ENGINEERING SOLUTIONS FOR SUSTAINABILITY:
MATERIALS AND RESOURCES 3

# Toward a Circular Economy

February 18–19, 2017 | Denver, Colorado

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MATERIALS AND RESOURCES 3

Toward a Circular Economy

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*Session 3: Educating the Future Engineer*

# An Interdisciplinary Research and Training Program in Sustainability - CIWESS

*Catherine N. Mulligan, Concordia University*

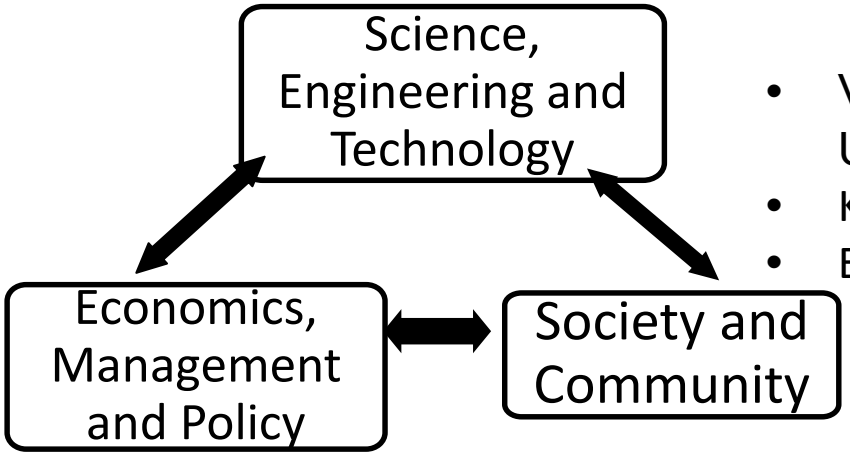
# Concordia Institute for Water, Energy and Sustainable Systems (CIWESS)

**Multi-faculty approach:**

- Engineering & Computer Science
- Arts & Science
- John Molson School of Business
- Fine Arts

**Inter-university initiative:**

- Concordia University
- McGill University
- Ecole Polytechnique
- Ecole de Technologie Supérieure
- University of Alberta




- Vietnam-Hanoi Water Resources University
- Kyoto University
- EIA -Colombia

# Secured Grants: NSERC CREATE Institute for Water, Energy and Sustainable Systems

**Long-term objectives** to train highly-qualified personnel (HQP) to design systems, solutions and technologies in a multidisciplinary manner with an emphasis on water, energy, and resource conservation

**Specific objectives:**

- To catalyze, through collaboration, internships, enhanced research opportunities in sustainability;
- To train HQP in an interdisciplinary manner for public, parapublic and industrial sectors;
- To maintain and enhance interdisciplinary areas of teaching and research;
- To attract external research funding and foster relationships with external researchers and internal Concordia researchers with similar interests.

# Co-applicants

- ***Water and energy***
- Dr. Gamal El-Din
- Dr. Nathalie Tufenkji
- Dr. Robert P. Chapuis
- Dr. David Walsh

- ***Sustainability***
- Dr. Damon Matthews

- ***Renewable energy and energy efficiency***
- Dr. Andreas Athienitis
- Dr. Pragesen Pillay
- Dr. Fariborz Haghighat
- Dr. Marius Paraschivoiu
- Dr. Ambrish Chandra

# Collaborators

- **George Rotor** CEO, EWB
- **Jalal Hawari** Principal Research Scientist, BRI
- **Mojtaba Kahrizi** Professor, Concordia
- **Laleh Yerushalmi** Affil. Assoc. Prof. Concordia
- **Eric Soucy,** Director, Industry Group, CanmetENERGY
- **Suzanne Barrington**, Affil. Prof., Concordia
- **Takeshi Katsumi** Professor, Graduate School of Global Environmental Studies, Kyoto University
- **Michel Dostie**, Technology Manager, Institut de recherché, HQ
- **Sophie Hosatte**, Director, Buildings Group, CanmetENERGY
- **Amin Hammad** Associate Professor, Concordia
- **Robert Noël de Tilly**, Golder Associates
- **Govind Gopakumar,** Centre for Engineering in Society, Concordia
- **N.T.L. Huong**, Natural Resources Management Division, Hanoi Water Resources University

# Non Science Partners

- **Paul Shrivastava** Professor, O'Brien Centre for Sustainable Enterprises, JMSB, Concordia, now with FutureEarth
- **Peter Stoett,** Assoc. Professor, Political Science, Arts and Science, Concordia
- **Frank Müller,** Professor, Economics, Concordia

# Partners since CREATE granted

- H2O Innovation
- Husky Energy
- Degremont Suez
- Consumaj
- Shell
- SNC Lavalin
- United Nations
- Ville de Montreal

# New additions to the Board

- Remi Haf of Ville de Montréal
- François Beaudoin of Golder Associates
- Charles Greer of NRC

# Research trainees

- *Admission*
- Applicants must apply to their respective universities for the Masters or Ph.D. program with high standing (a CGPA of at least 3.4 on 4.3 (Concordia, ETS) or 3.2 on 4.0 (McGill, Ecole Polytechnique) will be required).
- Applicants whose native language is not English or French must write the TOEFL and submit the scores along with the application.
- A short research proposal from the supervisor, prepared with the applicant (1 page maximum)

# Number of new trainees each year

| | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Total |
|---|---|---|---|---|---|---|---|
| **Undergraduate** | 3 | 3 | 4 | 4 | 4 | 4 | 22 |
| **Master's** | 6 | 5 | 6 | 5 | 6 | 5 | 61 |
| **PhD** | 4 | 4 | 0 | 4 | 4 | 0 | 44 |
| **PDF** | 1 | 1 | 1 | 1 | 1 | 1 | 11 |
| **Total** | 14 | 13 | 11 | 14 | 15 | 10 | 138 |

| | Currently | Completed | Predicted by end of year 4 |
|---|---|---|---|
| **Undergraduate** | 5 | 14 | 14 |
| **Master's** | 18 | 4 | 22 |
| **PhD** | 15 | 4 | 12 |
| **PDF** | 4 | 2 | 4 |
| **Total** | 31 | 24 | 52 |

# Internships

- **Presently**
- In total, 32/37 students have completed their internships or will have them completed,
- 7 are currently doing and process of confirming the internships for 6 others
- 8 require internships (4 are medium priority).

# Recently arranged internships

- Dalhousie University
- S2E Technologies, Groupe LML,
- NRC

# Professional skills training

- **Present:**
- Approximately 90% of the total have done at least 2 professional skills training courses or equivalent

# Socio-economic aspects training

- **Present:**
- Almost all have training in socio-economic aspects with exception of new students that started in 2016

# Socio-economic aspects

- A seminar series has been organized by CIWESS,
- Social Sustainability: A Challenge or Opportunity?' by Dr. Satoshi, Monday, Oct 19th, 2015 from 3:30 p.m. to 5:00 p.m.
- 'Should Sustainable Technologies be Governed?' by Dr. Govind Gopakumar, held on Tuesday, Nov 24th, 2015 from 4:00 p.m. to 5:10 p.m.
- 'Why should social entrepreneurship matter to engineers?' by Dr. Anita Nowak on Monday, Nov 30th, 2015 from 4:00 p.m. to 5:10 p.m.

- David O`Brien Centre for Sustainable Enterprises, Loyola Center for Biodiversity and Sustainability, TISED, etc..

# Seminar series

- Environmental Economics and Ecological Economics: Antagonistic Approaches?' by Dr. Frank Müller, April 27, 2016
- Influences and impacts of industrial symbiosis for eco-development' by Prof. Raymond Paquin, January 28th, 2016
- 'Environmental Impact Decoupling and the Importance of the Social Condition' by Dr. Carmela Cucuzzella, Wednesday March 2nd, 2016

# Socio-economic aspects

- New courses have been developed by collaborator Dr. Gopakumar to be offered in 2016 entitled Governing Sustainable Technologies
- **HENV 625 Sustainable Resource Management (3 credits)**
- **HENV 680 Advanced Seminar in Environmental Science (3 credits)**
- **HENV 610 Advanced Quantitative Research Methods (3 credits)**
- **Developing a course on sustainable engineering**

# Mitacs Accelerate-program overview

Objective:

- To initiate and support applied research collaborations between university researchers and industrial partners

Adopted model:

- Collaborative research projects are made up of multiples (blocks or internships) of 4 month increments, carried-out by graduate & post-graduate candidates and fellows

# Mitacs Accelerate

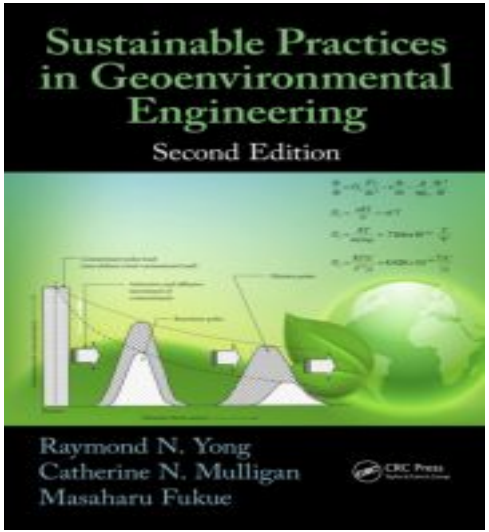
Key aspects per internship/block:

- $15,000 research grant
  - $10,000 funds must go towards student's stipend
  - $5,000 used for research expenses or add. student stipend
- The industrial partner contributes 50% of the grant on smaller (≤ 4 blocks) projects (SR&ED eligible)
- Four months of full-time research (could be stretched up to six months at part time)
- Open to MASc, PhD and PDF (MASc up to 2 blocks; PhD and PDF's up to 4 blocks; Foreign students are eligible)
- The student spends approx. half of the time at the partner site and the other half at the university (Min. of 25% on either site)

# Funding and Collaborations

- Mitacs funding with Consumaj, Degremont, HQ-H2O Innovation, Husky, S2E
- CRD with Drs. Yerushalmi (BIOCAST) and Walsh
- Engage and Engage Plus with Titan Environmental Containment, CRD application

# New book



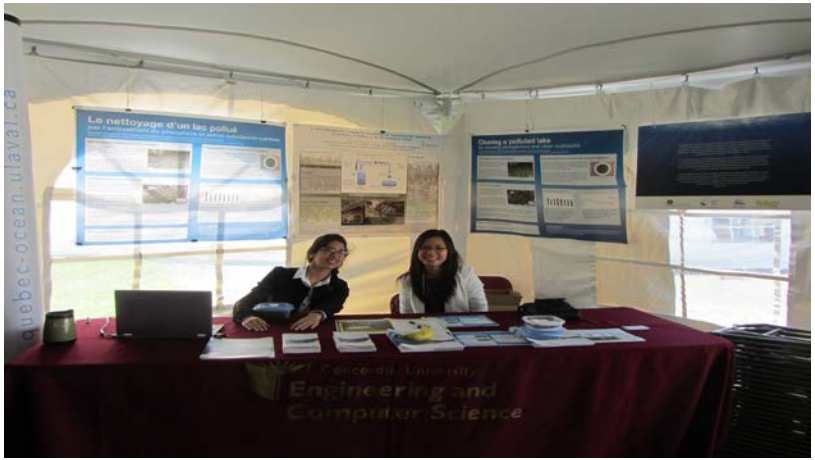

**Sustainable Practices in Geoenvironmental Engineering, Second Edition**
Published:
September 25, 2014 by CRC Press
Content:
561 Pages | 228 B/W Illustrations
Author(s):
Raymond N. Yong, Catherine N. Mulligan, Masaharu Fukue

Used for CIVI 469 and CIVI 6491 course in 2015 and reading course in 2016

# Mission in Japan  May 2016

- Smart Cities


# Ecosphere booth in June 2015

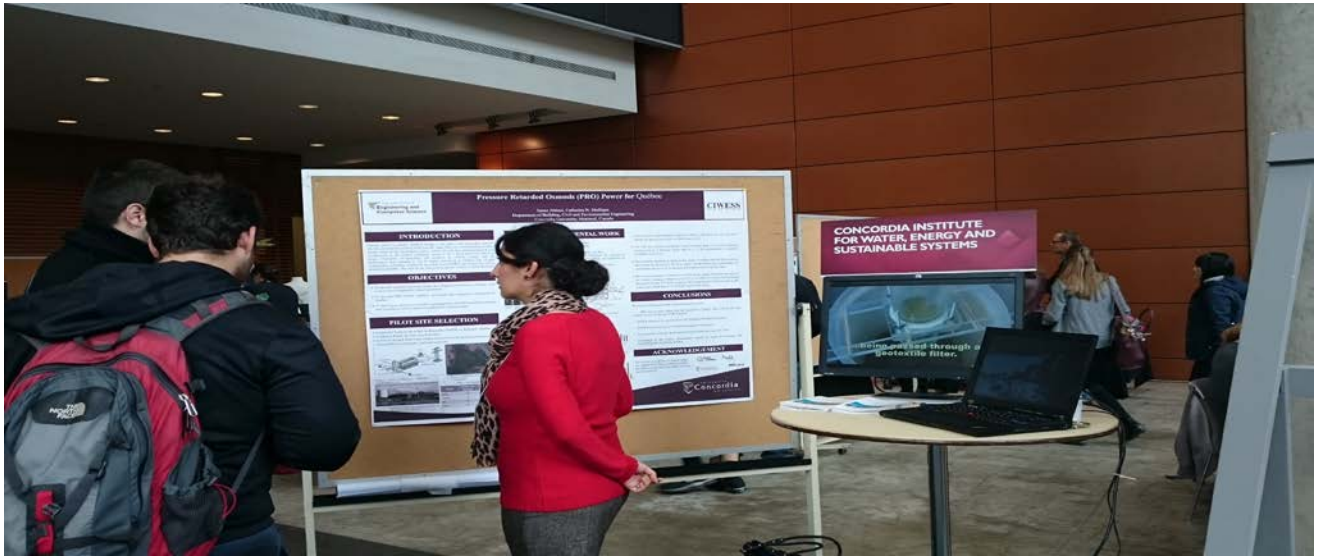



# Discussion event July 2015

# Conferences in 2015

- 14th Global Joint Seminar on Geo-Environmental Engineering (Japan, Korea and France)- approximately 60 participants

# Research Center Showcase at Concordia University , Nov. 2015 and 2016



# Workshop

- **Waste Management and Waste-to-Energy Solutions for Northern Communities**
- Hosted by: Concordia Institute for Water, Energy and Sustainable Systems (CIWESS)
- In Collaboration with: Polar Knowledge Canada
  Format: Teleconference presentations (GoToMeeting) and discussion with in-person attendance available at Concordia University EV Building
- Date: Thursday, June 9th, 2016

# Speakers

- **Robert Cooke**
  Senior Technology Advisor, Polar Knowledge Canada, Whitehorse
  **Nathan Curry**
  Post-Doctoral Fellow CIWESS, Concordia, Montreal
  **George Roe**
- Research Professor, Alaska Center for Energy and Power, Fairbanks, Alaska
  **Karen Petersen**
  Community Development Agent, Thorne Bay, Alaska
  **Ted Jacobson**
  Solid Waste Tribal Liaison, EPA/SEE Program, *Alaska*
- **Dr. Theodora Alexakis**
  VP Business Development at Terragon, Montreal
- **Joelle Simonpietri**
  Program Manager, Energy
  Applied Research Laboratory, University of Hawaii

# Filtration tests at a eutrophic lake

# Osmotic energy project (OSMOP) collaboration with HydroQuebec, H2O Innovation and Concordia University with funding from Mitacs

# CREATE Graduate students

| Student | Degree | Supervisor | Project | Funding source |
|---|---|---|---|---|
| Trevor Smith | M.Sc. | D. Matthews | Energy, Transportation and the Dedicated Climate Impact of Infrastructure | CREATE/Geography |
| Sanaz Abbasi/ Jonathan Maisonneuve | Both are Ph.D. | C. Mulligan/P. Pillay | OSMOP | MITACs/HQ |
| Cleverson Jacob Alves Dos Santos | MASc | C. Mulligan | OSMOP | MITACs/HQ |
| James Bambara | Ph.D | A. Athienitis | Net zero energy buildings | NSERC |
| Michael Mitzel | Ph.D. | N. Tufenkji & J. Whalen | Acoustic monitoring of *Pseudomonas aeruginosa* | CREATE/NSERC |
| Nariman Yousefi | M.Eng | N. Tufenkji S. Ghoshal in Civil Engineering (McGill) and K. Wilkinson at University of Montreal | *Interactions of Engineered Nanoparticles with Aquatic Organisms* | CREATE/NSERC |

# CREATE Graduate students

| Student | Degree | Supervisor | Project | Funding source |
|---|---|---|---|---|
| Patrick Larin | M.ASc. | M. Paraschiviou | Turbulence modeling for flow around vertical axis eind turbines (VAWT) | CREATE/ENCS |
| Gabriel Naccache | M.A.Sc. | M. Paraschiviou | Moving mesh and sliding interface for vertical axis wind turbines | CREATE/ENCS |
| Tara Walker | MBA | S.Ikeda/F.Haghighat | Impact of inconsistent electricity on businesses in Northern Uganda | CREATE |
| Nathan Curry | Ph.D | P. Pillay | Effect of small daily temperature fluctuations on anaerobic digestion of OFMSW | NSERC |
| Mona Kavianipour | M.Eng. | N. Tufenkji /S. Ghoshal in Civil Engineering | Transport, fate and impacts of selected industrial ENPs in wastewater treatment processes | CREATE/McGill |

# CREATE Graduate students

| Student | Degree | Supervisor | Project | Funding source |
|---|---|---|---|---|
| Shrabani Sarma | M.ASc. | C. Mulligan | Restoration of cyanobacteria impacted lakes | CREATE/ENCS/Mitacs/Degremont |
| Ryan Maliska | M.Eng | N. Tufenkji | Transport, fate and impacts of selected industrial ENPs in wastewater treatment processes | CREATE |
| Daniel Horen Greenford (Sept) | M.Sc. | D. Matthews | Different energy technology scenarios, assessing the effect on greenhouse gas (GHG) emissions and the associated climate response | CREATE |
| Aarti Ramachandran (Sept) | M.Sc. | D. Walsh | Investigating the role of bacteria in cycling VOCs, such as Methanol in aquatic systems | CREATE |
| Billa Cyprian (Sept 2014) | Ph.D. | C. Mulligan/K. Schmitt | Project in Africa related to water contamination | CREATE |
| Agil Azimzada (Sept 2014) | M.Eng. | N. Tufenkji | Point-of-use filtration device for water filtration in developing countries. | CREATE |
| M. Pourabadehei | Ph.D. | C. Mulligan | Provision and exploitation of biosolids in | Mitacs/Degremont |

# CREATE Graduate students

| Student | Degree | Supervisor | Project | Funding source |
|---|---|---|---|---|
| Abilash Krishnan | M.ASc. | M. Paraschiviou | CFD simulation of Vertical Axis Wind Turbines (VAWT) | CREATE/ENCS |
| Somayyeh Hazeri | MASc. | C. Mulligan | Piezoelectric materials for energy production | CREATE/ENCS |
| Farbod Vakili (Jan. 2015) | MASc | M. Paraschiviou | Hydrogen storage | CREATE/ ENCS |
| Pooya Ahmadi | Ph.D. | M. Paraschiviou | Computational study of VAWT: Wake dynamics | CREATE/ENCS |
| Amal Kassab (Jan.2015) | Ph.D. | M. Paraschiviou | CFD simulation of Vertical Axis Wind Turbines (VAWT) | CREATE |
| David Colatriano | Ph.D. | D. Walsh | Microbial communities in the North Atlantic and Arctic Oceans | CREATE |
| Fadoul Souleyman | Ph.D. | A. Chandra/P. Pillay | Integration of renewable energy, electric vehicle (EV) and utility grid to the building | CREATE |

# CREATE PDFs

| PDF | Supervisor | Project | Funding source |
|---|---|---|---|
| Martin Leduc | D. Matthews | Climate and carbon cycle modelling | CREATE/CURC |
| Lexuan Zhong | F. Haghighat | Air purification and catalyst development | CREATE/CARA |
| Dileep Veetil | C. Mulligan | Filtration of contaminated wastewaters | CREATE |
| Mert Guney | R. Chapuis/ G.Zaghury | Polycyclic aromatic hydrocarbons in particulate matter from contaminated soil and dust: bioaccessibility in lung fluid and risk characterization | CREATE |

# International collaborations

- Visit to Vietnam (Hanoi University of Natural Resources and Environment, Hanoi Water Resources University, now ), Mexico, Colombia
- Germany, Visits of Australian Embassy from Toronto, Ecole des Mines d’Alès, France

# Timeline- Milestones

- Official announcement CREATE : June 15
- First Advisory Board meeting: September 2012
- Projects definition: on-going
- Recruitment: began Fall 2012
- Establishment of industrial collaborations, recruitment, seminars, internships (on-going)
- Institute established: Nov. 2012
- New program coordinator engaged: Jan. 2014
- Input from industry and students to design new courses: June 2015
- New Masters in Sustainable Eng (MEng and MASc): Fall 2017

# Progress and indicators for report

- Number, quality and impact of publications (accumulating information on this)
- Locations and types of employment of graduates (eg. Director of operations, remote communities)
- Interdisciplinary theses and publications
- Types and amounts of grant proposals completed and funded (Mitacs, CRD, Engage)
- Collaboration with industry (internships, developing projects)
- New programs established (developing programs).

# Funding

- NSERC CREATE funding ($299,500 per year) until 2018
- HydroQuebec ($40,000 per year).
- $1.14 million in complementary funding

# Publications

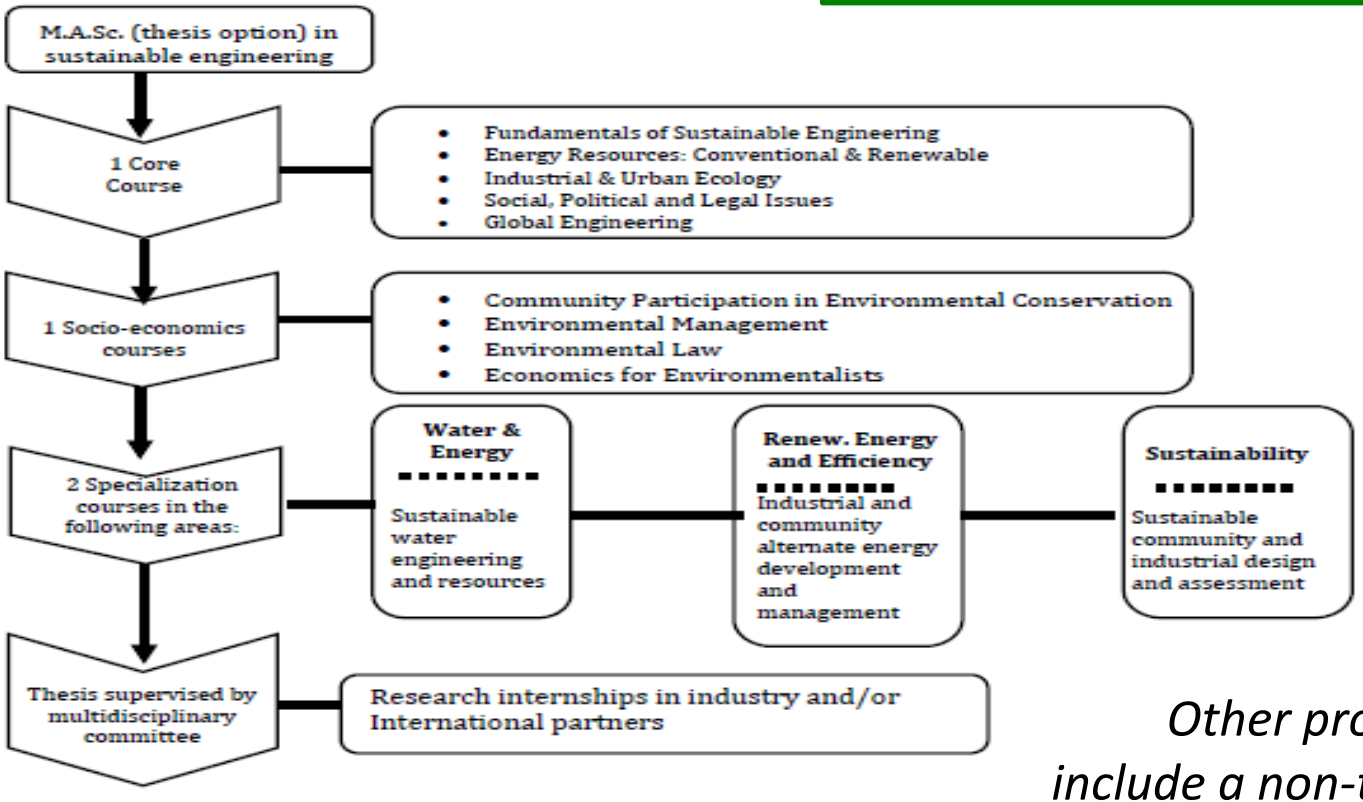
- 14 refereed journal papers have been submitted,
- 33 refereed journal articles have been accepted or published,
- 77 conference presentations/posters have been presented,
- 34 other technical reports, non-refereed articles, etc. have been prepared,
- 28 awards have been received,
- 3 patents have been filed,
- 10 theses have been submitted.

# Future plans

- Montreal one of five global hubs for Future Earth.
- Looking at identifying group funding for continuity
- CFI infrastructure application-LOI submitted
- Work on program development.

# Proposed Programs

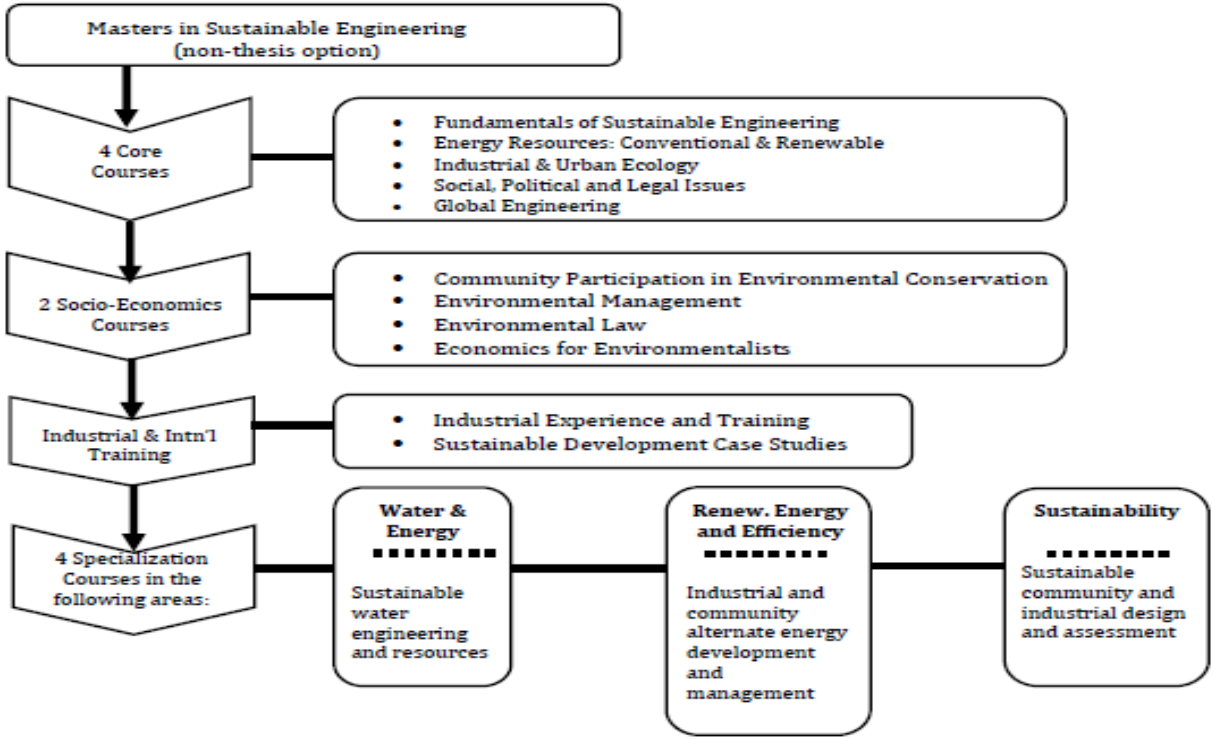
*The Master of Applied Science*




*Other programs offered include a non-thesis Master's and the PhD.*

# Proposed Programs

*The Master of Engineering*



# *Conclusions*

- Program includes internships, socio-economic and professional skills training
- Training program has been successful as graduates have successfully employed, significant external funding and publications obtained
- Need to ensure program sustainability