MEng in Sustainable Energy Engineering will help SFU deliver on their commitment to "pursue ecological, social and economic sustainability through its programs and operations".**Error! Bookmark not defined.**

9) How does the proposed program support the current academic and strategic plan of the institution?

The proposed course-based master's degree will build on the Faculty of Applied Sciences' (FAS) commitment to "shaping tomorrow's technology leaders through unique learning experiences that foster a spirit of innovation and entrepreneurship, professional

growth and leadership".[3] In close alignment to this, the SEE mission statement promises to "inspire and foster transformative innovations in energy systems that benefit society and the natural environment through outstanding interdisciplinary education, research, collaboration, and engagement amongst a diverse and equitable community".[4] Through partnerships with industry (e.g., Ballard, Corix, Fortis BC, and BC Hydro) and pan-university collaborations (e.g., Political Science, Resource and Environmental Management, and Beedie School of Business) to create a progressive curriculum, this program is positioned to help advance the academic goals at the faculty and school level. For example, the proposed MEng will deliver a bespoke, two-part 'Invention to Innovation (i2I)' course co-developed with the Beedie School of Business that will address the strong emphasis on innovation and entrepreneurship in engineering. This is especially important with the backdrop of the thriving clean-tech sector within BC that is looking for graduates with a keen sense of innovative business acumen. The program also aligns with the province's commitment to provide increased funding to industry-focused programs that support high demand occupations in the BC technology sector.

The proposed MEng in Sustainable Energy Engineering will also address the school and faculty goals to create programs that foster leadership, interdisciplinary education, and collaboration. The curriculum will consist of core courses in energy engineering, business, and policy (in collaboration with the Department of Political Science) as well as elective options from the School of Resource & Environmental Management (REM) and the Department of Chemistry. Thus, the proposed degree will be truly pan-university and interdisciplinary in nature such that graduates will leave SFU with a broad appreciation of the many facets of sustainability and energy engineering in a rapidly changing landscape. The interdisciplinary approach will provide graduates with a unique set of skills and breadth of knowledge that accelerate them into positions of leadership within the sector. Finally, the students will undertake a substantive master's level project in the latter part of their degree. This capstone project will be completed in collaboration with, and address problems faced by, industry partners from the local community with the intention to provide real-world challenges to the students and enhance collaboration with local businesses.

10) Target Audience

The primary target audience for this program is recent graduates from other engineering disciplines or related natural-sciences fields who want to develop a broad-based

[3] SFU FAS – About the Faculty: https://www.sfu.ca/fas/about-faculty.html

[4] SFU SEE – Mission Statement: https://www.sfu.ca/see/about/mission-statement.html

understanding of, and gain qualifications in, sustainable energy engineering. Both domestic and international students are expected to be interested. The program is also expected to appeal to early-career engineering graduates who are looking to focus their career on sustainable energy engineering. The MEng will therefore focus on newer graduates which is distinct from a professional master's program that focuses instead on skills upgrading for mid-career professionals and existing industry leaders.

A survey of the potential target audience within SFU was conducted in fall 2021 to assess potential interest in the MEng program as well as to provide guidance on what students perceived to be the strongest areas of interest. The survey, including the invitation, the questions posed, and the aggregated results are provided in Appendix 9. The survey was distributed to undergraduate students in the Faculty of Applied Sciences (Schools of Engineering Science - ENSC, Mechatronic Systems Engineering - MSE, and Sustainable Energy Engineering - SEE) as well as in the Departments of Chemistry and Physics in the Faculty of Science and the Resource and Environmental Management (REM) program in the Faculty of Environment. A total of 87 responses were received, primarily from students within the Faculty of Applied Sciences (ENSC, n = 23; MSE, n = 13; SEE, n = 23). Some interest was also expressed from REM (n = 8) and the Faculty of Science (n = 3) with a further 17 respondents not indicating a specific program. Overall, the results showed a strong appetite for the program, with >90% of respondents reported moderate, high, or very high levels of interest.

Along with gauging overall interest in the program, subject matter, program structure, and delivery methods were also assessed in the survey. The details of the specific questions are shown in Appendix 9. In summary, the respondents indicated:

- a strong interest across a wide range of sustainability areas, with clean energy, low-carbon transportation, and climate change resilience showing the highest interest levels;
- a preference for post-graduation employment in the private sector, with a focus on renewable energy, smart grids, energy storage, clean transportation, and green building design;
- a broad level of interest in non-technical skills and especially project management, creative thinking, communication, and teamworking skills;
- a strong desire for interaction with industry and hands-on/applied skills development in a laboratory or research setting; and
- a desire for a maximum program duration of 18 months or less (although a significant minority would consider a 2-year program duration).

Overall, the survey showed a promising level of interest in the program from students, most of whom are likely to have graduated before the program is initiated. The results were invaluable to the academic team developing the MEng in Sustainable Energy Engineering program to ensure that the program learning outcomes and structure emphasize the topics that were identified in the survey. The team recognizes, of course, that the survey sample was not representative of the anticipated student cohort, as many of the MEng students are expected to be recruited from other Canadian or international institutions.

11) Related programs in the institution or other British Columbia post-secondary institutions and outside of British Columbia

The proposed MEng in Sustainable Energy Engineering program is unique compared to other programs offered in BC and across Canada. Many institutions across BC and Canada have added a sustainability aspect to their existing master's programs. While this takes various forms, Delphi Group, a consulting firm hired to help with this proposal, did not identify any programs that offer the unique combination of attributes proposed for the SFU MEng in Sustainable Energy Engineering. These attributes include:

- bespoke programming with most units being dedicated courses that will be taken by all MEng students;
- incorporation of multi-disciplinary engineering fundamentals encompassing the key aspects of electrical, mechanical, and materials engineering as they relate to sustainable energy engineering;
- integration of business, policy, and resource management to provide all students with a unique interdisciplinary view of the multiple facets and challenges of sustainability; and
- a specifically designed capstone project, with topics selected through engagement with external partners that specifically reinforce the interdisciplinary focus of the MEng program.

The Delphi Group study provided in Appendix 8 includes a review of comparable academic programs. Comparable graduate-level degree programs with a focus on training early-career engineers in the fields of clean or sustainable energy can be divided into three main categories:

- Thesis-based degrees (e.g. SFU SEE MASc; the University of Victoria’s Institute for Integrated Energy Systems)
- Course-based MEng programs focusing on a specific discipline or technology (e.g. BCIT MEng in Smart Grid Systems and Technology); and

- Course-based MEng programs that are generally in a specific discipline but include a subset of interdisciplinary courses (e.g., Queen's University's Collaborative MEng in Applied Sustainability; the University of Toronto's MEng in Sustainable Energy).

None of the identified degrees are equivalent to the proposed SFU MEng in Sustainable Energy Engineering.

The thesis-based degrees such as SFU's MASc are focused on providing students with a deep technical specialization in a specific topic area. They typically include a major thesis, are two-years in duration, and require a relatively small number of courses that are selected to support the student's in-depth academic research activities. Options are provided to include external or interdisciplinary courses, but these are not a required part of the curriculum. They target a different set of graduate students, specifically those who want to develop into scientific research leaders or have interest in pursuing further academic study.

Course-based MEng degrees are common in many universities across Canada, providing a one-year advanced technical degree for students. This allows students to delve deeper into a specific field of interest or to redirect their career into a field separate from their undergraduate program. Some of these programs do include a focus or an option to investigate sustainable energy technologies across multiple courses. An example is BCIT's MEng in Smart Grid Systems and Technology. This program is focused on strengthening students' knowledge of the technology around this specific topic.

Other MEng programs offering a specialization or focus area in sustainable energy include: Queen's Collaborative MEng in Applied Sustainability; The University of Waterloo's MEng with a specialization in Green Energy; and the University of Toronto's MEng with an emphasis in Sustainable Energy. While the details of these programs differ, they all share a common approach. Students are registered in a specific specialization where a small subset of the courses are mandatory and focused on sustainable energy policy or related interdisciplinary considerations. The students then select the majority of their courses from a broad range of graduate electives within their home or closely related departments. Thus, these degrees provide a student with some flexibility but always within the bounds of the engineering discipline where they are studying. Students will generally graduate with an MEng from their home program with a degree notation of an "emphasis" or "specialization" in sustainable energy (e.g., University of Toronto's MEng in Mechanical and Industrial Engineering with an emphasis in Sustainable Energy).

In contrast, Carleton University offers an MEng in Sustainable Energy. This program retains a conventional engineering focus, with between 60-70% of the coursework being from either mechanical or electrical engineering electives. The Carleton program offers a close connection to sustainable energy policy as it sits immediately alongside a Master of Arts degree in Sustainable Energy aimed at policy students. This differs significantly from the dedicated and prescribed course offerings that are a feature of the proposed SFU MEng in Sustainable Energy Engineering, which will include an interdisciplinarity between engineering specializations (mechanical, electrical, and materials engineering) along with policy and environmental resource management.

Within BC, the University of British Columbia's Masters of Engineering Leadership (MEL) in Clean Energy has some similar features to the proposed SFU MEng. A key distinction is that UBC's MEL is a professional degree designed for mid-career professionals with at least three years of work experience. A strong focus is on leadership, as evidenced by one third of the courses having a leadership focus and taught by the UBC Sauder School of Business. This program targets a different set of students than the proposed SFU MEng in Sustainable Energy Engineering and focuses more on energy leadership than on providing an interdisciplinary understanding of sustainable energy. As such, there is not expected to be significant overlap or competition between the SFU MEng and the UBC MEL.

Table 1: Summary of Comparable Engineering Degrees across Canada

			MASc	MEng			
University	**Degree**	**Professional degree**	**Research intensive**	**Traditional engineering degree with sustainability option(s)**	**Focus on specific discipline or technology**	**Sustainability with conventional engineering foci**	**Sustainability curriculum with broad interdisciplinarity**
University of British Columbia	Master in Engineering Leadership						
Simon Fraser University	MASc in Sustainable Energy						
University of Victoria	MASc in Integrated Energy Systems						
University of Toronto	Meng in Aerospace, Chemical, Civil, Mechanical, etc						
University of Waterloo	MEng in Mechanical and Mechatronics						
Queens University	MEng in Applied Sustainability						
British Columbia Institute of Technology	MEng in Smart Grid Systems						
Carleton University	MASc/MEng in Sustainabile Energy Engineering						
Simon Fraser University	**MEng in Sustainable Energy Engineering**						

12) What differentiates the proposed program from all other related programs in the province?

As alluded to in the previous section, there are several differentiating factors that mean that the proposed MEng in Sustainable Energy Engineering program will be the first of its kind in Western Canada. The key differentiating features are first, a focus on *recent graduates* from a range of disciplines, second, a curriculum centred around sustainable energy with embedded interdisciplinarity and third, program requirements based on course work and a team-based, industry-facing project.

Considering each of these differentiating features in turn, the first relates to the difference between a *professional* master's and a more standard graduate degree that is being proposed here. The Master's of Engineering Leadership at UBC is an example of a

professional master's program that aims to attract mid-career professionals seeking to pivot their career into the clean-tech field. By contrast, the proposed MEng in Sustainable Energy Engineering will appeal to new or recent graduates from more traditional applied science and engineering fields that are looking to accelerate their entry into the sustainable energy space. Indeed, as the research from Delphi Group demonstrates (Appendix 8), many employers report a broad trend of job seekers looking for a career in climate action in order to make a positive impact.

The second differentiating feature of the proposed MEng in Sustainable Energy Engineering is the emphasis on sustainable energy with an interdisciplinary lens. This builds on the strengths of SFU as Canada's leading comprehensive university with the Beedie School of Business, the School of Public Policy, the Department of Political Science, and the School of Resource and Environmental Management all contributing to this comprehensive and interdisciplinary degree. This creates an opportunity for a student experience that is truly unique across Western Canada and provides the students with a breadth of knowledge that can prepare them for a wide variety of employment opportunities. No other graduate degree in the province has sought to structure a sustainable energy degree in this way.

The final important distinction between the proposed MEng in Sustainable Energy Engineering and many other master's degrees is that this will be a course-focused program instead of thesis-based. That is, it will consist of 27 units of course work and a 6-unit capstone team project. This is in contrast with our current MASc in Sustainable Energy Engineering which requires only 12 units of course work to compliment the 18-unit thesis. Looking outside of SFU, the University of Victoria offers conventional engineering degrees as both MEng and MASc degrees organized around the Institute for Integrated Energy Systems (an interdisciplinary research centre at UVIC), however, the focus is on in-depth academic study of a single primary topic leading to a thesis. Thus, the proposed MEng in Sustainable Energy Engineering program that emphasizes interdisciplinary courses and project-based study is distinctly different in character and student experience. Instead of individual and narrowly focused study leading to a thesis, the MEng in Sustainable Energy Engineering will have a collaborative team-based capstone project where, along with the application of technical knowledge to a solve a specific problem, soft skills such as teamwork, collaboration, and communication will be reinforced.

13) An overview of the level of support and recognition from other post-secondary institutions, and relevant regulatory or professional bodies

In addition to the broad survey of 52 relevant private- and public-sector organizations, 10 industry leaders have contributed to the analysis through detailed interviews (Appendix 8). This analysis has identified the top five areas with the highest potential for job market growth: electric vehicles and infrastructure; alternative fuels; renewable energy generation; energy efficient technologies and systems; and hydrogen vehicles and infrastructure. These sustainable energy themes have been incorporated into the curriculum design and are reflected in the learning outcomes for the proposed MEng in Sustainable Energy Engineering.

The supply-side analysis has reviewed six comparable Master's level academic programs in British Columbia and Alberta and another 25 programs across the world. The analytical report indicates that: "SFU's proposed MEng program will thus be first of its kind in western Canada, having specific application to clean energy industries and sustainability with an interdisciplinary approach. It will be uniquely suited to attract fresh undergraduate students and provide them with an interdisciplinary hands-on education to succeed in the workforce".[5] The program design will accommodate students from British Columbia, Canada, and around the world.

FAS and SEE leadership have discussed the proposed program with peers at various institutions across British Columbia. The proposed program was found to be strongly complementary to existing programs at the UBC and UVic. The Dean's of the Faculty of Applied Science at UBC and the Faculty of Engineering at UVic have both provided letters of support for the proposed MEng in Sustainable Energy Engineering (Appendix 3).

The proposed MEng program also strongly aligns with the Engineers and Geoscientists BC's (EGBC) strategic objectives.[6] Accordingly, program graduates will receive credit towards their employment experience requirements for their Professional Engineer (P.Eng.) certification. Support from EGBC is also indicated in a letter of support in Appendix 3.

[5] Delphi Group: Master's Program Research, Phase 2 Report, pg. 35 (Appendix 8)

[6] Engineers & Geoscientists, British Columbia – Strategic Plan: https://www.egbc.ca/About/Governance/Strategic-Plan

14) What added value will the proposed program offer graduates in terms of employment opportunities?

Graduates from the program are expected to have strong employment opportunities in business, consulting, and governmental settings as well as the potential to work with international development organizations and non-governmental organizations. Prior to initiating program development, the Delphi Group conducted a survey of 53 potential employers, to gain insight on demand for graduates and on desired skills and knowledge for the students (Appendix 8). The results from the survey highlighted employment opportunities within governments, non-governmental organizations, and private sector entities. The sectors where the students are most likely to find employment are clean and renewable energy; clean transportation and infrastructure; zero emission buildings; and sustainability policy.

The broad knowledgebase that the students will develop during the MEng program will prepare them for a wide variety of roles within these organizations. Recent graduates are expected to fill roles such as: renewable and sustainable energy consultants; energy policy analysts; remote/Indigenous community advisors; regulatory and government affairs liaisons; policy impact and risk assessors; and climate change risk management.

The potential employer survey conducted by Delphi indicated several common themes for desirable graduate attributes across the different sectors. From a technical side, interdisciplinary understanding needs to be combined with solid sector-specific knowledge. Examples included design and manufacturing; thermo-chemical engineering (fluid mechanics, thermodynamics, chemical processes); instrumentation and controls; and software and computer engineering. Technical skills gaps were identified around lifecycle analysis (LCA), energy systems understanding, and carbon accounting (for more detail, see Appendix 8). A particular gap in non-technical skills was focused on communication, especially for cross-discipline collaboration. These are all focus areas of the proposed MEng program, with LCA, energy systems analysis, and communication skills being central to the core courses of the program. By combining these core ‘breadth’ courses with graduate-level technical electives to provide depth and a focused project to provide real-world experience, the proposed program will directly address the identified gaps in currently graduate skills. This will make graduates from SFU’s proposed MEng in Sustainable Energy Engineering inherently more attractive to employers, providing employment opportunities while also adding value to the hiring organizations.

15) Do potential employers require a degree for graduates to gain employment in the field?

Degree requirements vary across the broad fields of employment anticipated for graduates from the MEng degree program. A consistent expectation across all anticipated roles is an ability to integrate diverse knowledge bases and to develop leadership and decision-making based on a strong technical foundation. These requirements were highlighted in the Delphi Group survey of potential employers (Appendix 8). The MEng program is designed and uniquely positioned to be able to meet these requirements, through a combination of courses that offer both technical depth and breadth, along with collaborative projects and leadership training opportunities. In high-tech sectors, such as BC's clean-tech economy, the addition of a graduate degree is needed for most advanced technical roles and interdisciplinary training at an advanced level is expected in leadership roles. This was reinforced by respondents to the survey noted above, suggesting that MEng graduates would add value to the industry and fill a current gap in the market.

Many of the employment activities that MEng graduates are expected to undertake will include the practice of engineering. In Canada, the right to independently practice as an engineer requires licensure as a Professional Engineer in the local jurisdiction (in British Columbia, this would be through Engineers and Geoscientists British Columbia – EGBC). Licensure requirements include an accredited undergraduate degree plus demonstrated professional experience. The MEng program will not meet the academic requirements for accreditation, and hence does not provide a direct path to licensure. However, as previously noted, the program graduates may receive credit towards their employment experience requirements for their Professional Engineer (P.Eng.) certification. Support from EGBC is also indicated in a letter of support in Appendix 3.

16) Potential areas/sectors of employment for graduates and/or opportunities for further study in the field

Graduates from the proposed program are expected to have strong employment opportunities in business, consulting, and governmental settings as well as the potential to work with international development organizations and non-governmental organizations. The sectors where the students are most likely to find employment are clean and renewable energy; clean transportation and infrastructure; zero emission buildings; and sustainability policy.

A survey of potential employers was conducted by the Delphi Group to understand the roles that potential MEng in Sustainable Energy Engineering graduates could fill (Appendix 8). The sectors covered in the survey included clean energy, clean

transportation, green buildings, sustainable resources, and climate policy. It covered private companies and government entities from small employers (<25 full-time equivalent employees (FTEs)) to large organizations (>500 FTEs). This study identified that a wide range of companies, from small companies to large organizations, expect to be hiring engineers in related fields. Of the responding organizations, 83% expected to hire at least one new engineer in the field in the next 3-5 years; nearly 40% of respondents expected to hire more than five engineers within this time-scale. The report from the Delphi Group (Appendix 8) is supported by letters from various sizes of organizations (Appendix 3) – including utilities (Corix), start-ups (Tap&Go EV, Carbon engineering) and local governments (City of Surrey, Township of Langley).

Depending on experience, course selection, and project activities, MEng students could consider a further academic degree (i.e., PhD). As a breadth-based program, graduates from the MEng program will be well suited for further study in environmental policy or multi-disciplinary studies. In general, SEE's existing MASc program is the typical route for students looking to pursue doctoral-level studies in an engineering technical specialization since the MASc thesis provides rigorous academic training and technical depth to underpin a successful PhD program. However, the MEng would meet the minimum requirement for admission to a PhD program within SEE and the breadth of the MEng could offer a useful background for a PhD in a breadth-based sub-discipline.

17) Does the proposal lead to a specific occupation?

The broad knowledgebase that the students will develop during the MEng program will prepare them for a wide variety of roles within organizations in the clean-tech space as well as in governmental policy and consulting roles. Recent graduates are expected to perform roles including renewable and sustainable energy consultants; energy policy analysts; remote/Indigenous community advisors; regulatory and government affairs liaisons; policy impact and risk assessors; and climate change risk management.

One of the key features of the proposed MEng degree program is that it is not targeting a specific role or occupation. Due to the breadth of the core courses and the availability of technical specialist courses offered in SEE and other graduate programs, students will be able to design their program to best position them for their desired future occupation. Future policy analysts, government or industrial leaders, advisors, and engineering consultants will all benefit from the program and will be able to structure their studies so that they have the underpinning information that they need on their career trajectory. For students who do not have a specific occupation in mind, the MEng in Sustainable Energy Engineering program will allow them to investigate different alternatives and find the

career direction where they can make the strongest contribution and that aligns with their interests.

18) What labour market needs would the proposed program meet for the province?

The graduates from the MEng in Sustainable Energy Engineering program are expected to fill specific roles in clean technology and green economy with a focus on achieving the ambitious national commitment to net-zero greenhouse gas emissions by 2050. The need for leaders with technical understanding has been identified in the Delphi employer survey (Appendix 8) and is recognized at the municipal, provincial, and national levels as being a key basis for future growth and development. Relevant examples include the provincial Clean BC program[7], the Canadian National Hydrogen Strategy,[8] and the Clean Technology report from Canada's Economic Strategy Tables.[9]

In terms of relevant NOCs, the most applicable are a combination of Mechanical (2132), Electrical (2133), Chemical (2134), Civil (2131), and "other" engineers (2146), along with Engineering managers (0211) and Natural and Applied Science Policy Researchers (4161). According to Human Resources and Development Canada's (HRDC) Canadian Occupational Projection Database[10] (2022-2031 future labour conditions) all of these sectors are projected to be in 'shortage' or 'balanced' in terms of employment opportunities (see Table 2). Thus, the MEng in Sustainable Energy Engineering will offer an opportunity for graduates with a degree in one of these fields to receive extra training needed to develop their career in a growth-oriented direction.

[7] Clean BC – Roadmap to 2030 (2021): https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/cleanbc/cleanbc_roadmap_2030.pdf

[8] NRCan – Hydrogen Strategy for Canada (Dec. 2020): https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/environment/hydrogen/NRCan_Hydrogen-Strategy-Canada-na-en-v3.pdf

[9] Innovation, Science, and Economic Development Canada – Report of Canada's Economic Strategy Tables: Clean Technology (Dec. 2018): https://www.ic.gc.ca/eic/site/098.nsf/eng/00023.html#fn1

[10] Canadian Occupational Projection System (accessed March 2023): https://occupations.esdc.gc.ca/sppc-cops/content.jsp?cid=occupationdatasearch&lang=en;

Table 2: HRDC Occupational Projection Database for relevant NOCs

Occupation (Code)	**Future Labour Market Conditions (2022-2031)**
Mechanical Engineers (2132)	Balanced
Electrical Engineers (2133)	Shortage
Chemical Engineers (2134)	Shortage
Civil Engineers (2131)	Shortage
Aerospace & Other engineers (2146)	Balanced
Engineering managers (0211)	Shortage
Applied Science Policy researchers (4161)	Balanced

Based on the results from the HRDC occupational projections and the commitment at the provincial government level to move towards a green, low-carbon future, there is an obvious need for experts in engineering and other technical-related fields with a strong understanding of the interplay between social and environmental sustainability, technology advancement, and economic growth. The proposed broad-based MEng in Sustainable Energy Engineering program is ideally suited to fill these gaps.

A recent report issued by RBC Economics, "Green Collar Jobs"[11] highlights that in the next 10 years, the transition to net-zero greenhouse gas emissions will have a dramatic impact on the skills required by many jobs. For example, approximately 31,000 existing natural and applied sciences jobs will require enhanced skills focused on green technologies along with an increased demand of more than 4,000 jobs. Skills enhancement to support green technologies will also be needed in business, management, and education. In all these roles, the proposed MEng in Sustainable Energy Engineering would be a key differentiator, providing skills enhancement opportunities to both the existing workforce and to recent graduates looking for improved employment opportunities.

Neither the HRDC data nor the RBC Economics report provide a detailed breakdown of opportunities within the clean-tech sector. The Delphi Report (Appendix 8) provides a higher granularity of demand within the sector. The report specifically recognized four distinct areas with the highest demand for job growth:

[11] Gulidmann and Powell. Green Collar Jobs: The skills revolution Canada needs to reach Net Zero. RBC Economics. February 2022 (accessed March 2022): https://thoughtleadership.rbc.com/green-collar-jobs-the-skills-revolution-canada-needs-to-reach-net-zero/.

1. Zero emission vehicles and supporting technology (e.g., EVs, fuel cells, battery chemistry)
2. Infrastructure for alternative energy/fuel supply (e.g., renewable natural gas, hydrogen supply and fuelling stations, EV charging infrastructure)
3. Renewable energy generation
4. Energy efficient and low-carbon technologies for the built environment

These are all areas of focus for the MEng in Sustainable Energy Engineering program, providing further evidence that the proposed program will meet employer needs.

19) Plans for admissions and transfer within the British Columbia post-secondary education system

Admissions requirements for the program will be articulated such that prior studies at other BC post-secondary institutions (e.g., bachelor's degrees in related areas of engineering and sciences) will be readily recognized during the application processes. The program will also allow transfer of credits from other, similar graduate-level engineering programs with comparable and compatible courses per SFU Graduate General Regulations.

It is anticipated that the MEng graduates, should they choose, would be able to move on to other graduate programs within BC, depending on admission requirements. Depending on individual circumstances, the MEng in Sustainable Energy Engineering graduate degree may be considered towards their employment experience requirements for registration by provincial certifying authorities, such as EGBC.

20) Enrolment plan

Students will be admitted once per year, with fall being the first term of the program. The steady-state number of students in each cohort will be 20, giving a maximum of 40 students in the program at any given time. The following sequencing of student admissions is anticipated:

- Year 1: 5-8 students
- Year 2: 10-15 students
- Year 3 and beyond: 20 students

21) Delivery methods

The program will be delivered through in-person interactions in which the students will engage as a cohort. The structure of the learning activities will vary between courses and will include lectures, small-group projects, and in-course experiential learning activities.

There will be no required practicum or co-op component to the program. The program will be delivered in a semester model where core courses will be offered once per year. The program will include a team-based capstone project that will be completed over two semesters.

22) Eligibility for scholarships, awards, and financial aid

Students will be able to apply for awards funded from the university's operating budget including scholarships, awards, and bursaries. Normally, students in this program will be eligible for financial aid so that they may qualify for a loan if necessary.

23) Does the proposed program offer an alternative exit, if appropriate?

Not applicable.

24) Resources required and/or available to implement the program

The proposed MEng in Sustainable Energy Engineering program falls within the overarching plan for the School of Sustainable Energy Engineering's graduate offerings. The School was established in 2019 with a trajectory to establish a learning and research infrastructure that will ultimately support approximately 120 graduate students (and 320 undergraduate students) at a steady state. This includes a hiring plan that will reach a steady state of approximately 20 faculty members and the equivalent of 16 FTE staff (8 administrative, and 8 technical).

The steady-state graduate student population is intended to include students registered in the SEE MASc and PhD programs (already launched) and the proposed MEng in Sustainable Energy Engineering program (which will complete the main, regular, graduate programs for the School). As such, the School's resource plan (including faculty, staff, and teaching and laboratory spaces) anticipates the launch of this program and will be sufficient to support it. The program will not result in the elimination of any other programs in the unit, nor will it have a negative impact on teaching loads. Similarly, the library resources established to support the overall SEE graduate program are expected to suffice and any new courses developed specifically for the program will be assessed for library resource needs through the established process.

25) Program evaluation and academic/administrative oversight

As mandated by Senate, the program will be externally reviewed at seven-year intervals. In addition, oversight will be provided by the SEE Graduate Program Committee. Further, regular input and guidance will be sought from the external SEE Advisory Board (this standing committee comprises representatives from industry, government, and

academia, with specific domain expertise in sustainable energy, and has been involved in shaping the program's design). Details are included in Appendix 5.

26) Faculty member's teaching/supervision

As noted above, the proposed MEng in Sustainable Energy Engineering program is encompassed by the overarching plan for the School's deployment. Resource and faculty hiring plans for the School anticipate the program's development and, as such, the involvement of faculty members in teaching courses associated with the MEng program will not have detrimental effects on other programs. In some cases, courses included in the MEng program will be taken by students in thesis-based programs (MASc, PhD) as well. In other cases, where a course is singularly designed and offered for the MEng program, the corresponding workload is expected to be approximately 15% of a given faculty member's bandwidth.

All faculty members in the School have backgrounds and areas of specialty that are suitable for involvement in delivery of the MEng in Sustainable Energy Engineering program (see Appendix 6 for Faculty CV's). This includes:

- Dr. Zafar Adeel (Water Security and Energy Systems)
- Dr. Mehran Ahmadi (Zero Emissions Buildings)
- Dr. Colin Copeland (Thermo-fluids for Energy Systems)
- Dr. Vahid Hosseini (Clean Transportation)
- Dr. Mahda Jahromi (Renewable Energy Technologies in Power Systems)
- Dr. Manpreet Kaur (Advanced Materials for Energy Systems)
- Dr. Sami Khan (Advanced Materials for Energy Systems)
- Dr. Gordon McTaggart-Cowan (Alternative Fuels and Clean Transportation)
- Dr. Molly McVey (Advanced Materials for Energy Systems)
- Vivian Neal (Communications and Sustainable Engineering Practice)
- Dr. Taco Niet (Energy Systems Modeling and Simulation)
- Dr. Kevin Oldknow (Clean Transportation)
- Dr. Vincenzo Pecunia (Sustainable Optoelectronics)
- Dr. Mariana Resener (Distributed Energy Resources and Power Systems Optimization)
- Dr. Amir Shabani (Zero Emissions Buildings)
- Dr. Mina Xu (Materials Innovation for Energy Systems)

27) Is the program focus primarily on meeting social benefit(s) or economic benefit(s)?

The program primarily focuses on the economic benefits to the sustainable energy domain and related fields in both public and private sectors. These economic benefits include the introduction of technological innovation that will boost the sustainable energy and clean-tech sectors in BC. This is expected to lead to the creation of more green jobs that can support both start-ups and larger firms that are looking to capitalize on the sustainable energy revolution within Canada and globally. The program will also arm graduates with a strong awareness of the how policy and regulation influence different engineering sectors and thus be able to help companies navigate these policy aspects in order to thrive in the green economy. The program also brings significant social benefits through increased public awareness regarding sustainable energy solutions that can reduce carbon footprint, minimize greenhouse gas emissions, and enhance resilience against climate change impacts. MEng graduates will be equipped with public-speaking and interface skills to successfully achieve these social benefits.

28) How would the proposed program advance social goods or government priorities?

The following priorities, as defined by the key stakeholders – public sector organizations, non-governmental organizations, industrial enterprises, and civil society groups – will be addressed:

- Environmental priorities: The program aligns strongly with the BC government's CleanBC targets[12] to reduce greenhouse gas emissions by providing highly qualified personnel to support such initiatives.
- Social priorities: The program will serve a number of social and economic priorities[13] by facilitating employment creation, notably in the clean-tech sector; raising awareness and fostering responsive citizenry around climate change (e.g., declaration of climate emergency by the City of Vancouver and the City of Surrey).
- Community priorities: The program's curriculum will include a focus on equity, diversity, and inclusion, which is aimed to contribute to enhancing resilience of vulnerable communities and engaging communities in the development of

[12] Clean BC: https://cleanbc.gov.bc.ca/

[13] BC Budget 2023: https://www.bcbudget.gov.bc.ca/2023/default.htm;
Stronger BC Economic Plan: https://strongerbc.gov.bc.ca/economic-plan/

community-level, collaborative engineering solutions. This approach is supportive of the BC Indigenous Clean Energy Initiative.[14]

- Intellectual benefits: The program will directly support exploration of new frontiers of engineering and technologies while motivating effective social engagement. This approach will contribute to the creation of innovative intellectual property.

29) What social, cultural, regional, community, environmental, institutional and/or intellectual benefit would the proposed program provide?

The range of benefits achieved through the program can be characterized as follows:

- Social and community benefits: The capstone project will be aimed to foster greater public awareness about sustainable energy challenges and innovative solutions. This benefit will be achieved through the engagement of communities in development of innovative solutions.
- Regional benefits: The MEng in Sustainable Energy Engineering program will contribute to and facilitate further growth of the lower mainland as a hub of green and innovative technology companies – attracting investments into new business ventures and the creation of more green jobs.
- Environmental benefits: The program will support CleanBC[15] and other Canadian initiatives to reduce carbon footprint and greenhouse gas emissions, helping BC and Canada meet international emissions reductions targets. Development of innovative engineering solutions through the capstone project that provide secure and sustainable water, energy, and food will further move the needle on climate action.
- Institutional benefits: Well-trained graduates of the MEng in Sustainable Energy Engineering program will contribute to planning and infrastructure development processes through professional organizations (such as EGBC) and strategic programs addressing climate change and energy sustainability.

30) How would the proposed program support economic growth and/or government economic priorities?

Addressing climate change is a critical priority for regional, provincial, and federal

[14] BC Government News – More First Nations communities to advance clean-energy projects in BC: https://news.gov.bc.ca/releases/2021EMLI0078-002407

[15] Clean BC: https://cleanbc.gov.bc.ca/

governments. Clean energy is a key economic priority for the provincial government, as demonstrated by the CleanBC program, the roadmap to 2030,[16] and net zero by 2050 pledges.[17] These are all based on the belief that the province is uniquely positioned to advance clean energy solutions that are applicable both locally and globally. As such, a dedicated MEng in Sustainable Energy Engineering is directly focused on the economic priorities demonstrated by these provincial government commitments.

The program is expected to support economic growth in BC through a range of mechanisms. A local supply of highly qualified graduates will contribute to the success of small and large private-sector organizations working in the clean-tech sector. Encouraging the growth of this sector is a clear priority for the provincial government. The business and entrepreneurial components of the multi-disciplinary MEng in Sustainable Energy Engineering program will encourage the development of new businesses that will contribute to economic growth and the pursuit of new opportunities. The local connections and engagement provided by the MEng program will encourage these businesses to remain within BC and contribute to local economic growth. Finally, program graduates will be uniquely equipped to support governmental and non-governmental organization activities in developing and advancing evidence-based public policy.

31) What direct and/or indirect economic, industrial or labour market benefits would the program offer the student, community, region or province?

The program will offer direct economic benefits to the community, region, and province by producing a steady supply of approximately 20 new graduates per year with the advanced knowledge and skills to immediately contribute to a low-greenhouse gas energy transition through industry, non-governmental organizations, and at all layers of government. The labour gaps identified in the Delphi Group survey (Appendix 8) and the attached letters of support from a diverse range of potential employers (Appendix 3), suggest that there is an urgent need for graduates with the skill sets provided by the proposed MEng program. This stream of additional students will contribute to British Columbia's talent pool and will help to maintain and advance the province's position as a leader in clean-tech. This may come in the form of direct industrial contributions, or indirect contributions through non-governmental organizations and government agencies

[16] Clean BC – Roadmap to 2030: https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/cleanbc/cleanbc_roadmap_2030.pdf
[17] Clean BC: https://cleanbc.gov.bc.ca/

where policy can be advanced to support economic growth.

The program will provide direct economic and societal benefits through the capstone project that all students will complete over an eight-month period at the end of their program. The project will involve a group of three or four students working directly with an external partner on a multi-disciplinary problem. Project sponsors will be drawn from local industry and regional government and not-for-profit sectors. Projects will be selected in part based on their potential to provide societal and economic benefits for the sponsor and for the wider community. Particular focus will be on supporting smaller organizations that would not have the resources to undertake the work independently. While the focus will be on partners within the region, projects are expected to be undertaken with organizations across the province. In the event industrial partners are not available, accommodations will be made to ensure students can complete the project with the help of an internal academic stakeholder within the faculty.

Overall, the proposed MEng in Sustainable Energy Engineering program will drive indirect growth in the clean-tech sector in BC. Attracting skilled and motivated students and engaging them with local partners increases the probability that they will choose to stay within the region or province once they graduate. This is critical as competition for graduates with the skill set provided by the MEng program is global, and a local supply of talent is critical to underpinning BC's continued growth as a world leader in the development and application of economically, environmentally, and socially sustainable energy.

SFU SIMON FRASER UNIVERSITY
ENGAGING THE WORLD

Master of Engineering (MEng)

Full Program Proposal

Appendices

November 2022

School of Sustainable Energy Engineering

Faculty of Applied Science

Table of Contents

Appendix 1: Calendar entry

Description of Program

The Master of Engineering (MEng) in Sustainable Energy Engineering (SEE), offered through the Faculty of Applied Sciences, is a course-based, interdisciplinary program. The primary emphasis of the program is to couple fundamental engineering knowledge with critical policy, business, and environmental considerations relating to the sustainable provision, conversion, and use of energy. Through formal coursework and an integrated team-based project, MEng in Sustainable Energy Engineering graduates will be equipped to assess, interpret, and communicate the complex trade-offs involved in the development, deployment, and use of clean energy technologies that address current energy needs without compromising the needs of future generations. Candidates will develop a strong interdisciplinary understanding of sustainable energy engineering and the intersecting and conflicting demands of policy, business, and environmental sustainability. Graduates will have demonstrated mastery of applying engineering tools to sustainable energy problems; analyzing energy engineering applications from diverse viewpoints; designing creative and inclusive solutions to energy engineering problems; and communicating risks, benefits, and trade-offs of alternative solutions to stakeholders.

Admission Requirements

Admission to the MEng program is competitive. Applicants must satisfy university admission requirements as stated in Graduate General Regulation 1.3 in the SFU Calendar, and have the following:

- An undergraduate (bachelor's) degree in a relevant field of engineering; *or*
- A degree in a closely related field in the natural sciences *and* demonstrated substantive experience in the application of sustainable energy or environmental engineering principles;

Program Requirements

This program is comprised of a set of mandatory courses (19 units), elective courses (minimum 8 units), and a team-based integrated project (6 units, taken over two consecutive terms). Students who lack the necessary background knowledge may, at the discretion of the program chair, be asked to complete additional courses to ensure an adequate breadth of knowledge to successfully complete the full program requirements.

Students must complete:

SEE 770 (3) Water, Energy and Food Nexus
SEE 771 (4) Sustainable Energy Systems I
SEE 772 (4) Sustainable Energy Systems II
SEE 773 (4) Sustainable Energy Policy

BUS 790 (2) Lab to market
BUS 793 (2) Business models

and one of:

SEE 820 (3) Materials Design for Energy Systems
SEE 821 (3) Membranes and Filtration
SEE 850 (3) Energy Storage Systems
SEE 893 (3) Special Topics I
SEE 894 (3) Special Topics II
SEE 895 (3) Special Topics III

and one of:

REM 650 (5) Energy and Materials Management and Policy
REM 658 (5) Energy and Materials Systems Modelling

and a major two-term integrated project:

SEE 799 (6) Capstone Project

Program Length

Students are expected to complete the program requirements within four terms.

Academic Requirements within the Graduate General Regulations

All graduate students must satisfy the academic requirements that are specified in the graduate general regulations, as well as the specific requirements for the program in which they are enrolled.

Appendix 2: Courses

New courses:

Course	Title	New Course Form	Sample Outline	Library Support
SEE 770	Water, Energy and Food Nexus	X	X	X
SEE 771	Sustainable Energy Systems I	X	X	X
SEE 772	Sustainable Energy Systems II	X	X	X
SEE 773 (co-list with POL 855)	Sustainable Energy Policy	X	X	X
SEE 799 (Summer/Fall)	Capstone project	X	X	X

Existing course outlines provided for context:

Course	Title	New Course Form	Sample Outline	Library Support
BUS 790	Lab to market		X	
BUS 793	Business models		X	
REM 650	Energy Management		X	
REM 658	Energy and Materials System Modelling		X	

The library has reviewed and approved all the new SEE courses, as confirmed via e-mail from SFU Library (Megan Crouch) on 22-04-2022 (see below; the memo is also included in Appendix 4).

seegpc@sfu.ca

From:	Megan Crouch <mcrouch@sfu.ca>
Sent:	June 3, 2022 1:33 PM
To:	SEE Graduate Program Chair
Cc:	SEE Graduate Program Chair; Gordon McTaggart-Cowan; Lorraine Kwan; Holly Hendrigan
Subject:	Library Report (revised) : SEE 770, 771, 772, 773, 799

Dear Gordon,

I've reviewed the proposals for the following courses:

- SEE 770: Water, Energy and Food Nexus
- SEE 771: Sustainable Energy Systems I
- SEE 772: Sustainable Energy Systems II
- SEE 773: Sustainable Energy Policy
- SEE 799: Capstone Project

No additional library resources will be required to support them.

This email will serve as your record that the Library has conducted the assessment of the proposals as they move through the approval process. Once the courses have been approved by Senate, they will appear on this list: http://www.lib.sfu.ca/about/overview/collections/course-assessments/applied-sciences

Do let me know if you have any questions.

Best,
Megan

Megan Crouch (she/her)
Collections Librarian
W.A.C. Bennett Library | Simon Fraser University
Occupied Squamish, Tsleil-Waututh, and Musqueam Territories.

1

SFU GRADUATE AND POSTDOCTORAL STUDIES

New Graduate Course Proposal

Course Subject (eg. PSYC) SEE	Number (eg. 810) 770	Units (eg. 4) 3

Course title (max. 100 characters)

Water, Energy and Food Nexus

Water, Energy, Food Nexus

Course description for SFU Calendar (course descriptions should be brief and should never begin with phrases such as "This course will..." or "The purpose of this course is..." If the grading basis is satisfactory/unsatisfactory include this in the description - max. 50 words)

Rapid population and economic growth in combination with accelerated urbanization and changing lifestyles are driving ever-increasing demands for water, energy, and food. All three sections are closely linked - 30% of global energy consumption is used for food production, which also takes up 70% of water consumption. Integrated policy and engineering solutions that simultaneously address the three nexus sectors are the focus of this course. It explores innovative technologies, engineering challenges, and supportive policy approaches. The overall scope of the course is international with a strong focus on Canadian applications. Students explore real-world problems through identification of innovative technological solutions.

Rationale for introduction of this course

As a core course for the MEng program, it introduces multidisciplinary concepts that cut across three major sectors of the economy - water, food, and energy - to students. Such notions of multidisciplinary have been identified as an important component of the knowledge base necessary for professional success in the sustainable energy engineering domains. It has also been identified by potential employers as a skill needed for graduates of the MEng program.

Term of initial offering (eg. Fall 2019) Fall 2024	Course delivery (eg. 3 hrs/week for 13 weeks) 3hrs/week for 13 weeks
Frequency of offerings/year 1	Estimated enrollment per offering 20

Equivalent courses (courses that replicates the content of this course to such an extent that students should not receive credit for both courses)

Prerequisite and/or Corequisite

Criminal record check required? ☐ Yes if yes is selected, add this as prerequisite

Additional course fees? ☐ Yes ☑ No

Campus where course will be taught ☐ Burnaby ☑ Surrey ☐ Vancouver ☐ Great Northern Way ☐ Off campus

Course Components * ☑ Lecture ☐ Seminar ☐ Lab ☐ Independent ☐ Capstone ☐ _____

Grading Basis ☑ Letter grades ☐ Satisfactory/ Unsatisfactory ☐ In Progress / Complete

Repeat for credit? ☐ Yes ☑ No	Total repeats allowed? _____	Repeat within a term? ☐ Yes ☑ No
Required course? ☑ Yes ☐ No	Final exam required? ☐ Yes ☑ No	Capstone course? ☐ Yes ☑ No

Combined with a undergrad course? ☐ Yes ☑ No If yes, identify which undergraduate course and the additional course requirements for graduate students:

* See important definitions on the curriculum website.

RESOURCES

If additional resources are required to offer this course, provide information on the source(s) of those additional resources.

Faculty member(s) who will normally teach this course
To be assigned from existing SEE compliment.
Additional faculty members, space, and/or specialized equipment required in order to offer this course
none

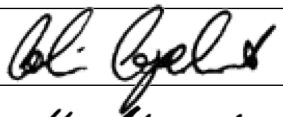
CONTACT PERSON

Academic Unit / Program	Name (typically, Graduate Program Chair)	Email
SEE	Colin Copeland	ccopeland@sfu.ca

ACADEMIC UNIT APPROVAL

A course outline must be included.

Non-departmentalized faculties need not sign

Graduate Program Committee Colin Copeland	Signature 	Date 2023-03-24
Department Chair Mehran Ahmadi	Signature 	Date March 24, 2023

FACULTY APPROVAL

The course form and outline must be sent by FGSC to the chairs of each FGSC (fgsc-list@sfu.ca) to check for an overlap in content

Overlap check done? ☑ YES

This approval indicates that all the necessary course content and overlap concerns have been resolved. The Faculty/Academic Unit commits to providing the necessary resources.

Faculty Graduate Studies Committee Parvaneh Saaedi	Signature 	Date March 28, 2023

A library review will be conducted. If additional funds are necessary, DGS will contact the academic unit prior to SGSC.

SENATE GRADUATE STUDIES COMMITTEE APPROVAL

Senate Graduate Studies Committee Jeff Derksen	Signature 	Date March 29, 2023

ADMINISTRATIVE SECTION (for DGS office only)
Library Check: _____
Course Attribute: _____
Course Attribute Value: _____
Instruction Mode: _____
Attendance Type: _____

If different from regular units:
Academic Progress Units: _____
Financial Aid Progress Units: _____

SEE 770 – Water, Energy, Food Nexus

Units: 3
Lecture hours: 39

Course Description:
Rapid population and economic growth in combination with accelerated urbanization and changing lifestyles are driving ever-increasing demands for water, energy, and food. All three sectors are closely linked – 30% of global energy consumption is used for food production, which also takes up 70% of water consumption. Integrated policy and engineering solutions that simultaneously address the three nexus sectors are the focus of this course. It explores innovative technologies, engineering challenges, and supportive policy approaches. The overall scope of the course is international, with a strong focus on Canadian applications. Students explore real-world problems through identification of innovative technological solutions.

Topics Covered:

- Theoretical underpinnings of the water, energy, food nexus
- Intersection between the three sectors with a focus on climate change and sustainable development
- Knowledge gaps in the nexus sectors
- Integrated engineering solutions: increasing resource productivity and closed-loop waste streams; reducing carbon/water footprint; multi-use hydropower units
- Emerging nexus innovations in engineering applications and policy frameworks with examples from around the world
- Case studies from Canada and elsewhere

Course Organization:

The classroom sessions introduce advanced concepts related to the water, energy, food nexus, reinforced by background readings from various sources. The problem-based learning approach used in the course means that learning in the classroom is matched by an application of skills and tools using the nexus approach for solving climate change and sustainable development problems. Students team up to undertake a practicum assignment, to be submitted in writing and presented at the end of the course; there is no final exam. Each team investigates a specific nexus problem – often picked up from the news headlines – and prepares the evidence base used to develop a policy-relevant written piece.

Course Learning Outcomes:

1. At the end of this course, students are expected to be able to: Display deep understanding of the water, energy, food nexus issues, challenges, and solutions;
2. Understand the policy framing around nexus approaches and identify emerging solutions being developed in Canada and elsewhere;

3. Critically evaluate existing and emerging technological solutions to nexus problems.
4. Communicate complex nexus concepts and engineering solutions to technical, non-technical, and multidisciplinary audiences; and
5. Develop team skills through collaborative work on solving the nexus practicum problem.

Grading Scheme:

- Mid-Term Exam: 20%
- Class Assignments (3): 30%
- Practicum: 30%
- In-class Participation: 15%
- Background Reading: 5%

SFU GRADUATE AND POSTDOCTORAL STUDIES

New Graduate Course Proposal

Course Subject (eg. PSYC) SEE	Number (eg. 810) 771	Units (eg. 4) 4

Course title (max. 100 characters)

Sustainable Energy Systems I

Short title (for enrollment/transcript - max. 30 characters) Sustainable Energy Systems I

Course description for SFU Calendar (course descriptions should be brief and should never begin with phrases such as "This course will..." or "The purpose of this course is..." If the grading basis is satisfactory/unsatisfactory include this in the description - max. 50 words)

Students will develop the engineering knowledge base needed to analyze modern sustainable energy systems, including electrical power engineering, material sciences, and thermodynamics. Physical laws relevant to each engineering discipline will be introduced and analytical approaches will be developed for application to representative energy systems.

Rationale for introduction of this course

This is a core course with the MEng program. It develops the engineering tools that will enable students to apply multidisciplinary engineering principles to courses in focused areas of sustainable energy engineering. The motivation is to provide the multidisciplinary engineering basis to ensure that all students can successfully complete the required coursework.

Term of initial offering (eg. Fall 2019) Fall 2024	Course delivery (eg. 3 hrs/week for 13 weeks) LEC: 4hrs/week for 13 weeks / Lab: 6/term, 3 hrs/lab
Frequency of offerings/year 1	Estimated enrollment per offering 20

Equivalent courses (courses that replicates the content of this course to such an extent that students should not receive credit for both courses)

Prerequisite and/or Corequisite

Criminal record check required? ☐ Yes if yes is selected, add this as prerequisite

Additional course fees? ☐ Yes ☑ No

Campus where course will be taught ☐ Burnaby ☑ Surrey ☐ Vancouver ☐ Great Northern Way ☐ Off campus

Course Components * ☑ Lecture ☐ Seminar ☑ Lab ☐ Independent ☐ Capstone ☐ _____

Grading Basis ☑ Letter grades ☐ Satisfactory/ Unsatisfactory ☐ In Progress / Complete

Repeat for credit? ☐ Yes ☑ No	Total repeats allowed? _____	Repeat within a term? ☐ Yes ☑ No
Required course? ☑ Yes ☐ No	Final exam required? ☑ Yes ☐ No	Capstone course? ☐ Yes ☑ No

Combined with a undergrad course? ☐ Yes ☑ No If yes, identify which undergraduate course and the additional course requirements for graduate students:

* See important definitions on the curriculum website.

RESOURCES

If additional resources are required to offer this course, provide information on the source(s) of those additional resources.

Faculty member(s) who will normally teach this course
To be assigned from existing SEE complement. Courses will be co-taught to ensure appropriate expertise.
Additional faculty members, space, and/or specialized equipment required in order to offer this course
Access to undergraduate thermo fluids and power systems labs.

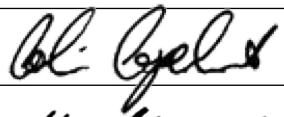
CONTACT PERSON

Academic Unit / Program	Name (typically, Graduate Program Chair)	Email
SEE	Colin Copeland	ccopeland@sfu.ca

ACADEMIC UNIT APPROVAL

A course outline must be included.

Non-departmentalized faculties need not sign

Graduate Program Committee Colin Copeland	Signature 	Date 2023-03-24
Department Chair Mehran Ahmadi	Signature 	Date March 24, 2023

FACULTY APPROVAL

The course form and outline must be sent by FGSC to the chairs of each FGSC (fgsc-list@sfu.ca) to check for an overlap in content

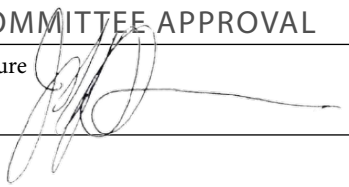
Overlap check done? ☑ YES

This approval indicates that all the necessary course content and overlap concerns have been resolved. The Faculty/Academic Unit commits to providing the necessary resources.

Faculty Graduate Studies Committee	Signature	Date
Parvaneh Saaedi		March 28/2023

A library review will be conducted. If additional funds are necessary, DGS will contact the academic unit prior to SGSC.

SENATE GRADUATE STUDIES COMMITTEE APPROVAL

Senate Graduate Studies Committee	Signature	Date
Jeff Derksen		march 29, 2023

ADMINISTRATIVE SECTION (for DGS office only)

Library Check: _____
Course Attribute: _____
Course Attribute Value: _____
Instruction Mode: _____
Attendance Type: _____

If different from regular units:
Academic Progress Units: _____
Financial Aid Progress Units: _____

SEE 771 – Sustainable Energy Systems I – Fundamentals

Units: 4
Lecture hours: 52

Course Description:

Students will develop the engineering knowledge base needed to analyze modern sustainable energy systems, including electrical power engineering, material sciences, and thermodynamics. Physical laws relevant to each engineering discipline will be introduced and analytical approaches will be developed for application to representative energy systems.

Topics Covered:

- Thermodynamics and energy conversion
- Electrical energy generation and power systems
- Material sciences with a focus on energy storage

Course Organization:

This course is focused on ensuring that all MEng students have at a minimum a basic level of understanding of the engineering principles relating to sustainable energy engineering. The course will be composed of lectures, tutorials, and labs, with supplemental activities defined based on individual student needs. The lecture components will focus on engineering knowledgebase including the underpinning physical laws and the methods in which they are applied in the field of sustainable energy engineering. Students who lack undergraduate training in a relevant engineering field will be expected to complete guided supplemental studies, supported by dedicated small-group tutorial sessions. Students with substantial prior expertise in core areas of the course will be expected to undertake self-directed study in advanced topics. The core lecture material will be supported through targeted laboratory experiments using existing equipment in the SRYE electrical, materials, and thermo-fluids laboratories.

Course Learning Outcomes:

At the end of this course, students are expected to be able to:

1. Explain fundamental engineering principles relating to electrical power engineering, material sciences, and thermodynamics;
2. Describe an energy system using standard engineering tools and identify principal energy transfer mechanisms within the system and between the system and its surroundings;
3. Define energy use and efficiency for a specified situation based on understanding of thermo-mechanical and electrical energy systems;
4. Assess energy transfer effectiveness and losses under various well-defined situations; and
5. Describe energy storage systems using fundamental of materials science, electrical power systems, and thermodynamics.

Grading Scheme:

- Class Assignments (3): 40%
- Practical (laboratory) activities (6): 20%
- Final Exam: 40%

SFU GRADUATE AND POSTDOCTORAL STUDIES

New Graduate Course Proposal

Course Subject (eg. PSYC) SEE	Number (eg. 810) 772	Units (eg. 4) 4

Course title (max. 100 characters)

Sustainable Energy Systems II

Short title (for enrollment/transcript - max. 30 characters) Sustainable Energy Systems II

Course description for SFU Calendar (course descriptions should be brief and should never begin with phrases such as "This course will..." or "The purpose of this course is..." If the grading basis is satisfactory/unsatisfactory include this in the description - max. 50 words)

Application of engineering principles from electrical engineering, material sciences, and thermodynamics to sustainable energy systems. Topics will include electrical energy production, sustainable buildings, smart grids, and low-carbon transportations.

Rationale for introduction of this course

This is a core course with the MEng program. It applies the engineering principles developed in SEE 771 to current challenges in sustainable energy engineering. The focus is on demonstrating and applying multidisciplinary engineering skills to current challenges in sustainable energy engineering in a defined and controlled environment.

Term of initial offering (eg. Fall 2019) Fall 2024	Course delivery (eg. 3 hrs/week for 13 weeks) 4hrs/week for 13 weeks
Frequency of offerings/year 1	Estimated enrollment per offering 20

Equivalent courses (courses that replicates the content of this course to such an extent that students should not receive credit for both courses)

Prerequisite and/or Corequisite SEE 771

Criminal record check required? ☐ Yes if yes is selected, add this as prerequisite

Additional course fees? ☐ Yes ☑ No

Campus where course will be taught ☐ Burnaby ☑ Surrey ☐ Vancouver ☐ Great Northern Way ☐ Off campus

Course Components * ☑ Lecture ☐ Seminar ☐ Lab ☐ Independent ☐ Capstone ☐ _____

Grading Basis ☑ Letter grades ☐ Satisfactory/ Unsatisfactory ☐ In Progress / Complete

Repeat for credit? ☐ Yes ☑ No	Total repeats allowed? _____	Repeat within a term? ☐ Yes ☑ No
Required course? ☑ Yes ☐ No	Final exam required? ☑ Yes ☐ No	Capstone course? ☐ Yes ☑ No

Combined with a undergrad course? ☐ Yes ☑ No If yes, identify which undergraduate course and the additional course requirements for graduate students:

* See important definitions on the curriculum website.

RESOURCES

If additional resources are required to offer this course, provide information on the source(s) of those additional resources.

Faculty member(s) who will normally teach this course
To be assigned from existing SEE complement. Courses will be co-taught to ensure appropriate expertise.
Additional faculty members, space, and/or specialized equipment required in order to offer this course
Access to undergraduate laboratory equipment.

CONTACT PERSON

Academic Unit / Program	Name (typically, Graduate Program Chair)	Email
SEE	Colin Copeland	ccopeland@sfu.ca

ACADEMIC UNIT APPROVAL

A course outline must be included.

Non-departmentalized faculties need not sign

Graduate Program Committee Colin Copeland	Signature 	Date 2023-03-24
Department Chair Mehran Ahmadi	Signature 	Date March 24, 2023

FACULTY APPROVAL

The course form and outline must be sent by FGSC to the chairs of each FGSC (fgsc-list@sfu.ca) to check for an overlap in content

Overlap check done? ☑ YES

This approval indicates that all the necessary course content and overlap concerns have been resolved. The Faculty/Academic Unit commits to providing the necessary resources.

Faculty Graduate Studies Committee	Signature	Date
Parvaneh Saaedi		March 28, 2023

A library review will be conducted. If additional funds are necessary, DGS will contact the academic unit prior to SGSC.

SENATE GRADUATE STUDIES COMMITTEE APPROVAL

Senate Graduate Studies Committee	Signature	Date
Jeff Derksen		March 29, 2023

ADMINISTRATIVE SECTION (for DGS office only)
Library Check: _____
Course Attribute: _____
Course Attribute Value: _____
Instruction Mode: _____
Attendance Type: _____

If different from regular units:
Academic Progress Units: _____
Financial Aid Progress Units: _____

SEE 772 – Sustainable Energy Systems II – Applications

Units: 4
Lecture hours: 52

Course Description:

Application of engineering principles from electrical engineering, material sciences, and thermodynamics to sustainable energy systems. Topics will include electrical energy production, sustainable buildings, smart grids, and low-carbon transportation.

Topics Covered:

- Sustainable and renewable electrical power generation technologies
- Robust electrical energy distribution and smart grids
- Vehicles and transportation systems for net-zero greenhouse gas emissions
- Efficiency improvements for buildings and the built environment

Course Organization:

This course is structured as a lecture series that builds on the fundamental principles developed in SEE 771. A series of lectures by subject-matter experts will use the tools of thermodynamics, material sciences, and electrical power system engineering to describe both current status and future trends in energy system development. A significant part of the course time will be focused on project-based assignments that develop the links between fundamental knowledge and its application to engineering systems. These assignments will be focused on the four main topic areas and will involve small-group discussions and tutorial sessions between the course instructor and teaching assistants. Each student will also be asked to develop an instructional lecture on a specific topic related to the course and deliver that to the class.

Course Learning Outcomes:

At the end of this course, students are expected to be able to:

1. Apply the principles of thermodynamics, electrical power systems, and materials engineering to assess defined challenges relating to sustainable energy systems;
2. Explain and quantitatively assess the main barriers to sustainable use of energy in each of the core topic areas;
3. Demonstrate how intermittent energy sources impact conventional electrical grids and how intermittency can impact power quality and network optimization;
4. Integrate new engineering knowledge and critically assess the potential of new sustainable energy technologies; and
5. Develop an in-depth understanding of a focused topic and disseminate that understanding to a technical audience.

Grading Scheme:

- Class Assignments (4): 40%
- In-class presentation: 20%
- Final exam: 40%

SFU GRADUATE AND POSTDOCTORAL STUDIES

New Graduate Course Proposal

Course Subject (eg. PSYC) SEE	Number (eg. 810) 773	Units (eg. 4) 4

Course title (max. 100 characters)

Sustainable Energy Policy

Short title (for enrollment/transcript - max. 30 characters) Sustainable Energy Policy

Course description for SFU Calendar (course descriptions should be brief and should never begin with phrases such as "This course will..." or "The purpose of this course is..." If the grading basis is satisfactory/unsatisfactory include this in the description - max. 50 words)

Writing intensive graduate course designed to examine one of the most pressing issues of our time: how to develop alternative and sustainable energy sources in the face of climate change. Students receive a technical introduction to how energy works, then moves to a historical perspective focusing on how petroleum-based economy has evolved, and what the future holds for it. Next, students review energy policy frameworks in economic, political, and regulatory terms. Students will learn how to write a policy brief or memo, using qualitative and quantitative analysis.

Rationale for introduction of this course

This is a core course with the MEng program that will be co-taught by the department of Political Science. Currently is being delivered in Political Science as a cross-listed undergrad and graduate course. Additional content pertaining to sustainable energy engineering will be incorporated. Will instill the capacity to effectively engage policy makers and undertake policy formulation and implementation. Provides imporant leadership skills needed for MEng graduates.

Term of initial offering (eg. Fall 2019) Fall 2024	Course delivery (eg. 3 hrs/week for 13 weeks) 4hrs/week for 13 weeks
Frequency of offerings/year 1	Estimated enrollment per offering 40 (20 POL, 20 SEE)

Equivalent courses (courses that replicates the content of this course to such an extent that students should not receive credit for both courses)

Students with credit for POL 452W/855 may not take this course for further credit

Prerequisite and/or Corequisite

Criminal record check required? ☐ Yes if yes is selected, add this as prerequisite

Additional course fees? ☐ Yes ☑ No

Campus where course will be taught ☑ Burnaby ☐ Surrey ☐ Vancouver ☐ Great Northern Way ☐ Off campus

Course Components * ☐ Lecture ☑ Seminar ☐ Lab ☐ Independent ☐ Capstone ☐ _____

Grading Basis ☑ Letter grades ☐ Satisfactory/ Unsatisfactory ☐ In Progress / Complete

Repeat for credit? ☐ Yes ☑ No	Total repeats allowed? _____	Repeat within a term? ☐ Yes ☑ No
Required course? ☑ Yes ☐ No	Final exam required? ☐ Yes ☑ No	Capstone course? ☐ Yes ☑ No

Combined with a undergrad course? ☑ Yes ☐ No If yes, identify which undergraduate course and the additional course requirements for graduate students:

POL 452W. Grad students will be help to appropriately higher standards while completing the same assignments, including developing deeper anaylsis of primary data.

* See important definitions on the curriculum website.

RESOURCES

If additional resources are required to offer this course, provide information on the source(s) of those additional resources.

Faculty member(s) who will normally teach this course
Co-taugh by Prof Anil Hira (POL) and a faculty member to be assigned from existing SEE complement.
Additional faculty members, space, and/or specialized equipment required in order to offer this course

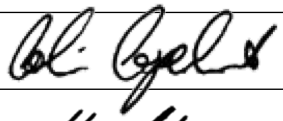
CONTACT PERSON

Academic Unit / Program	Name (typically, Graduate Program Chair)	Email
SEE	Colin Copeland	ccopeland@sfu.ca

ACADEMIC UNIT APPROVAL

A course outline must be included.

Non-departmentalized faculties need not sign

Graduate Program Committee Colin Copeland	Signature 	Date 2023-03-24
Department Chair Mehran Ahmadi	Signature 	Date March 24, 2023

FACULTY APPROVAL

The course form and outline must be sent by FGSC to the chairs of each FGSC (fgsc-list@sfu.ca) to check for an overlap in content

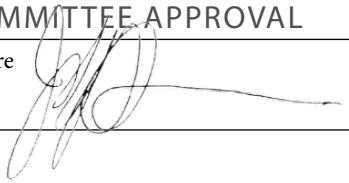
Overlap check done? ☑ YES

This approval indicates that all the necessary course content and overlap concerns have been resolved. The Faculty/Academic Unit commits to providing the necessary resources.

Faculty Graduate Studies Committee	Signature	Date
Parvaneh Saaedi		March 28, 2023

A library review will be conducted. If additional funds are necessary, DGS will contact the academic unit prior to SGSC.

SENATE GRADUATE STUDIES COMMITTEE APPROVAL

Senate Graduate Studies Committee	Signature	Date
Jeff Derksen		March 29, 2023

ADMINISTRATIVE SECTION (for DGS office only)

Library Check: _____
Course Attribute: _____
Course Attribute Value: _____
Instruction Mode: _____
Attendance Type: _____

If different from regular units:
Academic Progress Units: _____
Financial Aid Progress Units: _____

SEE 773 – Sustainable Energy Policy (cross-listed as POL 452W/855)

Units: 4

Course Description:

This writing-intensive course is designed to examine one of the most pressing issues of our time: how to develop alternative and sustainable energy sources in the face of climate change. The course starts with a technical introduction to how energy works and moves to an historical perspective, focusing on how the petroleum-based economy has evolved and what the future holds for it. It then moves to a review of energy policy frameworks in economic, political, and regulatory terms. The course is centered around helping students learn how to write a policy brief or memo, which is a standard document of analysis in the public, private, and non-profit arenas. The policy memo will develop an analysis of the feasibility of implementing a sustainable energy source or policy, using both quantitative and qualitative analysis. The policy memo will serve as a well-vetted and reviewed writing sample for students. The course is supplemented by site visits and guest speakers.

Topics Covered:

- Traditional and renewable energy sources in the context of climate change
- Energy basics including alternative fuels, history of petroleum markets, and oil and gas subsidies
- Sources of supply and demand of energy and future trends
- Sustainable energy and electricity regulation
- Electricity regulation and integration: Latin American case study
- Energy in transportation and the biofuels sector
- Energy efficiency, climate change, and sustainability
- Policy obstacles to climate change
- Debate of best ways to reduce consumption and to address climate change in Canada

Course Organization:

This is a combined graduate plus upper-level course, and the topics are wide ranging. All material will be available through article databases and reserve materials from Canvas, SFU library reserves and energy policy organization websites. There is an important link through the SFU library designed for this course to help you with your research:
http://www.lib.sfu.ca/help/research-assistance/subject/political-science/pol452w

Thorough preparation and active participation are key to success in this course. Students must attend every session and be prepared to participate in each meeting. To accomplish this objective, students should prepare an outline of the readings for each meeting and work ahead of time on all assignments. Detailed instructions and examples will be given for every stage, but students are advised to work well ahead of time on project stages to get appropriate feedback.

Students will be graded upon participation and writing assignments culminating in the policy brief, as well as the ability to demonstrate knowledge of the basic concepts of sustainable energy policy.

Grading Scheme:

The assignments will be graded proportionally as follows:

- Participation: 10%,
- Quizzes: 10%
- Peer review assignments: 5%
- Presentation of research paper: 10%
- Debate preparation and participation: 10% (5% oral, 5% written); 2 bonus marks for the winning team
- Policy memorandum: 55%

SFU GRADUATE AND POSTDOCTORAL STUDIES

New Graduate Course Proposal

Course Subject (eg. PSYC) SEE	Number (eg. 810) 799	Units (eg. 4) 6

Course title (max. 100 characters)

Capstone Project

Short title (for enrollment/transcript - max. 30 characters) Capstone Project

Course description for SFU Calendar (course descriptions should be brief and should never begin with phrases such as "This course will..." or "The purpose of this course is..." If the grading basis is satisfactory/unsatisfactory include this in the description - max. 50 words)

Students in this course will work in teams on an applied industry design project related to sustainable energy engineering. Students synthesize their learning from previous MEng courses to research , design, build and test a real-world industry project. Students deliver a final project report and presentation. Graded on a satisfactory/unsatisfactory basis.

Rationale for introduction of this course

The two term team project integrates knowledge and skills gained in previous courses through engagement in a team and industry-based sustainable energy engineering project. Students in this course will be exposed to real-world industry processes and engineering projects while being supported in the educational setting.

Term of initial offering (eg. Fall 2019) Fall 2024	Course delivery (eg. 3 hrs/week for 13 weeks) 1hrs/week for 13 weeks, plus industry meetings
Frequency of offerings/year 1	Estimated enrollment per offering 20

Equivalent courses (courses that replicates the content of this course to such an extent that students should not receive credit for both courses)

Prerequisite and/or Corequisite Completion of SEE 772

Criminal record check required? ☐ Yes if yes is selected, add this as prerequisite

Additional course fees? ☐ Yes ☑ No

Campus where course will be taught ☐ Burnaby ☑ Surrey ☐ Vancouver ☐ Great Northern Way ☐ Off campus

Course Components * ☐ Lecture ☐ Seminar ☐ Lab ☐ Independent ☑ Capstone ☐ _____

Grading Basis ☐ Letter grades ☑ Satisfactory/ Unsatisfactory ☐ In Progress / Complete

Repeat for credit? ☐ Yes ☑ No

Total repeats allowed? _____

Repeat within a term? ☐ Yes ☑ No

Required course? ☑ Yes ☐ No

Final exam required? ☐ Yes ☑ No

Capstone course? ☑ Yes ☐ No

Combined with a undergrad course? ☐ Yes ☑ No If yes, identify which undergraduate course and the additional course requirements for graduate students:

* See important definitions on the curriculum website.

RESOURCES

If additional resources are required to offer this course, provide information on the source(s) of those additional resources.

Faculty member(s) who will normally teach this course
To be assigned from existing SEE complement.
Additional faculty members, space, and/or specialized equipment required in order to offer this course
Industry partners will support group projects. This course will use existing lab facilities in the SEE School within the SRYE building

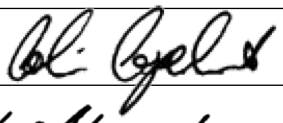
CONTACT PERSON

Academic Unit / Program	Name (typically, Graduate Program Chair)	Email
SEE	Colin Copeland	ccopeland@sfu.ca

ACADEMIC UNIT APPROVAL

A course outline must be included.

Non-departmentalized faculties need not sign

Graduate Program Committee Colin Copeland	Signature 	Date 2023-03-24
Department Chair Mehran Ahmadi	Signature 	Date March 24, 2023

FACULTY APPROVAL

The course form and outline must be sent by FGSC to the chairs of each FGSC (fgsc-list@sfu.ca) to check for an overlap in content

Overlap check done? ☑ YES

This approval indicates that all the necessary course content and overlap concerns have been resolved. The Faculty/Academic Unit commits to providing the necessary resources.

Faculty Graduate Studies Committee	Signature	Date
Parvaneh Saaedi		March 28/2023

A library review will be conducted. If additional funds are necessary, DGS will contact the academic unit prior to SGSC.

SENATE GRADUATE STUDIES COMMITTEE APPROVAL

Senate Graduate Studies Committee	Signature	Date
Jeff Derksen		March 29, 2023

ADMINISTRATIVE SECTION (for DGS office only)
Library Check: _____
Course Attribute: GCAP
Course Attribute Value: Project
Instruction Mode: _____
Attendance Type: _____

If different from regular units:
Academic Progress Units: _____
Financial Aid Progress Units: _____

SEE 799 Capstone Project (MEng Sustainable Energy Industry Project**)**

Units: 6

Course Description:

Students in this course will work in teams on an applied industry design project related to sustainable energy engineering. Students synthesize their learning from previous MEng courses to research, design, build, and test a real-world industry project. Students deliver a final project report and presentation.

Pre-requisites: Completion of SEE 772,

Topics Covered:

- Project management principles, step-by-step process, and tools (e.g., Gantt chart, task division)
- Review of the process of engineering design (e.g., problem definition, conceptualization, preliminary and detailed design, documentation and manufacturing)
- Industry guest experts on various subjects including engineering design for sustainability, renewable energy and energy use
- Review of environmentally conscious design, drawing examples from: solid waste management, environmental protection, pollution control, energy policy, etc.
- Team work skills
- Design for safety, engineering standards, and human factors in real world engineering projects

Course Learning Outcomes:

At the end of this course, students are expected to be able to:

1. As part of a team, design, undertake, critically evaluate, and disseminate the results of a sustainable energy systems design project, including:
    - Analysis of the economic, environmental, and societal impacts
    - Document each design phase in detail
    - Literature review to support the project
2. Contribute constructively to a team in the implementation of an engineering design project; and
3. Safely set up, manage, and use laboratory equipment or computational resources and apply results to an engineering prototype or model.

Grading Scheme:

- Class and small group meeting participation: 15%
- Test plan and analysis: 10%
- User or technical manual: 10%

- Prototype or model: 20%
- Project final report: 25%
- Oral presentation and poster demonstration: 20%

SFU BEEDIE SCHOOL OF BUSINESS | GRADUATE CERTIFICATE IN SCIENCE AND TECHNOLOGY COMMERCIALIZATION

BUS 790: Lab to Market

Instructors: Andrew Park
Email: andrew_park@sfu.ca

Semester: Fall 2021
LMS: canvas.sfu.ca

COURSE DESCRIPTION

Innovation management frameworks are introduced and applied to articulate value propositions, assess viability, and guide strategy in the commercialization of science. You will apply these frameworks to an invention within your research lab or to another innovation idea.

OBJECTIVES

This Lab to Market course is an introduction to the theory and practice of the management of innovation, from the creation of ideas through to the commercialization of new products and services. After successfully completing this course, you will be able to:

1) Articulate the technology attributes of your innovation idea
2) Prioritize market opportunities for your innovation idea
3) Develop comfort with managing under uncertainty
4) Assess the strategic management of IP for your innovation idea
5) Recognize the utility of innovation management concepts to enable you to bring your research to market
6) Develop the tools and techniques to make the transition to scientist-entrepreneur

BOOK AND MATERIALS

1. Selected readings are provided on Canvas
2. Selected readings are available at weblinks provided
3. Selected readings are available electronically through the SFU library

LEARNING AND ASSESSMENT

Learning and Assessment

Evaluation in the course will be based on individual work. Students will respond to each module's discussion questions in relation to their own innovation ideas. This is so that each student gets customized feedback on the application of weekly concepts to their innovation ideas. As in all courses in the Beedie School of Business, grading norms will be observed. In other words, students with the top marks relative to the class average will receive the top grades.

Discussion Posts / In-class Participation	Percentage of Final Grade
Module 1	10%
Module 2	15%
Module 3	15%
Module 4	20%
Module 5	15%
Module 6	25%

SFU BEEDIE SCHOOL OF BUSINESS | GRADUATE CERTIFICATE IN SCIENCE AND TECHNOLOGY COMMERCIALIZATION

Discussion Posts / In-Class Participation

Students will be expected to be prepared for each class by having read the course readings, reflected on how they might apply to their own innovation idea, and posting weekly responses to the discussion assignments. A rich cohort dynamic will be achieved through student engagement and participation in two ways: 1) in class questions and observations which elevate the learning of the cohort will lead to high grades in participation 2) students are expected to reply weekly to at least two other discussion responses from colleagues in their cohort. Exemplar discussion postings will elaborate, enrich, and engage learning within the cohort. A rubric will be provided to guide your postings and feedback.

Course Structure

This course will be based on a "flipped classroom" approach. That means that our class time, including our interactions with guests, requires participation to be successful. When students participate in class, they create the integrative material from which others learn. Thus, participation is rewarded—both since it is an indicator of your understanding of the materials, and also to incentivize you to speak so that we get enough participation to have an engaging dynamic. In addition, this course will include a mixture of short lectures, guest lectures, providing and receiving cohort feedback, and individualized work advancing your innovation idea through the frameworks of this course.

Reading Schedule

Readings are available electronically and can be found on Canvas, through provided weblinks, or through SFU library e-journals.

Pre-Work

1) Arora, A., Belenzon, S., Patacconi, A., & Suh, J. (2019). Why the US innovation ecosystem is slowing down. Harvard Business Review. https://hbr.org/2019/11/why-the-u-s-innovation-ecosystem-is-slowing-down

Module 1: The Journey from Lab to Market

September 15

1) Schaffer, A. (2015). The Problem Solver. MIT Technology Review. http://www.technologyreview.com/article/536351/the-problem-solver/
2) Thomas, V. J., Bliemel, M., Shippam-Brett, C., & Maine, E. (2020). Endowing university spin-offs pre-formation: Entrepreneurial capabilities for scientist-entrepreneurs. Technovation. Read sections 1, 5.2 and 5.3. http://doi.org/10.1016/j.technovation.2020.102153
3) Allen, K. (2010). Entrepreneurship for Scientists and Engineers. Chapter 4: Building a Team (p.51-63)

Module 2: Identifying Opportunities and Value

September 22

1) Maine, E., Soh, P. H., & Dos Santos, N. (2015). The role of entrepreneurial decision-making in opportunity creation and recognition. Technovation, 39, 53-72.
2) Christensen, C. M., Raynor, M. E., & McDonald, R. (2015). What is disruptive innovation?. Harvard Business Review, 93(12), 44-53.

SFU BEEDIE SCHOOL OF BUSINESS | GRADUATE CERTIFICATE IN SCIENCE AND TECHNOLOGY COMMERCIALIZATION

3) Pisano, G. (2015) You Need an Innovation Strategy. Harvard Business Review 6, 45-54. https://hbr.org/2015/06/you-need-an-innovation-strategy

Module 3: Managing Under Uncertainty

September 29

1) Schoemaker (2002) "Embracing Uncertainty," Chapter 1 from Profiting from Uncertainty, The Free Press, New York, USA.
2) Pisano, G. P. (2010). The evolution of science-based business: innovating how we innovate. Industrial and corporate change, 19(2), 465-482.
3) Christensen, C. M., Kaufman, S. P., & Shih, W. C. (2008). Innovation killers: how financial tools destroy your capacity to do new things. Harvard Business Review, 86(1), 98-105.
4) Thomas, V.J. and Maine, E., (2019). Market entry strategies for electric vehicle start-ups in the automotive industry – Lessons from Tesla Motors. Journal of Cleaner Production, 235, 653-663.

Module 4: Technology-Market Matching

October 6

1) Gruber, M and Tal, S. Where to Play - Select Readings [PDF], Pearson Publishing, 2017 https://canvas.sfu.ca/courses/47107/files/11117946/download?wrap=1
2) Maine, E. and Seegopaul, P. (2016). Accelerating Advanced-Materials Commercialization. Nature Materials, 15(5), 487-491.
3) Thomas, V. J., Bliemel, M., Shippam-Brett, C., & Maine, E. (2020). Endowing university spin-offs pre-formation: Entrepreneurial capabilities for scientist-entrepreneurs. Technovation. Read sections 4, 5.1 and 5.4. http://doi.org/10.1016/j.technovation.2020.102153

Module 5: Assessing Viability and Value Capture

October 13

1) Maine, E., & Ashby, M. F. (2002). Succeeding with new materials. A comprehensive guide for assessing market potential. Institute of Manufacturing, University of Cambridge.
2) O'Donnell, L., & Maine, E. (2015). Assessing development and commercialization priorities for a novel hydrogen production process through technical-economic cost modeling. Translational Materials Research, 2(1). doi:10.1088/2053-1613/2/1/016001
3) Markham, S. K. (2002). Moving technologies from lab to market. Research-Technology Management, 45(6), 31-42. https://www.researchgate.net/publication/228686775_Moving_Technology_from_Lab_to_Market

Module 6: Strategic Management of Intellectual Property

October 27

1) Gans, J., Scott, E. L., & Stern, S. (2018). Strategy for start-ups. Harvard Business Review, 96(3), 44-51.
2) Park, A., Maine, E. (2019). The Emergence of the Personalized Medicine Innovation Ecosystem in British Columbia: Strategic Timing and Success. PICMET Proceedings.
3) Maine, E. and Thomas, V.J. (2017). Raising Financing through Strategic Timing. Nature Nanotechnology, 12(2), 93-98.

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doi:10.1038/nnano.2017.1

Academic Honesty

Plagiarism is the unacknowledged use of other people's ideas or work. Plagiarism is often unintentional and can be avoided through careful work habits and familiarity with academic conventions. But whether intentional or unintentional, plagiarism is recognized as a serious academic offence. The university's strong stance against plagiarism reflects our shared commitment to intellectual honesty, and the original contributions of each student and faculty member validate and sustain the university as a vital centre of knowledge and research. It is your responsibility, as a student and a member of the academic community, to ensure that you have correctly acknowledged and cited all the resources you have used in writing your work.

The following examples are representative but not exhaustive of activities constituting academic dishonesty:

- Plagiarism (presenting the work of another person as your own)
- Submitting the same work more than once without prior approval
- Translating a work from one language to another without complete and proper citation.
- Cheating
- Impersonation (having someone else write your exam)
- Submitting false records or information (forged medical notes)
- Stealing or destroying the work of another student
- Unauthorized or inappropriate use of computers, cell phones, calculators and other forms of technology in course work, assignments or examinations
- Falsifying material that is subject to academic evaluation
- Any activity not specifically outlined in this document that is intended to circumvent the standards of academic honesty

You are expected to post comments, and write reports and exams in your own words. Whenever you take an idea or passage from another author, you must acknowledge it by appropriately citing the source. If you are struggling to complete an assignment please see your instructor or the program office for additional assistance.

Ignorance of these standards will not preclude the imposition of penalties for academic dishonesty.

For more information you will find the full SFU policy on Academic Honesty (from which the above was summarized) at: http://www.sfu.ca/policies/gazette/student.html

About the Course Instructor

Andrew Park, MBA, PhD(c)
Andrew Park is a PhD Candidate and the incoming Assistant Professor of Information Systems at the Peter B. Gustavson School of Business, University of Victoria. He has founded and sold a successful health technology venture that grew to over 50 employees, with offices in British Columbia and Washington State. He then returned to academia at SFU Beedie where he has been conducting research in innovation and entrepreneurship with a focus on healthcare and biotechnology. He is currently investigating how Open Innovation mechanisms impact value creation of firms within the emerging Personalized Medicine innovation ecosystem. He has been published in interdisciplinary journals such as Research-Technology Management, Business Horizons and The Journal of Engineering & Technology Management spanning the diverse fields of medicine, biotechnology, digital innovation and management. Andrew is also part of a national network of innovation scholars (4POINT0) evaluating innovation ecosystem models that accelerate the trajectory of Science & Technology innovations to foster strong economic development in Canada, and part of the international 2020 R&D Management Symposium Organizing Committee on the theme of Invention to Innovation – Creating Conditions for Impact. In addition, he recently co-founded another health technology start-up that aims to decentralize and improve access to personal health data. He holds a BSc. in Molecular Biology and Biochemistry and a Management of Technology MBA from Simon Fraser University.

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BUS 793: Business Models

Instructor: Dr. Sarah Lubik	Semester: Spring 2021
Email: slubik@sfu.ca	LMS: canvas.sfu.ca

Course Description

This course brings together key learnings from your previous courses. Business model concepts, considerations and competitive strategies for science and technology ventures, as well as non-tech ventures, are introduced and applied to the opportunities identified by the students in the course in order to create a compelling business model and pitch.

In this course, we will cover:

- Introduction to business models and their components
- The customer-facing elements of the business model
- The internal and ecosystem elements of business models
- Business model ideation & creativity
- Pitching and storytelling for a lay audience

Objectives

This course in an introduction to creating and validating a comprehensive business model, that is, the architecture that specifies of how a firm (or in this case a startup based on your unique science or technology) creates and captures value.

After successfully completing this course, you should be able to:

- Understand the concepts for business models and strategy, particularly in regard to science and tech-based ventures
- Create multiple business models for your specific startup idea that can help you realize your vision for your startup
- Create and evaluate alternative competitive strategies for a science or tech-based startup
- Communicate the value of your idea in a short compelling pitch

Book and Materials

Selected readings will be provided on Canvas or through external links

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Learning and Assessments

Assessment summary

Evaluation in the course will be based on individual work so that each student can customize their assignments to their own projects. As in all courses in the Beedie School of Business, grading norms will be observed. In other words, students with the top marks relative to the class average will receive the top grades.

Deliverables and Reflections	Week 1	5%
	Week 2	10%
	Week 3	10%
	Week 4	15%
	Week 5	10%
	Final Pitch Video	40%
Participation	Participation	10%
	Total	100%

Reflections and Deliverables

Due: Each week

Students will create a brief reflection on what they have learned during the course, including the answers to the questions proposed after the lecturers, videos and readings.

Throughout the class, we will also be making and verifying assumptions. Please come to each class with new evidence validating or invalidating one or more of your assumptions (this can be in the form of market research, expert interviews or secondary evidence).

Each week there will be time to work on your deliverables in breakout groups to give feedback to and learn from your colleagues. Submit your deliverables to canvas weekly and comment on the submissions of two of your peers.

Participation

Assessed each week, Graded at the end of the Course

Your participation will be assessed based on how you are engaging with the material and your colleagues, the curiosity that you are showing, contributing to in class and/or breakout room discussions, engaging with the embedded mentors and engaging thoughtfully and helpfully in the online discussion.

However, I also realize that contributing in an online environment can be challenging depending on your personality and your technology and more, so I welcome other forms of participation as well, including but not limited to emails, participation in canvas discussions, sharing new resources you have found, and other creative ways you find to show engagement.

Participation will be graded as follows:

10/10 - Shows up to class consistently, engages in class (discussions or breakout groups), insightful, detailed participation in online discussions

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8/10 - Shows up to class consistently, engages in class (discussions or breakout groups), participation in online discussions
6/10 - Shows up to class consistently, engages in class (discussions or breakout groups), brief/surface level comments in online discussion
4/10 - Shows up for class consistently, rarely engages in class (discussions or breakout groups), sometimes comments in online discussion
2/10 - Shows up to class sometimes, does not comment in online discussions
0/10 - Does not show up to class, does not engage online

Final Pitch Video — Due: End of Course

Your final deliverable will be a pitch the story of your business, guided by your business model. More details will be given later in the course.

Course Structure

This course will consist of a mixture of online lecturers, readings and videos. Each week you will be asked to prepare and upload an assignment based on the material covered in the readings and class, then to provide feedback and support to your classmates through the online discussions.

Please watch the online lecture before class and begin preparing the answers to the questions. In class each Wednesday evening, we will discuss the material and work on the questions in breakout rooms. Please post your answers and reflections by Friday at midnight and comment on the submission of two of your peers by Sunday at midnight.

Reading & Watching Schedule

Readings are available electronically and can be found through Canvas.

Module 1: Introduction to Business Models

Video: **STEMCELL Technologies head Dr. Allen Eaves**
https://www.youtube.com/watch?v=FkWvLfDrEZk

Reading 1. Chesborough, H. & Rosenbloom, R. (2003) The role of the business model in capturing value from innovation: evidence from Xerox Corporation's technology spin-off companies *Industrial and Corporate Change*. Vol 11 No. 3 529-555.

Reading 2*. Osterwalder, A., & Pigneur,Y (2010) *Business Model Generation* pg 10-51 (Canvas section). Wiley. Available as free e-resource from SFU library

*Based on (not required reading) Osterwalder, A., Pigneur, Y and Tucci, C (2015). Clarifying Business Models: Origins, Present and Future of the Concept. ***Communications of the Association for Information Systems: Vol. 16, Article 1***

Harvard Business Review: From Strategy to Business Models and to Tactics

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Business model vs strategy vs tactics
https://www.hbs.edu/faculty/Publication%20Files/10-036.pdf

Questions:
Define your Vision, Purpose and Objective:

- What is your WHY? (Purpose, Cause or Belief)
- What is you HOW? (What sets you apart from your competition?)
- What is your WHAT? (What is your technology, and what are the products, services, or other offering you hope to sell?)
- If you were wildly successful with your venture, how would the world have changed in five years time?

Module 2: Customer-Facing Considerations

Reading 1. Teece. (2010) Business Models, Business Strategy and Innovation. *Long Range Planning*. Vol 43 No. 2-3. Pg172-194; available on SFU Library (Links to an external site.).

Business model canvas: Customer Segments
https://www.cleverism.com/customer-segments-business-model-canvas/

Embracing the variety of sustainable business models: social entrepreneurship, corporate intrapreneurship, creativity, innovation, and other approaches to sustainability challenges
https://espace.curtin.edu.au/bitstream/handle/20.500.11937/15467/237256.pdf?sequence=2

Deliverables

1. Fill out Right side of Canvasizer.
2. Create a customer profile using Hubspot's make my persona. https://www.hubspot.com/make-my-persona (Links to an external site.)
   Export your customer persona – attach it in the discussion area and comment on:
   a) How realistic is this persona?
   b) How would you gather more information to make sure you are accurate?
3. Fill in the channel phases framework for your venture
   a) Awareness
   b) Evaluation
   c) Purchase
   d) Delivery
   e) After Sales
      I. What are your 1 or 2 most difficult barriers for your customers given these phases? And how will you overcome this?

Module 3: Inner-Workings

Reading 1. Pisano, G. (2006) Can Science be Business. *Harvard Business Review*. October pg. 1-16

Reading 2: Lubik, S. & Garnsey, E. (2015) Early Business Model Evaluation in Science-based Ventures: The Case of Advanced Materials *Long Range Planning*

Reading 3: Adner (2006) Match your strategy to your innovation ecosystem. *Harvard Business Review*.

Deliverables:

1. Fill in the left side of the Canvasizer:

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2. In a PowerPoint – draw your innovation ecosystem – A) as it is now B) and how it will be with you in it. Post in the discussion post with the following:
    - What needs to change in this environment for you to be successful? How will you make it change? (examples: Do you need to team with someone, do you need to find a partner?...)
    - Who are the influencers?
    - What would be your strategy in engaging and working with these influencers?
3. Your value proposition requires you to be unique and valuable, and that requires you to compare yourself to others. Please explain:
    - Who do you see as your current competitors and how do you compare to them?
    - What is your 'isolating mechanism' (how you will protect your innovation)?

Embedded Mentors: Understanding your innovation ecosystem and explaining it to others is an excellent place to get expert advice! Please show the before and after to your embedded mentor for their feedback.

Module 4: Business Models & Strategy

Reading 1: Maine, E., Lubik, S. & Garnsey, E. (2012) Process-based vs. product-based innovation: Value creation by nanotech ventures. (Links to an external site.) Technovation Vol 32 No 3-4 pg 179-192

Strategy for Startups. By: Gans, J., Scott, E. & Stern, S., Harvard Business Review, 00178012, May/Jun2018, Vol. 96, Issue 3 https://hbr.org/2018/05/do-entrepreneurs-need-a-strategy#strategy-for-start-ups

Optional Readings/Resources:
Minshall et al (2010) Making "Asymetrical" Partnerships Work https://web-a-ebscohost-com.proxy.lib.sfu.ca/ehost/pdfviewer/pdfviewer?vid=2&sid=6c082ab7-9478-47cd-9786-087cb7cdfabd%40sdc-v-sessmgr01

Deliverables and reflections:
Of the 4 strategies we discussed – which one of these strategies and business models is the closest to what you currently think your business will be and explain why?

Explain why this model fits your vision, customer considerations, internal operations, and financial structure.

NOW

Choose another – and explain how your business could work in this model.

Explain why this model fits your vision, customer considerations, internal operations, and financial structure.

Explain your rational for which one you think works best for your business.

Module 5: Creativity in Science-Based Business Model

Reading 1. Lubik, S., Garnsey, E., Minshall, T. & Platts, K. (2013) Value creation from the innovation environment: partnership strategies in university spin-outs, *R&D Management*. Vol. 43 No. 2 pages 136-150

Potentially Interesting Resources (not required):

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Ways In Which Entrepreneurs Can Enhance Their Creativity
https://www.entrepreneur.com/article/310904

Strategy Needs Creativity
https://hbr.org/2019/03/strategy-needs-creativity

Deliverables and Reflections:

In this class, you used several creativity exercises to get new ideas to test in your business model. Choose two and write a brief paragraph on each, including why you think this is particularly interesting and how it would change your business model.

Module 6: Pitching and Storytelling for Science-based Ventures

Reading 1: Effective storytelling: strategic business narrative techniques
https://pdfs.semanticscholar.org/5fa5/24d4d64ef7ded86c74d82c4e21a38bb71f6b.pdf

Resources:

Storytelling Canvas
https://www.itu.int/en/ITU-D/Innovation/Documents/Publications/Story%20Telling%20Canvas%20Factsheet.pdf

A Simple 10-step Brand Storytelling System to Clarify Your Business Story
https://businessofstory.com/story-cycle/

Deliverables and Reflections
Put all that you've learned into a brief pitch video (details will be given closer to the end of class) and post to canvas.

Embedded Mentors: When it comes to a story, what's really important is what the audience has to say. Please show the slide deck to your embedded mentor for their feedback before submission.

Final Reflection: There will be one final reflection survey at the end of the class:

1. How has your thinking evolved through the course or what was one of the most helpful new pieces of information you learned?
2. What is one thing you were hoping to learn and didn't?

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http://www.sfu.ca/policies/gazette/student.html

About the Course Instructor

Dr. Sarah Lubik is Simon Fraser University's first Director of Entrepreneurship, the Executive Director of the Chang Institute for Entrepreneurship, co-director of Technology Entrepreneurship@SFU and a lecturer in Entrepreneurship and Innovation at the Beedie School of Business. She specializes in university entrepreneurship, innovation support, incubation and the commercialization of advanced technologies, particularly those of university-origin. Away from SFU, Dr. Lubik an Innovation Leader for the Government of Canada and is Marketing Director of high-tech startup Lungfish Dive Systems, which develops and sells an innovative re-breather system for divers.

After graduating from the BBA program at the Beedie School of Business, Dr. Lubik earned an MPhil and PhD in Technology Commercialization from the University of Cambridge. She is also a certified expert business coach and has worked on several pan-European projects aimed at

FALL 2021 - REM 650 G100

ENERGY MANAGEMENT FOR A SUSTAINABLE CLIMATE AND SOCIETY (5)

Class Number: 5705
Delivery Method: In Person

Instructor: Mark Jaccard (mark_jaccard@sfu.ca; 1 778 782-4219)

CALENDAR DESCRIPTION:

Management strategies and policies to achieve sustainable flows of energy and materials in the economy. Eco-efficiency strategies reduce these flows while resource substitution strategies seek more environmentally benign flows. Applies expertise from economics, ecology, thermodynamics, engineering, geology and behavioral sciences. Students with credit for MRM 650 may not take this course for further credit.

COURSE DETAILS:

This course takes an interdisciplinary approach to addressing sustainability issues, especially related to energy. Because students may have backgrounds in diverse fields, such as engineering, natural sciences, economics and policy analysis, key concepts are introduced without requiring extensive background knowledge in any specific discipline. And while the course is more focused on energy flows in society, the analytical approaches are equally applicable to material flows (such as water, phosphorous and food). The course is applied, focusing on how research can contribute to issues of pressing concern to humanity – with special emphasis on the climate risk. There is also a focus on the communication of research findings to policy makers, media, industry, non-government organizations and the public at large, and the challenges for applied academics when engaging in social-political issues.

Key dimensions of the course include:

- Assessing how human-induced flows of energy and materials are, or might become, a challenge for sustaining the earth's life-support capability and the cohesion of human societies;
- Exploring thermodynamic, technological, geological and biological options for changing the character of these flows toward a greater likelihood of sustainability;
- Potential implications of these options from an ecological, economic and social perspective; and
- Institutional and policy mechanisms (local, regional, national, global) for advancing these options.

COURSE CONTENT:

- Efforts to define sustainability from a thermodynamic, geophysical, ecological, and economic perspective (Georgescu-Roegen, Ayres, economic growth debates, etc.);

- Analytical techniques and concepts for goal setting with respect to energy and material sustainability (conservation and abatement cost curves, rebound effect, biomimicry, etc.); and
- Assessing the effectiveness of alternative institutions and policies for initiating and implementing some of these techniques (policies for externalities, design of successful international energy-environment agreements, pursuit of energy access in developing economies, etc.).

GRADING:

- Book review or other assignment 20%
- Mid-term (1 hour) 20%
- Class participation (including 1 or more short presentations) 20%
- Term paper (max 10 pages, font 12, 1.5 space, 1.5 cm margins) 40%

NOTES:

The class format is mostly seminars to discuss readings and issues, with some lectures to explain key concepts. There are no prerequisites, but permission of the instructor is required. Permission should be requested ASAP as the class size is limited, and space will be allocated on a first-requested-first-accepted basis.

REQUIRED READING:

Available online, along with a more detailed course outline, by early September at www.emrg.sfu.ca.

SPRING 2021 - REM 658 G100

ENERGY AND MATERIALS SYSTEMS MODELING (5)

Class Number: 5933
Delivery Method: Remote

Instructor: Jonn Axsen (jaxsen@sfu.ca; 1 778 782-9365)

PREREQUISITES:

Permission of instructor.

CALENDAR DESCRIPTION:

Theory, background, and practical experience in the use of a range of techniques for policy modelling of energy and materials flows in society with the aim of demonstrating how more environmentally and socially sustainable trajectories can be achieved. Techniques include: simulation modelling, optimization modelling, econometric and other forms of parameter estimation, input-output modelling, game playing models, and integrated systems models.

COURSE DETAILS:

"All models are wrong. Some are more useful" – G. Box

This course is open to graduate students and professionals who seek a better understanding of research methods and models relating to social and technical sustainability.

Class format: Synchronous.

COURSE-LEVEL EDUCATIONAL GOALS:

By the end of this course, you will be able to:

- Identify and compare the major types of research methods and models being used to inform sustainability-oriented policy within social and technical systems.
- Explain the strengths and weaknesses of these methods and models, and identify their relative usefulness for different policy objectives or research questions.
- Evaluate and critique studies that utilize these methods (e.g. reports and peer-reviewed articles).
- Apply these models and methods to real-world problems in environment and sustainability, and policy.
- Effectively communicate research results (memos, papers, presentations), including text and visual aids (tables and figures). 6. Assess and effectively communicate uncertainty in results.

GRADING:

- Participation 10%
- Assignments 40%
- Mid-term exam 15%
- Research methods project: In-class presentation (10%) & Term Paper (25%) 35%

NOTES:

The course involves a mix of lectures, seminars and labs. In seminars, students are expected to play an active role in understanding and discussing the various research methods and models and their appropriateness for different policy and research objectives. Students will gain hands-on experience by applying research methods and models to simplified problems in labs and assignments. The course sections correspond to the main methods topics that will be covered, although there is room for some alteration depending on the preferences and expertise of students in a particular year.

Appendix 3: Letters of support

CITY OF SURREY

OFFICE OF THE MAYOR

October 13, 2021

Dr. Kevin Oldknow, P.Eng.
Director, School of Sustainable Energy Engineering
Simon Fraser University
5129 – 10285 University Drive
Surrey, BC V3T 0N1

Dr. Kevin Oldknow,

Re: Proposed Master of Engineering (MEng) in Sustainable Energy Engineering

On behalf of the City of Surrey (the "City"), I am pleased to provide this letter of support for Simon Fraser University's (SFU) Master of Engineering in Sustainable Energy Engineering program. This program, a first of its kind in Western Canada aligns strongly with the City's commitment to growing our innovation economy, increasing business competitiveness and developing a technologically-advanced workforce.

The City is undergoing a major transformation to become the region's nexus of commerce and a nationally recognized center for innovation. Industry-focused academic programs, such as SFU's new MEng in Sustainable Energy Engineering, will deliver world-class research and high-caliber interdisciplinary engineering professionals required to support the City's rapidly growing sustainability industry.

The interdisciplinary format of the program will support the region's economic diversification strategy empowering local employers and technology leaders to build entrepreneurial partnerships and research collaborations in key priority sectors including renewable energy, clean transportation and infrastructure, zero emissions buildings, and sustainability. The program will also strengthen the City and SFU's common objectives of enhancing the social, economic, and environmental prosperity and the wellbeing of our community.

SFU remains a key partner for the City, and our two organizations have a longstanding history of partnerships since SFU's arrival in Surrey City Centre over 10 years ago. We are proud to have invested in an Industrial Research Chair with SFU and are excited to see SFU pursuing innovative academic opportunities to expand the scope of its engineering programs in the area of sustainability, which is critically important to British Columbia and Canada.

SURREY
CITY OF PARKS

P 604 591 4126 MAYOR@SURREY.CA
13450-104 AVENUE SURREY BRITISH COLUMBIA CANADA V3T 1V8

WWW.SURREY.CA

I am delighted to support SFU's MEng in Sustainable Energy Engineering degree as a unique initiative well-positioned to strengthen and diversify the region's workforce, innovation, and economic growth.

Sincerely,

Doug McCallum
Mayor
City of Surrey

THE UNIVERSITY OF BRITISH COLUMBIA

Faculty of Applied Science
Office of the Dean
5000 – 2332 Main Mall
Vancouver, BC Canada V6T 1A4

Phone 604 822 6413
Fax 604 822 7006
www.apsc.ubc.ca

December 13, 2021

Dr. Eugene Fiume
Dean, Faculty of Applied Sciences
Simon Fraser University

Re: Proposed Master of Engineering in Sustainable Energy Engineering.

Dear Dr. Fiume:

I am writing to express strong support for the proposed Simon Fraser University's (SFU) Master of Engineering in Sustainable Energy Engineering program.

The program will:

- Deliver an interdisciplinary engineering degree that equips its graduates with advanced knowledge and specialized research skills within the sustainable energy domain; an ability to design and deploy technological solutions, and the skill set needed to succeed in a competitive work setting.
- Connecting several academic domains such as public policy, political science and environmental management, this program will fill a multitude of workforce gaps in a wide range of settings and industries including clean and renewable energy, clean transportation, zero emission buildings and sustainability policy.
- The interdisciplinary format of the program will facilitate diverse industry partnerships and research collaboration.
- Aligns with BC and Canada's emissions and climate change targets and supports the growing green economy through the development of highly qualified personnel.
- Aligns strongly with the Fraser Valley region's commitment to growing innovation economy, increasing business competitiveness and developing a technologically-advanced workforce.
- Increase number of graduate students and engineers in BC, enrich the talent pool and position BC as a global leader in cleantech innovation.

THE UNIVERSITY OF BRITISH COLUMBIA

I am confident that the program will attract top graduate students from BC, Canada and around the world. These graduates will be critical to the emerging sustainable economies.

Best Regards,

James Olson, PhD, P.Eng, FCAE
Dean, Faculty of Applied Science

University of Victoria Engineering

Faculty of Engineering
Office of the Dean

University of Victoria
Engineering Office Wing
RM 248

PO Box 1700 STN CSC
Victoria British Columbia
V8W 2Y2 Canada

Tel (250) 721-8677
Fax (250) 721 8676
www.uvic.ca/engineering

January 8 2022,

Dr. Eugene Fiume
Dean, Faculty of Applied Sciences
Simon Fraser University

Re: Proposed Master of Engineering in Sustainable Energy Engineering

I am writing to express strong support for the proposed Simon Fraser University's (SFU) Master of Engineering in Sustainable Energy Engineering program. I reviewed the supporting document and was very impressed by the vision and structure of the proposed program which has unique aspects as it will

- create a unique, interdisciplinary sustainable energy engineering education that instills systems thinking, understanding of the financial and economic landscape, and knowledge of policy-domain interactions;
- provide students with a comprehensive skill set that includes teamwork and collaborative problem solving needed to succeed in a complex work setting;
- fill workforce gaps and enrich the BC talent pool with more engineering professionals in a wide range of settings and industries including clean and renewable energy, clean transportation, zero emission buildings and sustainability policy;
- facilitate diverse industry partnerships and research collaboration;
- support Canada's Climate and Net-Zero plans and advance Clean Growth through research, education and workforce development;
- strengthen ties with the Fraser Valley region's communities and enhance their industrial competitiveness, and social, economic and environmental wellbeing.

Yours truly,

Mina Hoorfar, PhD, PEng. FCSME
Dean, Faculty of Engineering
Engineering Office Wing 248
PO Box 1700 STN CSC
Victoria BC V8W 2Y2 Canada
Tel: 250-721-8611
Uvic.ca/engineering

Township of Langley

Est. 1873

January 1, 2022 File No. 5280-31-001

Dr. Kevin Oldknow,
Director, School of Sustainable Energy Engineering
Simon Fraser University

Attention: Dr. Kevin Oldknow

Re: Proposed Master of Engineering in Sustainable Energy Engineering

I am writing in support for the proposed Simon Fraser University's (SFU) Master of Engineering in Sustainable Energy Engineering program. As you are aware Climate Action is a priority for all levels of government and programs such as this one will support the transition to a more sustainable future.

From my understanding the program will deliver an interdisciplinary engineering degree that equips its graduates with advanced knowledge and specialized research skills within the sustainable energy domain.

It will cover vast areas such as public policy, political science and environmental management, this program will fill a multitude of workforce gaps in a wide range of settings and industries including clean and renewable energy, clean transportation, zero emission buildings and sustainability policy.

This program aligns with BC and Canada's emissions and climate change targets, as well as local and regional government climate action plans, and supports the growing green economy through the development of highly qualified personnel.

Yours truly,

Tess Rouse
MANAGER, CLIMATE ACTION

ENGINEERS & GEOSCIENTISTS BRITISH COLUMBIA

December 7, 2021

Kristina Lebed
Senior Associate Director, Advancement & Alumni Engagement
Faculty of Applied Sciences
Simon Fraser University
5129 -10285 University Dr.
Surrey, BC V3T 0N1

Dear Kristina,

Re: Proposed Masters in Sustainable Energy Engineering Program 2022

Thank you for your email on November 10th informing the association regarding the planned launch of a new Masters in Sustainable Energy Engineering Program for the upcoming year. It is always encouraging to see reputable post-secondary institutions, such as Simon Fraser University, developing new learning opportunities for those entering the engineering profession.

With the implementation of the *Professional Governance Act* in February 2021, Engineers and Geoscientists BC has affirmed its role as a regulator whose primary purpose is to protect the public interest. As a result, our operations are currently under review to ensure we focus on that mandate and remain impartial so as not to be seen as an advocacy body. This means that as an organization we cannot endorse specific post-secondary programs.

On behalf of Engineers and Geoscientists BC, we would like to express that we have no objection to the launching of the new Masters in Sustainable Energy Engineering Program. As there is no accreditation of graduate engineering programs by Engineers Canada, we would encourage prospective students of this program to contact Engineers and Geoscientists BC should they have any questions on how to meet the academic the academic standards for registration.

We hope that all the hard work developing this program will be recognized by the government and commend your devotion to the promotion of continued learning especially in a practice area that is becoming increasingly important today.

Regards,

Mark G. Rigolo

Mark Rigolo, P. Eng. | Acting Chief Regulatory Officer and Registrar

Engineers and Geoscientists British Columbia

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CANADA V6E 4A2

T 604.697.6700
F 604.697.6703
WWW.CORIX.COM

October 5, 2021

DELIVERED VIA EMAIL

Simon Fraser University | Sustainable Energy Engineering
5129 - 10285 University Dr.
Surrey, BC, V3T 0N1

Attention: Kristina Lebed, Senior Associate Director, Advancement & Alumni Engagement

RE: Proposed Master of Engineering (MEng) in Sustainable Energy Engineering

Dear Kristina,

I am writing to express strong support for the proposed Simon Fraser University's (SFU) Master of Engineering in Sustainable Energy Engineering program that will deliver multidisciplinary engineering professionals skilled at developing technological solutions to help B.C. and Canada meet its sustainability goals and support a green economy.

We understand that the program will deliver an interdisciplinary engineering degree that equips its graduates with the conceptual knowledge of the sustainable energy domain, an ability to understand and design technological solutions, and the skill set needed to succeed in the competitive emerging field of sustainability. Connecting several academic domains such as public policy, political science and environmental management, this unique program will fill a multitude of workforce gaps in a wide range of settings and industries including clean and renewable energy, clean transportation, zero emission buildings and sustainability policy. The interdisciplinary format of the program will empower local employers and technology leaders to build entrepreneurial partnerships and research collaborations.

We see tremendous benefit in launching a multidisciplinary Engineering program dedicated to sustainable energy. This type of innovate program would serve companies like Corix in terms of developing a great pool of talent to support the growing sustainability industry. Through innovative research and collaborations with industry and other post-secondary institutions, the new engineering program has the potential to develop real-world solutions to some of world's most complex challenges in climate change mitigation.

Corix and SFU have a longstanding partnership focused on reducing the carbon footprint of the University community through the Burnaby Mountain District Energy Utility which provides thermal energy heating and domestic hot water to Simon Fraser University and the adjacent Residential Neighborhood (UniverCity). We are excited to see SFU pursuing innovative academic opportunities to expand the scope of its engineering programs in the area of sustainability, which is critically important to British Columbia and Canada.

Sincerely,

CORIX UTILITIES INC.

Per:

Travis Hickford-Kulak
Senior Vice President Canada and President of Canadian Utilities

October 7 2021

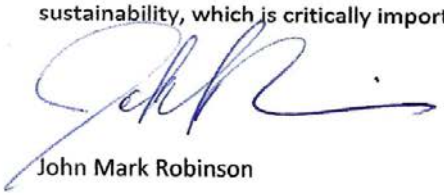
Re: Proposed Master of Engineering (MEng) in Sustainable Energy Engineering.

To whom it may concern:

I am writing to express strong support for the proposed Simon Fraser University's (SFU) Master of Engineering in Sustainable Energy Engineering program that will deliver multidisciplinary engineering professionals skilled at developing technological solutions to help B.C. and Canada meet its sustainability goals and support green economy.

The program will deliver an interdisciplinary engineering degree that equips its graduates with the conceptual knowledge of the sustainable energy domain, an ability to understand and design technological solutions, and the skill set needed to succeed in a competitive work setting. Connecting several academic domains such as public policy, political science and environmental management, this unique program will fill a multitude of workforce gaps in a wide range of settings and industries including clean and renewable energy, clean transportation, zero emission buildings and sustainability policy. The interdisciplinary format of the program will empower local employers and technology leaders to build entrepreneurial partnerships and research collaborations.

We see tremendous benefit in launching a multidisciplinary Engineering program dedicated to sustainable energy. Our organization is exploring potential research collaboration in our development of electric vehicle charging systems. We are excited about the opportunity to work with the SFU Faculty of Applied Science and are pleased to see SFU pursuing innovative academic opportunities to expand the scope of its engineering programs in the area of sustainability, which is critically important to British Columbia and Canada.



John Mark Robinson

Tap&Go EV Ltd.

4150 McConnell Drive

Burnaby, BC V5A 3Y9

778 899 7088

mark.robinson@tapgoev.com

37322 Galbraith Road
Box 187
Squamish BC V8B 0A2
www.carbonengineering.com

September 24, 2021

Subject: SFU's proposed Master of Engineering (MEng) in Sustainable Energy Engineering

To whom it may concern:

I am writing to express support for Simon Fraser University's (SFU's) proposed Master of Engineering in Sustainable Energy Engineering program. At Carbon Engineering, we are working hard to develop technological solutions to help BC, Canada, and the world to solve climate change. We understand that the proposed program at SFU will deliver multidisciplinary engineering professionals skilled at developing technological solutions and supporting a green economy.

Global decarbonization cannot happen with technology alone – it must be paired with carbon policies. We understand that the program will deliver an interdisciplinary engineering degree that equips its graduates with the conceptual knowledge of the sustainable energy domain, an ability to understand and design technological solutions, and the skill set needed to succeed in a competitive work setting.

- Connecting several academic domains such as public policy, political science and environmental management, this unique program will fill a multitude of workforce gaps in a wide range of settings and industries including clean and renewable energy, clean transportation, and zero emission buildings.
- The interdisciplinary format of the program will help empower local employers and technology leaders like Carbon Engineering to build entrepreneurial partnerships and research collaborations.

We see tremendous benefit in launching a multidisciplinary Engineering program dedicated to sustainable energy. This type of program would serve companies like Carbon Engineering in terms of developing a great pool of talent to support the growing sustainability industry. Through innovative research and collaborations with industry and other post-secondary institutions, the new engineering program has the potential to develop real-world solutions to some of world's most complex challenges in climate change mitigation.

Carbon Engineering is a proud member of the SFU Faculty of Applied Science External Advisory Board—a group of distinguished industry representatives providing advice and future direction in matters related to academic programs, teaching practices and research. We are excited to see SFU pursuing innovative academic opportunities to expand the scope of its engineering programs in the area of sustainability, which is critically important to British Columbia and Canada.

Sincerely,

Hollie Roberts
Manager, Human Resources
Carbon Engineering

Appendix 4: Memo from the library

Provide supportive memo from the library indicating that the necessary resources are available to meet the demand.

SFU SIMON FRASER UNIVERSITY

MEMO

SFU Library

8888 University Drive
Burnaby, BC V5A 1S6
Canada

ATTENTION Dr. Gordon McTaggart-Cowan

FROM Patty Gallilee

RE MEng in Sustainable Energy Engineering

DATE April 22, 2022

Dear Gordon,

The library fully supports the creation of a new program, the **Master of Engineering (MEng) in Sustainable Energy Engineering.**

We have been supporting the School Sustainable Energy & Engineering since the its inception in 2019, including Masters and PhD students. We anticipate being able to continue this level of support the newly proposed MEng Program.

The primary support person in the Library for this program is Holly Hendrigan, Liaison Librarian for Applied Sciences. Holly provides research and teaching support, and expertly stewards our ever-adapting collection of Sustainable Energy & Engineering resources.

Graduate students are also well supported by the SFU Library Research Commons, and other Library resources and services such as Research Data Management.

The SFU Library welcomes the creation of this program, and looks forward to continuing our partnership with the School.

Best,
Patty Gallilee
Associate Dean of Libraries, Collections and Scholarly Communication

Patty Gallilee

Appendix 5: Details of program steering committee (if applicable)

Graduate Program Committee Membership:

Colin Copeland, Associate Professor/GPC Chair*

Gordon McTaggart-Cowan, Associate Director and Associate Professor*

Zafar Adeel, Professor of Professional Practice*

Vahid Hosseini, Associate Professor*

Mariana Resener, Assistant Professor*

Vivian Neal, Lecturer*

Taco Niet, Assistant Professor (Practitioner)*

Vincenzo Pecunia, Associate Professor*

Mina Xu, Lecturer*

Tara Smith, Manager, Operations and Admin Services

*voting members

The Advisory Board membership:

Alex Boston: Executive Director, Renewable Cities

Fiona Famulak: President and CEO, BC Chamber of Commerce

Ron Klopfer: CEO, Etalim

Raymond Lings: President & CEO, Powertech Labs Inc.

Ged McLean: Associate Director, Pacific Institute for Climate Solutions (PICS)

Jason Owen: Manager, Sustainability and Energy Services, City of Surrey

Mark Warren: Director, Business Innovation, FortisBC Inc

Appendix 6: Abbreviated curriculum vitae for faculty

Mahda Jahromi, Ph.D., P.Eng., SMIEEE

Email: Mahda.Jahromi@ieee.org
Phone: (+1) 778-782-7184

SRYE – #5139
10285 University Drive
Surrey, BC, V3T 0N1

EDUCATION

- **Fellowship, Mechatronic Systems Engineering**
  Simon Fraser University – Canada, (Jan 2012 -Jul 2012)
  Project: *Precision Control of Electromechanical Systems Using Quadrature Vector Control Technique*

- **Ph.D., Electrical and Electronics Engineering**
  Nanyang Technological University – Singapore, (2008–2013)
  Thesis Title: *Study of Planning and Operational Aspects of Tidal In-Stream Power Generation*

- **M.Sc., Electrical Power Engineering** (Highest CGPA in cohort & Valedictorian)
  Shiraz University – Iran (2004 – 2007)
  Thesis Title: *Optimal Allocation of Distributed Generation in MV Grid-networks for Voltage Sag Mitigation*

- **B.Sc., Electronics Engineering** (1st Class Honors)
  Yazd University – Iran, (1999 – 2004)
  Thesis Title: *Design & Development of a Phone-Activated Supervisory Controller for Remote Control of Irrigation Systems*

ACADEMIC CAREER (IN CHRONOLOGICAL ORDER)

- **Simon Fraser University – Canada** *August 2019 – Present*
  - Chair - Undergraduate Program Accreditation Committee
  - Lecturer, Sustainable Energy Engineering, Simon Fraser University

  Courses (Developed & Taught): SEE 230, SEE 231, SEE 251, SEE 331, SEE 342, SEE 464

- **British Columbia Institute of Technology – Canada** *August 2016 - August 2019*
  - Program Head, Electrical and Computer Engineering
  - Instructor, Electrical and Computer Engineering

  Courses (Taught): ELEX 1102, ELEX 1117, ELEX 2117, ELEX 2105, ELEX 2205, ELEX 3403, ELEX 4440, ELEX 7350

- **Nanyang Technological University – Singapore** *September 2010 - September 2012*
  - Sessional Instructor, Electrical and Electronics Engineering

  Courses (Taught): EE2005

- **Shiraz Azad University – Iran** *September 2006 - July 2008*
  - Instructor, Electrical and Electronics Engineering

  Courses (Developed & Taught): Electric Machines, Power Systems Studies, Fuzzy Logic Systems, Linear Control Systems

INDUSTRIAL CAREER (IN CHRONOLOGICAL ORDER)

- **Mithra Solar Solutions Inc.** *(Technology Startup - Metro Vancouver) Feb. 2016 –Present,*
  - Founder and Director

- **Traxx Industrial Automation** *(System Integrator - Metro Vancouver) Apr 2015 – Jan 2016*
  - Senior Electrical Engineer & Engineering Lead

- **Endurance Wind Power Inc**. *(OEM - Metro Vancouver) Jul 2012 – Mar 2015*
  - Senior Electrical Engineer

- **Rolls-Royce Renewable Energies Lab at NTU**. *(R&D – Singapore)* *Aug 2009- Jan 2012*
  - Research Assistant
- **Cement Engineering Services** *(EPC/M - Iran)* *Sep 2004- Aug 2008*
  - Senior Electrical Engineer
  - Project Engineer

PATENTS & PUBLICATIONS

- **Mahda J. Jahromi**, Daryl Musselman, Endurance Wind Power, Portable Electric Braking System for Wind Turbines with Induction Generators – Int. Patent - WO2016095045

- **M. J. Jahromi**, *"Application of Feedforward Compensation in the Design of Active Front-End Converters"*, IEEE Vehicular Technology Conference, Helsinki, June 2022
- **M. J. Jahromi,** A. I. Maswood, and K. J. Tseng, *"Design and Evaluation of a Tidal In-Stream Generator Power Port"*, Systems Journal, IEEE, vol. PP, pp. 1-1, 2013.
- **M. J. Jahromi,** A. I. Maswood, and K.J. Tseng, *"Design and Evaluation of a New Converter Control Strategy for Near Shore Tidal Turbines"*, Industrial Electronics, IEEE Transactions, vol. PP, pp. 1-1, 2012.
- **M. J. Jahromi**, A. I. Maswood, and K.J. Tseng, "Long Term Prediction of Tidal Currents", Systems Journal, IEEE, vol. 5, pp. 146-155, 2011.
- **Mahda J. Jahromi**, A. I. Maswood, K.J. Tseng, Bicky Bhangu, *"Tidal In-Stream Generation with Improved PCC Voltage Profile"*, IEEE-PES Innovative Smart Grid Technologies Conference, Washington, D.C., 2012
- **Mahda J. Jahromi**, A.I. Maswood, and K.J. Tseng, Bicky Bhangu, *"Maximum Power Extraction of Tidal Streams"*, IEEE - PES Innovative Smart Grid Technologies Conference, Washington, D.C., 2012
- **Mahda J. Jahromi**, A.I. Maswood, and K.J. Tseng, *"Comparison of Different Techniques for Short Term Prediction of Tidal Current Speeds"*, IEEE PES General Meeting, Minneapolis, Minnesota, USA , July 2010
- **Mahda J. Jahromi**, M.H. Haque and K.J. Tseng, *"Siting and sizing of distributed generation using three new indices"*, IASTED International Conference on Solar Energy, SOE, Phuket, March 2009
- **M. J. Jahromi**, E. Farjah, and M. Zolghadri, *"Mitigating voltage sag by optimal allocation of Distributed Generation using Genetic Algorithm"*, in Electrical Power Quality and Utilization, 2007. EPQU 2007. 9th International Conference on, 2007, pp. 1-6.
- **M. J. Jahromi**, S. Meshksar, E. Farjah, and M. Zolghadri, *"Voltage Sag State Estimation for Power Distribution Systems Using Kalman Filter"*, IEEE International Symposium on Industrial Electronics, 2007, pp. 2449-2453.
- S. Meshksar, **M. J. Jahromi**, O. Dehzangi, and A. J. Jahromi, *"Nonlinear control of distillation column using feedback linearization"*, in Proceedings of the 26th IASTED International Conference on Modelling, Identification, and Control, 2007, pp. 277-284.
- S. Meshksar, A. Khayatian, **M. J. Jahromi**, and M. Hashemi, *"Modeling and Identification of a Pilot Distillation Column for Control and Estimation Using Genetic Algorithms"*, in Industrial Electronics Society, 2007. IECON 2007. 33rd Annual Conference of the IEEE, 2007, pp. 586-591.

Zafar ADEEL

+1 (778) 782 4378
zadeel@sfu.ca
https://www.linkedin.com/in/zafar-adeel-b0304b15/

Overview

As a passionate environmentalist, I bring over 25 years of experience in a broad range of environmental science and policy issues. This includes 18 years of work as a United Nations official, with progressively increasing responsibilities in the field of environmental conservation and international development.

Summary of Work Experience

Jan 2021 – ongoing: **Professor of Professional Practice,** School of Sustainable Energy Engineering, SFU (Surrey, Canada):
As a practitioner of science-policy interface, I build partnerships with industrial partners, contribute to the pedagogic and strategic design of new academic programs, and teach innovative courses. My research aims to foster technological solutions and effective policies for achieving Sustainable Development Goals (SDGs) and adapting to climate change.

2016 – ongoing: **Executive Director,** Pacific Water Research Centre, Simon Fraser University (Surrey, Canada):
I undertake strategic planning and management of PWRC, including oversight and organization of staffing and budget needs. A main objective of this position is to develop new, interdisciplinary proposals.

Jul 2016 – Dec 2020: **Professor of Professional Practice,** School of Resources and Environmental Management, SFU (Burnaby, Canada):
I conducted research projects related to water security and the nexus between water, energy, and food security, and supervised graduate students. My teaching emphasis was on water security at both graduate and undergraduate levels.

Jul 2006 – Jun 2016: **Director,** UNU-Institute for Water, Environment and Health (Hamilton, Canada):
I served as CEO and Chief Scientist of the Institute, reporting directly to a UN Under-Secretary-General. I was responsible for developing the strategic plans, fundraising, budget planning and research leadership. I brought significant growth to the Institute, growing from a handful of employees to a team of about 50 people.

Jun 2003 – Jun 2006: **Associate Director / Assistant Director,** UNU-INWEH (Hamilton, Canada):
In these key management roles, I contributed to the strategic development and human resources management. I was also responsible for fundraising, while providing scientific and research leadership.

Aug 1998 – May 2003: **Academic Programme Officer**, United Nations University (Tokyo, Japan):
I developed and managed a diverse portfolio of environmental projects and capacity building initiatives, focusing on impacts of extreme climate events, management of natural resources in dryland countries, and regional cooperation for management of nature reserves and parks.

Education

Ph.D., Civil and Environmental Engineering
Carnegie Mellon University
Pittsburgh, PA *(1995)*

M.S., Environmental Engineering
Iowa State University
Ames, IA *(1992)*

B.S., Civil Engineering
University of Engineering and Technology
Lahore, Pakistan *(1990)*

Affiliations & Distinctions

- 2018-2021: Chair, Steering Committee, CEC Flood Costing in Canada, Mexico, and the United States
- 2018-ongoing: Member, Advisory Board, Community Engaged Research Initiative (CERi), SFU
- 2014-ongoing: Book Series Editor, Water Security in a New World (Springer Publisher)
- 2013-2016: Board of Directors, Rotary Club of Hamilton
- 2009-2017: Board of Directors, UNU Land Restoration Training Programme, Iceland
- 2006-2016: Delegation Head for UNU at the UN-Water group

Sep 1995 – Jul 1998: **Senior Engineer**, HSI GeoTrans, Inc. (Sterling, VA, United States):
I led teams of engineers and scientists working on investigative and remedial projects for clients including Fortune 500 companies as well as the US government agencies. I also served as a technical expert in litigation for clients.

Selected Research Highlights

- *Nutrition through Engagement and Agricultural Technology* (2018-2023): This project aims to enhance the self-reliance of First Nations communities in Canada on sustainable, nutritious and organic foods, while ensuring sustainable access to water and energy and building on and expanding local and traditional. N-EAT is working with Kitasoo / Xai'xais First Nation and the Stó:lō Nation in BC.

- *Long-Term Scenarios for Energy, Water, and Food Security in North America* (2017-2020). This project, funded by the Willow Grove Foundation, studies the impacts of climate change, rapid urbanization, changing demographics and emerging consumption patterns in Canada and the United States.

- *Nutrition through Providing Sustainable Potable Water and Greenhouse Crops (2017-2021).* I developed this Queen Elizabeth Scholarship (QES/AS) project with Prof. Majid Bahrami (SFU School of Mechatronic Systems Engineering) as a co-PI. It aims to strengthen and broaden partnerships and enhance institutional capacity in the area of clean water-energy-food technologies, linked to water and food security. This project supports PhD candidates from and post-doc fellows from developing countries at Simon Fraser University.

- *Enhancing the Use of Science in GEF IW* (2010-2012): I initiated and executed this project designed to review, analyze and synthesize the science behind 20-year, $7 billion portfolio of international water projects.

- *Environmental Monitoring and Governance in the East Asian Coastal Hydrosphere* (1998-2005) – I served as the Project Manager for this 9-year, US$ 3.4 million project on pollution monitoring in 12 countries: Bangladesh, China, India, Indonesia, Japan, Malaysia, Pakistan, the Philippines, Singapore, South Korea, Thailand, Vietnam.

Selected Publications

Peer-reviewed Books:

- Stefanovic, I.L.., and Z. Adeel (Eds), 2020. Ethical Water Stewardship, Springer Publisher, Dordrecht, The Netherlands.
- Amer, K.M., Z. Adeel, B. Böer, and W. Saleh (Eds.), 2017. *Water-Energy-Food Security Nexus in the Arab Region*, Springer Publisher, Dordrecht, The Netherlands.
- Devlaeminck, D., Z. Adeel, and R. Sandford (Eds.), 2017. *The Human Face of Water Security*, Springer, Germany.
- Miyazaki N., Z. Adeel, and Kouichi Owada (Eds.), 2005. *Mankind and the Oceans*, UNU Press, Japan.
- Adeel, Z. (Ed.), 2003. *East Asian Experiences in Environmental Governance: Response in a Rapidly Developing Region*, UNU Press, Japan.

Peer-reviewed Papers:

- Adeel, Z., Alarcon, A.M., Bakkensen, L., Franco, E., Garfin, G.M., McPherson R.A., Mendez, K., Roudaut, M.B., Saffari H., Wen, X., 2020. Developing a comprehensive methodology for evaluating economic impacts of floods in Canada, Mexico and the United States, *International Journal of Disaster Risk Reduction*, 50: 1-86.
- Adeel, Z., 2018. Re-imagining Water (and Energy) Sharing in South Asia, *Georgetown Journal of International Affairs*, 27 Feb 2018.
- Adeel, Z., 2017. A renewed focus on water security within the 2030 agenda for sustainable development, *Sustain. Sci.*, 12:891-894.
- Switzman, H., B. Salem, M.Gad, Z. Adeel, and P. Coulibaly, 2017. Conservation planning as an adaptive strategy for climate change and groundwater depletion in Wadi El Natrun, Egypt, *Hydrogeol. J.*
- Adeel, Z., and U. Safriel, 2008. Achieving Sustainability by Introducing Alternative livelihoods, *Sustainability Science*, Vol. 3 (1).

DR. COLIN D COPELAND

Associate Professor, Faculty of Applied Science
School of Sustainable Energy
Simon Fraser University
Vancouver, Canada
Mobile: (001)-236-808-3456
Email: ccopelan@sfu.ca

EDUCATION

Doctor of Philosophy (PhD) Mechanical Engineering Imperial College London, 2005-2009	*Awarded*: March 01, 2010 *Research topic*: Steady & Pulsation Flow Performance of a Double-entry Turbocharger Turbine
Masters of Applied Science (MSc) Mechanical Engineering University of Waterloo, 2003 -2005	*Awarded*: September 2005 *Research topic*: Thermally assisted, laser induced fluorescence temperature measurements in a flame.
Bachelor of Engineering (BEng) Mechanical Engineering Ryerson University, 1999 -2003	*Awarded*: June 2003 *Final year project:* Natural gas dispersion characteristics in a fluidized bed furnace.

ACADEMIC APPOINTMENTS

2020 - present	Associate Professor	Simon Fraser University
2017 - 2020	Reader	University of Bath
2012 - 2017	Lecturer	
2011 - 2012	Lecturer	University of Bristol
2009 - 2011	Researcher	Imperial College London

TEACHING AND LEARNING

Institution	Teaching Unit	Years
Simon Fraser University	SEE 893 – Waste Heat Recovery	2021 – present
	SEE 324 – Heat and mass transfer	2021 - present
University of Bath	ME40345- Turbocharging and Engine Boosting	2015 - present
	ME30037– Internal Combustion Engine Technology	2014 - present
	ME30217- Vehicle Engineering	2014 - 2015
University of Bristol	MENGM6047; Engineering for the Built Environment	2012 - 2013

SELECTED PUBLICATIONS

Tüchler, S., Copeland, C., (2021). Numerical optimisation of a micro-wave rotor turbine using a quasi-two-dimensional CFD model and a hybrid algorithm. Shock Waves

Tüchler, S., and Copeland, C. D. (2020). "Validation of a Numerical Quasi-One-Dimensional Model for Wave Rotor Turbines With Curved Channels." ASME. J. Eng. Gas Turbines Power. February 2020; 142(2): 021017.

Adamou, A, & Copeland, C. (2020) "Experimental and Computational Analysis of Additive Manufactured Augmented Backside Liner Cooling Surfaces for Use in Micro Gas Turbines." Proceedings of the ASME Turbo Expo 2020: Turbomachinery Technical Conference and Exposition. September 21–25, 2020. GT2020-14960

Chagnon-Lessard, N, Copeland, C, Mathieu-Potvin, F & Gosselin, L (2020), Optimal Design of Novel Inverted Brayton Cycles for Heat Energy Recovery, Volume 191, *Journal of Energy*. 116350, ISSN 0360-5442,

Tüchler, S., Copeland, C. D., (2020) Experimental and numerical assessment of an optimised, non-axial wave rotor turbine, Applied Energy, Volume 268, 2020, 115013, ISSN 0306-2619,

Powers, K, Brace, C, Budd, C, Copeland, C & Milewski, P (2019), 'Modelling Axisymmetric Centrifugal Compressor Characteristics from First Principles' *Journal of Turbomachinery*.

Adamou, A, Kennedy, I, Farmer, B, Hussei, A & Copeland, C (2019), Experimental and Computational Analysis of an Additive Manufactured Vaporization Injector for a Micro-Gas Turbine. *ASME Turbo Expo 2019:* GT2019-90245

Kennedy, I, Duda, T, Liu, Z, Ceen, B, Jones, A & Copeland, C (2019), 'Investigation of a Combined Inverted Brayton and Rankine Cycle' *Journal of Engineering for Gas Turbines and Power*.

Tüchler, S & Copeland, C (2019), Experimental Results from the Bath μ-Wave Rotor Turbine Performance Tests, *Journal of Energy Conversion and Management*. ECM-D-19-00781.

Zhu, S, Hu, B, Akehurst, S, Copeland, C, Lewis, A, Yuan, H, Kennedy, I, Bernards, J & Branney, C (2019), 'A review of water injection applied on the internal combustion engine' Energy Conversion and Management, vol. 184, pp. 139-158.

Vijayakumar, R., Copeland, C., Akehurst, S., Reyes Belmonte, M., Liu, Z., & Brace, C. (2019). Design and Testing a Bespoke Cylinder Head Pulsating Flow Generator for a Turbocharger Gas Stand. *Journal of Energy*.

Zheng, L., Copeland, C (2018), New method for mapping radial turbines exposed to pulsating flows, *Energy*. Vol. 162, pp. 1205-1222, ISSN 0360-5442

Tüchler, S., Copeland, C. (2018), Multi-point and Multi-objective Shape Optimization of a Radial Compressor. *Energy*, Vol. 165, Part A, pp. 543-561

Zhang, Y., Duda, T., Scobie, J., Sangan, C., Redwood, A., & Copeland, C. (2018). Design of an Air-cooled Radial Turbine Part 1: Computational Modelling. *ASME Turbo Expo 2018,* GT2018-76378

Zhang, Y., Duda, T., Scobie, J., Sangan, C., Redwood, A., & Copeland, C. (2018). Design of an Air-Cooled Radial Turbine Part 2: Experimental Measurements. *ASME Turbo Expo 2018,* GT2018-76384

Kennedy, I., Chen, Z., Ceen, B., Jones, S., & Copeland, C. (2019). Experimental Investigation of an Inverted Brayton Cycle for Exhaust Gas Energy Recovery. *Journal of Engi. for Gas Turbines and Power*, GTP-18-1476

Kennedy, I, Chen, Z, Jones, S, Ceen, B & Copeland, C (2018), Inverted Brayton Cycle With Exhaust Gas Condensation *Journal of Engineering for Gas Turbines and Power*, GTP-18-1080

Avola, C., Copeland, C., Burke, R., & Brace, C. (2017). Effect of inter-stage phenomena on the performance prediction of two-stage turbocharging systems. *Energy, 134*, 743-756.

MEHRAN AHMADI, Ph.D., P.Eng.

1551, Salal Crescent, Coquitlam, BC – V3E2V6

phone: +1(604)367-5444

email: mahmadi@sfu.ca

Academic Experience

School of Sustainable Energy Engineering — May 2019 – Present
Simon Fraser University — Surrey, BC, Canada

- Lecturer
- School's Associate Director
- Undergraduate Curriculum Committee (UCC) chair

Laboratory Engineer — January 2015 – December 2015
Simon Fraser University — Surrey, BC, Canada

- Hands on work: Test rig design, machining, sensor selection/installation, data uncertainty analysis
- Coordination: Equipment usage coordination, Lab visit, delivery, and move coordination
- Finance: Research funds monitoring and budget management

Research Experience

Postdoctoral Fellowship – Research Associate — January 2015 – October 2017
Simon Fraser University — Surrey, BC, Canada

- Assisted in supervising 2 Ph.D. candidates and 1 M.Sc. students
- Designed high-efficiency graphite-based heat exchangers with application in heat recovery systems
- Designed and analyzed solar-assisted atmospheric water harvesting systems

Research Assistant — December 2010 – December 2014
Laboratory for Alternative Energy Conversion — Surrey, BC, Canada

- Assisted in supervising 1 M.Sc. student
- Analyzed, designed, and tested high-efficiency active and passive cooling systems
- Designed a low-pressure ejector-based water desalination system

Industrial Experience

Founder, Principal Engineer — June 2020 – Present
AYM Engineering Ltd. — Vancouver, BC, Canada

- Business administration
- Buildings' HVAC design, energy modeling, and inspection for new construction and retrofit projects
- FEA analysis on building assemblies and thermal bridging calculations
- Bidding and invoicing for the undertaken projects

Buildings Energy and Sustainability Engineer — September 2017 – April 2019
Norman Disney and Young – A Tetratech Company — Vancouver, BC, Canada

- Design, modeling, and rating of sustainable buildings
- Worked with cities and authorities to develop and improve codes and guidelines
- Developed more than 6 trade secrets for the company

Design Engineer – Refrigeration Cycles — September 2015 – September 2017
Watergenics Inc. — North Vancouver, BC, Canada

- Design, simulation and thermodynamic analysis of refrigeration systems
- Atmospheric water harvesting system prototyping and testing
- Achieved 10% power consumption reduction by innovative desiccant-coated condenser design

Thermal Engineer – Cooling System Design September 2014 – August 2015
Delta-Q (Research Contract) Burnaby, BC, Canada

- IP66-rated battery charger enclosure design, test and thermal performance evaluation
- CDF and numerical simulation of heat transfer in small and large-scale enclosures
- Achieved 15% higher thermal efficiency by redesigning the electronics mounting strategy

Thermal Engineer – Cooling System Design January 2011 – August 2014
Alpha Technologies (Research Contract) Burnaby, BC, Canada

- Outdoor power enclosures cooling system design and energy efficiency evaluation
- Realtime testing of high-voltage telecommunication power electronics cooling systems
- Achieved 10x cooling capacity improvement by designing a heatpipe-integrated cooling system

Mechanical Engineer – Piping Systems Design September 2007 – September 2010
National Iranian Natural Gas Company (NIGC) Tehran, Tehran, Iran

- High pressure steam and hot water pipelines design; piping support design and stress analysis
- CFD/FEA analysis of heat transfer and fluid flow in natural gas heaters and coolers
- Achieved 10% fuel consumption reduction by design and installation of baffles in gas heaters

Machinist and Shop Supervisor December 2002 – December 2006
National Iranian Copper Industries Company Kerman, Kerman, Iran

- Mechanical parts and heavy-duty mining machinery repair and maintenance
- Experienced with machines such as: lathe, vertical mill, press drills, cutting tools and laser cutters
- Responsible for shop safety policies training and implementation

Education

Ph.D. in Mechatronic Systems Engineering January 2011 – December 2014
Simon Fraser University Surrey, BC, Canada

- Research: Sustainable and energy-efficient cooling systems
- Thesis title: Pushing the limits of natural convection in passive cooling systems
- Honors: President scholarship, three graduate fellowships, and co-filed two provisional patents

M.Sc. in Mechanical Engineering – Energy Systems September 2007 – December 2009
Amirkabir University of Technology Tehran, Tehran, Iran

- Research: Energy-efficient heating systems in buildings
- Thesis title: High-efficiency natural gas combustion with application in large-scale residential boilers
- Honors: Ranked 3rd in mechanical engineering department, and filed one national patent

B.Sc. in Mechanical Engineering January 2003 – December 2006
Kerman University Kerman, Kerman, Iran

- Field of study: Mechanical engineering; Fluid Mechanics and Heat Transfer
- Project: Manufacturing a low-cost 2.5kW wind turbine with application in small residential buildings
- Honor: Ranked 2nd among 600 engineering school students

Publications

- Published more than 15 journal articles and 14 conference papers, a list of which can be found on my Google Scholar page.
- Received more than 240 citations.
- Presented in more than 20 training and technical sessions for industry peers and colleagues on improving energy efficiency and energy saving in buildings.

Graduate Supervision

- Served in supervisory committee of 5 graduate students (4 M.A.Sc. candidates and 1 Ph.D. candidate)

Taco A. Niet, Ph.D., P.Eng.
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☎ 604-221-1011 ◆ tniet@telus.net

Education

Doctor of Philosophy	University of Victoria	November 2018
Master of Applied Science	University of Victoria	December 2001
Bachelor of Engineering	University of Victoria	June 1998

Recent Experience

Assistant Professor of Professional Practice — July 2019 – Present
SFU School of Sustainable Energy Engineering

Faculty, Program Head (B.Eng., Mechanical) — June 2007 – June 2019
Mechanical Engineering, BCIT

Selected recently taught courses

SEE 893- ST: Modelling to support the SDGs (2021)
SEE 310 – Integrated Energy Solutions II (2020, 2021)
SEE 110 - Energy, Environment & Society (2019, 2020, 2021)
ENGR 7480 - Environment, Energy and Engineering (2019, BCIT)
MECH 8135 - Mechanical Engineering Laboratory (2008-2018, BCIT)
MECH 2240 - Strength of Materials (2006 - 2018, BCIT)

Selected recent publications

Note: Names in bold indicates students/post-docs whom I supervised/mentored for the cited item.

Ramos, E., Gardumi, F., Niet, T., Sridharan, V., Pappis, I., Strasser, L.D., Shivakumar, A., Zepeda, E., Howells, M., Holger, R., forthcoming. "Capacity development and knowledge transfer on the climate, land, water and energy nexus" in Brouwer, F. (ed.), in: *Handbook on the Water-Energy-Food Nexus*. Edward Elgar Pub.

Shivakumar, A., T. Alfstad, and T. Niet, "A clustering approach to improve spatial representation in water-energy-food models," Environ. Res. Lett., vol. 16, no. 11, p. 114027, Oct. 2021, doi: 10.1088/1748-9326/ac2ce9.

Niet, T., **N. Arianpoo, K. Kuling**, A.S. Wright (2021). Increasing the Reliability of Energy System Scenarios with Integrated Modelling: A Review. *SSHRC Knowledge Synthesis Grant 872-2019-1009* final report. March 17, 2021.

Niet, T., A. Shivakumar, F. Gardumi, W. Usher, E. Williams, M. Howells 2021. "Developing a community of practice around an open source modelling tool." *Energy Strategy Reviews* 35 (May): 100650. https://doi-org.proxy.lib.sfu.ca/10.1016/j.esr.2021.100650

Niet, T., **Arianpoo, N.**, **Kuling, K.**, & Wright, A. S. (2021). Embedding the United Nations sustainable development goals into energy systems analysis: Expanding the food–energy–water nexus. *Energy, Sustainability and Society*, 11(1), 1. https://doi.org/10.1186/s13705-020-00275-0.

Howells, M., J. Quiros-Tortos, H. Rogner, T. Niet, L. Petrarulo, et al. "The "U4RIA" Standards for Energy Modelling." *Environmental Research Letters* Manuscript in review.

Arianpoo, N., K. Kuling, A. Wright and T. Niet. "Representation of nexus modelling approaches in existing energy systems models." Presented at the 43rd International Association for Energy Economics Conference, Paris, France June 2021.

Kuling, K. and T. Niet. "A comparison of two different methods for modelling storage with OSeMOSYS." Presented at the 43rd International Association for Energy Economics Conference, Paris, France June 2021.

Sridharan, V, A. Shivakumar, T. Niet, E. Ramos, M. Howells. "Land, energy and water resource management and its impact on GHG emissions, electricity supply and food production- Insights from a Ugandan case study" *Environmental Research Communications* 2 (8): 085003. https://doi.org/10.1088/2515-7620/abaf38.

Ramos, E., M. Howells, V. Sridharan, R. Enström, T. Niet et al. "The Climate Land Energy Water systems (CLEWs) Framework: A retrospective of activities and advances to 2019." *Environmental Research Letters* December 2020 https://doi.org/10.1088/1748-9326/abd34f.

Niet, T. 2020. "Storage End Effects: An Evaluation of Common Storage Modelling Assumptions." Journal of Energy Storage 27 (February): 101050. https://doi.org/10.1016/j.est.2019.101050.

Saadeh, O, Z. Dalalah, T. Niet, E. Ramos and M. Howells. "Technoeconomic assumptions adopted for the development of a long-term electricity supply model for the Hashmite Kingdome of Jordan" *Data in Brief* Accepted for publication.

Kubulenso, S, E. Ramos, T. Niet, M. Howells. "The OSeMOSYS Teaching Kit – an example of open educational resources to support sustainable development" Presented at the *2019 International Conference on Sustainable Development (ICSD)*, New York, September 24-25, 2019.

English, J., T. Niet, B. Lyseng, V. Keller, K. Palmer-Wilson, B. Robertson, P. Wild, A. Rowe. "Impact of Flexibility Requirements on Electricity System Decarbonization." *Renewable Energy*. Vol 145, pp. 2770–2782, Jan. 2020.

Niet, T. "Building better models through collaboration." Invited presentation at the *INFORMS Annual Meeting*, Seattle, WA, October, 2019.

McLean, J., K Kan and T. Niet. "Energy OASIS Project - Energy Analysis." Presented at the EcoCity World Summit, Vancouver, BC, October 7-11, 2019

Storwick, M., T. Barnes, P. McWhannel, G. Jayadev, E Kutanoglu, B. Leibowicz, T. Niet. "Energy Independence Policies: Impacts on Emissions, Cost and System Operation." Presented at the EcoCity World Summit, Vancouver, BC, October 7-11, 2019

Niet, T. "The challenges of where to start - setting up an energy planning unit." Invited presentation at the UNDESA, UNDP, ICTP, WBG, ESMAP, UNECA, UKAID, OpTIMUS, KTH, High-level meeting and strategic discourse, Trieste, Italy, 27-28 June 2019

Niet, T., B. Lyseng, J. English, V. Keller, K Palmer-Wilson, B. Robertson, A. Rowe, P. Wild. "Valuing infrastructure investments to reduce curtailment." *Energy Strategy Reviews* (22) 2018 pages 196-206.

Mariana Resener
Ph.D., Senior Member IEEE
School of Sustainable Energy Engineering, Simon Fraser University
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Email: mresener@sfu.ca, LinkedIn, Google Scholar

Professional Employment

Assistant Professor, Simon Fraser University, Canada	01/2022-present
Assistant Professor, Federal University of Rio Grande do Sul, Brazil	01/2018-12/2021
Electrical Engineer, CEEE-D Power Distribution Utility, Brazil	09/2009-12/2017
Lecturer, University of Vale do Rio dos Sinos, Brazil	05/2011-08/2017

Education

Ph.D.	Electrical Engineering	Federal University of Rio Grande do Sul – UFRGS	2016
M.A.Sc.	Electrical Engineering	Federal University of Rio Grande do Sul – UFRGS	2011
B.A.Sc.	Electrical Engineering	Federal University of Rio Grande do Sul – UFRGS	2008

Research Interests

Optimization models applied to power systems
Distributed energy resources, voltage and reactive power control
Expansion and operation planning of power systems
Fault location in distribution systems

Grants

R&D project funded by CEEE-D Equatorial Power Distribution Utility. 2020-present
Title: Integrated Planning for the Definition of Expansion Plans in Distribution Networks Considering Probabilistic Criteria.
Investment: BRL 1.2 million.

Supervision

Currently serving as supervisor of 6 graduate students (4 M.A.Sc., 2 Ph.D.)
Served as supervisor of 3 M.A.Sc. students
Served as supervisor of 1 Postdoctoral Fellow

Selected Recent Publications

Note: Names in bold indicate students/post-docs whom I supervised for the cited item.

Book Edited

Resener M., Rebennack S., Pardalos P. M., and Haffner S., Handbook of Optimization in Electric Power Distribution Systems. Springer, 2020. ISBN 978-3-030-36114-3.

Journal publications

G. L. Aschidamini., **G. A. da Cruz**, M. Resener, M. J. S Ramos, L. A. Pereira, **B. P. Ferraz**, S. Haffner, P. M. Pardalos, "Expansion Planning of Power Distribution Systems Considering Reliability: A Comprehensive Review," Energies, vol. 15, no. 6, p. 2275, Mar. 2022, doi: 10.3390/en15062275.

B. P. Ferraz, M. Resener, L. A. Pereira, F. A. B. Lemos, and S. Haffner, "MILP Model for Volt-var Optimization Considering Chronological Operation of Distribution Systems Containing DERs," Int. J. Electr. Power Energy Syst., vol. 129, p. 106761, Jul. 2021, doi: 10.1016/j.ijepes.2021.106761.

M. J. S. Ramos, M. Resener, A. S. Bretas, D. P. Bernardon, and R. C. Leborgne, "Physics-based analytical model for high impedance fault location in distribution networks," Electr. Power Syst. Res., vol. 188, p. 106577, Nov. 2020, doi: 10.1016/j.epsr.2020.106577.

M. Resener, S. Haffner, L. A. Pereira, P. M. Pardalos, and M. J. S. Ramos, "A Comprehensive MILP Model for the Expansion Planning of Power Distribution Systems – Part II: Numerical results," Electr. Power Syst. Res., vol. 170, pp. 317–325, May 2019, doi: 10.1016/j.epsr.2019.01.036.

M. Resener, S. Haffner, L. A. Pereira, P. M. Pardalos, and M. J. S. Ramos, "A Comprehensive MILP Model for the Expansion Planning of Power Distribution Systems – Part I: Problem formulation," Electr. Power Syst. Res., vol. 170, pp. 378–384, May 2019, doi: 10.1016/j.epsr.2019.01.040.

M. Resener, S. Haffner, L. A. Pereira, and P. M. Pardalos, "Optimization techniques applied to planning of electric power distribution systems: a bibliographic survey," Energy Syst., vol. 9, no. 3, pp. 473–509, Aug. 2018, doi: 10.1007/s12667-018-0276-x.

M. Resener, S. Haffner, L. A. Pereira, and P. M. Pardalos, "Mixed-integer LP Model for Volt/var Control and Energy Losses Minimization in Distribution Systems," Electr. Power Syst. Res., vol. 140, pp. 895–905, Nov. 2016, doi: 10.1016/j.epsr.2016.04.015.

Conference publications

G. A. Da Cruz, S. Haffner, **B. P. Ferraz**, M. Resener, and B. Venkatesh, "Model for the Expansion Planning Problem of Distribution Systems Considering Reliability," in 2021 IEEE PES Innovative Smart Grid Technologies Conference - Latin America, Lima, Peru, Sep. 2021, pp. 1–5. doi: 10.1109/ISGTLatinAmerica52371.2021.9543067.

G. Castiglio, J. Klas, M. Dal Forno, and M. Resener, "Power Line Routing Considering Aspects of Sustainable Development and Complex Environments," in 2021 IEEE PES Innovative Smart Grid Technologies Conference - Latin America, Lima, Peru, Sep. 2021, pp. 1–5. doi: 10.1109/ISGTLatinAmerica52371.2021.9543060.

A. D. Costa, B. P. Ferraz, M. Resener, and S. Haffner, "Linear Load Flow Formulation for Unbalanced Distribution Systems," in 2019 IEEE PES Innovative Smart Grid Technologies Conference - Latin America, Gramado, Brazil, Sep. 2019, pp. 1–6. doi: 10.1109/ISGT-LA.2019.8895503.

Book Chapters

A. D. Costa, S. Haffner, M. Resener, L. A. Pereira, and B. M. P. Ferraz, "Linear Model to Represent Unbalanced Distribution Systems in Optimization Problems," in Handbook of Optimization in Electric Power Distribution Systems, M. Resener, S. Rebennack, P. M. Pardalos, and S. Haffner, Eds. Cham: Springer International Publishing, 2020, pp. 69–120. doi: 10.1007/978-3-030-36115-0_3.

M. J. S. Ramos, M. Resener, P. H. E. Oliveira, and D. P. Bernardon, "Self-Healing in Power Distribution Systems," in Smart Operation for Power Distribution Systems, D. P. Bernardon and V. J. Garcia, Eds. Cham: Springer International Publishing, 2018, pp. 37–70. doi: 10.1007/978-3-319-93922-3_3.

M. Resener, S. Haffner, P. M. Pardalos, and L. A. Pereira, "A Convex Model for the Optimization of Distribution Systems with Distributed Generation," in Advances in Energy System Optimization, V. Bertsch, W. Fichtner, V. Heuveline, and T. Leibfried, Eds. Cham: Springer International Publishing, 2017, pp. 231–245. doi: 10.1007/978-3-319-51795-7_15.

Min (Mina) Xu, Ph.D., P.Eng.

Lecturer, Sustainable Energy Engineering, SFU
Room 5136, 10285 University Dr., Surrey, BC, V3T0N1; Cell: +1 778-855-3483, Email: min_xu@sfu.ca
Google Scholar: https://scholar.google.ca/citations?user=YdDDP-gAAAAJ&hl=en

EDUCATION

Ph.D.	Chemical and Materials Engineering	University of Alberta	2014
M.A.Sc	Materials Science and Engineering	Central South University	2010
B.A.Sc	Materials Science and Engineering	Central South University	2007

PROFESSIONAL EMPLOYMENT

Lecturer, SFU	01/2022-present
Postdoctoral/Research Associate/Engineer, UBC	05/2016-12/2021
Research Scientist, Green Innovative Technologies R&D Center, BC	10/2015-04/2016

TEACHING EXPERIENCE

SEE 402: Professional Engineering Ethics and Practice (SFU)	Summer 2022
SEE 300: The Business of Engineering (SFU)	Summer 2022
SEE 896/897: MASc/PhD Research Seminar (SFU)	Spring 2022
IGEN 450: Pipeline Engineering (UBC)	Winter 2020/21; Winter 2019/20, Term 1
IGEN 451: Pipeline Systems and Infrastructure (UBC)	Winter 2020/21; Winter 2019/20, Term 2

RESEARCH INTERESTS

Corrosion Prediction and Prevention
Anti-corrosion Coatings and Hydrogen Permeation Barrier Coatings
Materials Innovation for Energy Storage Devices

SELECTED PUBLICATIONS

Journal Articles

- H. Liang, **M. Xu**, E. Asselin, Corrosion of monometallic iron- and nickel-based electrocatalysts for the alkaline oxygen evolution reaction: A review, Journal of Power Sources, 2021, 510 (2021) 230387.
- S. Tesfamariam, H. Woldesellasse, **M. Xu**, E. Asselin, General corrosion vulnerability assessment using a Bayesian belief network model incorporating experimental corrosion data for X60 pipe steel, Journal of Petroleum Science and Engineering, 1 (2021), 329-338.

- **M. Xu**, H. Liang, Y. Liu, E. Asselin, Predicting the External Corrosion Rate of X60 Pipeline Steel: A Mathematical Model. Metals, 11(2021), 583.
- **M. Xu**, C.N. Lam, D. Wong, E. Asselin, Evaluation of cathodic disbondment resistance of pipeline coatings – a review, Progress in Organic Coatings, 146 (2020) 105728.
- S. N. Hasan, **M. Xu**, E. Asselin, Electrosynthesis of metallic molybdenum from water deficient solution containing molybdate ions and high concentrations of acetate, Surface and Coatings Technology, 357 (2019) 567-574.
- S. N. Hasan, **M. Xu**, E. Asselin, Electrodeposition of metallic molybdenum and its alloys – a review, Canadian Metallurgical Quarterly, 58 (2019) 1-18.
- **M. Xu**, G.K. Yue, D. Bizzotto, E. Asselin, Electrodeposition of aluminum onto copper-coated printed circuit boards, Journal of The Electrochemical Society, 164 (2017) D729-D736.
- **M. Xu**, D.G. Ivey, W. Qu, Z. Xie, Study of the mechanism for electrodeposition of dendrite-free zinc in an alkaline electrolyte modified with 1-ethyl-3-methylimidazolium dicyanamide, Journal of Power Sources, 274 (2015) 1249-1253. (Reported by Renewable Energy Global Innovation as a key scientific article).
- **M. Xu**, D.G. Ivey, Z. Xie, W. Qu, Rechargeable Zn-air batteries: Progress in electrolyte development and cell configuration advancement, Journal of Power Sources, 283 (2015) 358-371.
- **M. Xu**, D.G. Ivey, W. Qu, Z. Xie, Improved Zn/Zn(II) redox kinetics, reversibility and cyclability in 1-ethyl-3-methylimidazolium dicyanamide with water and dimethyl sulfoxide added, Journal of Power Sources, 252 (2014) 327-332.
- **M. Xu**, D.G. Ivey, W. Qu, Z. Xie, E. Dy, X. Z. Yuan, Zn/Zn(II) redox kinetics and Zn deposit morphology in water added ionic liquids with bis(trifluoromethanesulfonyl)imide anions, Journal of The Electrochemical Society, 161 (2014) A128-A136.
- **M. Xu**, D.G. Ivey, Z. Xie, W. Qu, E. Dy, The state of water in 1-butyl-1-methyl-pyrrolidinium bis(trifluoromethanesulfonyl)imide and its effect on Zn/Zn(II) redox behavior, Electrochimica Acta, 97 (2013) 289–295.
- **M. Xu**, D.G. Ivey, Z. Xie, W. Qu, Electrochemical behavior of Zn/Zn(II) couples in aprotic ionic liquids based on pyrrolidinium and imidazolium cations and bis(trifluoromethanesulfonyl)imide and dicyanamide anions, Electrochimica Acta, 89 (2013) 756-762.

Book Chapters

- **M. Xu**, D.G. Ivey, W. Qu, Z. Xie, E. Dy, Exploration of electrolytes for Zn-anode rechargeable batteries: room temperature ionic liquids as major or supporting components, in: Ionic liquids: synthesis, characterization and applications, A. Brooks (Eds.), Nova Science Publishers, Inc., (2014) pp 99-123.

Manpreet Kaur, Ph.D.

Lecturer, Sustainable Energy Engineering, SFU
Room 5128, 10285 University Dr., Surrey, BC, V3T0N1
Email: *manpreet_kaur_3@sfu.ca* ♦ Phone: 604 726 7749 ♦ LinkedIn

EDUCATION

2015 – 2019	Ph.D. in Mechatronic Systems Engineering Simon Fraser University (SFU), BC, Canada
2008 – 2014	M.Tech. in Nanotechnology (Integrated Bachelor's and Master's) Amity University, Noida, UP, India

PROFESSIONAL EMPLOYMENT

Mar 2021 – Present	Lecturer, School of Sustainable Energy Engineering (SEE), SFU
Oct 2019 – Feb 2021	Limited-term Lecturer, SEE, SFU
May – Aug 2019	Research Associate, Simon Fraser University
May 2015 – Apr 2019	PhD Research Assistant, Simon Fraser University

TEACHING EXPERIENCE

Course (at SFU)	Year taught
SEE 460: Additive manufacturing and Sustainable Design	2022
SEE 354: Energy Storage	2021-22
SEE 341: Signals and Systems	2020
SEE 242: Computational Methods	2020-21
SEE 241: Measurement, Analysis and Forecasting	2021-22
SEE 222: Materials for Energy Systems	2020-22

RESEARCH INTERESTS

Cellular Solids and their mechanical behaviour

Additive Manufacturing

Materials for energy systems

Manpreet Kaur, Ph.D.

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Email: mka104@sfu.ca ♦ Phone: 604 726 7749 ♦ LinkedIn

PUBLICATIONS

- **M. Kaur**, T.H. Kim, and W.S. Kim, "New Frontiers in 3D Structural Sensing Robots" *Advanced Materials* 2002534 2021. DOI

- T. Kim, **M. Kaur**, and W. S. Kim, "Humanoid Robot Actuation through Precise Chemical Sensing Signals," *Adv. Mater. Technol.*, 4, 1900570, 2019. DOI

- **M. Kaur**, and W. S. Kim, "Toward a Smart Compliant Robotic Gripper Equipped with 3D-Designed Cellular Fingers," *Adv. Intell. Syst.*, 1: 1900019, 2019. DOI

- C. Bao, **M. Kaur**, and W. S. Kim, "Toward A Highly Selective Artificial Saliva Sensor using Printed Hybrid Field Effect Transistors," *Sensors Actuators B Chemical*, vol. 285, November 2018, pp. 186–192, 2019. DOI

- S. H. Park, **M. Kaur**, D. Yun, and W. S. Kim, "Hierarchically Designed Electron Paths in 3D Printed Energy Storage Devices," *Langmuir*, vol. 34, no. 37, pp. 10897–10904, 2018. DOI

- **M. Kaur**, T. Gwang Yun, S. Han, E. L. Thomas, and W. S. Kim, "3D printed stretching-dominated micro-trusses," *Materials & Design*, vol. 134, pp. 272–280, Nov. 2017. DOI

- **M. Kaur**, S. M. Han, and W. S. Kim, "Three-dimensionally printed cellular architecture materials: perspectives on fabrication, material advances, and applications," *MRS Communications*, vol. 7, no. 1, pp. 1–12, 2017. DOI

- Datta, A. Sadhu, B. Sen, **M. Kaur**, R. Sharma, S. Ch Das. and S. Bhattacharyya, "Analysis of the acid, base and air oxidized carbon microspheres synthesized in a single step from waste engine oil, *Corrosion Science, Elsevier*, vol. 45, pp. 356-364, 2013. DOI

- Conference Publication:
  Paper presentation in *MRS Spring Symposium 2018* in Phoenix, Arizona. SM01.08.04 Soft Materials, Sensors, Electronics, Displays and Actuators – Functional Components for Soft machines and Robots, 2875732.

GORDON McTAGGART-COWAN

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Education:

- **Ph.D. (Mechanical Engineering)** University of British Columbia. November 2006.
- **M.A.Sc. (Mechanical Engineering)** University of British Columbia. May 2002.
- **B.Eng. (Mechanical Engineering co-op)** (with distinction) University of Victoria. May 1999.

Selected Competitive Awards:

- Governor General's Academic Gold Medal as UBC's top graduating Ph.D. student, May 2007
- Natural Sciences and Engineering Research Council (NSERC) Post-Doctoral Fellowship, 2006 *(declined)*
- NSERC Canada Graduate Scholarship - D2 (Ph.D. level), 2004-2006
- NSERC Post-Graduate Scholarship 'A' (M.A.Sc. level), 1999 - 2001
- Canada Scholarship, 1994 - 1999

Employment:

Simon Fraser University, Surrey, BC
Associate Professor, School of Sustainable Energy Engineering Dec 2019-Current

- Active research program focused on low-carbon thermo-fluid energy technologies
- Funding to date: **$1.4M** from CFI, NSERC, Mitacs, Innovate BC and industrial partners including Westport Fuel Systems, Hydra Energy Inc., Enbala Power Networks and Hydrogen Technology Energy Corp. (HTEC).
- Supervising 8 graduate students (4 PhD / 4 MASc)

Westport Fuel Systems Inc., *Vancouver, Canada*
Engine Research and Development Application Lead Aug 2010-Nov 2019

- Led multi-year, multi-million dollar programs to develop and test new fuel and combustion systems for heavy-duty gaseous-fuelled engines, from concept to design to testing and dissemination
- Work led directly to 9 patent *families*, >15 publications and significant internal development
- Responsible for advanced development using analytical and simulation for next generation engine
- Developed novel fuelling, combustion, and air handling strategies to optimize current and future products
- Industrial lead for 7 academic research projects (MTU, UofT, UBC, KIT) with total value **>$5M**

Wolfson School of Mechanical Engineering, *Loughborough University, Loughborough, UK*
Lecturer, *Thermofluids* November 2006 – July 2010

- Raised over **£600k** funding to support research (>£340k as lead applicant)
- Supervised 3 Ph.D., 1 M.Sc. research theses and 6 graduate (M.Eng.) research projects
- Industrial collaborators: Ford, Lotus, Jaguar Land Rover, Cambustion Inc.

Alternative Energy Group, **Dept. of Mechanical Engineering**, *UBC, Vancouver, BC*
PhD candidate, Research Engineer, MASc candidate September 1999 - October 2006

- Led new research into natural gas engines with focus on reducing emissions / improving efficiency
- Key research focus on fuel composition sensitivity and fuel-cycle analysis for heavy-duty natural gas engines

Selected Relevant Projects (as project lead/PI):

Alternative/flexible fuel Engine research and development:

- **Sustainable / low-carbon diesel fuels** (Lboro, WFS) – testing and evaluation of alternative fuels and biodiesel blends in advanced diesel engines; commercial assessment and materials evaluation of bio-diesel pilot ignited dual-fuel / flex fuel diesel engines;
- **Diesel dual-fuel engines** (WFS, SFU) – development of new combustion processes, engine system optimization, commercial validity assessment, testing and validation for net greenhouse gas reductions;
- **Hydrogen-natural gas blended engine systems** (PhD, WFS, SFU) – modelling, injection studies, combustion evaluation, fuel system development, commercial viability assessment;
- **High efficiency / low emission engine optimization** (Lboro, WFS, SFU) – application of conventional and advanced combustion processes and full-engine optimization for specific applications, optimization of engine systems for alternative and low-carbon fuels;

- **Engine emissions controls systems** (WFS, SFU) – impacts of alternative fuels, engine operating conditions, and engine and fuel system configuration on exhaust aftertreatment systems;

Powertrain systems modelling and assessment:

- **Optimized engines for gas-electric hybrid commercial vehicles** (WFS, SFU) – select, size, and optimize powertrain for future commercial vehicles, comparing different engine and fuel combinations for regional and long-haul commercial vehicles, including life-cycle and well-to-wheel analysis;
- **New modelling structure for hybrid-electric vehicles** (Lboro) – led development of a custom-built modelling tool to comparatively assess powertrain options for specific vehicle segments;
- **Future commercial vehicle powertrains** (WFS, SFU) – technology assessment and benchmarking of current and future diesel engine technologies, efficiency improvement potential, emissions control strategies and potential for integration with hybrid-electric powertrains in well-to-wheel analysis;
- **Hydrogen-fuelled vehicles** (SFU) – modelling and assessment of engine, fuel system, emissions control and vehicle life-cycle analysis of H_2-diesel dual fuel engines for commercial vehicles, infrastructure implications and improvements;

Selected Peer Reviewed Publications (64 total):

- Vinhaes, VB., **McTaggart-Cowan, G**., Munshi, S., Shahbakhti, M. and Naber, J. *Development of a medium-duty stoichiometric diesel micro-pilot natural gas engine* International Journal of Engine Research. Online March 2022.
- Oldknow, K., Mulligan, K. and **McTaggart-Cowan, G.** *The Trajectory of Hybrid and Hydrogen Technologies in North American Heavy Haul Railway Operations*. Railway Engineering Science. 2021, 29: 233-247.
- **McTaggart-Cowan, G.**, Huang, J., and Munshi, S., *Impacts and Mitigation of Varying Fuel Composition in a Natural Gas Heavy-Duty Engine*, SAE Int. J. Engines 10(4):1506-1517, 2017.
- **McTaggart-Cowan, G.P.**, Mann, K., Huang, J., Singh, A., Patychuk, B., and Munshi, S.R. *Direct Injection of Natural Gas at 600 bar in a Pilot-Ignited, Heavy-Duty Engine*. SAE Int. J. Engines 8(3):981-996, 2015.
- Michailidis, A.D., Stobart, R.K., and **McTaggart-Cowan, G.P.** *Low Temperature Combustion (LTC) Optimization and Cycle-by-Cycle Variability through Injection Optimization and Gas-To-Liquid Fuel-Blend Ratio.* ASME Journal of Engineering for Gas Turbines and Power. Vol. 135. 2013.
- **McTaggart-Cowan, G.P.** and Pallett, E.J. *Using a New Driveline Model to Define Quasi-Transient Engine Operating Conditions.* SAE International Journal of Materials and Manufacturing. Vol. 199 No. 5. 2010.
- **McTaggart-Cowan, G.P.**, Rogak, S.N., Munshi, S.R., Hill, P.G. and Bushe, W.K. *Combustion in a Heavy-Duty Direct-Injection Engine using Hydrogen-Methane Blend Fuels* International Journal of Engine Research, Vol. 10, No. 1. 2009. Pp. 1-13.

Selected Patent families (12 total):

- **McTaggart-Cowan, G.P.**, Mann, K., Huang, J. and Munshi, S.R. *Method and Apparatus for Operating Gaseous-Fuelled Direct Injection Internal Combustion Engine*. US patent 10167786. **Issued** January 2019.
- Hill, P.G., Patychuk B., **McTaggart-Cowan, G.P.**, and Ning, W. *Reducing Unburned Hydrocarbons in Gaseous Fuelled Lean-Burn Engines*. US Patent 10526983. **Issued** Jan 2020.
- Munshi, S.R., Welch, A. and **McTaggart-Cowan, G.P**. *Gaseous-Fuelled Stoichiometric Compression Ignition Internal Combustion Engine*. US Patent 8555852. **Issued** October 2013.
- Munshi, S, **McTaggart-Cowan, G.P.**, Rogak, S.N., Bushe, W.K. *Method and Apparatus of Fuelling an Internal Combustion Engine with Hydrogen and Methane*. US Patent 8,469,009. **Issued** October 2017.

Professional Activities:

- Professional Engineer. Registered with EBGC May 2018
- Associate Editor, Proc. of the I. Mech. E., Part D – Journal of Automobile Engineering. 2017-current
- SAE Combustion Committee member and session organizer, 2019-current
- Chair – program oversight committee for NSERC CREATE AAP. Sept 2010-Jan 2017

Revised 26/04/2022

MOLLY A. MCVEY

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Education

Ph.D, Mechanical Engineering *The University of Kansas* *Lawrence, KS, USA*
August 2012

M.S., Mechanical Engineering *The University of Kansas* *Lawrence, KS, USA*
December 2007

B.S., Mechanical Engineering *The University of Kansas* *Lawrence, KS, USA*
May 2003

Professional Experience

Lecturer *Simon Fraser University* *Surrey, BC, Canada*
Sustainable Energy Engineering
Fall 2021- present
- Courses include SEE 100 (Engineering Graphics), SEE 111 (Integrated Energy Solutions I), SEE 242 (Computational Methods), SEE 465 (Life Cycle Assessment and Sustainability).

Postdoctoral Teaching Fellow *The University of Kansas* *Lawrence, KS, USA*
School of Engineering
August 2016- July 2021
- Taught CE 895 (Engineering Education I and II)

Lecturer *The University of Kansas* *Lawrence, KS, USA*
Department of Mechanical Engineering
Spring 2015
- Taught ME 455 (Mechanical Measurements and Experimentation).

Publications (peer reviewed):

1. **McVey, M.**, Luchies, C., Wilson, S., Maletsky, L., Liu, L. (2020, June). *Student Success in Mechanical Engineering: Utilizing Data to Understand Success for Under-Represented Groups.* Paper presented at the 2020 American Society of Engineering Education (ASEE) Virtual Conference.
2. Whorley, B., Giraldo, C., Kamath, A., **McVey, M.**, Patterson, M., Luchies, C. (2019, September). *Restructuring a Modeling Dynamics Course with Absorb-Do-Connect Learning Units.* Paper presented at the Midwest Section of the American Society of Engineering Education (ASEE). Witchita, KS.
3. **McVey, M.,** & Luchies, C. W., & Giraldo, C., & Sidener, L. (2019, June), *Developing Problem-Solving Skills in Dynamics: Implementation of Structured Homework Assignments.* Paper presented at 2019 ASEE Annual Conference & Exposition , Tampa, Florida. https://peer.asee.org/32643
4. **McVey, M.,** & Bennett, C. R., & Greenhoot, A. F. (2019, June), *Impact of an Embedded*

Expert Model on Course Transformation in Engineering. Paper presented at 2019 ASEE Annual Conference & Exposition , Tampa, Florida. https://peer.asee.org/32921

5. Johnson, D. O., & **McVey, M. A.**, & Melgares, C. P. (2019, June), *The Impact of Course Transformation on Student Learning and Success in Fundamental Electrical Engineering/Computer Science Courses.* Paper presented at 2019 ASEE Annual Conference & Exposition , Tampa, Florida. https://peer.asee.org/33394
6. Kondyli, A., & **McVey, M.**, & Melgares, C. P. (2019, June), *Assessment of Active and Team-based Learning Techniques in a Transportation Engineering Introductory Course.* Paper presented at 2019 ASEE Annual Conference & Exposition , Tampa, Florida. https://peer.asee.org/32126
7. Shew, D. P., & Maletsky, L. P., & Clark, G., & **McVey, M.** (2019, June), *Practice Exam Program Impact on Student Academic Performance and Student Retention.* Paper presented at 2019 ASEE Annual Conference & Exposition, Tampa, Florida. https://peer.asee.org/33182
8. **McVey, M. A.**, & Bennett, C. R., & Collins, W. N., & Lequesne, R., & Luchies, C. W., & Wilson, S. E., & Sutley, E. J., & Fadden, M. F., & Melgares, C. (2018, June), *Board 45: Peer Mentoring for All: Investigating the Feasibility of a Curricular-Embedded Peer Mentoring Structure.* Paper presented at 2018 ASEE Annual Conference & Exposition, Salt Lake City, Utah. https://peer.asee.org/30036
9. **McVey, M.**, & Bennett, C. R., & Luchies, C. W., & Lequesne, R. (2018, June), *An Investigation of the Effect of Curriculum-embedded Peer Mentoring on Student Learning in Two Undergraduate Mechanics Courses.* Paper presented at 2018 ASEE Annual Conference & Exposition, Salt Lake City, Utah. https://peer.asee.org/29797
10. **McVey, M. A.,** & Bennett, C. R., & Kim, J. H., & Self, A. (2017, June), *Impact of Undergraduate Teaching Fellows Embedded in Key Undergraduate Engineering Courses.* Paper presented at 2017 ASEE Annual Conference & Exposition, Columbus, Ohio. https://peer.asee.org/28471
11. **McVey, M. A.**, & Luchies, C. W., & Villicana, A. J. (2017, June), *Impact of High-Performing Teams on Student Learning.* Paper presented at 2017 ASEE Annual Conference & Exposition, Columbus, Ohio. https://peer.asee.org/28465
12. Bennett, C. R., & Collins, W. N., & **McVey, M. A.** (2017, June), *A Tiered Mentoring Model for Deepening Student Learning Across Undergraduate and Graduate Design Courses.* Paper presented at 2017 ASEE Annual Conference & Exposition, Columbus, Ohio. https://peer.asee.org/27528
13. **McVey MA**, Barnds AN, Lyons KE, Pahwa R, Mahnken JD, Luchies CW. "The characterization of a base-width neutral step as the first step for balance recovery in moderate Parkinson's disease." *Int J Neurosci*, epub (Oct. 2015): 1-10.

Sami Khan, Ph.D.	Assistant Professor, Sustainable Energy Engineering Simon Fraser University	s_khan@sfu.ca 778-782-7378

EDUCATION

Ph.D. Mechanical Engineering — **Jan 2016 – Oct 2019**
Massachusetts Institute of Technology (MIT) — GPA: 5.0/5.0

S.M. Mechanical Engineering — **Sep 2013 – Dec 2015**
Massachusetts Institute of Technology (MIT) — GPA: 4.9/5.0

B.A.Sc Chemical Engineering — **Sep 2007 – Jun 2012**
University of Toronto — GPA: 3.92/4.00

RECENT RESEARCH FUNDING HISTORY

Natural Sciences and Engineering Research Council (NSERC) Discovery Grant 2022
Award Value: $157,500 I Proposal: Accelerating gas capture and conversion in aqueous systems

Canada Foundation for Innovation (CFI) John R. Evans Leaders Fund (JELF) 2022
Award Value: $200,000 I Proposal: Multifunctional Materials for Enhancing the Performance and Longevity of CO_2 Capture and Conversion Systems

British Columbia Knowledge Development Fund (BCKDF) 2022
Award Value: $200,000 I Proposal: Multifunctional Materials for Enhancing the Performance and Longevity of CO_2 Capture and Conversion Systems

National Research Council of Canada (NRC) 2021
Award Value: $25,000 I Proposal: Advanced Coatings to Mitigate Hydrogen Embrittlement in Natural Gas Pipelines

Mitacs Accelerate 2021
Award Value: $180,000 over 2 years, divided equally with co-PI Dr. McTaggart-Cowan Proposal: High Efficiency Biomass for Remote and Off-Grid Homes

GRADUATE STUDENTS SUPERVISED

Omar Nemir (MASc Student) 2022-present
Thesis topic: Surface functionalization on spherical and cylindrical surfaces

Gahee Im (MASc Student) 2021-present
Thesis topic: Studying crystallization phenomena in ionic liquids on nano-engineered surfaces
Awards and recognitions: Mitacs Globalinks Award for internship at University of Kansas in 2022

Oz Oren (MASc Student, co-supervised with Dr. Gordon McTaggart-Cowan) 2021-present
Thesis topic: Reducing soot accumulation in biomass combustors
Awards and recognitions: CMC MNT Award for microfabrication at 4D labs

PUBLICATIONS

Khan, S., Hwang J., Shao-Horn Y., and Varanasi, K.K. Catalyst-proximal plastrons enhance activity and selectivity of CO_2 electroreduction. Cell Reports Physical Science 2 (2) 100318 (2021)

Khan, S. and Varanasi, K.K. Designing Lubricant-Impregnated Surfaces for Corrosion Protection. CORROSION. (2020) 76 (12), 1095-1098

McBride S., Dash S., **Khan S.,** Varanasi K. K. Evaporative Crystallization of Spirals, Langmuir, 35, 10484-10490 (2019)

Girard H., **Khan S.,** Varanasi K. K. Multilevel robustness, Nature Materials 17, 298-300 (2018)

Khan S., Azimi G., Yildiz B., Varanasi K. K. Role of surface oxygen-to-metal ratio on the wettability of rare-earth oxides, Applied Physics Letters, 106, 061601 (2015)

Sami Khan, Ph.D. s_khan@sfu.ca

Azadi P., **Khan S.,** Strobel F., Azadi F., Farnood R. Hydrogen Production from Cellulose, Lignin, Bark, and Model Carbohydrates in Supercritical Water using Nickel and Ruthenium Catalysts, Applied Catalysis 'B' Journal, 17-118, 330-338 (2012)

Notzl H.*, **Khan S.*,** Verbaan N. Hydrometallurgical Plant Design Parameters for the Avalon Rare Earth Extraction Process, Proceedings of the Conference of Metallurgists, Montreal (2013)

SELECTED INVITED TALKS

1. Invited Presentation, "Innovating at Electrochemical Interfaces", Norwegian University of Science and Technology (NTNU), Trondheim, Norway, **November 2021**
2. Invited Speaker and Panelist, "Innovating at Interfaces: Enhancing Performance and Longevity of Sustainable Energy Systems", University of Oslo (UiO) Energy Forum, Oslo, Norway, **November 2021**
3. Invited Presentation, "Innovating at Interfaces: Enhancing Performance and Longevity of Sustainable Energy Systems", Lund University, Malmo, Sweden, **November 2021**
4. Invited Presentation, "Innovating at Interfaces: Enhancing Performance and Longevity of Sustainable Energy Systems", Technical University of Denmark, Department of Chemical Engineering, Lyngby, Denmark, **November 2021**
5. Invited Research Seminar, "Innovating at Interfaces: Enhancing Performance and Longevity of Sustainable Energy Systems", Fraunhofer Institute for Nanotechnology, Hamburg, Germany, **November 2021**
6. Invited Speaker, "Boosting the Efficiency of CO_2 Capture and Conversion Systems using Gas-capturing Surfaces", Carbon Capture Summit, **November 2021**
7. Invited Speaker, "Innovating at Interfaces: Enhancing Performance and Longevity of Sustainable Energy Systems", Simon Fraser University, Department of Chemistry, **October 2021**
8. Invited Speaker, "Smart, self-healing coatings to mitigate corrosion and hydrogen embrittlement", 49th Annual Review Meeting of the National Research Council of Canada, Oil Sands Mining and Corrosion Research Group, **June 2021**
9. Invited Speaker, "Innovating at Interfaces: Enhancing Performance and Longevity of Sustainable Energy Systems", Chartered Engineers Pacific Monthly Talk Series, **May 2021**

TEACHING CONTRIBUTIONS

Course	Term	Level	Students
SEE 475 "Fundamentals of Process Design"	Spring 2022	Undergrad	9
SEE 221 "Statics and Mechanics of Materials"	Summer 2021	Undergrad	36
SEE 820 "Materials Design for Energy Systems"	Spring 2021	Graduate	18

SELECTED AWARDS & HONOURS

- Recognition at SFU's Annual Awards Celebration for Action Canada **2022**
- Action Canada Fellowship **2021**
- Finalist, Hydrogen Can Science Slam Competition held at the Berlin Science Week **2020**
- Government of Canada Instant Award for outstanding teamwork and commitment **2020**
- Marcel Pourbaix Prize (1st place) for Best Poster, Annual NACE Corrosion Conference **2019**
- Best Presenter Prize, MIT Microsystems Technical Lab Annual Research Conference **2018**
- NSERC PGS-D Graduate Award **2016**
- Young Researcher Award received at the World Hydropower Congress in Beijing **2015**
- Hydro Research Foundation Award from the US Department of Energy **2014**

Associate Professor Vincenzo Pecunia, PhD Cantab., FIMMM, SMIEEE

Pecunia Research Group—Sustainable Optoelectronics
School of Sustainable Energy Engineering, Simon Fraser University, Surrey (BC), Canada
vincenzo_pecunia@sfu.ca, www.pecuniaresearch.com, www.sfu.ca/see/people/faculty/vincenzo-pecunia.html

Current Role

- **Associate Professor** and **Head** of the ***Pecunia Research Group—Sustainable Optoelectronics***, School of Sustainable Energy Engineering, **Simon Fraser University** (Canada).

Professional Designations

- **Fellow** of the **Institute of Materials, Minerals and Mining** (FIMMM).
- **Senior Member** of the **Institute of Electrical and Electronics Engineers** (SMIEEE).

Education

- **2009-2015, PhD in Physics**, Cavendish Laboratory, University of Cambridge (UK).
- **2007-2009, MSc in Electronic Engineering**, Politecnico di Milano (Italy), *cum laude*.
- **2007-2008, Postgraduate Exchange Program in Electronic Engineering**, University of Texas at Austin (USA).
- **2003-2007, BSc in Electronic Engineering**, Politecnico di Milano (Italy), *cum laude*.

Research Experience

- **2021-present**, **Associate Professor** and **Head** of the ***Pecunia Research Group—Sustainable Optoelectronics***, School of Sustainable Energy Engineering, **Simon Fraser University** (Canada)
- **2016-2021, Associate Professor** and **Head** of the ***Pecunia Research Group—Thin-Film Optoelectronics***, Institute of Functional Nano & Soft Materials, **Soochow University** (China).
- **2016-2020, Visiting Researcher** at the **Cavendish Laboratory, University of Cambridge** (UK).
- **2014-2016, Postdoctoral Research Associate** at the ***Optoelectronics Group*** of the **Cavendish Laboratory, University of Cambridge** (UK).
- **2009-2015, doctoral researcher** at the ***Optoelectronics Group*** of the **Cavendish Laboratory, University of Cambridge** (UK).
- **2008-2009, full-time research** at the ***Organic Electronics Group***, **Politecnico di Milano** (Italy).

Research Interests

- Environmentally friendly, printable semiconductors.
- Development, optimization, and integration of devices (e.g., solar cells, thin-film transistors, photodetectors) for environmentally friendly, printable (opto-)electronics and photovoltaics.
- Experimental characterization of the optoelectronic properties of printable semiconductors.

Teaching Experience

- ***Feedback Control Systems,*** MSc and PhD in Sustainable Energy Engineering, Simon Fraser University (Canada).
- ***Photovoltaics for Green Energy,*** MSc in Sustainable Energy Engineering, Simon Fraser University (Canada).
- ***Charge Transport Physics of Advanced Optoelectronic Materials***, Master's and PhD in Nanoscience and Nanotechnology, Soochow University (China).
- ***Fundamentals* of *Electronics,*** Bachelor's in Nanoscience and Nanotechnology, Soochow University (China).
- ***Thin-Film Transistors***, Nano Science & Technology Doctoral Training Centre, University of Cambridge (UK).
- **Research supervision** of undergraduate and postgraduate students (12 in total to date) within own research group.

Postgraduate Research Theses Supervised as Principal Supervisor

- Kai Xia, 'Solution-Processed Non-Fullerene-based Organic Photodiodes for Narrowband Red-Light Detection', June 2019.
- Yue Yuan, 'Impact of Morphology and Device Structure on Silver-Bismuth Iodide Solar Cells', June 2019
- Fengzhu Li, 'Harnessing Lead-free $Rb_3Sb_2I_9$ Perovskite Derivative Towards Higher Photovoltaic Performance', June 2019.
- Yueheng Peng, 'Perovskite-Inspired Antimony- and Bismuth-Based Lead-Free Photovoltaics', June 2020.
- Yang Cao, 'Solution-Processed Fullerene-Free Organic Photodiodes for Narrowband Green Light Detection', June 2020.
- Yachen Li, 'Electrical Characteristics of Organic and Semiconducting Single-Walled Carbon Nanotubes Thin-Film Transistors for Solution-Processible Electronics', June 2020.
- Yan Wang, 'Fabrication of Perovskite Thin-Film Hall Devices for the Study of Their Charge Transport Properties', June 2020.
- Jing Zhao, 'Defect Characterization of Perovskite Derivatives via Photo-Induced Current Transient Spectroscopy', June 2021.
- Ting Zhao, 'Photodetectors Based on Solution-Processed Organic Semiconductors towards a Dual-Band Vertically-Stacked Device Architecture', June 2021.
- Jianjun Mei, 'Dual-function $A_3Sb_2X_9$ Optoelectronic Devices for Self-powered Photodetection and Indoor Photovoltaics', June 2022.

Selected Peer-Reviewed Books

- **V. Pecunia**, 'Organic Narrowband Photodetectors: Materials, Devices and Applications', ***Institute of Physics (IOP) Publishing***, Bristol, UK, 2019.
- **V. Pecunia**, M. Fattori, S. Abdinia, E. Cantatore, H. Sirringhaus, 'Organic and Amorphous-Metal-Oxide Flexible Analogue Electronics', ***Cambridge University Press***, Cambridge, UK, 2018.

Selected Peer-Reviewed Journal Articles

- D. Venkateshvaran, M. Nikolka, A. Sadhanala, V. Lemaur, M. Zelazny, M. Kepa, M. Hurhangee, A. J. Kronemeijer, **V. Pecunia**, I. Nasrallah, I. Romanov, K. Broch, I. McCulloch, D. Emin, Y. Olivier, J. Cornil, D. Beljonne, H. Sirringhaus†, Approaching Disorder-Free Transport in High-Mobility Conjugated Polymers, ***Nature***, 515, 384–388, 2014 (IF = 49.962).
- **V. Pecunia†**, M. Nikolka, A. Sou, I. Nasrallah, A. Y. Amin, I. McCulloch, H. Sirringhaus†, Trap Healing for High-Performance Low-Voltage Polymer Transistors and Solution-Based Analog Amplifiers on Foil, ***Advanced Materials***, 29, 1606938, 2017 (IF = 30.849).
- F. S. F. Brossard*† and **V. Pecunia*†**, A. J. Ramsay, J. P. Griffiths, M. Hugues, H. Sirringhaus, Inkjet Printed Nanocavities on a Photonic Crystal Template, ***Advanced Materials,*** 29, 1704425, 2017 (IF = 30.849).
- Y. Hu* and **V. Pecunia***, L. Jiang, C. Di, X. Gao, H. Sirringhaus†, Scanning Kelvin Probe Microscopy Investigation of the Role of Minority Carriers on the Switching Characteristics of Organic Field-Effect Transistors, ***Advanced Materials***, 28, 4713–4719, 2016 (IF = 30.849).
- J. Kronemeijer†, **V. Pecunia**, D. Venkateshvaran, M. Nikolka, A. Sadhanala, J. Moriarty, M. Szumilo, H. Sirringhaus†, Two-Dimensional Carrier Distribution in Top-Gate Polymer Field-Effect Transistors: Correlation between Width of Density of Localized States and Urbach Energy, ***Advanced Materials***, 26, 728–733, 2014 (IF = 30.849).
- **V. Pecunia†**, C. Kim, J. Zhao, B. Tuttle, J. Mei, F. Li, Y. Peng, T. N. Huq, N. D. Kelly, S. Dutton, R. L. Z. Hoye, K. Xia, J. L. MacManus-Driscoll, H. Sirringhaus, Assessing the Impact of Defects on Lead-Free Perovskite-Inspired Photovoltaics via Photoinduced Current Transient Spectroscopy, ***Advanced Energy Materials***, 11, 2003968, 2021. (IF = 29.368)
- **V. Pecunia*†**, L. Occhipinti, R. L.Z. Hoye*†, Emerging Indoor Photovoltaic Technologies for Sustainable Internet of Things, ***Advanced Energy Materials***, 11(29), 2100698, 2021 (IF = 29.368).
- Y. Peng, T. N. Huq, J. Mei, L. Portilla, R. A. Jagt, L. G. Occhipinti, J. L. MacManus-Driscoll, R. L. Z. Hoye†, **V. Pecunia†**, Lead-Free Perovskite-Inspired Absorbers for Indoor Photovoltaics, ***Advanced Energy Materials***, 11, 2002761, 2021, (IF = 29.368).
- J. Mei*, M. Liu, P. Vivo, **V. Pecunia*†**, Two-Dimensional Antimony-Based Perovskite-Inspired Materials for High-Performance Self-Powered Photodetectors, ***Advanced Functional Materials***, 31, 2106295, 2021 (IF = 18.808).
- T. N. Huq, L. C. Lee, L. Eyre, W. Li, R. A. Jagt, C. Kim, S. Fearn, **V. Pecunia**, F. Deschler, J. L. MacManus-Driscoll, and R. L. Z. Hoye†, Electronic Structure and Optoelectronic Properties of Bismuth Oxyiodide Robust against Percent-Level Iodine-, Oxygen-, and Bismuth-Related Surface Defects, ***Advanced Functional Materials***, 30, 1909983, 2020 (IF = 18.808).
- S.V.N. Pammi, M. Reddeppa, V.D. Tran, J.H. Eom, **V. Pecunia**, S. Majumder, M.D. Kim, S. G. Yoon†, CVD-Deposited Hybrid Lead Halide Perovskite Films for High-Responsivity, Self-Powered Photodetectors with Enhanced Photo Stability Under Ambient Conditions, ***Nano Energy***, 74, 104872, 2020 (IF: 17.881).
- **V. Pecunia†**, Y. Yuan, J. Zhao, K. Xia, Y. Wang, S. Duhm, L. Portilla, F. Li, Perovskite-Inspired Lead-Free Ag_2BiI_5 for Self-Powered NIR-Blind Visible Light Photodetection, ***Nano-Micro Letters***, 12:27, 2020 (IF = 16.419).
- L. Portilla*, J. Zhao†, Y. Wang, L. Sun, F. Li, M. Robin, M. Wei, Z. Cui, L. G. Occhipinti†, T. D. Anthopoulos†, **V. Pecunia*†**, Ambipolar Deep-Subthreshold Printed-Carbon-Nanotube Transistors for Ultralow-Voltage and Ultralow-Power Electronics, ***ACS Nano***, 14, 14036–14046, 2020 (IF = 15.881).

Selected Patents

- H. Sirringhaus, K. Banger, **V. Pecunia**, US Patent no. 10,573,759 B2, 25 February 2020.
- F. S. F. Brossard, **V. Pecunia**, Photonic Device, European Patent no. EP3333605, October 2019.
- **V. Pecunia**, L. Portilla, J. Zhao, Carbon Nanotubes Devices, PCT No.: PCT/CN2020/095722, June 2020 (pending).

Selected Scholarly Activities

- **Invited speaker at international conferences:** IEEE International Conference on Communication Technology; IEEE Optoelectronics Global Conference; International Thin-Film Transistor Conference, International Flexible Electronics Technology Conference; Materials Research Society (MRS) Meeting; IEEE Electron Devices Technology and Manufacturing Conference; International Conference on Advanced Electromaterials; International Meeting on Information Display; World Nano Congress on Advanced Science and Technology.
- **Editorial Board Member** of ***Nanotechnology*** (Institute of Physics Publishing), ***Journal of Physics: Materials*** (Institute of Physics Publishing), ***SN Applied Sciences*** (Springer Nature), and ***Frontiers in Electronics.***
- **Lead Editor or Co-Guest Editor** of **Special/Focus Issues** for ***Journal of Physics: Materials*** **(Institute of Physics Publishing),** ***Nanotechnology*** **(Institute of Physics Publishing),** ***IEEE Sensors Journal, Materials Today Chemistry, Frontiers in Electronics, Frontiers in Sustainability***.
- **Conference organization: Organizing Committee Member** for Innovation in Large Area Electronics Conference; **Organizing Committee Member** for IEEE International Conference on Flexible and Printable Sensors and Systems; **International Advisory Committee Member** for World Nano Congress on Advanced Science and Technology.

VAHID HOSSEINI, Ph.D., P.Eng.

ACADEMIC APPOINTMENTS

Simon Fraser University – Associate Professor of Sustainable Energy Engineering (2021- Now)
University of Alberta - Adjunct Professor of Mechanical Eng. (2018- 2121)
Sharif University of Technology - Associate Professor of Mechanical Eng. (2010-2021)
Carleton University - Sessional instructor (2008-2009)

EDUCATION

Doctor of Philosophy (Ph.D.), Mechanical Engineering	2008
University of Alberta, Edmonton, Alberta, Canada	
Master of Science (MSc), Mechanical Engineering	1999
Sharif University of Technology, Tehran, Iran	
Bachelor of Science (BSc), Mechanical Engineering	1997
Sharif University of Technology, Tehran, Iran	

TEACHING EXPERIENCES

Simon Fraser University, Thermodynamics for energy engineering	2022
University of Alberta, Applied thermodynamics, Fluid mechanics II	2019-2021
Sharif University of Technology, Thermodynamics I and II, Fuel and combustion, Mechanical measurement, Marine propulsion, Internal combustion engine, Advanced internal combustion engine, Advanced combustion	2010-2021
Carleton University, Applied thermodynamics, Convective heat and mass transfer	2009-2010

Selected peer-reviewed journal PUBLICATIONS

- Shahbazi*, H., Mostafazade, A., Alizadeh*, H., Salavati, H., Zokaei, H., Zandavi, R., Torbatian, S., Yazgi, D., **Hosseini, V.**, An emission inventory update for Tehran: The difference between air pollution and greenhouse gas source contributions, Atmospheric Research, Volume 275, 2022, 106240.
- Zarrinkolah*, M., T., **Hosseini, V.**, Detailed Analysis of the Effects of Biodiesel Fraction Increase on the Combustion Stability and Characteristics of a Reactivity-Controlled Compression Ignition Diesel-Biodiesel/Natural Gas Engine, Energies 2022, 15(3), 1094
- Wine, O., Osornio-Vargas, A., Campbell, S.M., **Hosseini, V.**, Koch, C.R., Shahbakhti, M., Cold Climate Impact on Air-Pollution-Related Health Outcomes: A Scoping Review, International Journal of Environmental Research and Public Health, 19 (3), 1473 (link)
- Moradpour* M. **Hosseini, V.**, (2020). An investigation into the effects of green space on air quality of an urban area using CFD modelling, Urban Climate, 34, 100686.
- Shahbazi*., H., Hosseini, V., (2020) Impact of mobile source emission inventory adjustment on air pollution photochemical model performance, Urban Climate, 32, 100618.
- Torbatian, S., Hoshyaripour, A., Shahbazi*., H., Hosseini, V., (2020), Air pollution trends in Tehran and their anthropogenic drivers, Atmospheric Pollution Research 11 (3), 429-442.
- Esmaeilirad*, S., Lai, A., Abbaszade, G., Schnelle-Kreis, J., Zimmermann, R.,Uzu, G., Daellenbach, K., Canonaco, F., Hassankhany, H., Arhami, M., Baltensperger, U., Prévôt, A., Schauer, J., Jaffrezo, J.-L., Hosseini, V., El Haddad, I., (2020). Source Apportionment of Fine Particulate Matter in a Middle Eastern Metropolis, Tehran-Iran, Using PMF with Organic and Inorganic Markers, Science of Total Environment, 705, 135330.
- Taheri A., Aliasghari*, P. Hosseini, V., (2019). Black carbon and PM2.5 monitoring campaign on the roadside and residential urban background sites in the City of Tehran, Atmospheric Environment, 218, 116298.

- Shahbazi*, H., **Hosseini, V.**, Torbatian, S., Hamedi, S., (2019). Assessment of emission reduction scenarios with a focus on the impact of vehicle fleets on Tehran air quality: case study, Transportation Research Record: Journal of the Transportation Research Board, 2673(5), 197-207.
- Shahbazi*, H., Hasani*, A., **Hosseini, V.**, (2019). Evaluation of Tehran clean air action plan using emission inventory approach, Urban Climate, 27. 446-456.
- Esmailirad*, S., **Hosseini, V.**, (2018). Modelling the formation of traditional and non-traditional secondary organic aerosols from in-use, on-road gasoline and diesel vehicles exhaust, Journal of Aerosol Science, 124, 68-82.
- Reyhanian*, M., **Hosseini, V.**, (2018). Various effects of reformer gas enrichment on natural gas, iso-octane and normal-heptane HCCI combustion using artificial inert species method, Energy Conversion and Management, 2018
- Doozandegan*, M., **Hosseini, V.**, Ehteram, M., (2017). Solid nanoparticle and gaseous emissions of a diesel engine with a diesel particulate filter and use of a high-sulphur diesel fuel and a medium-Sulphur diesel fuel, Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering, 231(7), 941-951.
- Hasani*, A., **Hosseini, V.**, (2016). An assessment of gasoline motorcycle emissions performance and understanding their contribution to Tehran air pollution, Transportation Research Part D: Transport and Environment, 47, 1-12.
- Banitalebi*, E., **Hosseini, V.**, (2016). Development of Hot Exhaust Emission Factors for Iranian-made Euro-2 Certified Light-Duty Vehicles, Environmental Science and Technology, 50(1), 279-284.
- Tabatabaie*, T., Ehteram, M., **Hosseini, V.**, (2016). Investigating the effect of the heat transfer correlation on the predictability of a multi-zone combustion model of a hydrogen-fueled spark ignition engine, Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering, 230(1), 70-81.

Gradute Student supervision

Ph.D. Thesis (7)

- H. Shahbazi, Ph.D. thesis adviser, use of inverse modelling to improve emission inventory, 2015-2021
- H. Amini, Ph.D. thesis committee member (Main adviser Prof. Nino Künzli, Swiss Tropical and Public Health Institute, University of Basel, Basel, Switzerland), Air quality in Tehran, Iran: evaluating acute health effects and modelling the long-term spatial variability, 2014-2017
- M. Zarrinkolah, Ph.D. thesis adviser, Experimental and numerical analyses of various modes of diesel-natural gas low-temperature RCCI combustion, 2013- present
- M.Moradpour, Ph.D. thesis adviser, Analyses of the effects of urban green space on local air pollution using computation fluid dynamics, 2012- 2020
- S. Esmailairad, Ph.D. thesis adviser, Understanding secondary organic aerosol formation in Tehran air by numerical simulation, 2012- 2019
- M. Mohebbi, Ph.D. thesis co-adviser (Prof. Azhar AA and Prof. Farid, M.M.S of UTM University of Malaysia), reactivity controlled compression ignition combustion in a light-duty diesel engine using alternative fuels, 2012-2019
- M. Reyhanian, Ph.D. thesis adviser, Experimental and numerical simulation of HCCI combustion of fuels of different chemical characteristics, 2011- 2022

MSc theses (35)

VIVIAN ELAINE NEAL, M.E.T., P.Eng.
School of Sustainable Energy Engineering, Simon Fraser University
10285 University Drive, Surrey BC V3T 0N1
vneal@sfu.ca 1-778-782-7466

SCHOOL OF SUSTAINABLE ENERGY ENGINEERING, June 2019-present

Teaching:

- SEE 101W Process, Form and Convention in Professional Genres
  - Fall 2019, Fall 2020, Fall 2021
- SEE 896 MASc Research Seminar / SEE 897 PhD Research Seminar
  - Fall 2019, Spring 2020, Summer 2020, Fall 2020, Spring 2021, Summer 2021, Fall 2021

Service:

- Work Integrated Learning Liaison, Fall 2019-Summer 2021
- SEE Graduate Program Committee, Spring 2020-present
- SEE Undergraduate Program Committee, Fall 2021-present
- SEE Undergraduate Program Accreditation Committee, Fall 2020-Fall 2021
- SEE Hiring Committees for faculty positions: 4 tenure track, 4 teaching track, 2 professor of professional practice, Dec 2019-Oct 2022
- School of Computing Science Hiring Committee - Lecturer, Oct 2019-May 2020

Teaching Innovation:

- Initiated and shepherded the development of the SEE Sustainability and Equity Guiding Principles and Commitments
- Co-organized, with Faculty Teaching Fellow, monthly discussions about teaching for FAS faculty members, June 2019-June 2020
- Aga Khan University – pro bono support
  - Adjudicator for teaching and learning grants, Fall 2020-present
  - Outcome Based Education – member of high-level committee to direct the institutional transition, Fall 2021-present

EDUCATION

- Master of Educational Technology, Faculty of Education, University of British Columbia, Vancouver, BC, 2008. Focused on education for sustainable development.
- Bachelor of Applied Science, Systems Design Engineering, University of Waterloo, Waterloo, ON, 1986. Interdisciplinary engineering program oriented to technical as well as economic, social and political problems.
- Bachelor of Independent Studies, Integrated Studies, University of Waterloo, Waterloo, ON, 1982. Self-directed studies focusing on solar energy and energy conservation.

PROFESSIONAL AFFILIATIONS

- Professional Engineer, Professional Engineers Ontario, member since 1993
- Society for Teaching and Learning in Higher Education, member since 2004
- International Journal of Sustainability in Higher Education, referee since Jan 2014

WORK EXPERIENCE

Educational Consultant, Teaching and Learning Centre, SFU, Aug 2010-May 2019

- Enhancing academic programs through consultations on curriculum development and program assessment, collaborating with deans, program directors and faculty members to design, revise and evaluate the programs.
- Improving approaches to faculty development by integrating national and international best practices such as facilitating peer teaching observations, encouraging the sharing of resources on effective teaching and course design, and providing opportunities for faculty peer dialogue about teaching

Sessional Lecturer, Mechatronic Systems Engineering, SFU

- MSE801 Writing for Engineers, Fall 2017, Fall 2018
- MSE401W Project Documentation and Group Dynamics, Spring 2014
- MSE402 Engineering Ethics, Law and Professional Practice, Spring 2014

Academics Without Borders Volunteer, Aga Khan University, Nairobi, Kenya, May-Sept 2014 & Apr-Aug 2017

- Mentored Director and staff to establish a teaching and learning unit, and development of the Teaching and Learning Strategic Plan 2015-2020
- Brought SFU's Rethinking Teaching workshop to AKU

Lecturer, Educational Development Unit, Plymouth University, UK, 2008-2010

- Program Director, Graduate Teaching Associates Program
  - LTHE300, 2008-2009 and 2009-2010
  - GTA Workshop, a one-week intensive course, taught seven cohorts, 2008-2010
- Instructor, Post Graduate Certificate in Learning and Teaching in Higher Education
  - LTHE561 Learning Technologies, co-taught in 2008-2009, lead in 2009-2010
  - LTHE511 Introduction to LTHE, co-taught in 2008-2009 & 2009-2010
  - LTHE521 Teaching Development Project, co-taught in 2008-2009 & 2009-2010

Program Director, Educational Support and Innovation, SFU, 2004-2008

- Lead curriculum development teams to develop and enhance online and in-person courses and programs, collaborating with faculty members, program directors, and learning technology specialists.
- Improved teaching practices for online, blended and in-person courses, through consultations, leading workshops, and sharing literature and resources.

Mahda Jahromi, Ph.D., P.Eng., SMIEEE

Email: Mahda.Jahromi@ieee.org
Phone: (+1) 778-782-7184

SRYE – #5139
10285 University Drive
Surrey, BC, V3T 0N1

EDUCATION

- **Fellowship, Mechatronic Systems Engineering**
  Simon Fraser University – Canada, (Jan 2012 -Jul 2012)
  Project: *Precision Control of Electromechanical Systems Using Quadrature Vector Control Technique*

- **Ph.D., Electrical and Electronics Engineering**
  Nanyang Technological University – Singapore, (2008–2013)
  Thesis Title: *Study of Planning and Operational Aspects of Tidal In-Stream Power Generation*

- **M.Sc., Electrical Power Engineering** (Highest CGPA in cohort & Valedictorian)
  Shiraz University – Iran (2004 – 2007)
  Thesis Title: *Optimal Allocation of Distributed Generation in MV Grid-networks for Voltage Sag Mitigation*

- **B.Sc., Electronics Engineering** (1st Class Honors)
  Yazd University – Iran, (1999 – 2004)
  Thesis Title: *Design & Development of a Phone-Activated Supervisory Controller for Remote Control of Irrigation Systems*

ACADEMIC CAREER (IN CHRONOLOGICAL ORDER)

- **Simon Fraser University – Canada** *August 2019 – Present*
  - Chair - Undergraduate Program Accreditation Committee
  - Lecturer, Sustainable Energy Engineering, Simon Fraser University
    Courses (Developed & Taught): SEE 230, SEE 231, SEE 251, SEE 331, SEE 342, SEE 464

- **British Columbia Institute of Technology – Canada** *August 2016 - August 2019*
  - Program Head, Electrical and Computer Engineering
  - Instructor, Electrical and Computer Engineering
    Courses (Taught): ELEX 1102, ELEX 1117, ELEX 2117, ELEX 2105, ELEX 2205, ELEX 3403, ELEX 4440, ELEX 7350

- **Nanyang Technological University – Singapore** *September 2010 - September 2012*
  - Sessional Instructor, Electrical and Electronics Engineering
    Courses (Taught): EE2005

- **Shiraz Azad University – Iran** *September 2006 - July 2008*
  - Instructor, Electrical and Electronics Engineering
    Courses (Developed & Taught): Electric Machines, Power Systems Studies, Fuzzy Logic Systems, Linear Control Systems

INDUSTRIAL CAREER (IN CHRONOLOGICAL ORDER)

- **Mithra Solar Solutions Inc.** *(Technology Startup - Metro Vancouver) Feb. 2016 –Present,*
  - Founder and Director

- **Traxx Industrial Automation** *(System Integrator - Metro Vancouver) Apr 2015 – Jan 2016*
  - Senior Electrical Engineer & Engineering Lead

- **Endurance Wind Power Inc.** *(OEM - Metro Vancouver) Jul 2012 – Mar 2015*
  - Senior Electrical Engineer

- **Rolls-Royce Renewable Energies Lab at NTU**. *(R&D – Singapore)* *Aug 2009- Jan 2012*
  - Research Assistant
- **Cement Engineering Services** *(EPC/M - Iran)* *Sep 2004- Aug 2008*
  - Senior Electrical Engineer
  - Project Engineer

PATENTS & PUBLICATIONS

- **Mahda J. Jahromi**, Daryl Musselman, Endurance Wind Power, Portable Electric Braking System for Wind Turbines with Induction Generators – Int. Patent - WO2016095045

- **M. J. Jahromi**, *"Application of Feedforward Compensation in the Design of Active Front-End Converters"*, IEEE Vehicular Technology Conference, Helsinki, June 2022
- **M. J. Jahromi,** A. I. Maswood, and K. J. Tseng, *"Design and Evaluation of a Tidal In-Stream Generator Power Port"*, Systems Journal, IEEE, vol. PP, pp. 1-1, 2013.
- **M. J. Jahromi,** A. I. Maswood, and K.J. Tseng, *"Design and Evaluation of a New Converter Control Strategy for Near Shore Tidal Turbines"*, Industrial Electronics, IEEE Transactions, vol. PP, pp. 1-1, 2012.
- **M. J. Jahromi**, A. I. Maswood, and K.J. Tseng, "Long Term Prediction of Tidal Currents", Systems Journal, IEEE, vol. 5, pp. 146-155, 2011.
- **Mahda J. Jahromi**, A. I. Maswood, K.J. Tseng, Bicky Bhangu, *"Tidal In-Stream Generation with Improved PCC Voltage Profile"*, IEEE-PES Innovative Smart Grid Technologies Conference, Washington, D.C., 2012
- **Mahda J. Jahromi**, A.I. Maswood, and K.J. Tseng, Bicky Bhangu, *"Maximum Power Extraction of Tidal Streams"*, IEEE - PES Innovative Smart Grid Technologies Conference, Washington, D.C., 2012
- **Mahda J. Jahromi**, A.I. Maswood, and K.J. Tseng, *"Comparison of Different Techniques for Short Term Prediction of Tidal Current Speeds"*, IEEE PES General Meeting, Minneapolis, Minnesota, USA , July 2010
- **Mahda J. Jahromi**, M.H. Haque and K.J. Tseng, *"Siting and sizing of distributed generation using three new indices"*, IASTED International Conference on Solar Energy, SOE, Phuket, March 2009
- **M. J. Jahromi**, E. Farjah, and M. Zolghadri, *"Mitigating voltage sag by optimal allocation of Distributed Generation using Genetic Algorithm"*, in Electrical Power Quality and Utilization, 2007. EPQU 2007. 9th International Conference on, 2007, pp. 1-6.
- **M. J. Jahromi**, S. Meshksar, E. Farjah, and M. Zolghadri, *"Voltage Sag State Estimation for Power Distribution Systems Using Kalman Filter"*, IEEE International Symposium on Industrial Electronics, 2007, pp. 2449-2453.
- S. Meshksar, **M. J. Jahromi**, O. Dehzangi, and A. J. Jahromi, *"Nonlinear control of distillation column using feedback linearization"*, in Proceedings of the 26th IASTED International Conference on Modelling, Identification, and Control, 2007, pp. 277-284.
- S. Meshksar, A. Khayatian, **M. J. Jahromi**, and M. Hashemi, *"Modeling and Identification of a Pilot Distillation Column for Control and Estimation Using Genetic Algorithms"*, in Industrial Electronics Society, 2007. IECON 2007. 33rd Annual Conference of the IEEE, 2007, pp. 586-591.

Appendix 7: Budget for the proposed program (financial and personnel)

The MEng in Sustainable Energy Engineering program was a core component of the financial plan when the School of Sustainable Energy Engineering was approved. The cohort size and resource needs of the MEng program described in this FPP are aligned with the approved school plan. The required lab space, equipment, and support resources are available within the Faculty of Applied Science and SEE footprint in the SRYE building. No additional resources beyond what were previously approved are anticipated. In particular:

- The anticipated graduate student population used in the resource planning for SEE is 120 students. This includes a total of 40 students in the proposed MEng cohorts as they progress through the program outlined in this FPP.
- The SEE faculty hiring plan included the MEng program. This included teaching resources to support the six new courses that will be developed for the program. The teaching load requirements are expected to be met without additional faculty hires specific to this program.
- External (service) courses are being provided through the Beedie School of Business and the School of Resource and Environmental Management (REM). Delivery of these courses, which are not dedicated solely to the MEng program, can be accommodated within their existing faculty complements.
- The SEE support staff plan included the MEng program. No additional administrative or technical team roles will be needed to support this program.
- The MEng program will have access to the existing SRYE instructional laboratories (specifically, SRYE 1040 and SRYE 1056). Both laboratories have space to accommodate the additional demand within their existing schedules. In particular, SEE 771 – which will make most use of these labs – will run in the fall semester. Due to program schedules, the fall semester typically sees the lowest SEE utilization of these teaching lab spaces.
- The MEng will include a dedicated project workspace during the capstone project activities. This can be made available from the SRYE footprint allocated to SEE.

The proposed MEng degree will be classed as a Regular Program and as such, will carry standard tuition rates as per the following link: https://www.sfu.ca/gradstudies/apply/tuition-and-fees/tuition-types.html

Appendix 8: Delphi Report

DELPHI GROUP

TRANSFORM
CONVENE
ACTIVATE
EMPOWER

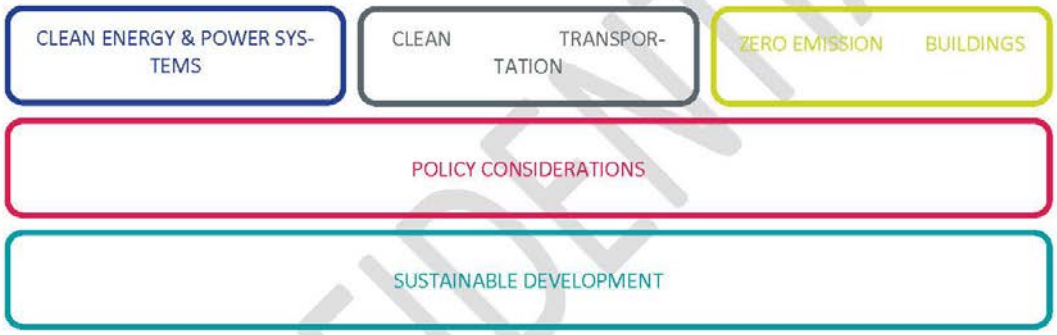
Executive Summary

Context

The climate imperative has led to a global low carbon transition. Mitigating environmental impacts, reducing and offsetting emissions, and building low carbon resilience to adapt to future climate scenarios are all topics at the top of mind of governments, corporations, and NGOs.

The response to the need for climate solutions is driving the development of new interdisciplinary training offerings in technology, governance, and policy. New skillsets needed include technical fundamentals, non-technical skills, leadership, communications, and problem solving.

Research Framework



Primary and secondary research was conducted to draw from existing knowledge on the demand for skills related to sustainable energy. This research sought to identify how industry and market trends link to driving the demand for new skills and the need for training.

The research included a series of key informant interviews with relevant stakeholders in industry, with a goal to better understand the demand for the potential graduates of the proposed MEng program. The research also included a comparative program analysis to better understand where FAS can add value to the market of related sustainable energy engineering programs.

Demand for Professionals in Sustainable Energy Engineering

Sustainable Development & Climate Resiliency

To account for the externalities from engineering activities, sustainability principles espouse systems-based thinking and a cradle-to-cradle approach in managing solutions, products, and projects. Additionally, they seek engineers to be innovative and proactive in identifying and mitigating risks and negative impacts.

Universities can help students become familiar with these concepts by including sustainable development and life cycle accounting approaches as key learning outcomes and course content.

Policy Considerations for a Sustainable Energy Future

From international climate targets to federal and provincial regulations, to professional codes of practice, to corporate sustainability policies, many important policy layers need to be considered by professionals.

Governments at all levels have commitments to carbon neutrality, creating a need for innovative leadership in the management of government building portfolios and corporate fleets. Engineers are being sought for roles that include both technical and policy aspects. For example, "plan-engineers" is an emergent field that in addition to engineering skills provides policy planning and economics support.

Clean Energy & Power Systems

Industries involved in planning, building, and maintaining clean energy and power systems are growing due to declining costs, growing demand for technologies, and support from conducive policies and investments.

Employers in clean energy and power systems described the need for fundamental skills in fields such as electrical and mechanical engineering, thermal engineering, renewable fuel technology and supply chain, and material science. Other important skills highlighted in the research include understanding the business and policy context of remote community development and First Nations engagement, and the impact of the projects on biodiversity and ecology.

Clean Transportation

Trends in the Clean Transportation sector include electrification, low carbon and renewable fuels, integration of digital and smart technologies to manage fleets and logistics, and the use of advanced materials as lightweight alternatives.

Employers in clean transportation described the need for engineers with foundational skills in several fields, including mechanical, electrical, systems, reliability, software, and controls. Due to advances in robotics and computer-controlled systems technology, employers are struggling to fill engineering positions that rely on combined skillsets in this key area.

Net Zero Energy Buildings & Sustainable Building Materials

Trends in net-zero energy buildings and materials include the development and implementation of high-performance building codes, building envelope technologies, digital platforms, low carbon materials, prefabrication and modular construction, and nature-based infrastructure.

Employers of engineers in the built environment are increasingly looking for a well-rounded knowledge of energy modelling, building science, and software applications. An understanding of practical applications of life cycle assessment and embodied carbon will prepare graduates for the growing building science and engineering job market.

Skills such as programming, data analysis, and data visualization can help graduates create a niche for themselves and build a career in this field.

Interdisciplinary Skills for Sustainability

Succeeding in emerging energy and environmental technology systems requires a broader set of knowledge and skills to complement foundational engineering training.

These include specific skills such as environmental awareness and risk analysis, as well as broader skills like leadership, communication, time management and teamwork.

Program Design Considerations

A core strength of leading programs lies in providing a "distinct interdisciplinary' experience which not only includes close collaboration with other faculties, but also that of students across different disciplines.

Some of the leading programs offer specializations in specific cleantech industries, while others provide a broad range of elective modules across cleantech sectors, their applications, as well as non-engineering disciplines. Seminars and workshops are also commonly included in curricula to expose students to different areas of sustainability practices.

Summary

An opportunity exists for SFU to shape and market their new program to the next generation of climate leaders. Many job seekers entering the workforce are looking specifically for a career in climate action, as they want their work to have a positive impact on the world.

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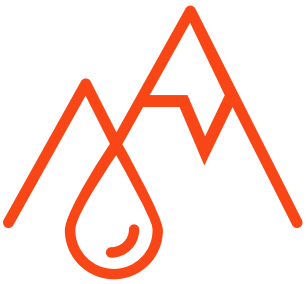
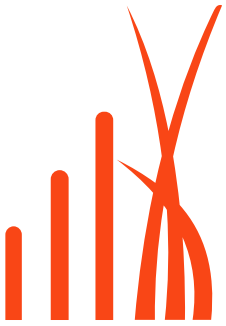
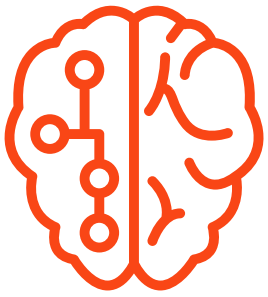




DELPHI GROUP



SFU Sustainable Energy Engineering

Master's Program Research

Phase 2 Report (Revised March 2022)

Disclaimer

The information, concepts and recommendations expressed in this document are based on information available at the time of the preparation of this document. Action or abstinence from acting based on the opinions and information contained in this document are the sole risk of the reader and Delphi shall have no liability for any damages or losses arising from use of the information and opinions in this document. All information is provided "as is" without any warranty or condition of any kind. The document may contain inaccuracies, omissions or typographical errors.

This report contains initial research findings from interviews and secondary research as part of a broader suite of project activities to support the SFU Sustainable Energy Engineering Master's Program Research. Further updates will be made to this report as and when other activities are completed, including additional interviews, an employer survey, and a student survey. As such, this report presents an interim summary of trends and drivers related to the demand for masters-level sustainable energy engineering graduates and the value of interdisciplinary training and skillsets.

Confidential

This document should be treated as confidential business information and should not be shared outside of "Simon Fraser University" without the expressed written consent of The Delphi Group and "Simon Fraser University".

Project Lead on behalf of The Delphi Group:

Ben Clark
bclark@delphi.ca

Contents

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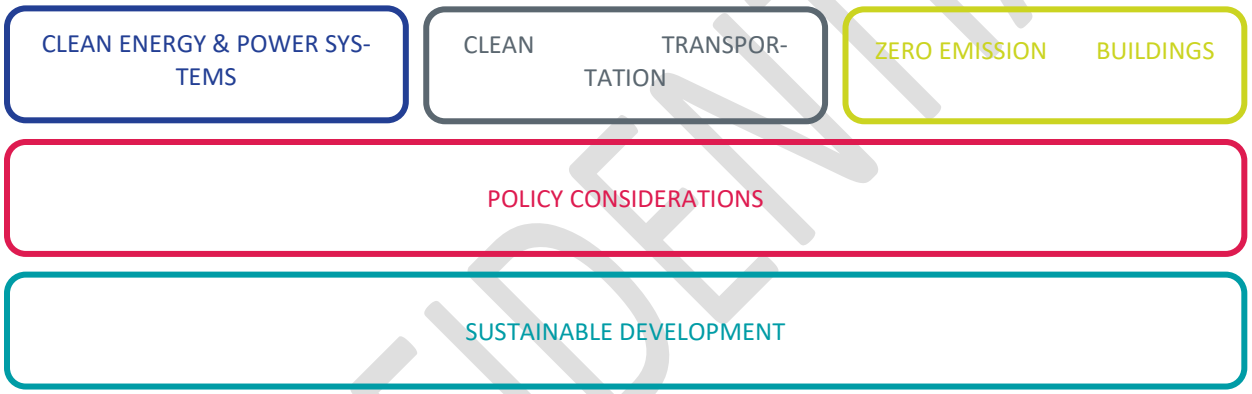

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1 Background

1.1 Context

The global shift to a low carbon economy is underway, driven by the ongoing and increasing threat of climate change. Extreme variations in climate and associated impacts are being felt across the globe in the form of flooding, droughts, forest fires, and sea level rise. This climate imperative is leading to a response in all sectors – in the form of government policy, business leadership, and civil society action.[1]

Sustainable, renewable energy sources are being mainstreamed and implemented at an accelerated rate, bringing down costs and making them accessible to more of the population. Related advances in technology, governance, and policy are driving the need for training in many areas - from improving the efficiency of existing processes and industries, to supporting the growth of new industries born through the need for climate solutions.

The complexity of the world and rapid pace of change in cleantech industries demands that training not be limited to a single discipline, but rather includes a broader set of knowledge and skills. The skillsets to support a low carbon economy include technical fundamentals, non-technical skills such as project management and policy analysis, and also soft skills including leadership, communication, and problem solving.

1.2 Purpose of study

To help meet the demand for training in the field of engineering, Simon Fraser University (SFU) launched a new interdisciplinary, application-focused undergraduate engineering program and a new set of thesis-based MASc and PhD graduate programs in Sustainable Energy Engineering (SEE) in 2019. The programs include foundational courses and specializations and provide a unique portfolio of subjects to prepare students for today's emerging energy and environmental technology systems.

The SFU Faculty of Applied Sciences (FAS) is now considering expanding on the initial flagship program with a new non-thesis-based Master of Engineering program (MEng), with a goal to have its Full Program Proposal (FPP) approved by SFU before the end of 2022. This proposed new interdisciplinary program will complement the existing thesis-based Master of Applied Science (MASc) program by combining elements of engineering with other fields, such as business, policy, and sustainability into the program design.

SFU's new MEng program will expand on existing graduate program offerings in SEE including a focus on three key sectors of clean technology: zero-emissions vehicles and transportation; zero-carbon / net-zero energy materials (e.g., for buildings); and clean power systems and smart grid / energy storage. Moreover, the program will have an underlying focus on broader sustainability and policy considerations to sustainable energy. These proposed program foci are described further in section 2.1 below.

[1] Civil society, also known as the 'third sector', includes community groups, non-governmental organizations, labour unions, professional associations, and foundations. https://www.weforum.org/agenda/2018/04/what-is-civil-society/

Master of Applied Sciences (MASc)

Deeply technical research-oriented thesis program

Master of Engineering (MEng)

Applied and practitioner-oriented course-based program

It should be noted that an MEng program is a course-based program suitable for those who want to work directly in the industry. By contrast, a MASc. program involves extensive research culminating in a thesis, so it prepares students for academia and research-based career. Thus, the proposed MEng will be distinct from the existing SEE MASc. in its program structure and approach.

The intended target audience for the program is undergraduate and graduate students seeking to enter the clean technology industry and relevant policy fields. Thus, this practitioner-oriented program will be designed to equip students with the skills necessary to support the low carbon transition and implement climate solutions in roles across many sectors and types of organizations.

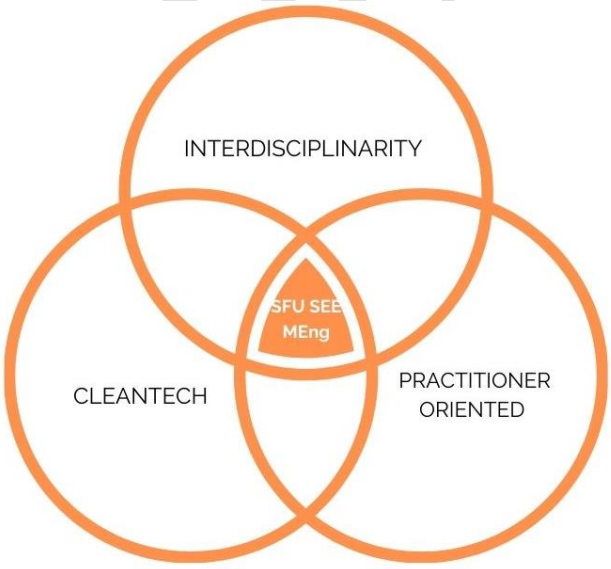


Figure 1 SFU SEE MEng Focus Areas

1.3 Approach

The project team took a collaborative approach to this background research by working with SEE faculty and staff to refine the scope and stakeholder engagement and iterate based on early findings.

Secondary research was conducted to draw from existing research on sustainable energy subsectors. This research sought to identify how industry and market trends link to driving the demand for new skills and the need for training. The research also focused on the need for an interdisciplinary workforce with a solid understanding of the complexity of twenty-first-century energy systems.

The research included a series of key informant interviews with relevant stakeholders in industry, with a goal to better understand the demand for the potential graduates of the proposed MEng program. Twelve key informant interviews were conducted by the project team, while additional advice was sought from the program advisory committee and other SEE partners.

A survey of cleantech employers was conducted in May 2021. The survey received 53 responses from both public and private sector employers working in areas such as renewable energy, clean transportation, green building design and construction, and resource sectors. A summary of survey results can be found in Appendix A2 of this report.

The research also included a comparative program analysis to better understand where FAS can add value to the market of related sustainable energy engineering programs. This analysis examined the content and design of other programs with specific considerations for the combination of interdisciplinary offerings and delivery formats, and how industry partnerships support ongoing program and curriculum development.

2 Research Findings

Through primary and secondary research, this study found a strong rationale for the establishment of a new graduate-level engineering program combining technical fundamentals, interdisciplinary skills, and hands-on experience. This section describes the factors driving demand for these skills in roles and industries related to sustainable energy engineering, and considerations for effective program design based on comparable programs in Canada and globally.

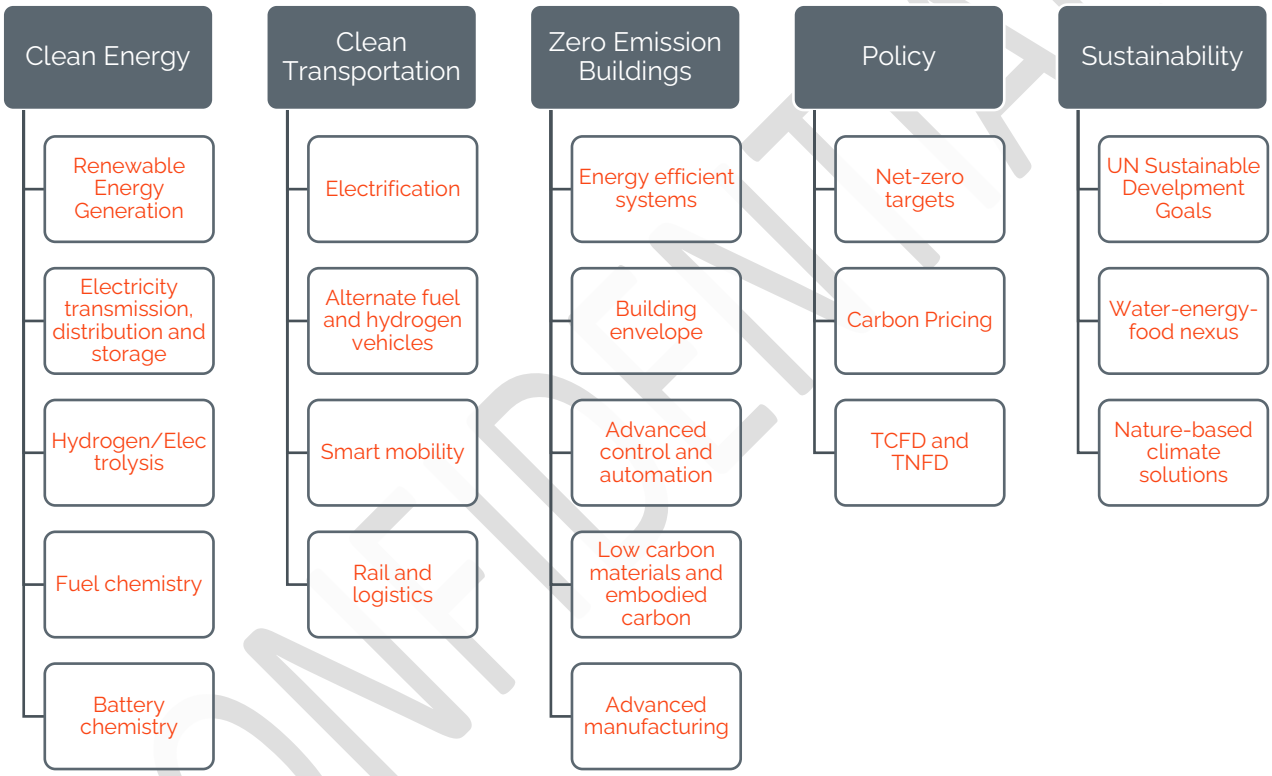


Figure 2: Research framework

2.1 Demand-side Analysis

Many factors influence the growing need for sustainable energy and climate solutions, and the subsequent demand for professionals with the right mix of skills and knowledge to design and implement solutions. These factors include policy drivers at all levels of government, market forces leading to major projects and investments, and technology advances in established and nascent fields.

This complex environment of policy, market forces, and technology is demanding a new kind of professional in many occupations and particularly in engineering. Engineers play a key role in addressing the climate imperative; they are expected to stay informed about potential climate impacts on their professional activities, and in turn are expected to consider the impacts of their work on the climate.[2]

The skills required for interdisciplinary engineers to meet the demands of today's complex work environment include technical skills in the form of traditional engineering fundamentals, non-technical or interdisciplinary skills in the form of policy analysis and stakeholder relations, and soft skills gained through experience in areas such as teamwork, leadership, and problem solving.

Sustainable Development & Climate Resiliency

Sustainable development and the many industries within it rely on professionals with an understanding of the environment, society, and economy as an interdependent system. Collaboration between professionals across sectors is necessary to effectively evaluate trade-offs in decision making and interdisciplinary inquiry is needed to develop a comprehensive understanding of the resource nexus.[3]

Following many years of work by numerous sub-national organizations to integrate climate and sustainability with engineering, the 2019 World Engineers Convention made a formal pledge to advance the UN Sustainable Development Goals (SDGs). Following this pledge, industry associations around the world have formalized guiding principles for engineers to address the broader issues of climate change and sustainable development in the local context.[4]

The UN SDGs where engineering skills are directly applicable include clean water and sanitation for all (Goal 6), availability of sustainable energy sources (Goal 7), creating strong and resilient infrastructure (Goal 9) and livable cities (Goal 11).

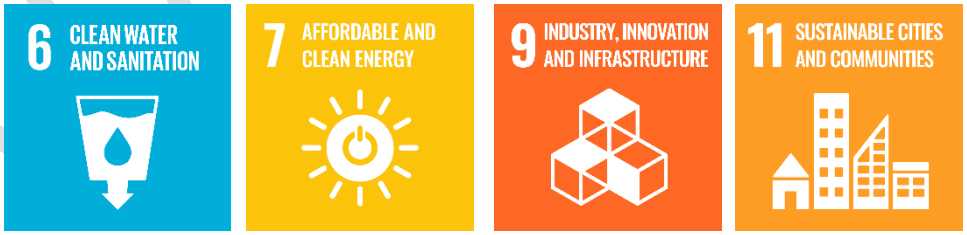


Figure 3: UN SDGs related to sustainable energy engineering

[2] EGBC Climate Change Action Plan, https://www.egbc.ca/Practice-Resources/Consultations/Climate-Change-Action-Plan
[3] https://iwaponline.com/aqua/article/70/2/138/79167/Environmental-sustainability-a-review-of-the-water
[4] https://www.engineersaustralia.org.au/News/engineering-sustainability-finding-right-tools-meet-crucial-un-goals

To internalize the externalities from engineering activities, sustainability principles espouse a systems-based thinking and cradle-to-cradle approach in managing solutions, products, and projects. Additionally, they seek engineers to be innovative and proactive in identifying and mitigating risks and negative impacts. Considerations of fairness and equity, as well as stakeholder engagement in the decision-making process, are also deemed important in achieving sustainability.[5] Universities can help students get familiarized with these capabilities by including concepts of sustainable development and life cycle accounting approaches in key learning outcomes. Additionally, all learning modules – both technical and interdisciplinary – can be tied back to the practice of sustainable development, to foster industry-specific sustainability considerations. [6]

Table 1: Trends and Drivers in Sustainability and Climate Policy

TREND	DESCRIPTION
Net zero energy / carbon targets	Many corporations and governments are setting net-zero emissions targets for the next 10-30 years, leading to an increased demand for mitigation, carbon sequestration projects, and supporting policies.
Carbon pricing	The Supreme Court of Canada has recently confirmed the validity of a federal carbon price and cleared the pathway to achieve a $170/tonne carbon price by 2030.
TCFD and TNFD	The Task Force on Climate Related Financial Disclosures (TCFD) is a group of 31 members across the G20 that developed recommendations to help companies improve disclosure related to climate risk, strategy, and governance.[7] A similar group has formed around Nature-related Financial Disclosures (TNFD) and is currently developing recommendations for improved disclosure related to maintaining biodiversity and preventing nature loss.[8]
UN Sustainable Development Goals (SDGs)	A universal call to action in 2015 to end poverty, protect the planet, and ensure that everyone enjoys peace and prosperity provided a common framework of 17 goals for companies and governments across the globe to align their efforts on all aspects of sustainability.
Water-energy-food nexus	A sustainable development concept for achieving resource security highlights the linkages between water, food, and energy production.
Nature-based climate solutions	A broad suite of approaches to conservation, restoration, and green infrastructure management provides important social and environmental services while maintaining ecosystem functions.

Engineers and Geoscientists BC (EGBC) has recently introduced its climate change action plan to provide strategic direction to engineering professionals on climate risk and GHG emissions. Its objectives

[5] https://www.engineersaustralia.org.au/News/engineering-sustainability-finding-right-tools-meet-crucial-un-goals
[6] https://www.raeng.org.uk/publications/reports/engineering-for-sustainable-development
[7] https://www.fsb-tcfd.org/about/
[8] https://tnfd.info/who-we-are/

include developing leadership and collaboration, incorporating climate change competencies, building education and knowledge capacity in climate change, and disseminating appropriate resources.[9] As this plan gets more widely embraced, climate adaptation and GHG mitigation practices are expected to become industry standards in BC.

Understanding the bigger picture of resource scarcity and the water-energy-food nexus can help engineers design sustainable climate solutions to meet the basic needs of people. Technological solutions are important in making the most of available fresh water and energy sources. Transportation is an important component in the system of providing water, energy, and food to society, with many potential impacts and interdependencies. Clean energy helps to power sustainable modes of transportation, which in turn lowers the footprint of food and water provision.

Bringing together traditional engineering approaches with nature-based solutions are necessary in achieving the SDGs, as these hybrid green-grey infrastructure projects have the potential to improve water security, reduce disaster risks, and build overall resiliency to climate impacts. Indeed, widespread adoption of these solutions can mitigate 10-12 gigatons of CO_2 emissions annually, thus providing over one-third of the cost-effective mitigation strategy required to achieve the Paris Agreement goal.[10]

Policy Considerations for a Sustainable Energy Future

Policy comes in many forms relevant to engineers and other environmental professionals, as our governments and broader society strive to meet growing energy needs sustainably. From international climate targets to federal and provincial regulations, to professional codes of practice, to corporate sustainability policies, there are many important policy layers that need to be considered by professionals. Understanding specifically where the work intersects with policy at all levels can help professionals mitigate risk and ensure successful projects.

Energy is a critical piece of many parts of our economy, and it is important that engineering professionals understand the evolving policy landscape impacting their area of work. Climate targets such as those in the Pan-Canadian Framework and Clean BC plan are being embedded in every Minister's mandate, not just those working directly on climate policy. Governments at all levels also have commitments to make their organizations carbon neutral, creating a need for innovative leadership in the management of government building portfolios and corporate fleets. Thus, governments are hiring engineers into roles that include both technical and policy aspects. For example, "plan-engineers" is an emergent field that in addition to engineering skills provides policy planning and economics support.[11]

Table 2 below lists some of the most relevant government policies and programs related to sustainable energy.

[9] https://www.egbc.ca/Practice-Resources/Consultations/Climate-Change-Action-Plan
[10] https://nature4climate.org/news/nature-based-solutions-are-the-real-climate-resilient-route-to-water-security/
[11] Government of BC Engineer-in-Training Program, https://www2.gov.bc.ca/gov/content/careers-myhr/job-seekers/featured-careers/eit-git-program

Table 2: Federal & Provincial Policy Initiatives Relevant to Sustainable Energy

POLICY OR PROGRAM	DESCRIPTION
Paris Agreement	Global Climate Policy to limit temperature rise to below 2˚C
Mission Innovation	$775m in federal clean energy investment
Pan-Canadian Framework	30% reduction of GHG emissions from 2005 levels by 2030
Low Carbon Economy Fund	$2b in federal funding to support the Pan-Canadian Framework
Investing in Canada Infrastructure	$4b in BC infrastructure over 10 years starting in 2018
Mid-Century, Low Emissions Development Strategy	Long term strategic framework about how Canada can achieve a long-term, low-carbon economy
Federal Clean Fuel Standard	Requirement to reduce the carbon intensity of liquid fuels by 13% by 2030
Federal Output-based Pricing System	Price on carbon for facilities emitting 50kt or more per year
Green Municipal Fund	Federal endowment of $625m to this FCM program for innovative municipal projects that address environmental challenges
CleanBC Climate Plan	Provincial climate plan to reduce GHGs by 18.9 Mt by 2030 including interim and sector-specific targets
CleanBC Industry Fund	Fund for large industrial emitters to make operations cleaner
Innovate BC	Several programs to support cleantech growth, skills development, and coop student placement
BC Tech Fund	$100m for early-stage funding to emerging tech companies
Innovative Clean Energy (ICE) Fund	Fund to support pre-commercial clean energy projects and tech
BC Energy Step Code	Voluntary code for high-efficiency buildings and roadmap to make all new buildings net-zero energy ready by 2032
Building Regional Adaptation Capacity and Expertise (BRACE)	Federal program to build capacity and advance climate adaptation in resource sectors, infrastructure, and nature-based solutions

Interdisciplinary Skills for Sustainability

Succeeding in emerging energy and environmental technology systems requires a broader set of knowledge and skills to complement foundational engineering training. Interviews with key informants in this study highlighted the need for graduates with both engineering fundamentals and interdisciplinary skills.

The International Labor Organization's global synthesis report on green jobs has outlined eleven soft and interdisciplinary skills as core skills for green occupations (see box on right). Among those skills, *environmental awareness, leadership skills*, *risk analysis*, and *consulting skills* are pivotal in roles supporting the transition to a more sustainable economy.[12] Employers interviewed for this study echoed the critical need for these skills, especially in the context of masters-level graduate students.

In order to work effectively in the context of climate change, engineering professionals need to consider projected changes in climate and evaluate the risk associated with such uncertainty. Thus, employers believe risk analysis skills and risk assessment tools (e.g., ISO 14090 series) are essential to engineers for managing climate risks in their areas of practice. An understanding of transitional risks associated with aggressive climate policies can help engineers navigate their clients' business through this change.

Core Skills Necessary for Green Jobs:

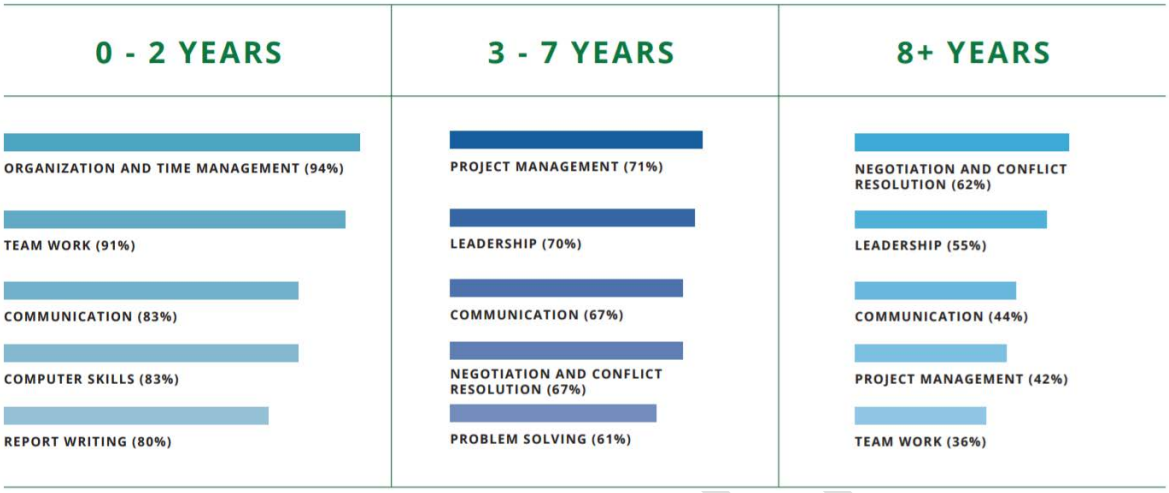
1. Strategic and leadership skills
2. Adaptability and transferability
3. Environmental awareness
4. Coordination, management, and business
5. Systems and risk analysis
6. Entrepreneurial skills
7. Innovation skills
8. Communication and negotiation
9. Marketing
10. Consulting
11. Networking, IT, and language skills

Source: International Labour Organization

ECO Canada's report *Skills Essential for Success in the Environmental Industry* provides valuable insight into the technical and non-technical skills that Canadian employers are looking for in environmental professionals.[13] They note that while many soft skills are expected to develop on the job, there are expectations around which skills job seekers possess based on years of experience (see Figure x below). This report also notes that project management can be considered a blend of both soft and technical skills, combining communication and people management with an understanding of project requirements and objectives.

[12] ILO(2011), Skills for Green Jobs: A Global View, https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_159585.pdf

[13] ECO Canada, Skills https://www.eco.ca/wp-content/uploads/eBook-Skills-For-Success-in-the-Environmental-Industry.pdf



Source: ECO Canada

Figure 4: Soft Skills Required in Environmental Professionals Based on Years of Experience

Rivera et al (2020) categorize twenty characteristics that an innovative engineer should have to address the industry 4.0 and the SDGs (as shown in the box). They suggest educational institutes must adapt their curricula to promote competencies in technical and practical knowledge, interpersonal skills, reasoning, and management and business skills so that these innovative characteristics can be seeded in their students early on.[14]

20 characteristics of innovation that engineers should possess

1. Adapter
2. Multiple alternative seeker
3. Experimenter
4. Knowledge integrator
5. Deep Knowledge
6. Curious about doing and learning
7. Communicator
8. Responsible
9. Persistent
10. Passionate
11. Collaborative and integrative
12. Creative
13. Risk-taker
14. Visionary
15. Challenging
16. Team leader and manager
17. Implementer
18. Analytical
19. Business savvy
20. User-focused

Source: Rivera et al (2020), The Sustainable Development Goals (SDGs) as a Basis for Innovation Skills for Engineers in the Industry 4.0 Context

[14] https://www.mdpi.com/2071-1050/12/16/6622/pdf

"It is critical that new engineers are set up to succeed in a multi-disciplinary/inter-disciplinary team of professionals…Many times environmental issues could be avoided by collaborating with other professions early to understand the natural systems, regulatory expectations, etc…" – clean-tech employer

Engineering graduates seeking jobs involving policy-making and entrepreneurial decision-making will require leadership and strategic planning skills to generate conducive conditions to drive change. As one employer described: "(when hiring) *at the masters level you want someone to be a change-maker";* these skills are useful at all levels and invaluable as employees move to senior positions.

Additionally, employers have expressed the need for specific analytical skills such as the ability to incorporate various forms of inputs (such as environmental policies and climate risk scenarios) into decision-making and use analysis results to develop a product or solution.

As described above, understanding broader sustainability, being able to apply policy considerations, and having a diverse set of interdisciplinary skills are ingredients for a successful engineering career. Factors like increasing environmental threats, provincial and national policy development, international compacts, and broader buy-in from businesses are all driving the demand for a wide range of new careers in engineering. The following sections detail the demand for engineering skills in three key sectors that fit into the bigger picture of sustainable energy:

1. Clean Energy & Power Systems
2. Clean Transportation
3. Net Zero Energy Buildings & Sustainable Building Materials.

Clean Energy & Power Systems

The industries planning, building, and maintaining clean energy and power systems are growing due to declining costs, growing demand for technologies, and support from conducive policies and investment. This area has also seen increased competition, as more investments are being made from both the private sector and the government. In 2020, the sector attracted almost $300 billion worth of investment globally – a 2% increase from 2019 amidst the disruption from the pandemic.[15]

Over the past decade, the cost of solar and wind energy has reached a record low, earning their status as the cheapest new sources of electricity. This has been possible due to the improvements in photovoltaic and wind technology and economies of scale. At the beginning of 2020, the global benchmark levelized cost of electricity for onshore wind and utility-scale PV plummeted to $44 and $50/MWh respectively.[16] In the same year, investment in solar energy expanded by 12% to almost $149 billion,

[15] https://assets.bbhub.io/professional/sites/24/Energy-Transition-Investment-Trends_Free-Summary_Jan2021.pdf
[16] https://about.bnef.com/blog/scale-up-of-solar-and-wind-puts-existing-coal-gas-at-risk/#_ftn2

while wind, experienced a 9% drop to about $143 billion.[17] Wind and solar energy market is projected to see continued expansion – accounting for 56% of global electricity demand by 2050.[18]

Battery storage has facilitated widespread adoption of renewable energy, by compensating for the intermittency of such sources. The global battery energy storage system market is expected to grow with a compound annual growth rate of 33% from 2019 to 2024.[19] Another study estimates that the energy storage system market is anticipated to reach $14.8 billion USD by 2025.[20]

The declining cost and improved performance, especially relating to lithium-ion batteries have increased the demand for such technology. Lithium-ion prices have steeply dropped over the last decade – with a 90% decrease to $135.kWh - and are forecast to decline by another 50% by 2030.[21] Private investments in lithium-ion have rapidly bloomed as well; a report suggests the market has received $649 billion in venture capital funding in 2020.[22] Other flow battery materials and technologies such as zinc-bromide, iron-flow and vanadium-redox batteries are examples of rapidly emerging solutions that can complement existing energy storage technologies.[23]

Grid modernization efforts generate a resilient and responsive energy supply system, by enabling prosumer participation, predictive maintenance, and intelligent system configuration.[24] New business models are emerging for utility and grid operators through smart grid technologies with support from energy storage.[25]

Alternative fuels such as hydrogen are promising in achieving global net-zero carbon commitments given its applications across multiple industries and its energy carrying capacity. The global hydrogen plant and equipment investments market is expected to reach $26.8 billion by 2024 at a compound annual growth rate of 10.7% for the period of 2019 to 2024.[26] More broadly, the rapidly growing hydrogen market is estimated to attract more than USD $300 billion by 2030 – representing 1.4% of energy investment worldwide.[27]

[17] https://assets.bbhub.io/professional/sites/24/Energy-Transition-Investment-Trends_Free-Summary_Jan2021.pdf
[18] Bloomberg NEF, New Energy Outlook 2020
[19] https://www.prnewswire.com/news-releases/global-battery-energy-storage-systems-market-outlook-2020-2024---increasing-demand-for-grid-connected-solutions-high-demand-for-lithium-ion-technology-in-the-renewable-energy-industry-301106611.html
[20] https://www.marketstudyreport.com/reports/global-energy-storage-systems-ess-market-insights-forecast-to-2025
[21] https://about.bnef.com/blog/battery-pack-prices-cited-below-100-kwh-for-the-first-time-in-2020-while-market-average-sits-at-137-kwh/
[22] https://www.forbes.com/sites/rrapier/2021/02/06/funding-for-battery-technology-companies-exploded-in-2020/
[23] https://www.forbes.com/sites/rrapier/2020/10/24/why-vanadium-flow-batteries-may-be-the-future-of-utility-scale-energy-storage/
[24] https://www2.deloitte.com/content/dam/Deloitte/bg/Documents/energy-resources/gx-er-challenges-opportunities-global-battery-storage-markets.pdf
[25] https://www.pwc.com/gx/en/utilities/publications/assets/pwc-future-utility-business-models.pdf
[26] https://www.bccresearch.com/market-research/energy-and-resources/the-global-hydrogen-economy-technologies-and-opportunities.html#:~:text=The%20global%20hydrogen%20plant%20and,period%20of%202019%20to%202024.
[27] https://hydrogencouncil.com/wp-content/uploads/2021/02/Hydrogen-Insights-2021-Report.pdf

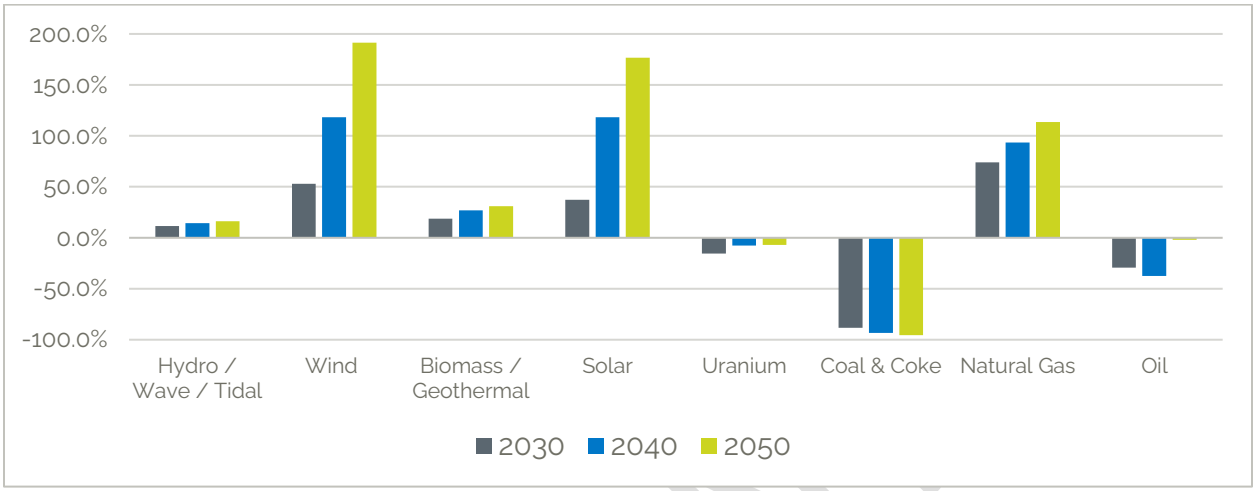
Table 3: Trends and Drivers in Clean Energy and Power Systems

TREND	DESCRIPTION
Renewable energy technologies	Renewables such as solar PV, onshore and offshore wind, and hydro are growing as significant investments are going towards increased capacity.
Electricity distribution	New business models are emerging for utility and grid operators through smart grid technologies with support from energy storage.
Energy storage	The cost of batteries and storage systems is expected to fall by up to 70% from 2018 levels by 2025.[28]
Hydrogen production	The global hydrogen economy is anticipated to be worth $1 trillion by 2025. This includes green hydrogen production from renewable energy sources and value-added applications in transportation and industry.

The energy mix varies across Canada by province and includes hydroelectricity, natural gas, coal, nuclear, and an increasing share of renewables such as solar, wind, and geothermal. A recent report by the Canada Energy Regulator forecast the change in energy sources out to 2050, with major growth in demand expected in wind, solar, and natural gas.[29]

Hydrogen is an important piece of the Canadian energy mix expected to grow and create new demand for skilled professionals. In 2020, the Government of Canada introduced its nation-wide Hydrogen Strategy that aims to diversify the hydrogen sector from 2025 to 2030, which is projected to create 350,000 high-paying jobs.[30] In Alberta, ATCO's Fort Saskatchewan Hydrogen Blending Project is a unique project that will blend up to 5% hydrogen into Fort Saskatchewan's residential natural gas distribution network. The $2.8 million worth project will be a major step to decarbonizing utilities.[31]

[28] https://www.airdberlis.com/insights/blogs/energyinsider/post/ei-item/2018-energy-storage-developments-in-the-last-twelve-months
[29] https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/2020/index.html
[30] https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/environment/hydrogen/NRCan_Hydrogen-Strategy-Canada-na-en-v3.pdf
[31] https://www.atco.com/en-ca/about-us/news/2020/122900-atco-to-build-alberta-s-first-hydrogen-blending-project-with-era.html



Source: Canada Energy Regulator (2020)

Figure 5: Forecast of primary energy sources in Canada, percentage change from 2020 to 2050

In BC, the abundance of hydroelectric power has allowed most of the province to benefit from a relatively low carbon electricity grid and is driving the electrification of the transportation sector and heavy industry. A significant piece of the Province's CleanBC Climate Plan involves providing clean energy to some of the highest-emitting industrial users like the oil and gas sector in the northeast, pulp mills, and the future LNG Canada project in Kitimat.[32]

In BC, companies providing energy storage solutions are experiencing high demand for their products.[33] Corvus Energy, a Vancouver-based supplier of energy storage solutions, recently announced a partnership with Toyota and several Norwegian companies to develop fuel cell systems for the international marine market.[34] Another Vancouver-based company, Portable Electric, recently announced a partnership with Rotterdam-based software company Skoon Energy to provide e-generators to mobile battery customers in Europe, with the added value of an online platform for data-driven insights on energy use.[35]

Employer Demand

Employers in clean energy and power systems described the need for fundamental skills in fields such as electrical and mechanical engineering, thermal engineering, renewable fuel technology and supply chain, and material science.

Engineering graduates seeking jobs in this sector will benefit from understanding the business and policy context of remote community development and First Nations engagement. Projects are often

[32] https://archive.news.gov.bc.ca/releases/news_releases_2020-2024/2021PREM0006-000153.htm
[33] https://corvusenergy.com/corvus-energy-to-expand-production-in-response-to-high-demand-for-energy-storage/
[34] https://corvusenergy.com/corvus-energy-to-start-development-of-maritime-fuel-cell-systems-with-hydrogen-fuel-cell-technology-supplied-by-toyota/
[35] https://portable-electric.com/portable-electric-and-skoon-energy-join-forces-to-expand-clean-energy-solutions-to-europe/

situated in remote locations and have the potential to make a significant impact on local populations. Additionally, understanding the impact of the projects on biodiversity and ecology will increase employability in this sector. Employers emphasized a need to address this knowledge gap among engineers, as the social and environmental impact of projects is often not covered in existing engineering curricula.

"Indigenous people and groups will be important partners and owners in the renewable energy generation and natural systems sectors. It is important to learn about their history, customs, protocols, etc. to develop good, relationships, projects and grow our understanding from an individual basis." – cleantech employer

Employers have highlighted that a more general education with a focus on multiple domains, as opposed to specialization, can help an engineer succeed in this sector. Additionally, employers suggested that practical, hands-on experience with technologies can greatly improve employability for a fresh graduate.

"Communication is very important – many engineers are not able to describe the technical challenges, as well are not able to properly sell a business case" – cleantech employer

Business acumen, communication, and financial analysis are some of the key non-technical skills highlighted by employers in this sector.." Thus, beyond writing reports and delivering presentations, an effective set of communication skills also includes the ability to strategically negotiate with project partners and community stakeholders.

Clean Transportation

Trends in the Clean Transportation sector include electrification, low carbon and renewable fuels, integration of digital and smart technologies to manage fleets and logistics, and the use of advanced materials as a lightweight alternative. The shift to low carbon and zero-emissions vehicles began largely with passenger vehicles and is now seeing significant growth in other areas, such as heavy-duty and commercial applications. Electric buses are the fastest-growing segment of the EV market at 100% growth since 2013.[36] Bloomberg NEF estimates that the share of electric vehicles in passenger vehicle sales will continue to rapidly grow – from representing 10% of the market in 2025 to almost 60% in 2040. [37]

Cities that were once designed around the personal automobile are increasingly planning and building infrastructure to support other modes of transportation, including active transportation (walking and cycling), motorized scooters, e-bikes, ride sharing, and public transit. Mobile apps and the integration of sensors and IT into transit systems have allowed for more seamless integration across these modes, such as cycling to a transit station or use of 'last-mile' solutions like electric scooters. Apps have also enabled the application of 'sharing economy' principles to cars, bikes, and scooters, thereby reducing the need to personally own and store these vehicles when not in use. The shared mobility market in

[36] https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/fast-transit-why-urban-e-buses-lead-electric-vehicle-growth
[37] https://bnef.turtl.co/story/evo-2020/page/3/1

China, Europe and the United States is forecasted to be cumulatively valued at from $300 billion to $500 billion in 2030[38].

Underlying forces enabling these advances in clean transportation include electricity, smart city infrastructure and charging infrastructure. Another underlying technology enabling clean transportation is battery chemistry and design, which has advanced significantly in recent years with regards to the power to weight ratio achievable.[39]

Shipping, logistics, and rail have also been transformed by the power of digital and IT, leading to increased automation and efficiencies. Canadian National (CN) Railway is Canada's largest freight railroad, providing transportation and intermodal services throughout North America. The company currently employs approximately 2,400 workers in British Columbia and has made more than $1.1 billion in capital investments since 2013.[40] Current expansion projects include infrastructure on corridors between Prince Rupert and Jasper and between Vancouver and Edmonton. Canadian Pacific Railway (CP) also provides freight services in BC with a direct link to the Port of Vancouver, an intermodal terminal in Pitt Meadows, and lines connecting to the East and West Kootenays. Current CP projects include a track reconfiguration project in Field to accommodate longer trains and increase crossing efficiency.[41]

In the marine sector, Seaspan and BC Ferries have been operating LNG-diesel hybrid vessels for several years and these hybrid ships have been designed to be fully electric in the future.[42] BC Ferries also has 5 larger vessels currently in the design phase for its Victoria-Vancouver routes. These will be LNG-battery hybrids with a 2023 delivery timeline, with the potential to go to full battery or hydrogen fuel cell in the future (still 10 years out).

Policies driving clean transportation include GHG reduction targets and low carbon fuel standards, requiring a reduction in the carbon intensity of fuels through blending renewable alternatives like ethanol and biodiesel. Biofuels' share of road transport energy demand is expected to grow from 4.8% in 2019 to 5.4% in 2025.[43] Chemical engineers are especially important in this area and demand for them is expected to grow.

In addition to its potential in stationary combustion and natural gas blending applications, hydrogen is a fuel that can be produced from a variety of sources and only produces water when consumed in a fuel cell.

[38] https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/the-future-of-mobility-is-at-our-doorstep
[39] https://wikicars.org/en/Power-to-weight_ratio
[40] https://www.cn.ca/en/news/2018/06/cn-investing-approximately-340-million-to-expand-and-strengthen/
[41] https://www.cpr.ca/en/community/living-near-the-railway/rail-projects-near-you
[42] https://www.bcferries.com/in-the-community/projects/introducing-island-class-ferries
[43] https://www.iea.org/reports/renewables-2020/transport-biofuels

Table 4: Trends and Drivers in Clean Transportation

TREND	DESCRIPTION
Electrification	The global decline in battery costs for light-duty and commercial vehicle applications is driving a broad shift to electricity-powered fleets.
Renewable fuels	Driven by low carbon fuel standards, fuel refineries are now able to produce or blend fuel using low carbon and renewable feedstocks such as ethanol, biodiesel, and hydrogen-derived renewable diesel (HDRD).
Smart mobility	In 2017 the market saw $32 billion invested in ridesharing start-ups alone, and connected cars are emerging as key components of an intelligent transportation network. Intelligent mobility is enabled by sensors and software as part of the 'Smart City' and allows riders to make informed transportation choices based on real-time situation data.
Logistics	Logistics hubs are growing due to the significant increase in e-retailing, resulting in the need for local distribution points, apps, and other mobile technologies that enable a proliferation of last-mile solutions.

Canada's transportation sector is experiencing an influx of federal green infrastructure funding through the Investing in Canada Infrastructure Program. Since 2016, Natural Resources Canada has provided funding to support alternative transportation fuels, charging infrastructure, and other technology demonstration projects such as natural gas and hydrogen refuelling stations.[44]

The production of an electric vehicle by top original equipment manufacturers (OEM) in Canada is growing – in fact, it is estimated to reach 13 million by 2025.[45]. BC is one of the leading provinces in Canada in advancing clean transportation, from high rates of EV ownership to incentives for electric bicycles, to supporting active transportation infrastructure in communities.[46, 47, 48]

Many local governments are seeking the assistance of engineering firms to help plan and implement low-carbon, multi-modal transportation solutions.[49] A new set of skills and understanding of social considerations and user experience is required to effectively retrofit a mix of charging stations, bike lanes, transit service, and other components on existing infrastructure.

Employer Demand

Employers in clean transportation described the need for engineers with foundational skills in several fields, including mechanical, electrical, systems, reliability, software, and controls. Engineering graduates seeking jobs in clean transportation would do well to equip themselves with experience in areas like rapid prototyping, geometric dimensioning and tolerancing (GD&T), project management, analysis,

[44] https://www.infrastructure.gc.ca/plan/gi-iv-eng.html
[45] https://assets.kpmg/content/dam/kpmg/ca/pdf/2020/02/canadas-automotive-future-2020.pdf
[46] https://emc-mec.ca/wp-content/uploads/Sales-Report-2019-Q2_revised.pdf
[47] https://pluginbc.ca/new-e-bike-cargo-e-bike-rebates/
[48] https://cleanbc.gov.bc.ca/active/
[49] https://www.pollutionprobe.org/low-carbon-mobility-actions/

familiarity with parametric 3D modelling software such as CREO, design failure modes and effects analysis (DFMEA).

Today's complex cities and built environments require engineers to design simple, reliable, and economic transportation systems. Employers described challenges in hiring engineers that bring a combined skillset in electrical, software, and controls, as these mechatronics skills are important in the context of advances in robotics and computer-controlled transportation systems.

"Grads are lacking basic industrial business acumen. They want to do the work but need to also understand how to pay the bills. It would be helpful if everyone understood the needs of the company to make money" – cleantech employer

Non-technical skills highlighted as being important to employers in transportation include many under the broader theme of effective project management. These skills are decision making (structured, effective, and timely), oral and written communication, active listening, knowing when to share information and how to use different communications mediums (phone, text, chats, etc.), time management, multitasking, prioritizing, and remaining calm under pressure and dealing with stress. Basic entrepreneurial skills also stood out as a key non-technical skill to succeed in this industry.

Net Zero Energy Buildings & Sustainable Building Materials

Trends in the net-zero energy buildings and materials include the development and implementation of high-performance building codes, building envelope technologies, digital platforms, low carbon materials, prefabrication and modular construction, and nature-based infrastructure.

Currently, buildings are mainly viewed as contributing to climate change via operational GHG emissions. In fact, 2019 marked the highest-ever recorded carbon emission from operational buildings: 10 G tCO2 or 28% of the total global emissions. An additional 11% of emissions came from the manufacturing, transportation, and construction of the built environment – which is also commonly known as embodied carbon, [50] Thus, governments and organizations such as the Carbon Leadership Forum and C40 are leading decarbonization efforts within the industry.

As the energy grid decarbonizes through the integration of renewable energy and lifecycle accounting is more widely adopted, embodied carbon considerations become more important. This, in turn, is driving the demand for low carbon and renewable materials used in buildings, such as cross-laminated timber (CLT). The ability for engineers to be able to perform GHG accounting that includes considerations for LCA, and embodied carbon calculations is expected to grow in relevance and importance.[51]

Building envelope technologies such as high-performance windows, air sealing, and high thermal conductive fasteners are becoming a best practice in the construction industry for providing insulation and achieving greater energy efficiency. Advancements in building envelope practices have the potential for a 35% improvement in the average thermal performance of the global building stock by 2050.[52] In

[50] https://www.iea.org/reports/tracking-buildings-2020
[51] https://www.worldgbc.org/sites/default/files/WorldGBC_Bringing_Embodied_Carbon_Upfront.pdf
[52] https://webstore.iea.org/download/direct/2496?fileName=Perspectives_for_the_Clean_Energy_Transition_2019.pdf

addition to reduced heating and cooling cost and emissions reduction, envelope improvements can also increase the comfort and productivity of the residents.[53]

Increased use of digital platforms during the design phase has allowed professionals to compare and choose designs that optimize energy performance and minimize cost. Software skills to support practices such as Building Energy Modelling (BEM) and Life-Cycle-Assessment (LCA) are becoming an industry requirement, as more companies aim to meet net-zero building certifications and standards.[54]

Prefabrication and modular construction practices shift production offsite and allow materials to be premanufactured according to energy efficiency standards, saving both materials and costs. Offsite construction also reduces the number of labourers required onsite, which can further streamline construction processes and lead to increases in worker productivity. By 2030, modular construction is forecast to account for more than $130 billion in the new construction market in Europe and the United States, while bringing annual cost savings of $22 billion.[55]

Table 5: Trends and Drivers in Net Zero Energy Buildings and Materials

TREND	DESCRIPTION
Net zero energy ready building codes	Advances in materials and building design are making it feasible to construct buildings that produce enough energy to operate onsite using renewable energy sources.
Mass timber construction	Engineered wood is increasingly being used as a low-carbon and reliable material. Tall wood building design is a growing area of focus in BC specifically.
High performance building commissioning	Higher energy efficiency standards require a more sophisticated set of skills in the design stages to ensure building systems are properly integrated and perform to specifications.
Prefabrication and modular construction	Major efficiency gains are being made through offsite construction of entire buildings, walls, or other components, shifting labor needs to factories and preassembly yards.

A 2020 Delphi Group report estimates that Canada's green building industry will generate 94.9 billion dollars in direct GDP from green building investments, without targeted government intervention by 2030. That roughly translates to 940,000 direct employment and 22.5 Mt CO_2 reduction compared with

[53] https://webstore.iea.org/download/direct/455
[54] Programmer for Energy Efficiency Building (2019), Smart and Efficient. Digital solutions to save energy in buildings, https://www.peeb.build//imglib/downloads/PEEB_DigitalSolutions_web.pdf
[55] https://www.mckinsey.com/business-functions/operations/our-insights/modular-construction-from-projects-to-products

2018 levels. With the government's green-building-focused recovery program, the gains increase significantly, as the industry could produce $150 billion in direct GDP, with an additional 53 billion jobs and 30.5 Mt CO2 reduction compared with 2018 levels.[56]

Some of the additional Canada specific trends and drivers of high-performance green buildings growth include the impact of circular economy, popularity of healthy, equal, and inclusive buildings, and retrofit economy,

Canada's green building industry includes a variety of sectors and professions, but much of the successful implementation of standards begins with building science and engineering specialists.[57] Whether they are working in heavy civil engineering construction or in architecture and engineering-related services, engineers have an important role in the development and construction of high-performance buildings.

The BC Energy Step Code provides a roadmap to the future requirements that all new buildings will be net-zero energy ready by 2032. Within this broader roadmap, many guidelines and practices are defined for the different professions working together on high-performance buildings.[58] Engineers and Geoscientists BC has recently published Professional Practice Guidelines for Building Enclosure Engineering Services, recognizing that much of this work crosses between the fields of building science engineering and architecture.[59]

Another demand for engineering skills in buildings comes from companies manufacturing high-performance building products. One local example of this is Cascadia Windows, a leader in high-performance windows and the only manufacturer of fiberglass and windows on the west coast.[60] Other examples of green building products being produced by local cleantech companies include insulation, HVAC suppliers, prefab assembly, and air barriers.[61]

Employer Demand

Employers of engineers in the built environment are increasingly looking for a well-rounded knowledge of energy modelling, building science, and software applications. Understanding these concepts and how guidelines and policy documents are implemented in practice is important for all building professionals, including engineers.

> *"Life cycle impact analysis (skill) is lacking (in new grads). Zero emission is a myth. Every energy source has an impact and good LCIA will show the true impact." – cleantech employer*

Policies and commitments around net-zero targets have shifted the industry focus on embodied carbon and life cycle assessment, and an understanding of the tools required, and practical applications of these concepts will prepare graduates for the future building science and engineering job market.

[56] https://www.cagbc.org/cagbcdocs/advocacy/CaGBC_CanadasGreenBuildingEngine_EN.pdf
[57] https://www.cagbc.org/CAGBC/Advocacy/market_impact_report.aspx
[58] https://energystepcode.ca/publications/
[59] https://www.egbc.ca/getmedia/f62d1717-7103-47c0-b81a-caa6c639fa93/EGBC-Building-Enclosure-Eng-Serv-V2-0.pdf
[60] https://www.cascadiawindows.com/corporate-resume
[61] https://www.vancouvereconomic.com/research/green-buildings-market-research/

Programming, data analysis, and data visualization skills can help graduates create a niche for themselves and build a career in this field. Employers interviewed described a demand for experts at the intersection of technical and programming skills, who can provide a tailored approach to analysis. As one of them pointed out "*Regardless of the specific engineering background programming skills can help with complex workflow*". Specific software tools that were highlighted include Rhinoceros 3D software and Grasshopper visual programming language.

Employers in the building sector described the value of international studies and business acumen to support the growth of business outside of Canada. For many companies, exports and international partnerships represent the majority of their business. How to work with offshore engineering firms, understanding subsidies, importing and exporting, supply chain considerations, and where to source components and consulting help were specifically highlighted as important for engineering positions.

Among the non-technical skills in demand for engineers working on buildings, employers focused on the ability to communicate effectively written and orally, and concisely and compellingly. They also highlighted the need for policy analysis skills to interpret and translate policy implications to a wide range of audiences and extrapolate the effect of those policies on clients.

3 Key Takeaways from Industry Survey

An industry survey was conducted to gauge the demand for potential graduates of the proposed new SEE MEng Program. The section delineates the key takeaways from the survey highlighting the relevant technical and non-technical skills that are demanded, as well as the gaps in the current job market. This section also highlights the main program considerations suggested by the respondents. Appendix A1 provides a full overview of the survey and the results.

3.1 Skills Development

Technical skills

Based on the survey, employers prioritize the following technical skills when hiring, and regard them as crucial to have a deeper understanding and practical experience:

1. Interdisciplinary understanding for systems integration / development
2. Mechanical engineering skills (mechanics, thermofluids, manufacturing, etc.)
3. Chemical engineering skills (chemical reactions, processes, etc.)
4. Understanding of advanced instrumentation and controls
5. Engineering design and prototyping
6. Computer engineering and ICT skills (coding, wireless, ICT systems, software management and programming etc.)

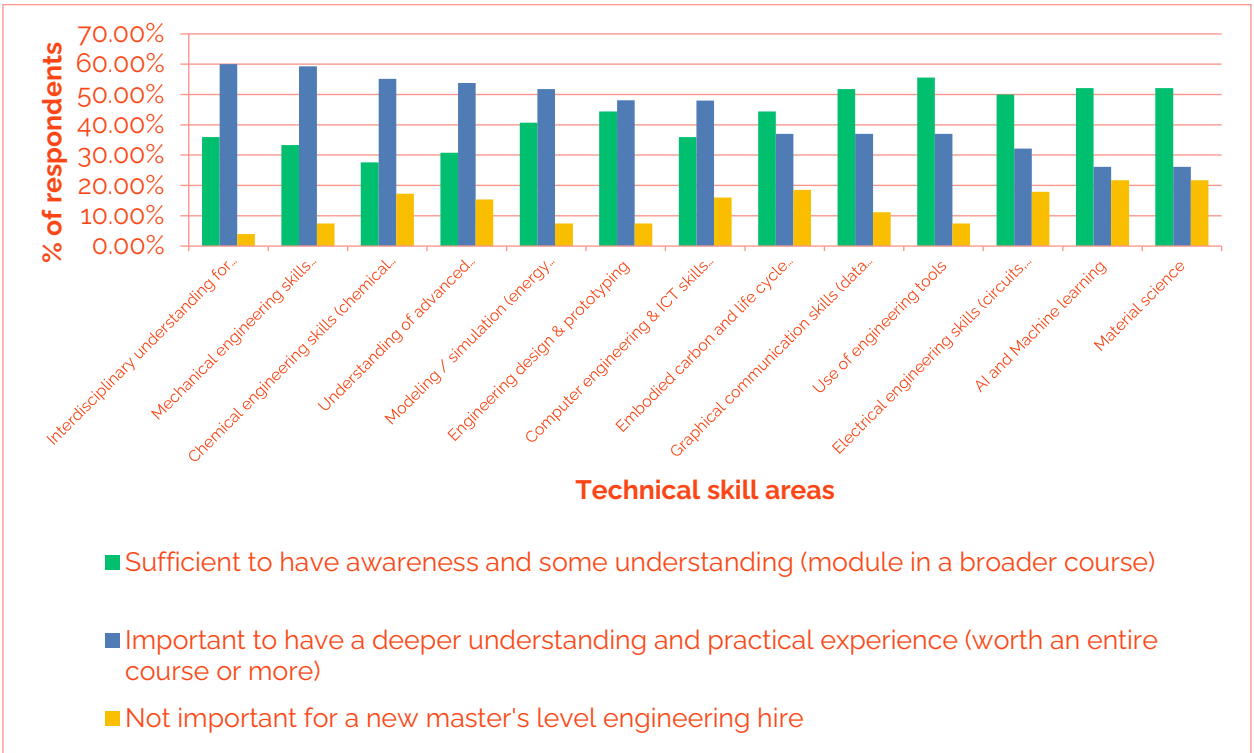


Figure 6: Responses to the question "In addition to the essential skills in mathematics and basic sciences, what other technical skills do you most often look for when recruiting a new engineering hire at a master's degree level? Please indicate whether you are looking for simply awareness" (n=52)

Non-technical skills

In terms of non-technical and/or inter-disciplinary skills that recruiters look for in recruiting engineer hires with a master's degree, those that were ranked as the top five were also identified as those that require a medium to high depth of skill.

Top Ranked Nontechnical Skills	Depth of Skill Required
Inter-personal / teamwork skills	High
Creative thinking / problem solving	High
Strong communication / presentation skills	High
Ethics and professional responsibility	High
Business planning and entrepreneurship	Medium

When asked what other qualities are valued and sought after in new hires, many respondents pointed to those who exhibit curiosity, have a multidisciplinary background, and have a mind for systems thinking/integration.

Critical Skills Gaps

When asked about critical skills gaps, the most commonly cited gaps identified by respondents were:

- Communication skills
- Carbon accounting
- Understanding energy systems
- Lifecycle analysis
- Cross discipline communication and collaboration

The findings from the survey echoed the overall skill needs and gaps identified through the desktop research and interviews, making a robust case for the demand for the proposed SEE MEng program.

3.2 Program Considerations

Respondents identified the following as the top 3 priority technical learning outcomes and top 3 non-technical learning outcomes they would expect from a new graduate of a Master's level Engineering program:

Top Priority Technical Learning Outcomes	Top Priority Non-technical Learning Outcomes
Able to analyze, formulate, and handle technical problems from a system perspective	Ability to approach problem solving in an interdisciplinary way.
Broad knowledge on sustainable systems, conventional and renewable energy sources and conversion, as well as technical, economical, and environmentally related consequences for different energy systems.	Communicate effectively with colleagues, other engineering professionals and the broader community employing a range of communication media and tools.
Professionally apply systematic engineering methods to address complex, multi-disciplinary real-world engineering problems related to generation, transmission and utilization of renewable energy.	Ability to successfully carry out advanced tasks and projects, both independently and in collaboration with others, as well as across disciplines.

Below are some of the common topic areas that the respondents believed was necessary to include in a new Master's level Engineering program with a focus on sustainability energy systems and clean technology:

1. Grid integration and management
2. AI, Data analytics and Machine Learning
3. Economics and accounting of engineering technologies
4. Advanced material sciences
5. Life cycle impact analysis and GHG calculation
6. Indigenous and cultural competency studies

3 Key Takeaways from Student Survey

A student survey was carried out to evaluate the demand for both the content and the structure of the proposed MEng program, while also allowing students to suggest alternatives. Overall, the respondents demonstrated a strong interest in both the type of program and the industry focus of the proposed program, Appendix A2 provides additional insights into the respondent demographics as well as respondents' responses on program consideration and industry focus.

When asked about the proposed MEng program, more than half of the respondents expressed (56%) high to very high interest in the proposed structure while almost 35% showed moderate interest. Only 1 out of 10 of the respondents said that they have low or no interest in the program described.

Program considerations

Non-technical skills development

Among the non-technical and interdisciplinary skills, (in Figure 7) the respondents ranked the following as the top five skills that are important for their future career, which were also identified as the most important skills sought by recruiters:

1. Project management
2. Creative thinking / problem solving
3. Inter-personal / teamwork skills
4. Written and verbal communication/ presentation
5. Business planning / entrepreneurship

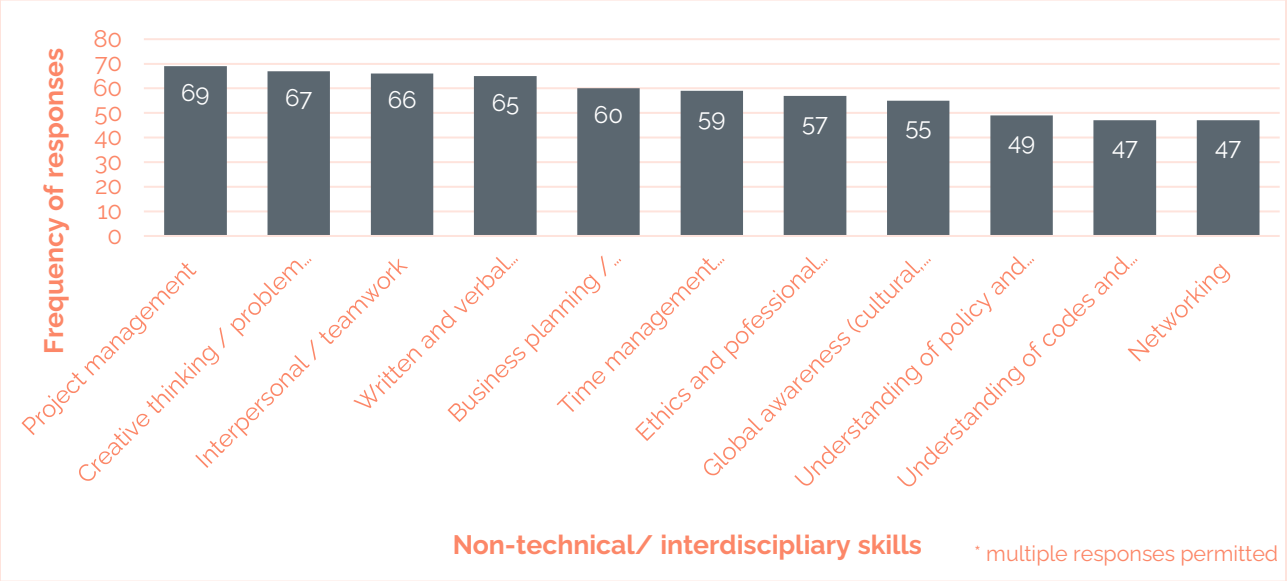


Figure 7: Responses to the question "What non-technical and/or interdisciplinary skills do you think are important for your future learning and career?" (n= 87)

Learning experiences

On average, students prefer industry interaction and applied research opportunities over other types of learning experiences. This fact suggests that students are keen on applying their theoretical knowledge in an industry setting as well as building networks for future career opportunities.

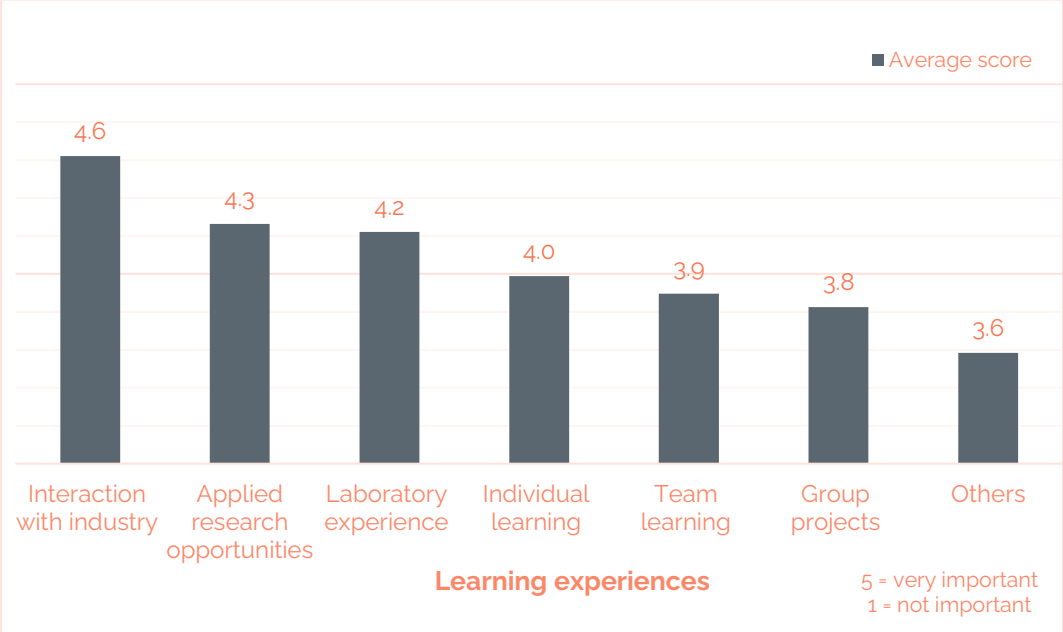


Figure 8: Responses to the question "How important are the following learning experiences?" (n=86)

Program length

Of the 87 students surveyed, a large proportion of students (41%) indicated 18 months to be the most ideal program duration for course/project-based master's level inter-disciplinary engineering programs. For the alternative durations of 24 months and 12 months, the percentage of students preferring the options were close – with 32% and 26% respectively.

Our scan of comparative leading academic programs showed that the programs of 18-24 months duration usually have a targeted applicant of undergraduate students. Moreover, such programs are better suited to integrate industry interaction, work term options as well as deeper involvement in program content– all of which students have identified as important criteria that they look for in a graduate inter-disciplinary engineering program. At the same time there is an increasing number of shorter-duration master's programs being created to respond to allow students to enter the workforce faster and fill job vacancies. Thus, based on the survey results and comparative scan, it might be suggested that a program length somewhere between 12-24 months is the most suitable for the proposed program.

Industry focus

The students indicated strong support for the Clean Energy, Clean Transportation and Zero Emission Buildings industry focus, as these areas broadly formed their top 5 preferences. Figure 9 shows the breakdown of the responses.

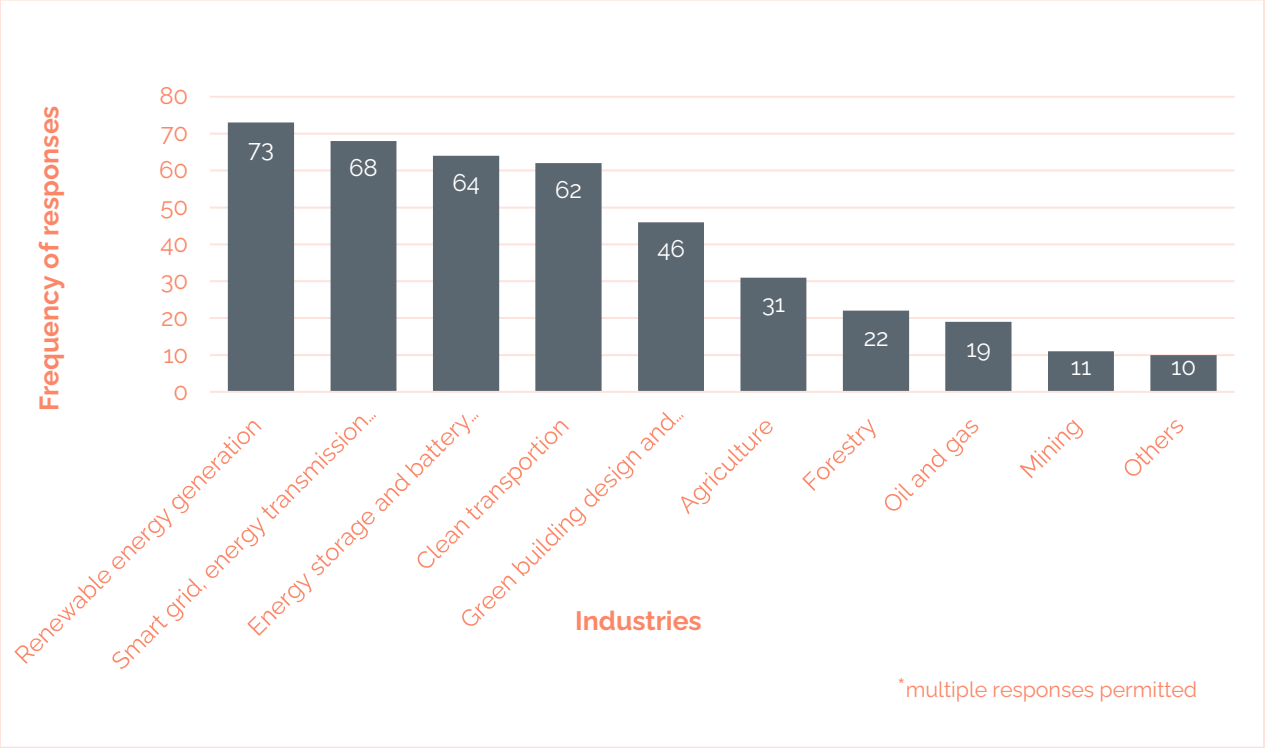


Figure 9: Responses to the question "In which of the following industries would you be interested in applying your engineering and sustainability skills to solve local and/or global problems?" (n= 86)

4 Scan of Comparative Academic Programs

In the interest of helping SFU develop a compelling graduate program that complements existing program offerings, the study undertook a scan of relevant engineering programs across Canada and globally. This scan looked at other graduate engineering programs with a clean energy focus and the level of interdisciplinary subject matter included.

Graduate Energy Engineering Programs across Canada

The scan of comparable programs offered through nearby institutions in BC and Alberta revealed that while most engineering programs include some content related to clean and sustainable energy systems, a few also include an interdisciplinary focus.

Table 6: Clean Energy-focused Engineering Master's Programs in BC and Alberta

PROVINCE	UNIVERSITY	PROGRAM	AREAS OF FOCUS	DURATION	INTERDISCIPLINARY?
BC	SFU	MASc in Sustainable Energy Engineering	Conversion, storage, distribution, management of energy and environmental resources	2 Yr	N
BC	UBC	Master of Engineering Leadership (MEL) in Clean Energy Engineering	Energy system fundamentals, sustainable energy systems, energy storage and transmission	1 Yr	Y
BC	UVic	MASc in Civil Engineering	Green structures and materials; smart buildings, infrastructure, and cities; sustainable water	2 Yr	N
AB	U of Alberta	MEng/MSc in Mechanical Engineering	Less of a focus on clean energy, but includes a research area in Energy and Environment	2 Yr	N
AB	U of Calgary	MEng Electrical and Computer Engineering	Energy systems and environment; tools for systems analysis	2 Yr	Y
AB	U of Calgary	MEng Mechanical and Manufacturing Engineering	Energy systems and environment; tools for systems analysis	2 Yr	Y

Within BC, the closest comparisons to SFU's proposed program are UBC's Master of Engineering Leadership (MEL) in Clean Energy Engineering and UVic's MASc in Civil Engineering.

UBC'S MEL program is a professional program catering to mid-level professionals and includes an interdisciplinary focus. A key strength of the MEL program lies in its collaboration with the Sauder School of Business – one of the top-ranked business schools across Canada and worldwide.[62] The project-based program offers 12 credits out of 30 credits on leadership courses, with one module dedicated to sustainability and leadership. The value of the leadership focus is reflected in the employability of the graduates of these programs, as key informant interviews repeatedly mentioned the MEL program as an industry standard and highlighted the leadership exhibited by its graduates. It is important to note that the MEL program is designed for mid-career professionals with at least three years of work experience, and the proposed SFU program would likely be aimed at a slightly different demographic coming straight from undergraduate programs.

UVic's MASc is a thesis-based masters, having a focus on five broad areas of green economy: green structures and materials, smart buildings, infrastructure and cities, industrial ecology, and sustainable water. To gain practical work experience, students have the option to participate in a two-work term co-op program in-lieu of a thesis. UVic's civil engineering department identifies as the greenest civil engineering department in Canada, with their comprehensive and interdisciplinary focus on sustainability related themes at both undergraduate and graduate level[63].

SFU's proposed MEng program will thus be the first of its kind in western Canada, having specific applications to clean energy industries with an interdisciplinary approach. It will be uniquely suited to attract fresh undergraduate students from both domestic and international markets and provide them with an interdisciplinary hands-on education to succeed in the workforce. Given MEL's target audience of practicing professionals, it can be considered complementary to the SFU's proposed MEng.

[62] https://www.sauder.ubc.ca/news/school-news/ubc-takes-top-spot-canada-qs-world-university-rankings-business-and-management
[63] https://www.uvic.ca/engineering/civil/green/index.php

Snapshot of Comparative Program Scan

31	Business and Policy	2 years
Total number of programs examined	**Most common interdisciplinary subjects**	**Most common program length**

Figure 6 Geographic breakdown of examined programs

Interdisciplinary Graduate Energy Engineering Programs Globally

Most of the MSc and MEng programs examined globally are targeted towards undergraduate students with 3-4 years of engineering background. The scan also found professional master's programs such as UBC's MEL and U of Colorado Boulder's Master of Science in Electrical Engineering (MSEE) program, both of which are specifically designed to help mid-level professionals pivot their career into cleantech. The most common duration among the programs is 2 years, However, for project-based MEng and MSc, the program length seems to fall equally across 1 to 2 years of duration.

Given the sustainable and renewable energy considerations, most programs' core engineering focus is on renewable and alternative energy production, storage, transmission, and distribution. These include topics under mechanical engineering such as thermodynamics, combustion, fluid dynamics, energy conversion as well as electrical engineering such as power electronics and grid technologies. Among the practical applications of different renewable energy sources, solar and wind-related modules such as photovoltaic technology and wind power generation systems are most common. Fuel cells and smart grids are other examples of commonly included cleantech modules.

Business, policy, economics, and data science were found to be the most common interdisciplinary offerings, in order of frequency. Business modules typically include entrepreneurial skills, decision making, financial modelling, accounting, and project management. Policy and economics considerations include national and global environmental policy, sustainable energy policy and regulation, energy market analysis, energy economics etc., Some programs also focus on data science applications in sustainable energy such as Internet-of-Things (IoT), artificial intelligence, and big data.

Key Takeaways from Leading Programs

Programs such as Carleton's Sustainable Energy Engineering and Policy Program, or University Michigan's Energy Systems Engineering Program are examples of relevant programs combining sustainable energy engineering with holistic interdisciplinary curricula and unique approaches to policy and sustainability.

A core strength of leading programs lies in providing a "distinct interdisciplinary' experience which not only includes close collaboration with other faculties, but also that of students across different disciplines. University of Michigan's unique collaboration across the schools of Environment, Business and Public Policy, the College of Architecture and Urban Planning, and the College of Literature, Science, and Art expose their students to a wide array of disciplines. On the other hand, Carleton's sustainable engineering is an example of interdisciplinary collaboration within the class, as students from both engineering and public policy degree tracks closely engage with the other component.

Some of the leading programs offer specializations in specific cleantech industries such as clean transportation and zero-emission buildings, so that students can gain more in-depth and specialized technical knowledge. Others provide a broad range of elective modules across cleantech sectors, and their applications, as well as non-engineering disciplines allowing students to customize their expertise.

Seminars and workshops are also commonly included in curricula to expose students to different areas of sustainability practices. They are also meant to help students develop their presentation, critical thinking, and communication skills.

Overall, these programs introduce sustainability in both the industry-specific modules and other applied modules. Some of the direct application-based modules include systems thinking, forecasting and modelling, environmental impact assessment, sustainability ethics, and LCA. These topics are included to prepare professionals for the common sustainability and climate adaptation-related practices and principles established by engineering associations across the world. KTH's Sustainable Energy Engineering program exposes students to more rigorous sustainability training including Integrated Climate-Land-Energy-Water (CLEWs) modelling and scenario analysis.

SFU's SEE is well-positioned to introduce interdisciplinarity in its proposed MEng program, given its reputation as Maclean's #1 Comprehensive school in Canada.[64] Thus, it has the breadth to collaborate with multiple faculties to provide the students with a truly interdisciplinary experience. Moreover, SEE's guiding principles of sustainability will be a strength in introducing sustainability considerations in the proposed program and attracting a range of both domestic and international students.

[64] https://www.macleans.ca/education/university-rankings/canadas-top-comprehensive-university-2021-simon-fraser/]

Table 7: Benefits and Limitations of 1- and 2-year Programs

	1 year Program	2-year Program
Examples	UBC Queens Exeter Manchester	Carleton Waterloo Oregon Tech Lund University
Key components	Less co-op/work term options End of program projects for hands-on-experience	Greater coop/work term options Deeper involvement in program content and interdisciplinary options
Target audience	Mid-career Professionals Undergraduate students	Undergraduate students
Benefits	More suitable for specializing in one area of concentration More suited to mid-career professionals and those who are trying to pivot to a new field Accelerated entry into the job market Less expensive for students	More time to optimize learning outcomes and provide the opportunity to take electives More opportunities for students to create professional networks and gain practical experience More suitable in unstable job market Better option for someone who may later consider doing a PhD
Limitations	Less opportunity to include a broad range of courses and electives Less time for practical experience Less time with other students and networking opportunities	More expensive for students More time required of students Delay for those eager to enter the job market

5 Summary

The skills required for interdisciplinary engineers to meet the demands of today's complex work environment include technical skills in the form of traditional engineering fundamentals, non-technical and interdisciplinary skills in the form of policy analysis and stakeholder relations, and soft skills gained through experience in areas such as teamwork, leadership, and problem-solving. While some of this skillset can only be gained through time on the job, there are ways for SFU to prepare engineering graduate students through industry partnerships, work-integrated learning, applied project work, and field trips.

Engineers working in clean power and renewable energy have a greater need for skills in communication, policy, and stakeholder engagement. Many new renewable energy projects are anticipated to meet the demand for clean power, and these projects are often situated in rural and remote areas with overlapping resource tenures and critical considerations around First Nations rights and title.

The vast potential of task automation means that robotics and computer-controlled systems are key areas of demand for engineers. Employers described challenges in filling positions with engineers specialized in electrical, software, automation, and controls as these are some of the most valuable and transferable skills to several industries integrating more robotics in their processes.

In the area of net-zero buildings, programming, data analysis, and data visualization skills can help graduates create a niche for themselves and build a career. Employers are demanding skills at the intersection of technology and programming and the ability to provide a tailored approach to their analyses. In BC, the roadmap provided by the BC Energy Step Code provides some certainty about what will be required in the next decade, with all new buildings required to be net-zero energy ready by 2032. Understanding how this policy is implemented in practice along with considerations embodied carbon and life cycle assessment will prepare graduates for the future building science and engineering job market.

Finally, the research found that beyond offering a range of applicable courses and subject matter to prospective students, there is a great opportunity for SFU to shape and market their new program to the next generation of climate leaders. Many employers described a broad trend of job seekers looking specifically for a career in climate action, as they want their work to have a positive impact on the world. With its enviable location in Metro Vancouver, the range of exciting industry partnership opportunities, and existing work on low carbon and resilient cities, SFU has the ingredients to attract both domestic and international students to a world-leading engineering program with sustainability at its core.

Appendices

A1 Summary of Industry Survey

A2 Summary of Student Survey

A2 Summaries from Key Informant Interviews (separate document)

A3 Summary of Comparative Academic Programs (separate document)

Appendix A1: Industry Survey Results

An industry survey was conducted in May and June 2021 to capture insights from potential employers across Canada, to better understand the demand for the potential graduates of the proposed new SEE MEng program. The survey asked respondents about job and skills trends in the subsectors, drivers of investments and employment opportunities at their organization, specific technical and non-technical skills priorities from the new engineering workforce, and the learning outcomes of the proposed MEng program.

The survey was disseminated directly via email through the Survey Monkey platform to over 800 individuals across Canada, representing public sector organizations (including government, post-secondary institutions, NGOs, and organizations representing workers), and private sector organizations (including businesses and organizations representing industry). Multiple reminders were sent, and 52 responses were received after approximately 4 weeks.

Respondent Type

Figure A1.1 shows the breakdown of the responses by broader respondent categories.

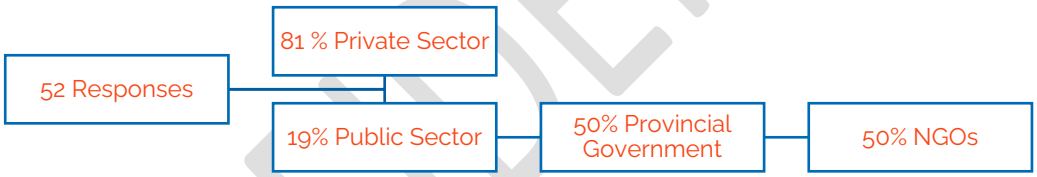


Figure A1.1: Respondent categories by percentage

Responses from the private sector largely came from companies in renewable energy, energy storage and battery technology, and manufacturers of clean technology (identified as other).

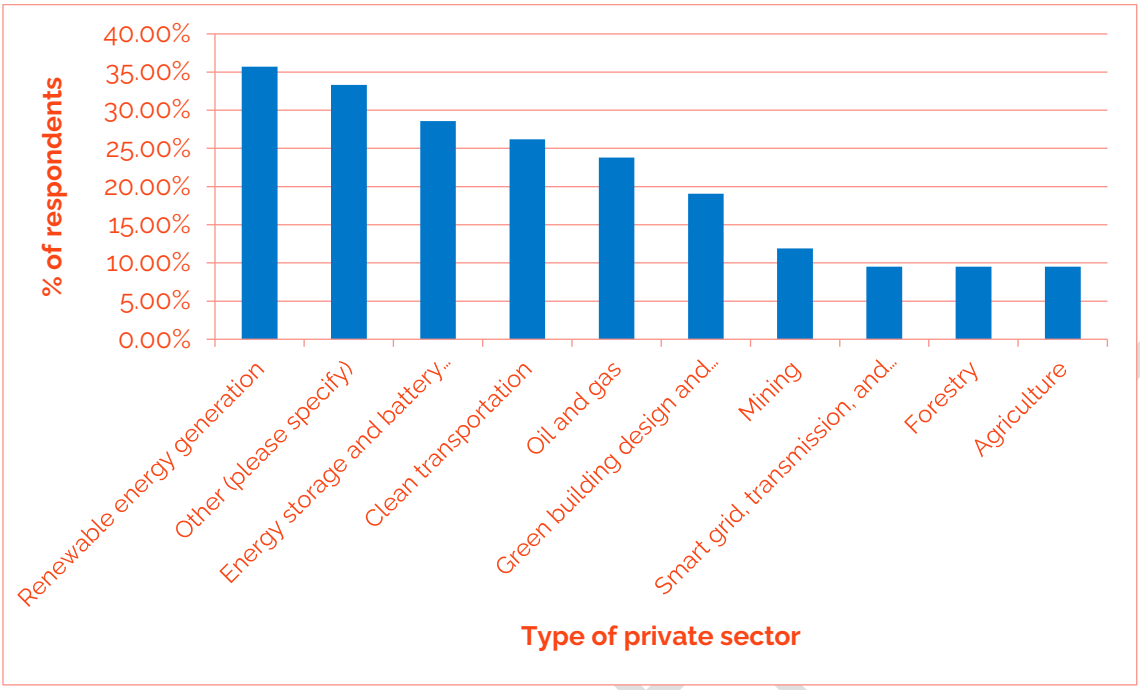


Figure A1.2: Respondent breakdown by type of private sector organisation (n=52)

Organization structure

Years of Operation

When asked about the years of operation of their respective organizations, 75 percent of the respondents indicated it to be more than 11 years, while about 9 percent indicated 6-10 years. An additional 9 percent reported that their organization has been in operation for 3-5 years. Only 2 respondents indicated less than 2 years of operation.

Number of full-time equivalent (FTE) employees

Responses suggest most of the organizations surveyed are small to medium-sized, as about 43 percent of the companies employ 1-25 FTE employees, and about 12 percent employ 26-50 FTE employees. For the larger companies, there was almost an equal proportion (16-18 percent) employing 101-500 and more than 500 FTE employees, respectively. Only 2 respondents indicated having no full-time equivalent workers.

Number of full-time equivalent (FTE) engineers.

Nearly half of companies who completed the survey employ 1-25 FTE engineers. About one out of ten companies indicated employing 26-50 FTE engineers, as well as another equal proportion employing more than 100 FTE engineers. There was a large segment of organisations that did not employ FTE engineers, representing almost 20 percent of the respondents.

Trends and Opportunities in Job Growth

The top 5 areas in which companies expect to see the highest growth in demand for jobs and skills in the next 3-5 years include:

1. Electric vehicles and infrastructure (zero emission vehicles, electric air/marine crafts)
2. Alternative fuels (renewable natural gas, hydrogen), battery chemistry (vanadium, li-ion)
3. Renewable energy generation (solar wind, hydroelectric, geothermal, tidal)
4. Energy efficient technologies and systems (heat recovery, solar thermal hot water, HVAC, and building envelope)
5. Alternative fuel and hydrogen vehicles and infrastructure (biofuel, hydrogen-derived renewable diesel, fuel cells)

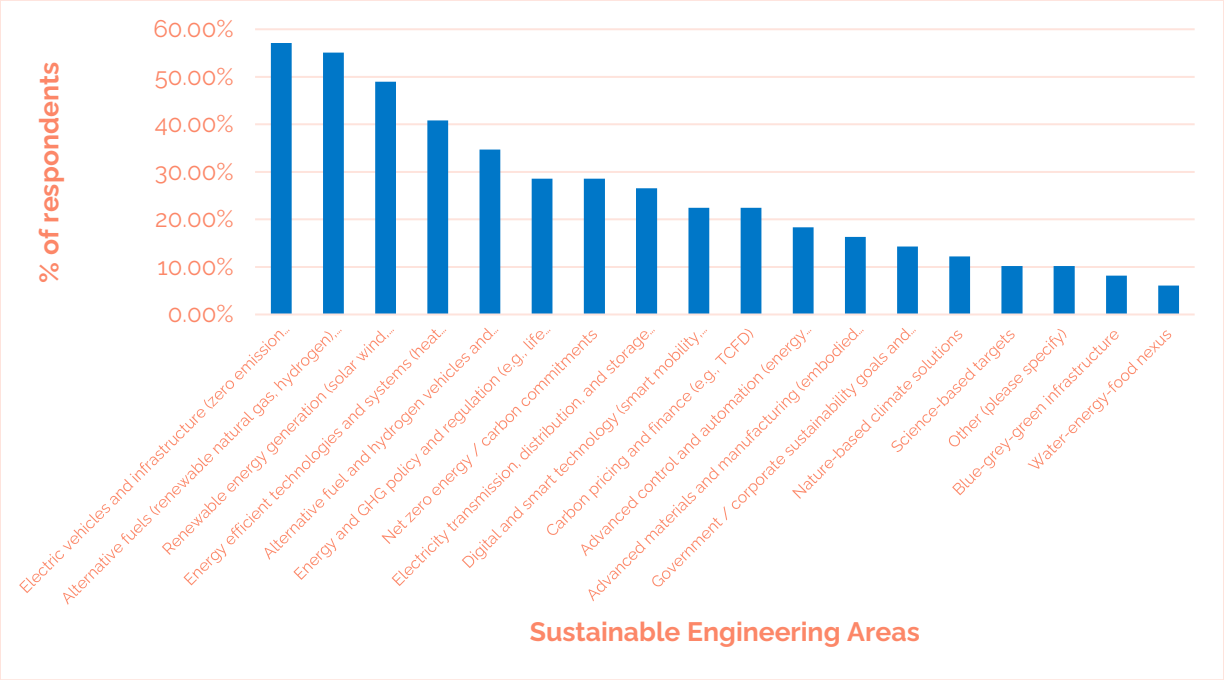


Figure A1.3: Responses to the question" Please select up to 5 areas in which you expect to see the highest growth in demand for jobs and skill in the next 3-5 years" (n=52)

In terms of the factors (e.g., technologies, market forces, policies, etc.) driving investments and/or employment opportunities, companies identified the following top 5 factors as being the most influential over the last 3-5 years (Figure A1.4):

1. Energy and GHG policy and regulation (e.g., life cycle analysis and embodied carbon)

2. GHG reduction technologies
3. Decreasing costs of renewable energy technology
4. Sustainable Development Goals (SDG) driven commitments
5. Net zero energy / carbon commitments

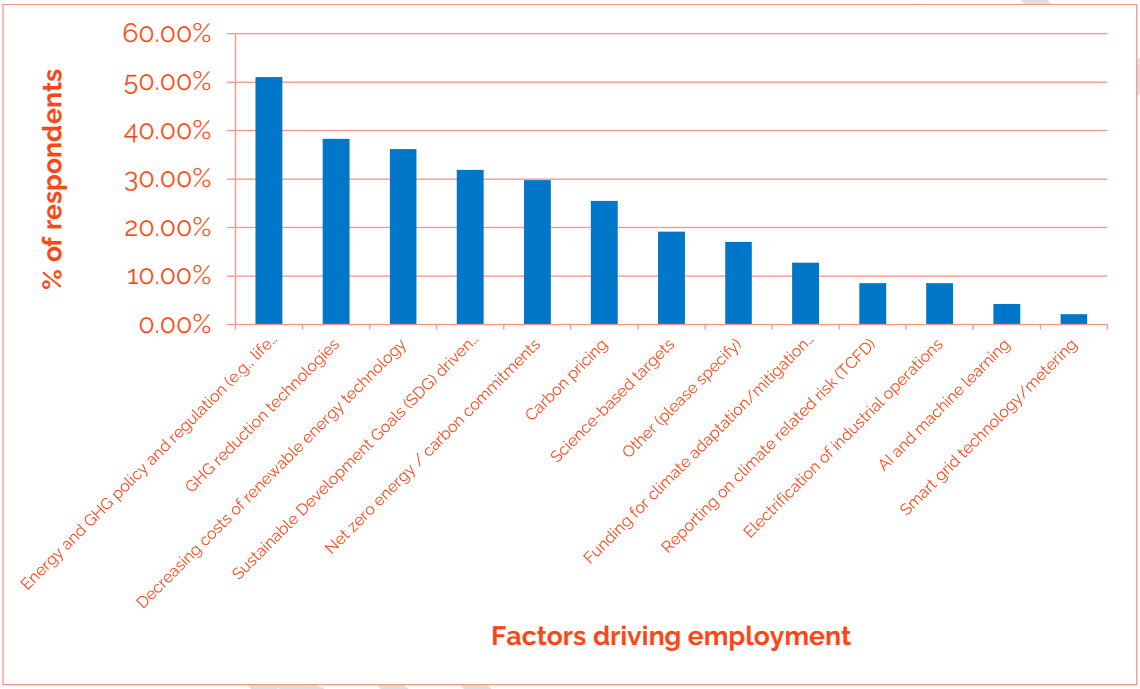


Figure A1.4: Responses to the question "Which factors (e.g., technologies, market forces, policies, etc.) have been the most influential in terms of driving investments and/or employment opportunities for your company over the last 3-5 years?" (n=52)

Trends in hiring engineering students

Most of the respondents (45%) expected to hire 1-4 engineers over the next 2-3 years. There was a significant proportion of companies at about 18% who did not anticipate employing any engineers.

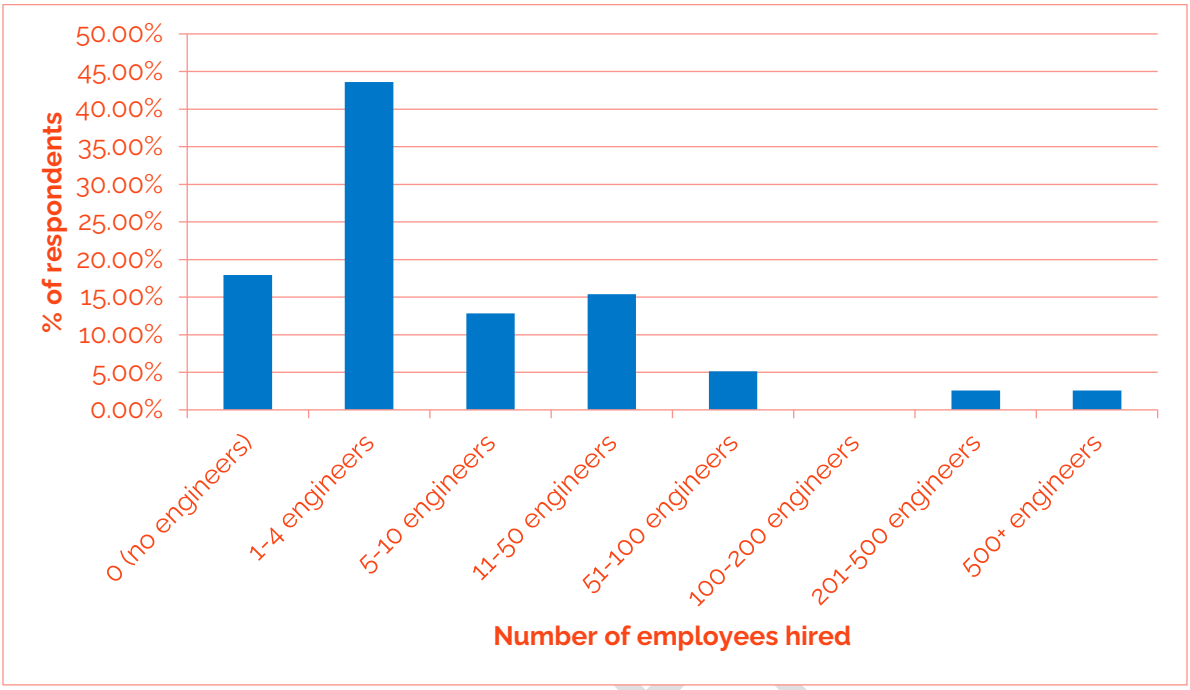


Figure A1.5: Responses from the question: "Approximately how many full-time equivalent engineers does your company expect to hire in the next 2-3 years?" (n=52)

The top 3 types of engineers employed across public and private sectors are: mechanical engineers, chemical engineers, and environmental engineers.

Collaborative opportunities

When asked about the most important aspects of a successful collaborative partnership between respondent organizations and an academic institution, the most common responses were:

- Co-ops
- Applied Research
- Formal Working relationships
- Funding support

Among the respondents, almost 30% showed interest in potential collaborative opportunities with SFU, while 65% said they are interested to learn more about the outcome of this study.

Gap Analysis:

The gap analysis provides a snapshot of the distribution of interviewees and survey respondents representing each of the sub-sectors of the study.

Among the survey respondents, there is a higher proportion of the companies representing the energy sector compared to the other sectors discussed in the study. Individuals representing the climate policy sector were proportionately the least in the survey.

Table A1.1: Gap analysis between the interviewees and survey respondents

Sector	Interviews	Survey Responses
Clean Energy	2	45
Clean Transportation	3	13
Green Buildings	2	10
Sustainability (Includes agriculture, forestry)	1	20
Climate Policy	2	6
Others[65]	n/a	3
Total	10	52[66]

[65] Other sectors identified by respondents include manufacturing, waste management and water remediation
[66] For the survey, two respondents could not be categorised under any of the categories. Additionally, survey respondents had the opportunity to self identify under multiple categories, so the total of the survey here is not equal to the total number of respondents.

Appendix A2: Student Survey Results

Following the industry survey, a student survey was disseminated to potential students of the proposed MEng program. 10 questions were placed in the context of respondent demographics, industry/career focus and program considerations. For some specific questions related to program design, students were asked to indicate the importance associated with certain characteristics. The survey was conducted on the Survey Monkey platform over 4 weeks in September and October 2021.

Student Profiles

Education status

The respondents mostly (84%) comprised of undergraduate students, with greater representation of 1st year (less than 30 completed units) and final year (91 or more completed units) students. Only 16% of the respondents were from a graduate program. There were no recent graduates among the respondents. Figure A2.1 shows the breakdown of the responses by broader respondent categories.

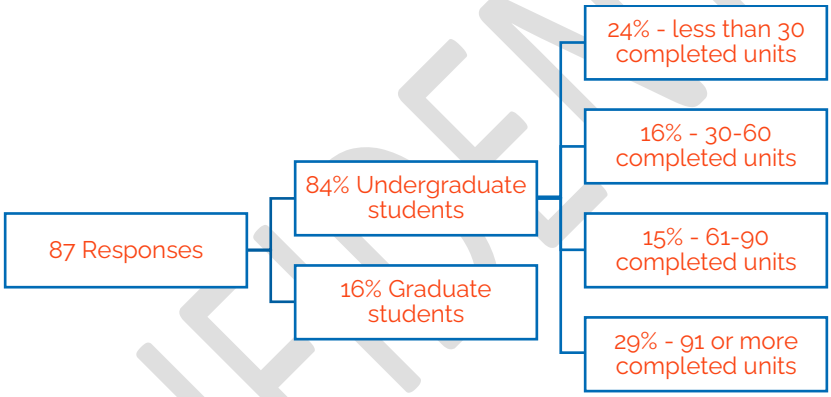


Figure A2.1 Respondent categories by percentage

Program/Major

The respondents came from a diverse range of engineering/STEM programs. Among the programs, sustainable energy engineering (26%) computer science (identified as others at 20%) and mechatronics engineering (15%) represented the highest proportion of students. There was a sizeable representation from the faculty of engineering science and faculty science, accounting for 27% and 3% of the respondents respectively. Figure A2.2 illustrates a detailed summary of the program categories.

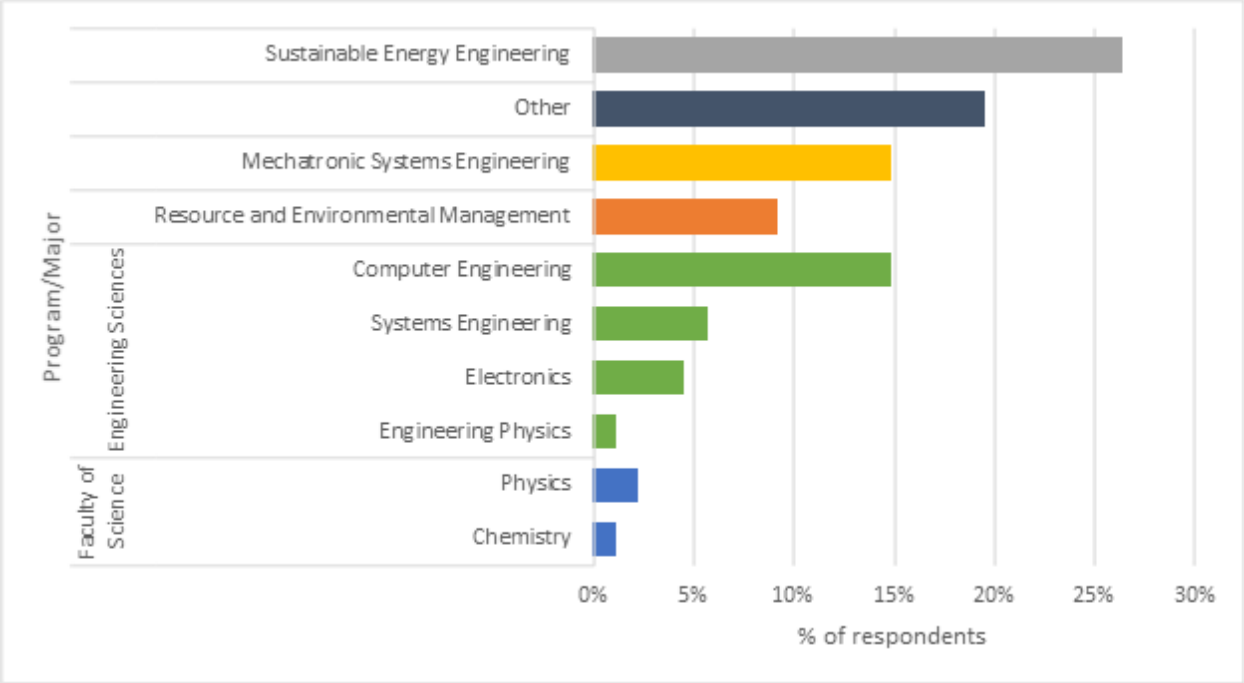


Figure A2.2 Responses to the question What program or major are you currently enrolled in at SFU? (n=87)

Residency status

Among the respondents, 67% were Canadian citizens, while 31% were international students. Only 2% of the students were permanent residents.

While the demographic data suggests that an average respondent profile consisted of an undergraduate student with Canadian citizenship, the significant proportion of international students that responded to the survey should not be ignored. Thus, the viewpoints from the survey represent both domestic and international students, both of which are important audiences for the proposed program.

Program Considerations

Preliminary areas of interest

The respondents ranked clean energy and low-carbon transportation as the top climate action and sustainability areas of interest. In the industry consultation, these areas were also identified as having the highest growth in demand for jobs and skills in the coming 5 years. Thus, the program can appeal both to students and employers by continuing to focus on these two areas. Additional program focus on climate change resiliency will address both the growing interest among students and the urgent skill gap in the industry in this area.

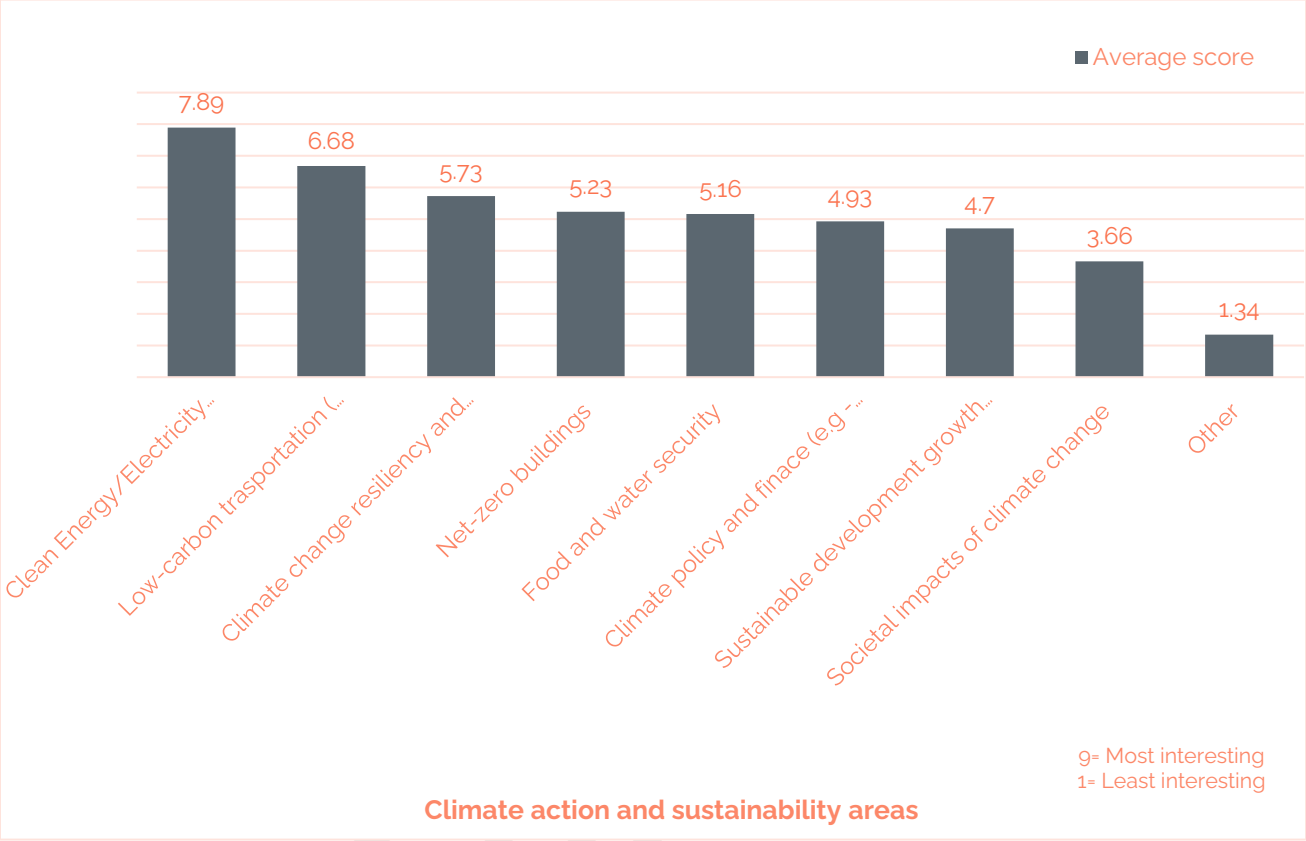


Figure A2.3 Responses to the question "Which of the following climate action and sustainability areas most interest you?" (n=86)

Industry focus

Type of employers preferred

The following figure provides a breakdown of the preferred type of employers among the respondents:

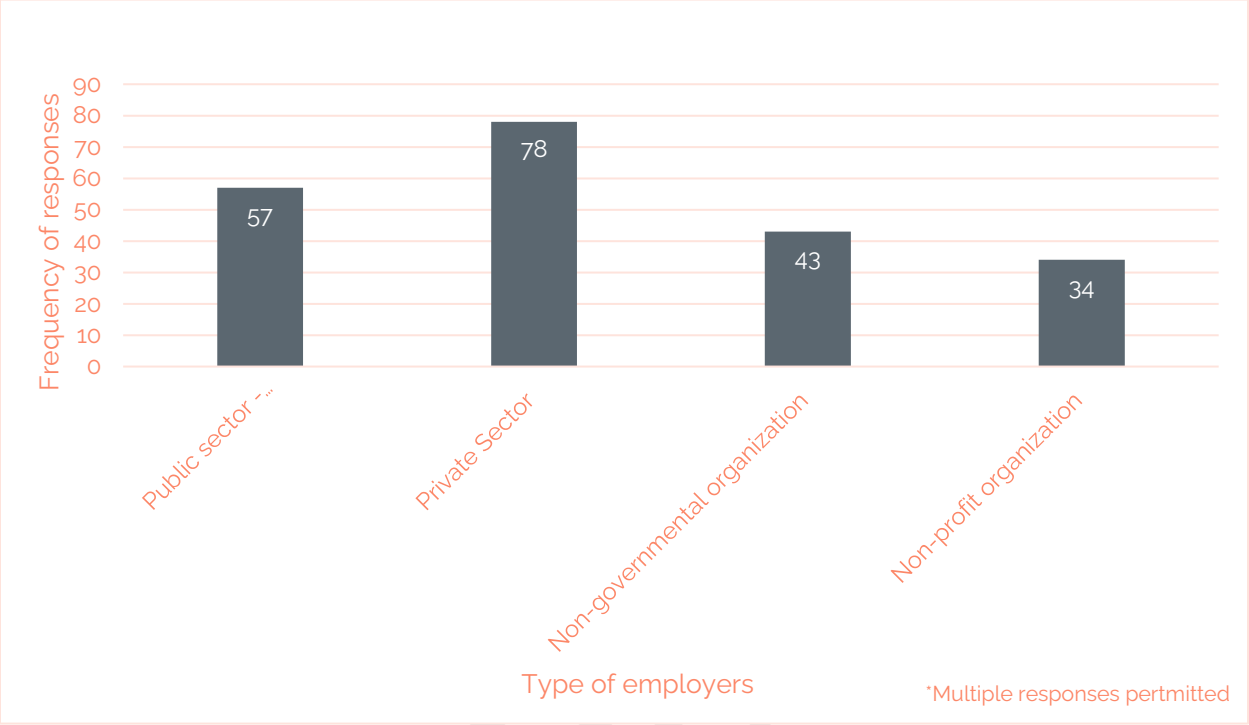


Figure A2.4: Reponses to the question "which type of employers would you be interested in working for?" (n=86)

Region	Institution	Program Title	Degrees Offered	Program Duration	Core Engineering Foci	Engineering Elective/Specialization Foci	Other non-engineering disciplines	Faculty partnership	Target Audience	Policy and	Why?	Co-op/ Work	Project/Thesis Based	Link to Program Website
Canada	SFU	MASc in Sustainable Energy Engineering	MASc	2 yrs	Clean energy technology	N/A	N/A	N/A	Undergraduate students	Y	Sustainability as a guiding principle	N	Thesis	https://www.sfu.ca/students/calendar/2020/spring/programs/sustainable-energy-engineering/master-of-applied-science.html
Canada	Carleton	Master in Sustainable Energy	Engineering degree (MASc or MEng in Sustainable Energy), Public policy degree (MA in Sustainable Energy)	2 yrs	1) Sustainable Energy; 2)Mechanical Energy Conversion ; 3) Electrical Energy Systems	Climate change collaborative specialization (Optional)	Policy, Economics, Development studies	School of Public Policy and Administration, the Department of Mechanical and Aerospace Engineering, and the Departments of Electronics and Systems and Computer Engineering.	Undergraduate students	Y	Multiple policy/sustainability related modules , Climate change specialisation	Y	Project	https://graduate.carleton.ca/cu-programs/sustainable-energy-masters/
Canada	UBC	Master of Engineering Leadership in Clean Energy Engineering	Master of Engineering Leadership (MEL)	1 yr	1) Alternative energy systems; 2) Transmission and Distribution; 3) Energy utilization and management	N/A	Policy, Leadership/business, Analytics	Sauder's Robert H. Lee Graduate School	Professionals	Y	Energy policy (1) module	N	Project	https://apscpp.ubc.ca/programs/mel/clean-energy-engineering/
Canada	UofT	Master of Engineering with Technical Emphasis in Sustainable Energy	MEng	1 yr	1) Alternative energy systems; 2) Transmission and Distribution; 3)Energy utilization and management	Multiple categories	N/A	N/A	Undergraduate students	Y	Multiple sustainable modules - electives	N/A	N/A	https://gradstudies.engineering.utoronto.ca/professional-degrees/emphasis-in-sustainable-energy/
Canada	Waterloo	Master of Engineering in Mechanical and Mechatronics Engineering with a Graduate Diploma in Green Energy	Meng (Under Mechanical and Mechatronics Engineering)	1-2 yrs	1) Energy and Environment	Hydrogen storage material, Fuel cell technology, Solar energy, Wind Energy Low Energy Building, Air Pollution and Green House Gas	Communication	N/A	Undergraduate students, Foreign-trained engineers, Professionals	N	N/A	N	N/A	https://uwaterloo.ca/mechanical-mechatronics-engineering/master-engineering-graduate-diploma-green-energy
Canada	Queen's University	Master in Applied Sustainability	MEng or MASc	1 yr	1) Sustainable Energy Technologies, 2) Sustainability and Fresh Water Systems and 3) Sustainable Resource Management.	Multiple categories	Public policy, Environmental studies, Geological science, Urban and Regional Planning	Chemical Engineering, Civil Engineering, Electrical and Computer Engineering, Geological Sciences and Geological Engineering, Mechanical and Materials Engineering and Mining Engineering, Public Policy	Undergraduate students	Y	Public policy module; Sustainability (2) modules - core	N	Project (Optional)	https://engineering.queensu.ca/programs/graduate-professional/collaborative/mas/
USA	Oregon Tech	Master of Science in Renewable Energy Engineering	MS	2 yrs	Renewable and conventional energy production storage and distribution	1) Advanced Energy Storage, 2) Biofuels and Biomass, 3) Electrical Power Systems,4) Electrochemical Systems, 5) Energy Efficient Building Systems,6) Energy Storage, 7) Fuel Cell Systems, 8) Geothermal Energy, Global Energy Issues, 9) Hydro Power Systems and Integration, 10) Photovoltaic Systems, 11) Wind Power Systems.	N/A	N/A	Undergraduate students, Professionals	N	N/A	N	Project (Optional)	https://www.oit.edu/academics/degrees/ms-ree
USA	University of Colorado Boulder	Professional Master's Programs in Next-Generation Power and Energy Systems	MSEE/ ME	1-2 yrs	1) Renewable energy, 2) Future Power grid, 3) Power system, 4)Distribution system	Multiple categories	Energy policy, Business, Data Analytics	N/A	Undergraduate students, Professionals	Y	Policy (1) and sustainability (1) module - elective	N	N/A	https://www.colorado.edu/ecee/graduate-program/degrees-programs/professional-masters-programs/next-generation-power-and-energy
USA	University of Maryland	Masters in Energy Systems Engineering	Professional Master of Engineering (M.Eng.)	1-2 yrs	1) Sustainable energy conversion 2) Renewable energy application 3) Environmental risk analysis	Broad Categories - 1) Reliability Engineering; 2) Renewable and Conventional Energy systems	Business (Risk analysis, Energy Audit, Innovation)	N/A	Undergraduate students	Y	Sustainability (2) modules - core and elective	N	N/A	https://mage.umd.edu/energy-systems-engineering
USA	University of Michigan	Masters in Energy Systems Engineering	MEng	1-2 yrs	1) Energy generation 2) Advanced Energy Solutions 3) Sustainable design of technology systems	Track - 1) Energy Generation, Distribution, and Usage; 2)Transportation Power; 3) Sustainable Chemical Conversion; 4) Energy Analysis	Natural and Social sciences, Public policy, Environmental science, and Business	College of Engineering, the School for Environment and Sustainability, the Ross School of Business, the Gerald R. Ford School of Public Policy, the Taubman College of Architecture and Urban Planning of Art and Architecture, and the College of Literature Science and Arts	Undergraduate students	Y	Multiple sustainable & policy modules - core and electives		Project	https://isd.engin.umich.edu/graduate-degree-programs/energy-systems-engineering-program/energy-systems-engineering-program-curriculum/
USA	Rutgers University	Master of Engineering Graduate Degree Program in Energy Systems Engineering	Meng	1-2 yrs	1) Clean and renewable energy;2)Smart grid; 3)Built environment energy modeling; 4)Renewable energy generation 5) Materials and devices	1)Energy policy and regulations 2)Eco-systems 3)Asset management and reliability 4)Data analytics 5)Cyber-security 6)IT and communication 7)Energy supply chain 8)Energy market	Business, Data Science/IT, Public policy, Regulatory study	Six School of Engineering departments and the Graduate School-New Brunswick, along with the Edward J. Bloustein School of Planning and Public Policy, and the Rutgers School of Business.	Undergraduate students	Y	Multiple sustainable & policy modules - core and electives	Y	Project (Optional)	https://soe.rutgers.edu/energy-systems-engineering
USA	Santa Clara University	Master of Science in Power Systems and Sustainable Energy	MS	2 yrs	Fundamentals of power systems Different types of renewable energies Storage systems	Track- 1) Mechanical Engineering - Energy storage/conversion; thermodynamics 2) Electrical Engineering - Energy storage/conversion/management 3 Computer Engineering - Big Data, AI; 4) Civil engineering - sustainable building	Economics, Public policy, Ethics, Business/Entrepreneurship , Data Science	N/A	Undergraduate students	Y	Policy (1) and sustainability (2) module - core and elective	Y/O	N/A	https://www.scu.edu/engineering/academic-programs/power-systems-and-sustainable-energy-program/master-of-science-program/
USA	University of Arizona	Innovation, Sustainability, and Entrepreneurship	ME	1-2 yrs	1) Material Science	N/A	Business/Entrepreneurship	N/A	Professionals	Y	Program focus on sustainability	N	Research Proposal	https://online.arizona.edu/programs/graduate/online-master-engineering-innovation-sustainability-and-entrepreneurship-mesie
UK	University of Exeter	MSc Renewable Energy Engineering	MSc	1 yr	1) Renewable energy systems 2) Networking Engineering	Broad Categories - 1) Solar, Wind and Marine Energy 2)Sustainable built environment 3) Electrical and Electronics Engineering 4)LCA 5)Low carbon transportation	Policy, Ethics	Not available	Undergraduate students, Professionals	Y	Modules: 1) Energy policies for a low carbon economy; 2) Climate change 3) Sustainable Architecture	N	Project	https://www.exeter.ac.uk/postgraduate/courses/engineering/renewableenergyengineeringmsc/
UK	University of Manchester	MSc Renewable Energy and Clean Technology	MSc	1 yr	1) Clean energy systems 2) Smart grids 3) Solar, Marine energy 4) Zero carbon built infrastructure	N/A	N/A	N/A	Undergraduate students	N	N/A	N	Dissertation	https://www.manchester.ac.uk/study/masters/courses/list/09009/msc-renewable-energy-and-clean-technology/course-details/#course-profile
UK	Cranfield University	MSc in Renewable Energy	MSc	1 yr	1) Renewable Engineering Technologies, 2) Engineering Stress Analysis 3)Fluid Mechanics and Loading 4) Design of Offshore Energy Structures,	N/A	Entrepreneurship, Economics and Policy	Bettany Centre for Entrepreneurship	Undergraduate students, Professionals	Y	Policy (1) and sustainability (1) module - core.	N	Project	https://www.cranfield.ac.uk/courses/taught/renewable-energy
UK	Imperials College London	MSc in Sustainable Energy Futures	MSc	1 yr	1) Energy Systems Technology, 2) Bioenergy 3) Nuclear Energy 4) Energy Transmission and Storage 5) Urban Energy Systems 6) Sustainable Transport	N/A	Entrepreneurship, Economics and Policy; Data Science	Faculty of Engineering with the Faculty of Natural Sciences and the Imperial College Business School,	Undergraduate students, Professionals	Y	Policy (1) and sustainability (1) module - core.	N	Project	https://www.imperial.ac.uk/energy-futures-lab/msc-in-sustainable-energy-futures/
UK	University of Portsmouth	Electrical and Renewable Energy Engineering	MEng	4-5 yrs	1) Energy Conversion and Storage 2) Solar energy 3) Sustainable transport 4) Battery and fuel cell 5) Smart grid 6) Renewable and alternative energy	Broad categories - 1) Low Carbon Heating Systems; 2) Control Systems Analysis; 3) Power electronics	Economics, Data Science (AI), Entrepreneurship (Risk analysis; Innovation and enterprise)	N/A	High school students	N	N/A	N	Project	https://www.port.ac.uk/study/courses/meng-beng-renewable-energy-engineering
Germany	Berlin University of Applied Sciences	Engineering and Sustainable Technology Management in Renewable Energy, Water and Waste Management	MEng	2 yrs	1) Renewable energy - heating, cooling 2) Mechanical Engineering 3) Electrical Engineering 4) Waste and Water Processing	N/A	Business (Finance, Marketing, Accounting, Negotiation and Management); Data Science (AI)	N/A	Undergraduate students	Y	Module on LCA	Y	Thesis	https://www.srh-university-berlin.de/en/master/engineering/
Germany	Berlin University of Applied Sciences	Engineering and Sustainable Technology Management in Smart Building Technologies	MEng	2 yrs	1) Building control system 2) Building information modelling 3) Electrical and Electronics Engineering	N/A	Business, Data Science	N/A	Undergraduate students	Y	Modules (5) on sustainable technology	Y	Thesis	https://www.srh-university-berlin.de/en/master/engineering/
Germany	Berlin University of Applied Sciences	Engineering and Sustainable Technology Management in Mobility and Automotive Industry	MEng	2 yrs	1) Electrical and Electronics Engineering 2)Battery Electric Vehicles and Charging Infrastructure 3)Alternative Power Supply incl. Infrastructure	N/A	Business, Data Science, IT	N/A	Undergraduate students	Y	Modules (5) on sustainable technology	Y	Thesis	https://www.srh-university-berlin.de/en/master/engineering/

Germany	University of Applied Sciences Stralsund	Renewable Energy and E-Mobility	MEng	1-2 yrs	1) Renewable energy systems 2) Systems theory 3) Power engineering	Broad Categories - 1) Renewable energy use 2) Solar and Wind energy 3) Power electronics 4) Sustainable mobility 5) Hydrogen technology	Business (Accounting. Human Resource)	N/A	Undergraduate students	Y	Module on sustainability	Y	Both	https://www.hochschule-stralsund.de/en/host/schools/electrical-engineering-and-computer-science/range-of-courses/renewable-energy-and-e-mobility-master-reemm-engl/
Germany	Hamburg University of Applied Sciences	Renewable Energy Systems – Environmental and Process Engineering	MSc	1 yr	1) Wind energy 2) Bio energy 3) Solar energy	Broad categories - 1) Energy Conversion and Distribution 2) Electrical Engineering 3) Advanced Control System 4) Plant Engineering and Project Management	Business (Finance, Project Management), Energy policy	N/A	Undergraduate students	Y	Module on international policy	N	Thesis	https://www.haw-hamburg.de/en/study/degree-courses-a-z/study-courses-in-detail/course/courses/show/renewable-energy-systems-environmental-and-process-engineering/Studieninteressierte/
Netherlands	University of Twente	Sustainable Energy Technology	MSc	2 yrs	1) Energy conversion 2) Electrical power engineering and system integration 3) Solar & Wind energy 4)Energy storage	N/A	Economics, Business (business development, innovation, supply chain management)	N/A	Undergraduate students	Y	Modules on sustainability (1) and LCA (1)	Y	Thesis	https://www.utwente.nl/en/education/master/programmes/sustainable-energy-technology/
Switzerland	ETH	Master in Energy Science and Technology	MSc	1-2 yrs	1) Electrical Power Engineering 2) Energy Flows and Processes	N/A	Economics, Energy Policy, Business (innovation and management)	Departments of Information Technology & Electrical Engineering; Mechanical & Process Engineering; Energy Science Centre	Undergraduate students	Y	Modules on policy (1) and interdisciplinary sustainable energy case studies (2)	Y	Both	https://master-energy.ethz.ch/the-programme/about-mest.html
Sweden	Lund University	Sustainable Energy Engineering	MSc	2 yrs	1) Energy engineering 2)Sustainable transport 3) Environmentally friendly power generation 3) Turbomachinary 4) PV systems 5)Thermochemical conversion of biomass	Track - 1) Automotive 2) Computational fluid dynamics 3)Electric power systems 4)Heating and cooling		Departments of Energy Sciences, Architecture and the Built Environment, Biomedical Engineering and Technology and Society at LTH – the faculty of Engineering at Lund University.	Undergraduate students	Y	Module in sustainable transportation (1)	N	Project	https://www.lunduniversity.lu.se/lubas/i-uoh-lu-TAHET#requirements
Sweden	Chalmars University	Sustainable Energy Systems	MSc	2 yrs	1) Heat and power systems engineering 2) Sustainable energy futures 3) Industrial energy systems	Broad categories - 1)Energy systems, 2) Process industry, 3) Heat and power, 4) Buildings, 5) Computational fluid dynamics	Environmental policy, Business(Leadership, stakeholder management)	N/A	Undergraduate students	Y	Multiple modules in sustainability and 1 policy module	N	Thesis	http://www.chalmers.se/en/education/programmes/masters-info/Pages/Sustainable-Energy-Systems.aspx#third-page
Sweden	KTH	Masters in Sustainable Energy Engineering	MSc	2 yrs	1) Energy engineering, including conversion technologies, systems and applications.	Track - 1) Sustainable Power Generation, 2) Sustainable Energy Utilization, 3) Solar Energy 4) Transformation of Energy Systems: Policy and Management	Business, Climate change policies, Energy system analysis, Economics	N/A	Undergraduate students	Y	Modules with heavy focus on SDGs, climate adaptation and mitigation	N	Thesis	https://www.kth.se/en/studies/master/sustainable-energy-engineering/description-1.8711
Australia	UNSW	Master of Engineering Science in Renewable Energy	MEngSc	2 yrs	1) Renewable energy technologies, 2) Systems engineering, 3) Energy efficiency, 4) Assessment frameworks.	N/A	Business (Entrepreneurial engineering; Ethics and leadership; Project management, Economic decision analysis) ,	N/A	Undergraduate students	Y	Module on LCA(1)	N	Project	https://www.engineering.unsw.edu.au/study-with-us/postgraduate-degrees/renewable-energy#outlines
Australia	UNSW	Master of Engineering Science in Sustainable Systems	MEngSc	2 yrs	1) Life cycle engineering 2) Industrial ecology and sustainable engineering	Broad categories - 1) Materials management 2) Sustainable and renewable energy 3) Energy storage 4)Sustainable infrastructure 5) Sustainability of energy systems	Humanities and Languages (e.g. environmental humanities); Business; Biological and Environmental Sciences; Built Environment; Indigenous studies; Art and design	N/A	Undergraduate students	Y	Modules with heavy focus on sustainable development, sustainability across industries and climate change	N	Project	https://www.handbook.unsw.edu.au/postgraduate/specialisations/2021/ENGGAS
Australia	ANU	Master of Engineering in Renewable Energy	MEng	2 yrs	1) Introduction to Systems Engineering 2) Systems Modelling 3)Energy Resources and Renewable Technologies 4) Power Systems and Microgrids	Broad categories - 1) Solar and Wind Energy 2) Energy Efficiency and Decarbonisation 3) Semiconductors, 4) Fluid Mechanics and Heat Transfer	Professional practice (communication)	N/A	Undergraduate students	Y	Modules on broader sustainability consideration - 1) Urban Energy (with focus of climate change) and Industrial 2) Energy Efficiency and Decarbonisation	N	N/A	https://programsandcourses.anu.edu.au/program/NENRE#career-options

Appendix 9: Student Survey

In September 2021, a survey was conducted through the SFU SurveyMonkey portal to gauge student interest in the program as a whole and also to help in developing the program structure and focus areas. The invitation was sent to senior undergraduate and graduate students in the Faculty of Applied Sciences (Schools of Sustainable Energy Engineering, Mechatronic Systems Engineering, and Engineering Sciences), the Departments of Physics and Chemistry in the Faculty of Science, and the School of Resources and Environmental Management in the Faculty of Environment. The survey was open from September 17 to October 17, 2021 and a total of 87 responses were received. The survey results are included here.

The invitation was:

From: Fac of Applied Science Departmen
Sent: Friday, September 17, 2021 11:14 AM
Subject: SFU Sustainable Energy Engineering Master's Program Student Survey Questionnaire

This message is sent on behalf of the SFU School of Sustainable Energy Engineering

SFU's Faculty of Applied Sciences is aiming to deliver a new Master's level interdisciplinary engineering degree. Graduates from the program are expected to work in business, consulting, and governmental settings. The sectors where the students are most likely to find employment are clean and renewable energy; clean transportation and infrastructure; zero emission buildings; and sustainability policy.

The main objectives of this survey are to provide insight on the evolving demand for skilled, inter-disciplinary engineering graduates at the master's level, and identify ways the program can add value to the existing market of related engineering programs in Canada and globally.

We want to hear your views about interdisciplinarity and engineering education, how it might shape your career choices, and how graduate programs can better equip you to succeed in the workplace.

This short survey consists of mostly multiple-choice questions and should take less than 10 minutes to complete: https://www.surveymonkey.ca/r/SEEMeng. **We request that you please complete this survey before its closing date: September 24, 2021 at 4:00 PM.**

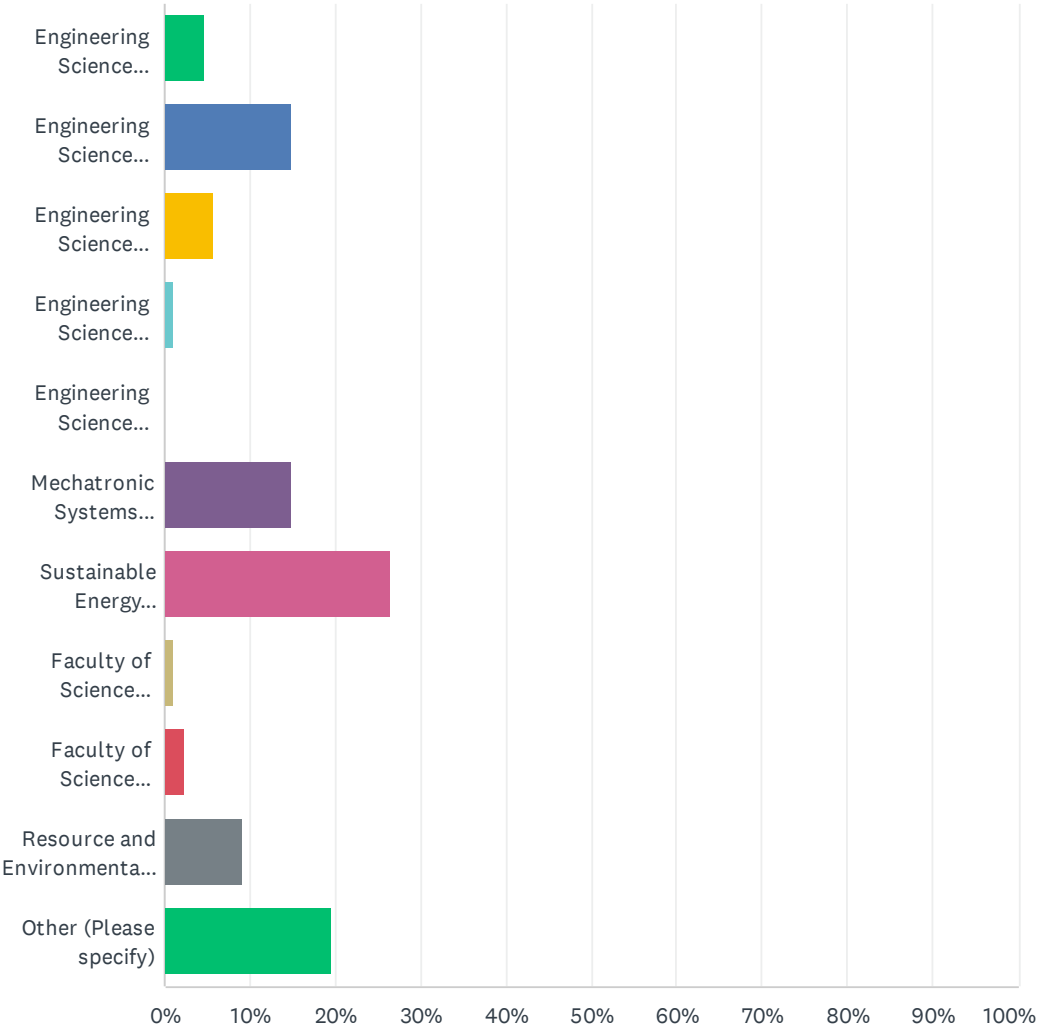
Note with respect to Confidentiality: Please note that your responses to the questions below will remain anonymous and will not be directly attributed to you but may be shared in a final report as high-level, aggregated findings.

If you have questions about this survey or would like more information about the broader research, please contact:

Colin Copeland
SEE Graduate Program Chair,
Sustainable Energy Engineering, SFU
see_graduate_chair@sfu.ca

Q1 What program or major are you currently enrolled in at SFU?

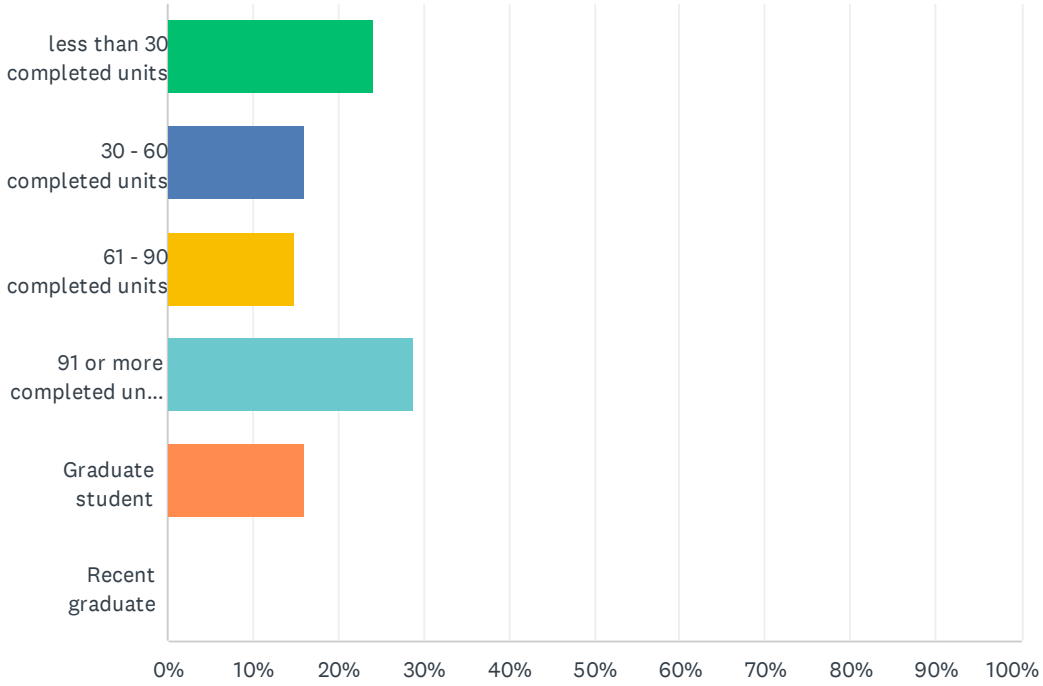
Answered: 87 Skipped: 0



ANSWER CHOICES	RESPONSES	
Engineering Science (Electronics)	4.60%	4
Engineering Science (Computer Engineering)	14.94%	13
Engineering Science (Systems Engineering)	5.75%	5
Engineering Science (Engineering Physics)	1.15%	1
Engineering Science (Biomedical Engineering)	0.00%	0
Mechatronic Systems Engineering	14.94%	13
Sustainable Energy Engineering	26.44%	23
Faculty of Science (Chemistry)	1.15%	1
Faculty of Science (Physics)	2.30%	2
Resource and Environmental Management	9.20%	8
Other (Please specify)	19.54%	17
TOTAL		87

Q2 Which of the following best describes your education status at SFU?

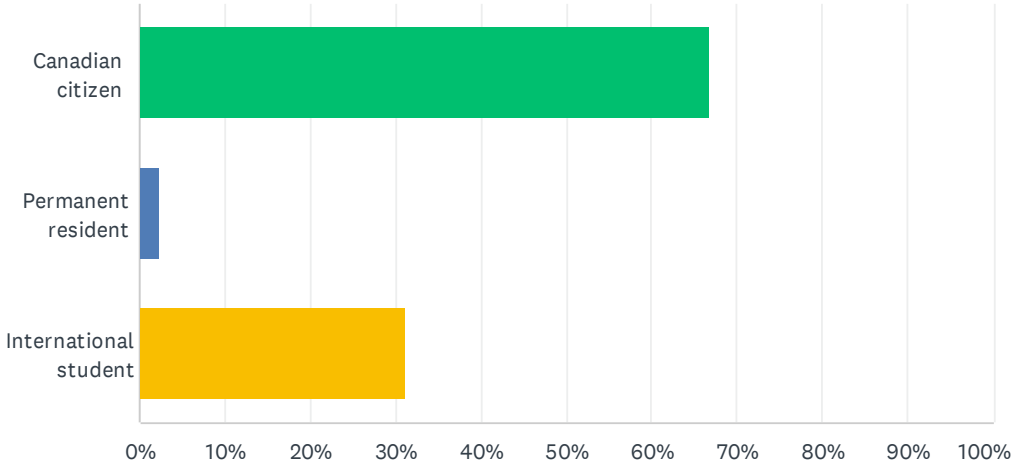
Answered: 87 Skipped: 0



ANSWER CHOICES	RESPONSES	
less than 30 completed units	24.14%	21
30 - 60 completed units	16.09%	14
61 - 90 completed units	14.94%	13
91 or more completed units	28.74%	25
Graduate student	16.09%	14
Recent graduate	0.00%	0
TOTAL		87

Q3 Are you a(n)…?

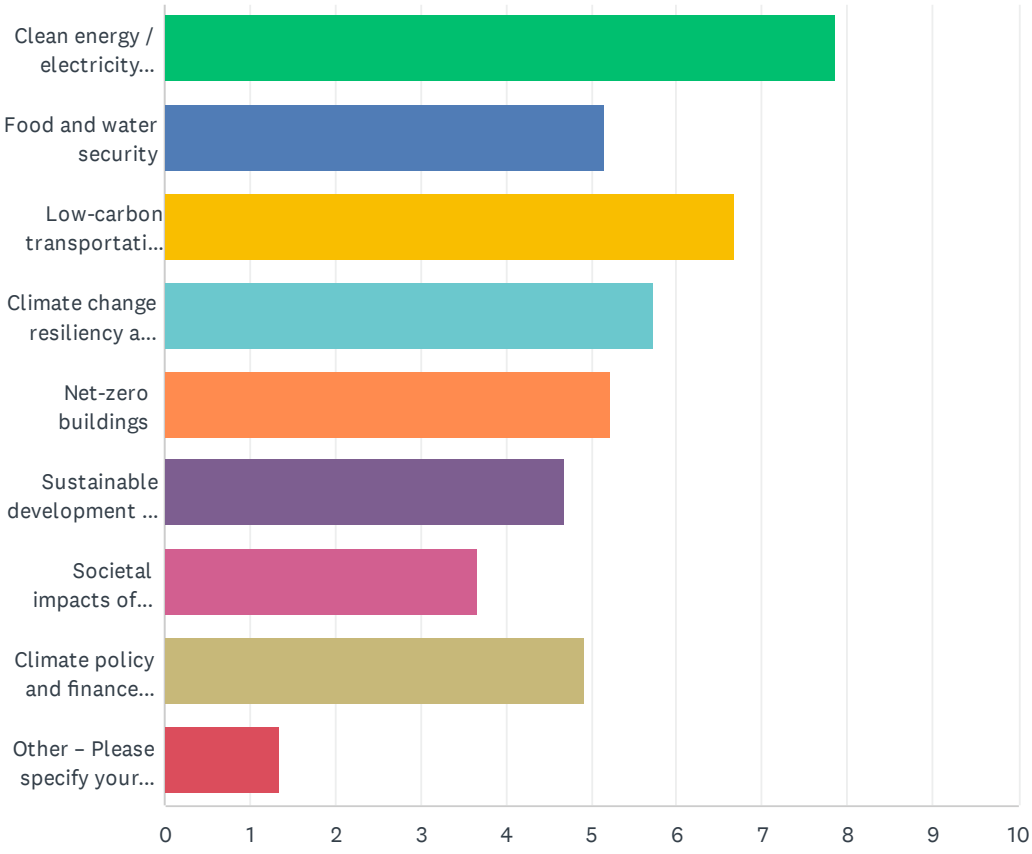
Answered: 87 Skipped: 0



ANSWER CHOICES	RESPONSES	
Canadian citizen	66.67%	58
Permanent resident	2.30%	2
International student	31.03%	27
TOTAL		87

Q4 Which of the following climate action and sustainability areas most interest you? (rank the following areas below)

Answered: 86 Skipped: 1



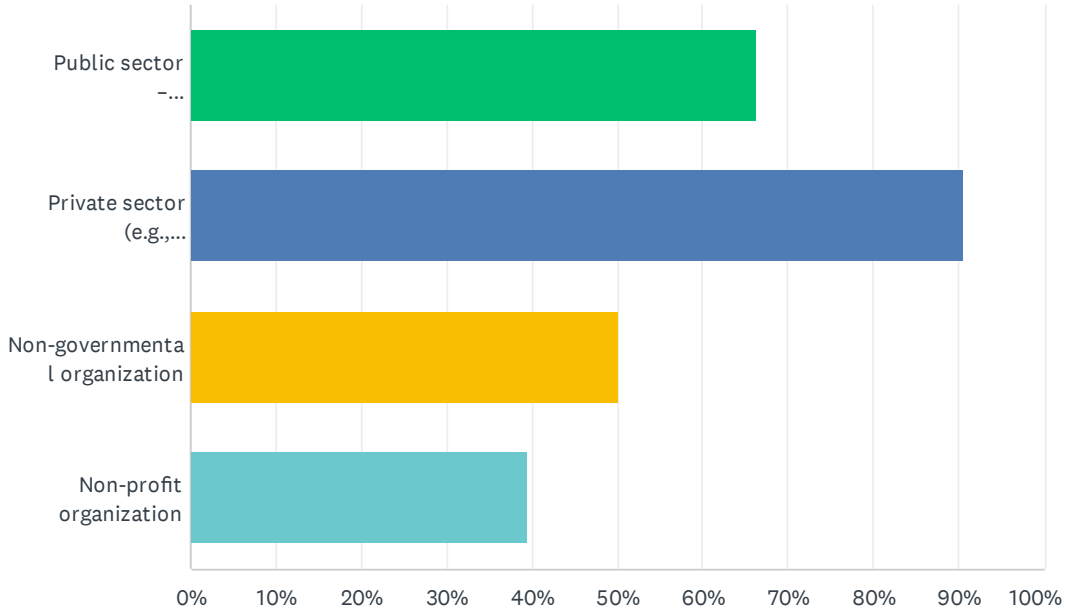
	1	2	3	4	5	6	7	8	9	TOTAL	SCORE
Clean energy / electricity production	51.19% 43	25.00% 21	7.14% 6	3.57% 3	8.33% 7	2.38% 2	0.00% 0	1.19% 1	1.19% 1	84	7.87
Food and water security	17.07% 14	4.88% 4	12.20% 10	10.98% 9	12.20% 10	6.10% 5	13.41% 11	23.17% 19	0.00% 0	82	5.16
Low-carbon transportation (systems, vehicles, infrastructure)	13.10% 11	28.57% 24	21.43% 18	14.29% 12	7.14% 6	7.14% 6	4.76% 4	3.57% 3	0.00% 0	84	6.68
Climate change resiliency and adaptation	4.82% 4	9.64% 8	12.05% 10	34.94% 29	16.87% 14	10.84% 9	9.64% 8	1.20% 1	0.00% 0	83	5.73
Net-zero buildings	3.70% 3	11.11% 9	25.93% 21	8.64% 7	12.35% 10	9.88% 8	12.35% 10	13.58% 11	2.47% 2	81	5.23
Sustainable development and growth (e.g., UN SDGs)	3.70% 3	4.94% 4	7.41% 6	17.28% 14	12.35% 10	27.16% 22	18.52% 15	7.41% 6	1.23% 1	81	4.70
Societal impacts of climate change	3.75% 3	5.00% 4	2.50% 2	3.75% 3	7.50% 6	17.50% 14	26.25% 21	32.50% 26	1.25% 1	80	3.66
Climate policy and finance (e.g., carbon pricing, cap-and-trade)	2.47% 2	12.35% 10	12.35% 10	8.64% 7	22.22% 18	14.81% 12	12.35% 10	11.11% 9	3.70% 3	81	4.93
Other – Please specify your ranking here and the climate action and sustainability area in the next question	1.49% 1	0.00% 0	1.49% 1	0.00% 0	0.00% 0	2.99% 2	0.00% 0	4.48% 3	89.55% 60	67	1.34

Q5 If you selected "Other - Please specify" in the previous question, please provide your specific response here.

Answered: 3 Skipped: 84

Q6 Which type of employers would you be interested in working for? (check all that apply)

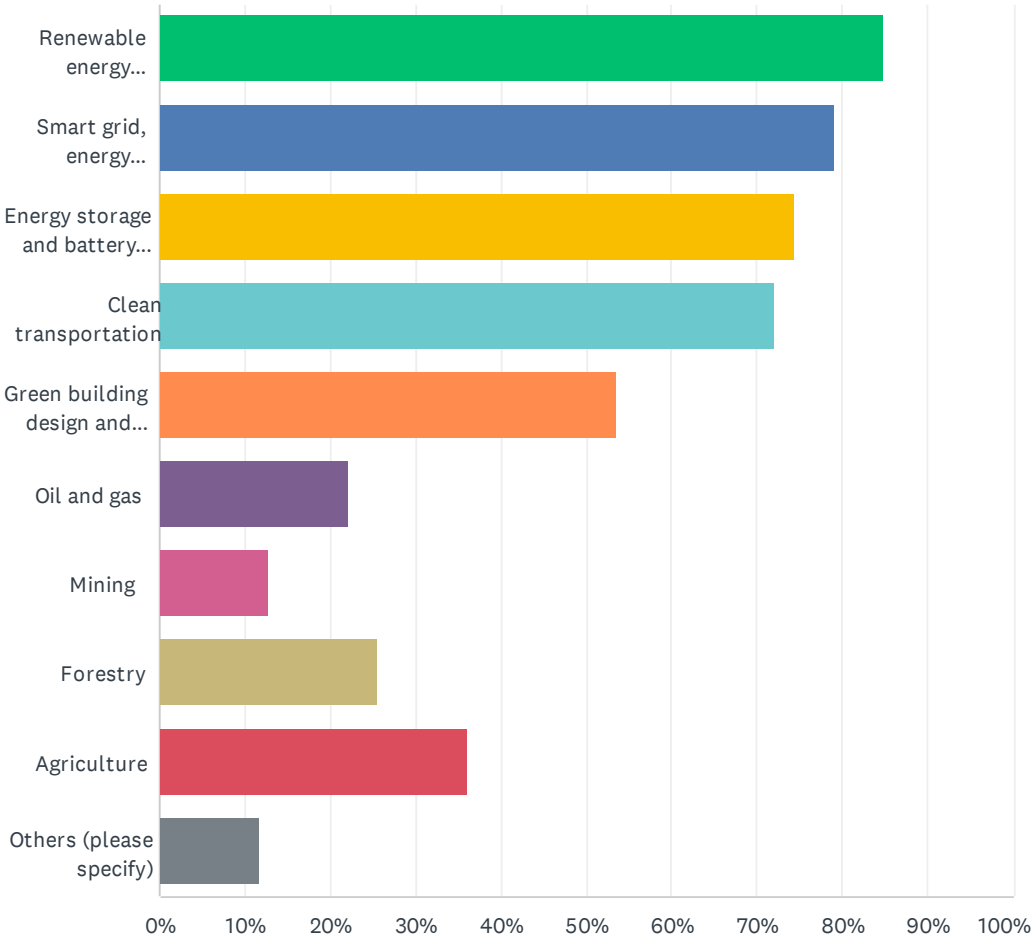
Answered: 86 Skipped: 1



ANSWER CHOICES	RESPONSES	
Public sector – Federal/Provincial/Municipal Government	66.28%	57
Private sector (e.g., industry, consultants)	90.70%	78
Non-governmental organization	50.00%	43
Non-profit organization	39.53%	34
Total Respondents: 86		

Q7 In which of the following industries would you be interested in applying your engineering and sustainability skills to solve local and/or global problems? (check all that apply)

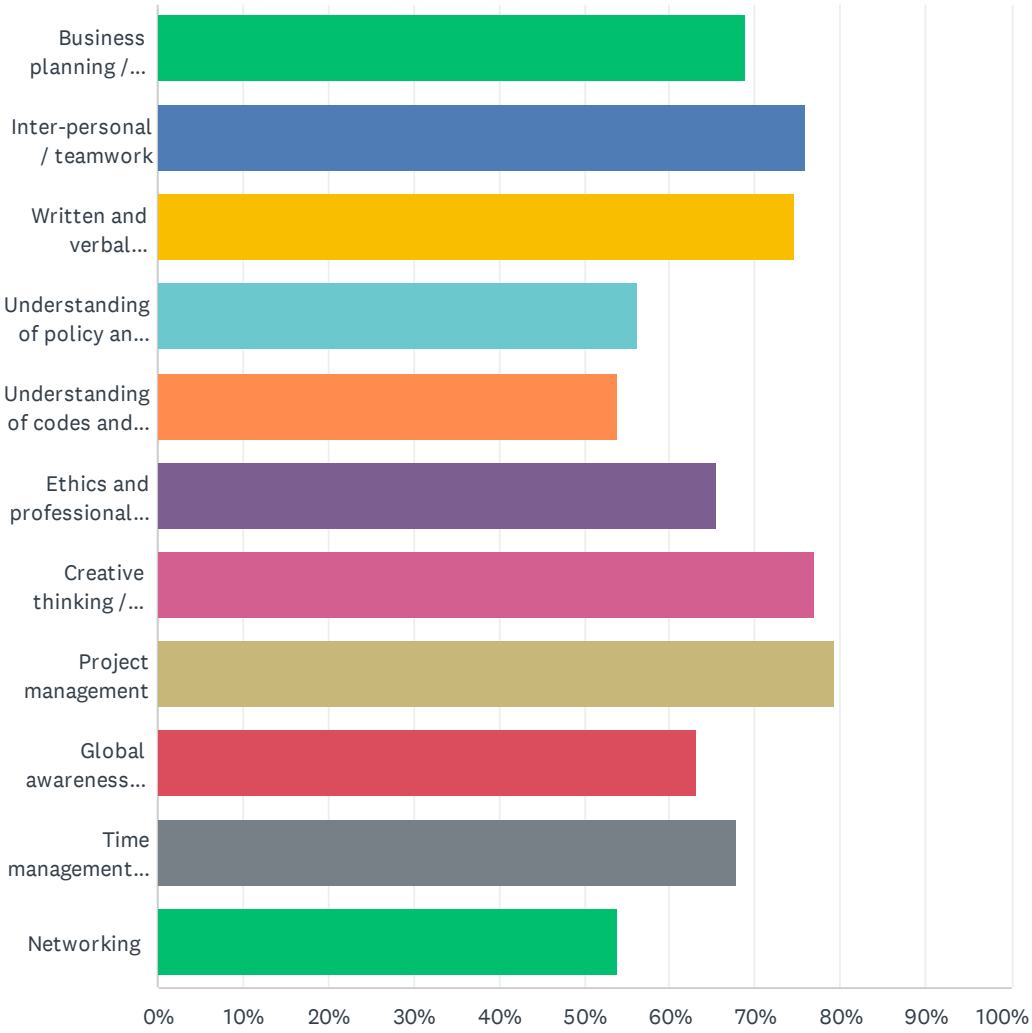
Answered: 86 Skipped: 1



ANSWER CHOICES	RESPONSES	
Renewable energy generation	84.88%	73
Smart grid, energy transmission and distribution	79.07%	68
Energy storage and battery technologies	74.42%	64
Clean transportation	72.09%	62
Green building design and construction	53.49%	46
Oil and gas	22.09%	19
Mining	12.79%	11
Forestry	25.58%	22
Agriculture	36.05%	31
Others (please specify)	11.63%	10
Total Respondents: 86		

Q8 What non-technical and/or interdisciplinary skills do you think are important for your future learning and career? (check all that apply)

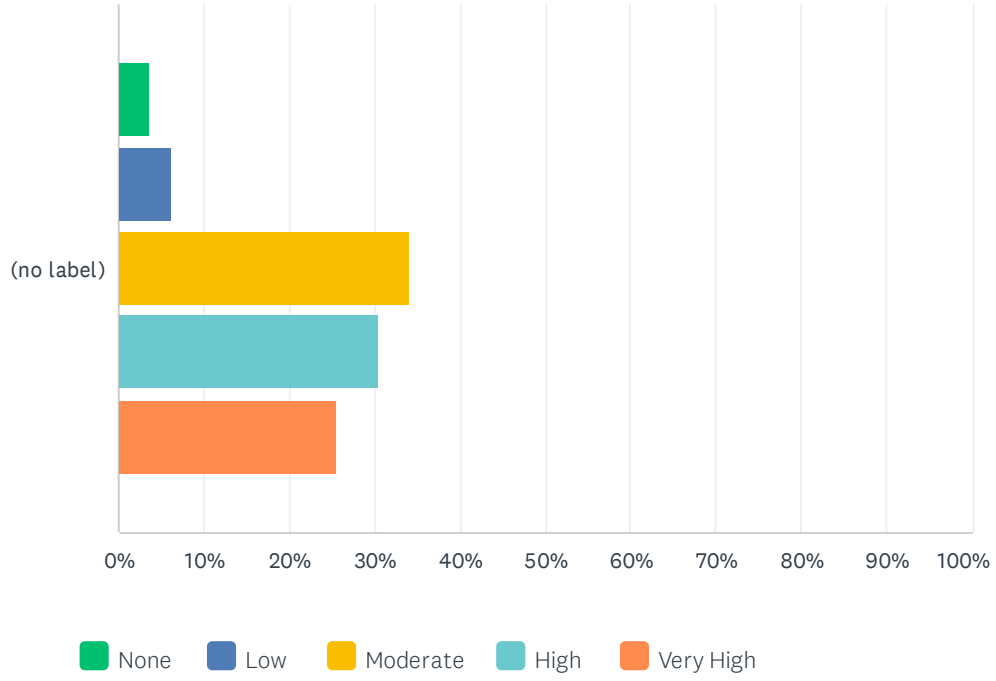
Answered: 87 Skipped: 0



ANSWER CHOICES	RESPONSES	
Business planning / entrepreneurship	68.97%	60
Inter-personal / teamwork	75.86%	66
Written and verbal communication / presentation	74.71%	65
Understanding of policy and regulatory environments	56.32%	49
Understanding of codes and standards	54.02%	47
Ethics and professional responsibility	65.52%	57
Creative thinking / problem solving	77.01%	67
Project management	79.31%	69
Global awareness (cultural, socio-economic, and political contexts)	63.22%	55
Time management (multitasking, prioritizing tasks)	67.82%	59
Networking	54.02%	47
Total Respondents: 87		

Q9 Please rate your level of interest in a new M.Eng. program, where the students will study:- How clean energy technologies work and where they can be applied- What role clean energy solutions have in social and environmental sustainability- Why sustainable energy challenges need to be addressed at a system level- How government policy influences sustainable energy application- How to explain and promote sustainable energy challenges and solutions- What it takes to solve complex problems as part of a team

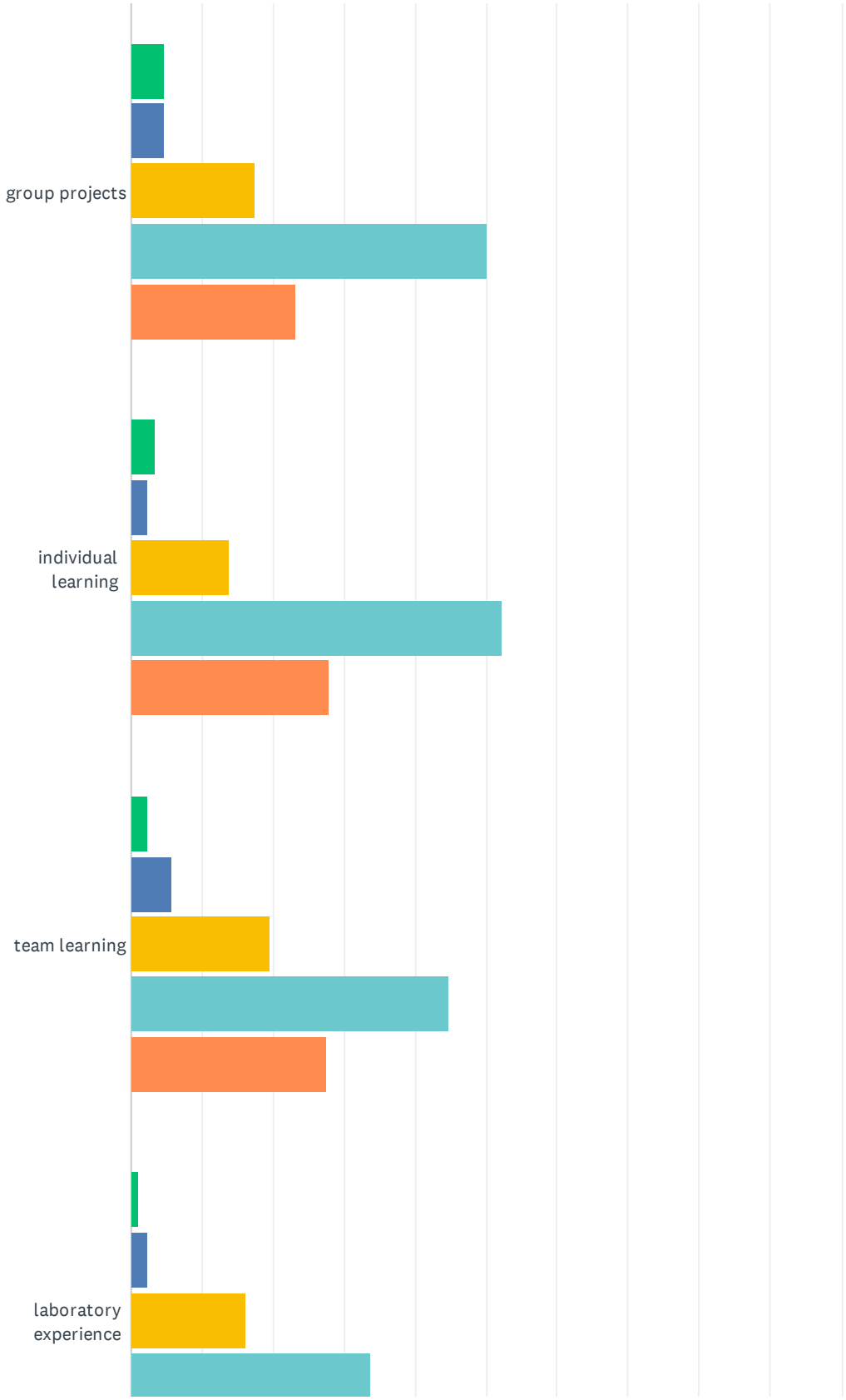
Answered: 82 Skipped: 5

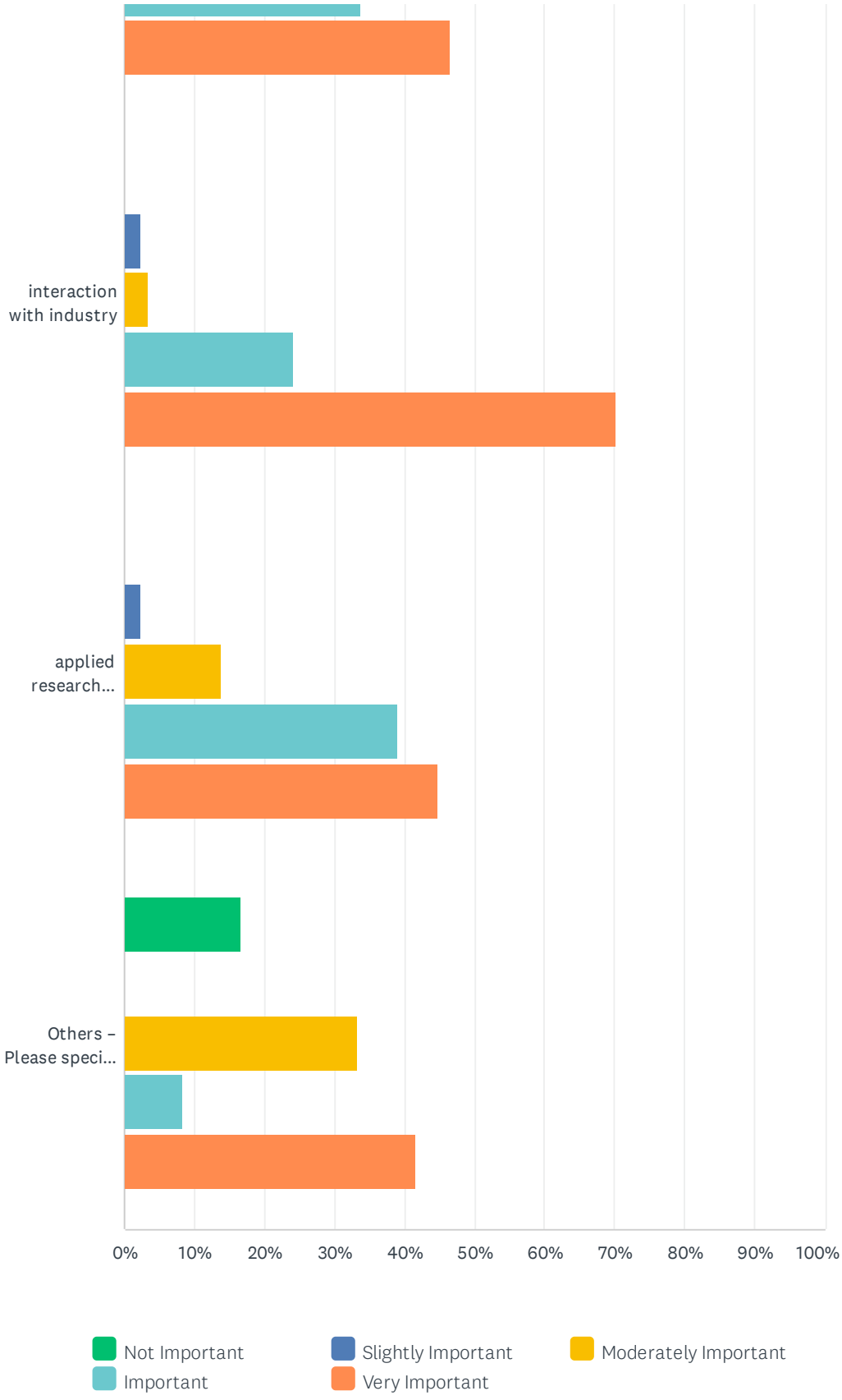


	NONE	LOW	MODERATE	HIGH	VERY HIGH	TOTAL	WEIGHTED AVERAGE
(no label)	3.66% 3	6.10% 5	34.15% 28	30.49% 25	25.61% 21	82	2.68

Q10 How important are the following learning experiences?

Answered: 87 Skipped: 0




interaction with industry
applied research...
Others – Please speci...
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Not Important
Slightly Important
Moderately Important
Important
Very Important

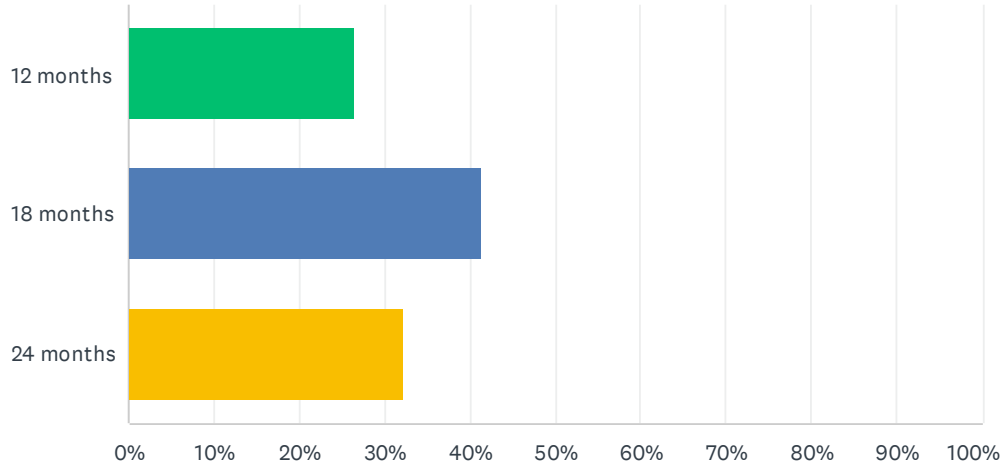
	NOT IMPORTANT	SLIGHTLY IMPORTANT	MODERATELY IMPORTANT	IMPORTANT	VERY IMPORTANT	TOTAL	WEIGHTED AVERAGE
group projects	4.65% 4	4.65% 4	17.44% 15	50.00% 43	23.26% 20	86	2.83
individual learning	3.49% 3	2.33% 2	13.95% 12	52.33% 45	27.91% 24	86	2.99
team learning	2.30% 2	5.75% 5	19.54% 17	44.83% 39	27.59% 24	87	2.90
laboratory experience	1.16% 1	2.33% 2	16.28% 14	33.72% 29	46.51% 40	86	3.22
interaction with industry	0.00% 0	2.30% 2	3.45% 3	24.14% 21	70.11% 61	87	3.62
applied research opportunities	0.00% 0	2.30% 2	13.79% 12	39.08% 34	44.83% 39	87	3.26
Others – Please specify your ranking here and the learning experience in the next question	16.67% 2	0.00% 0	33.33% 4	8.33% 1	41.67% 5	12	2.58

Q11 If you selected "Others - Please specify" in the previous question, please provide your specify your response here.

Answered: 5 Skipped: 82

Q12 What is the maximum duration you would be willing to consider for a new non-thesis (i.e., course/project based) master's level inter-disciplinary engineering program

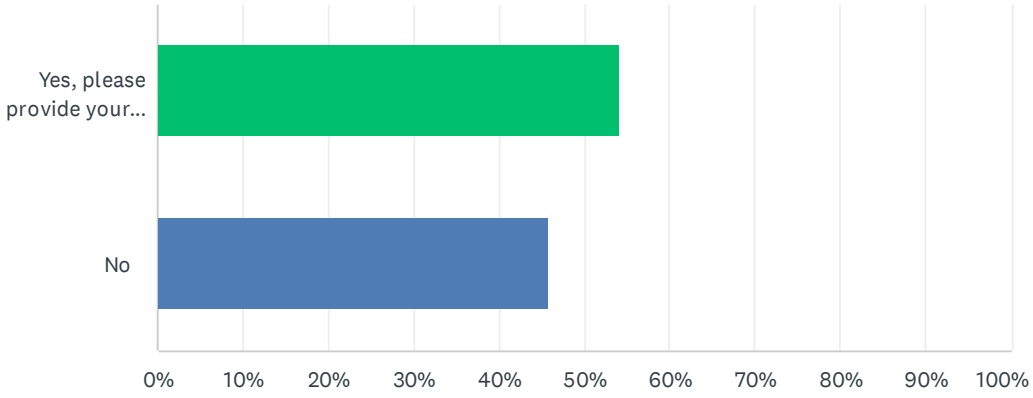
Answered: 87 Skipped: 0



ANSWER CHOICES	RESPONSES	
12 months	26.44%	23
18 months	41.38%	36
24 months	32.18%	28
TOTAL		87

Q13 If the proposed program is approved and launched, would you like us to contact you when we begin accepting applications?

Answered: 85 Skipped: 2



ANSWER CHOICES	RESPONSES	
Yes, please provide your contact information here	54.12%	46
No	45.88%	39
TOTAL		85

Appendix 10: Notes of support from Beedie School of Business and the School of Resource and Environmental Management

Colin Copeland

From: zadeel@sfu.ca
Sent: May 11, 2022 5:19 PM
To: Colin Copeland
Subject: FW: Introduction: Elicia Maine / Zafar Adeel
Attachments: BUS 790 Lab to Market Course Outline - Fall 2020.pdf; i2I-brochure-July2020.pdf

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From: Elicia Maine <emaine@sfu.ca>
Date: Tuesday, October 26, 2021 at 4:29 PM
To: zadeel <zadeel@sfu.ca>
Cc: VPR Innovation Executive Assistant <vprinnea@sfu.ca>, i2I Program <i2i_sfu@sfu.ca>, Jennifer Beale <jennifer_beale@sfu.ca>
Subject: Re: Introduction: Elicia Maine / Zafar Adeel

Great to talk to you just now Adeel.

Here is the 2020 course syllabus for the Lab to Market (BUS 790) course and an overview i2I program brochure.

Bailey can send you the latest course outlines for the Lab to Market and the Business Model (BUS 794) courses next week, after the national launch of our Mitacs i2I program.

To recap what we discussed today, it could make sense to have the interdisciplinary SEE masters program you are developing to include two or more of the 2 unit courses from the i2I program.

For the first year (likely Sept 2023) that could be 8-10 more students taking the BUS 790 course on Wednesday evenings at the Segal Graduate School of Business at 500 Granville Street. You envision this masters program reaching a steady state size of 20-25 students per year, which could still fit within this same teaching structure, or might justify another offering of the course at the SFU Surrey campus.

Happy to continue the discussion,

Elicia

Elicia Maine, PhD
W.J. VanDusen Professor of Innovation & Entrepreneurship
Special Advisor on Innovation to the VP Research and International
Academic Director, Invention to Innovation (i2I)
Simon Fraser University
Vancouver, Canada
https://www.sfu.ca/research/directory/elicia-maine
https://beedie.sfu.ca/programs/graduate/invention-to-innovation

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TASC 1 Building, Room 8405
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Burnaby BC
Canada V5A 1S6

SGSC
Simon Fraser University

RE: Masters of Sustainable Engineering Program

November 28, 2022

Dear SGSC,

On behalf of the School of Resource and Environmental Management (REM), I offer our support to the School of Sustainable Energy Engineering (SEE) in the development of their Masters of Sustainable Engineering program. Specifically, REM has agreed to list REM 650 - Energy Management for a Sustainable Climate and Society and REM 658 - Research Methods and Models for Sustainability as optional courses within the program for MEng students (subject to availability of space).

Please don't hesitate to contact me if you have any questions about our contributions to the MEng program. We wish SEE well with their new important degree initiative.

Yours sincerely,

Sean Markey, PhD
Professor and Director
School of Resource and Environmental Management
Simon Fraser University
spmarkey@sfu.ca