

An Interdisciplinary Research and Training Program in Sustainability-CIWESS

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ABSTRACT

Engineers must be able to work in multidisciplinary teams incorporating public policy, economics, and social responsibility. In light of the above, Concordia University has established the Concordia Institute for Water, Energy, and Sustainability Engineering (CIWESS) that provides a unique interdisciplinary training in water, energy and sustainability engineering. The specific objectives of this program are: To catalyze, through collaboration, internships, enhanced research opportunities in sustainability; to train highly qualified personnel in an interdisciplinary manner for public, parapublic and industrial sectors; to maintain and enhance interdisciplinary areas of teaching and research; and to attract external research funding and foster relationships with external researchers and internal Concordia researchers with similar interests. Examples of the research and training will be provided, showing the importance of this type of education and research.

INTRODUCTION

Since engineers are builders and problem solvers in industry and society, it stands to reason that engineering education is an excellent platform for imparting additional skills that can address contemporary challenges. Multi- and interdisciplinary approaches are necessary to address these complex social, economic and technological challenges. These approaches can effectively complement the results-oriented analytical approach to problem-solving that engineers receive as an integral part of their rigorous training. There also exists a clear trend towards multidisciplinary education in all fields of engineering: de Graaff and Ravesteijn (2001) describe the crucial need for the 'complete engineer', an individual who not only has technical-scientific skills, but also an understanding of the interplay between technology and society, organizational and management skills, as well as social and communications skills (de Graaff and Ravesteijn 2001). This new perspective on the role of engineers has developed in parallel with what Jonathan M. Fishbein, the Director of Canadian Curriculum Enhancement for the *Engineers Without Borders* (EWB), calls the "global engineer". A global engineer is a person who has expertise in a specific engineering field, but is comfortable working around many engineering disciplines (de Graaff and Ravesteijn 2001). A movement towards encouraging the idea of the global engineer coincides with the decision of the *Canadian Engineering Accreditation Board* (CEAB) to implement an outcome-based accreditation process at the university level: it has been shown that "global engineering outcomes present a smaller set of more detailed statements (than CEAB's original outcomes)" (de Graaff and Ravesteijn 2001). The Johannesburg World Summit on Sustainable Development (WSSD, 2002) identified 5 priority themes that strongly influenced the direction ENCS is presently adopting. These five thematic areas are: (a) Water and Sanitation, (b) Energy, (c) Health, (d) Agriculture, and (e) Biodiversity, and are referred to collectively as WEHAB.

Combining a technical engineering discipline with courses in policy, economics, and social sciences will allow for more effective policy design, keener political decision-making, and an informed civil society in Canada and worldwide (de Graaff and Ravesteijn 2001). Formalized training in interdisciplinary approaches to problem-solving is not just an added bonus to engineers - it is an

increasingly required skill. Furthermore, the complex nature of environmental systems invites a multiaxial approach to solving environmental problems in engineering, economics, and policy. Finally, de Graaff and Ravesteijn (2001) point to engineers as serving a role in bridging the gulf between technology and society; the role of engineers in interpreting and disseminating environmental knowledge will become critical.

This trend towards interdisciplinarity in engineering education is reflected by an increasing number of interdisciplinary sustainability initiatives at universities and research institutions. In Canada, a prime example is the University of Victoria that has been the recipient of NSERC CREATE funding for its *Training Program in Interdisciplinary Climate Science (University of Victoria 2016)*. The University of Toronto has applied an interdisciplinary approach to identifying the role of engineers in solving complex global problems – including those related to sustainable development – at the *Centre for Global Engineering (CGEN) (University of Toronto 2009)*. In its *Cinbiose* interdisciplinary environmental research centre, *L'université du Québec à Montréal (UQAM)* has collaborated with the World Health Organization since 1998 on problems in several fields such as health care, ecosystem dynamics, urban ecosystem governance, and climate change (UQAM 2017). Western University offers graduate-level courses on interdisciplinary approaches to sustainability studies, and also maintains a standing research faculty contributing to sustainability research across 33 different academic disciplines (Western University 2017). In the United States of America, initiatives in multidisciplinary environmental research are well established. Stanford University's *Precourt Energy Efficiency Center (Stanford University 2016)* is an example. Universities by setting curriculum standards have the moral responsibility to educate their graduates to play a crucial role in developing a socially just, ecologically aware, and economically responsible society. At the same time, engineers have the obligation to develop and implement design, construction, and management techniques that minimize environmental and energy footprints. In addition, engineers must also be able to work in multidisciplinary teams that incorporate perspectives from public policy, economics, and social responsibility. These demands place a unique burden on engineering educators to design programs that will train engineers for future challenges.

The Canadian funding agency, the Natural Science and Engineering Research Council (NSERC), has established the Collaborative Research and Training Experience (CREATE) program. The funding is up to \$150,000 in the first year and up to \$300,000 for up to five subsequent years, for a maximum of \$1.65M over 6 years. It supports the training of teams of highly qualified students and postdoctoral fellows from Canada and abroad through the development of innovative training programs that “encourage collaborative and integrative approaches, and address significant scientific challenges associated with Canada’s research priorities; and facilitate the transition of new researchers from trainees to productive employees in the Canadian workforce”.

While Concordia University has been a leader in operationalizing sustainability on campus, it needed to be able to extend this leadership to education. The university already had faculty members conducting research in a wide range of water, energy, and sustainability-related issues. Concordia has unique expertise in wind and biomass energy, solar energy, energy efficiency, and fuel cell research. Graduate training in this concentration gives the university the visibility needed to demonstrate to government and industry that Concordia concretely supports these valuable efforts. Another powerful motivation was its commitment to social engagement and outreach. A proposal was made to the CREATE program and \$1.63 million over 6 years was awarded starting in 2012. Following the award, Concordia University *Faculty of Engineering and Computer Science (ENCS)* established the *Concordia Institute for Water, Energy, and Sustainability* in 2012 wherein undergraduate and graduate-level university students, as well as post-doctoral fellows (PDFs) can be trained to evaluate

environmental conditions and solve problems that incorporate a number of perspectives. The paper describes this initiative.

The long-term objectives of the NSERC CREATE-funded program are 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. The program is aimed towards providing students with practical experience through internships and multidisciplinary training in various fields, including alternative energy sources, sustainable water management, infrastructure development, sustainable land use and design, green industrial engineering and materials, global natural resource conservation, and environmental economics, laws and policies.

In order to foster these goals, the objectives of the training program are:

- To catalyze, through collaboration, 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; and
- To attract external research funding, and foster relationships with external researchers and internal Concordia researchers with similar interests.

PROGRAM COMPONENTS

The research program is engaged with the areas of industrialization, urbanization, agriculture (food production), and resource exploitation (including energy) that Yong et al. (2006) describe as basic activities associated with a vibrant, modern society. Directed by questions regarding how these activities accord with the aims of societal sustainability, and how one should manage these activities in order to provide for a sustainable society, this research program engages with the challenge of working towards a more sustainable society by integrating the research activities of this program into three themes: sustainable water, sustainable energy, and other sustainability aspects.

A stellar team of researchers (including seven Research Chairs) participates in this program and contribute towards the training of HQP in water, energy and environmental sustainability. The research team participating in this program, is drawn from several fields, and has articulated a strong commitment through high quality research and training. Currently, ENCS has expertise in a diverse spread of related domains such as renewable energy (hydrogen, wind, biomass, solar) development, energy efficiency, green buildings, electrical and hybrid vehicles, transportation systems, sustainable infrastructure, water resources, life cycle assessment, environmental remediation (brownfields), and resource (air, soil and water) protection. There are three areas of focus.

Sustainable water and environment

The trainees in the water group work (under the supervision of *Drs. Catherine Mulligan (Dept. Bldg, Civil and Environ Eng) and David Walsh (Biology) of Concordia University, Gamal El-Din (Civil and Environ. Eng., University of Alberta), Nathalie Tufenkji (Chemical Engineering, McGill University), Robert P. Chapuis (Civil, Geological and Mining Eng. Ecole Polytechnique)*) on developing models and methods to ensure sustainable water quality and supply in rural and urban settings. Water purification, wastewater treatment, groundwater supply, protection of surface and groundwater quality, and detection of water contaminants is the focus of this theme. Water treatment systems must be sustainable in terms of energy requirements, resource requirements, greenhouse gas emissions and waste production. Technologies for optimization of water supply in developing countries are highly important and are developed through collaboration with CAWST. Given that sustainability of water and energy are tightly coupled, the multifaceted linkages between these two themes is developed by students and PDFs who work on a wide range of topics of importance to water and energy security, including evaluating the effect of climate change impacts on water resources, waste and wastewater

treatment and management, drinking water safety, and environmental remediation. Since energy can also be produced via anaerobic systems that employ farm waste, industrial or municipal wastewater, optimization models for anaerobic treatment to aid in design, and operation of full-scale wastewater treatment systems are being developed. A range of topics includes water and energy security, and climate change impacts on water resources.

Sustainable alternative energies and energy efficiency

The energy theme (under the supervision of Drs. Andreas Athienitis and Fariborz Haghighat (Dept. Bldg. , Civil and Environ. Eng), Pragesen Pillay (Electrical and Computer Eng.), Marius Paraschivoiu (Mechanical and Industrial Eng.) and Amrish Chandra (Electrical Eng., Ecole Technologie Superieure) focuses on emerging technologies for new urban planning and building design practices, supported by the introduction of innovative technologies to capture, store, distribute, and optimize renewable energy. The possibility of wind and solar energy utilization in urban and suburban areas to support zero energy and positive energy buildings are investigated in collaboration with the NSERC NetZero Buildings Research. Current work with Hydro Quebec within the industrial chair involves the design and operation of renewable energy systems such as osmotic energy. The CREATE expands and complements this work as the amount of work to be done and the range of problems exceeds the current support through the program from Hydro Quebec.

Sustainability

The sustainability theme provides trainees (Dr. Damon Matthews, Geography and Urban Planning) with a broad perspective that enhances the training by integrating social, economic and policy system considerations into technological innovations. Specific evaluative tools to be developed include climate change forecasting, life cycle analysis, sustainability indicators, energy balances, methods to incentivize science-based performance measurements, and policy analysis. The sustainability group is involved in the assessment of social, economic and regulatory effects on technological diffusion within a world of extraordinary interconnection in information, law and regulation, finance and economy. For example, trainees have worked on the evaluation of various approaches to water recycling using a sustainability framework.

Activities and training events

The CREATE program is producing trainees with unique knowledge and skills related to sustainable water and energy systems through a combination of multiple programmatic pathways such as undergraduate minors, graduate degrees and courses, capstone courses, research seminars, internships, conferences, and public outreach.

Since interdisciplinarity is an essential prerequisite of any type of research related to sustainability, this program incorporates it at the level of content and program. The underlying philosophy of interdisciplinarity of the CREATE program is revealed in the schematic in Figure 2. All research content while being grounded in scientific and technological aspects nevertheless incorporates economic/policy and society/community aspects. A key mechanism to facilitate interdisciplinarity in research content is through the constitution of supervisory committees that includes members from all aspects.

Since environmental and social issues are by their very nature complex and interrelated, students are required to cross disciplinary boundaries in order to collaborate with those in other disciplines. Interdisciplinary collaboration requires skills that demand modifying traditional ways of thinking and being open to novel means of cross-disciplinary communication. Internships are provided to allow trainees to work in the modern collaborative workplace to improve their academic and professional

strengths and acquire program-relevant work experience. They gain important soft skills (communications, team work, interpersonal cooperation) essential to today's work environment, learn more about the expectations and needs of employers, develop independence and maturity and take advantage of networking opportunities. The skills obtained enable CREATE students to work in policy development, governmental agencies, international organizations, industry, and NGOs. An internship is a required element of every trainee's program. An annual research event showcasing the achievements of the program provides a venue for trainees to present and discuss their work.

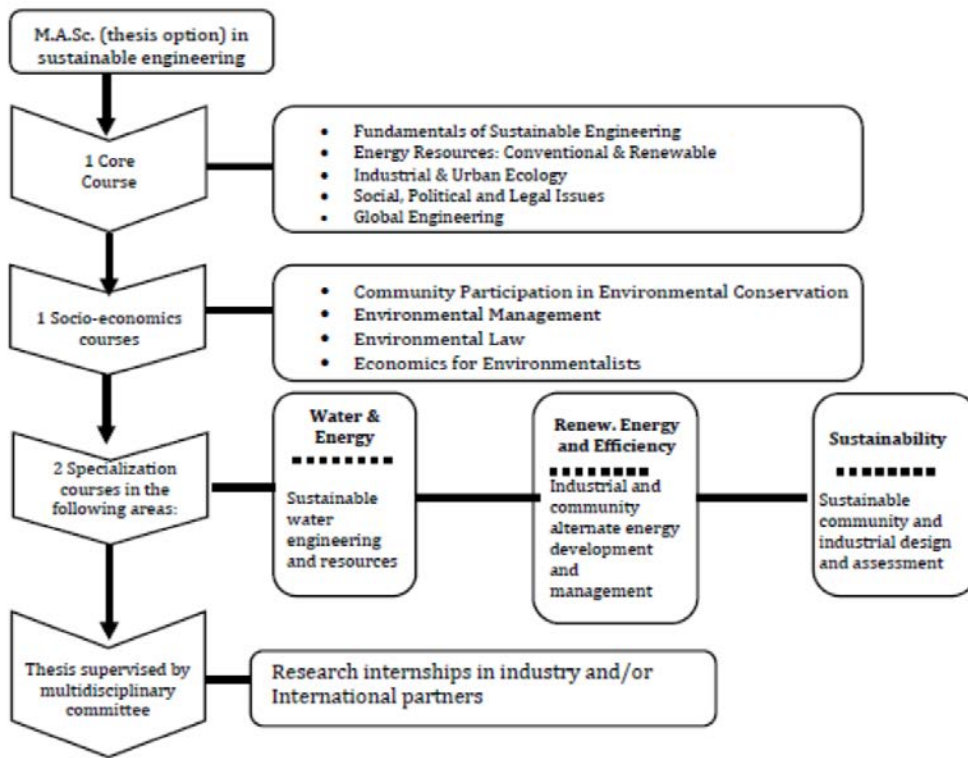


Figure 1. Schematic of proposed Master program.

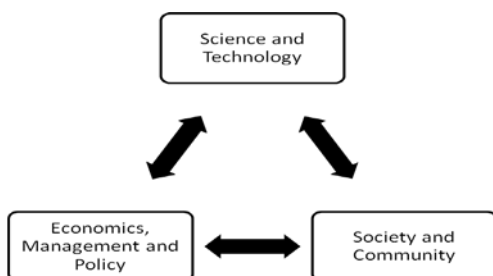


Figure 2. Interdisciplinary aspects of the program

The CREATE program facilitates these collaborations by integrating opportunities that arise from these research exchanges into training. In addition, by enhancing international exposure these collaborations fosters globally sustainable work practices in trainees. For example, HQP develop

international expertise through these collaborations in water-related disciplines as water engineering and management, land use planning, or water environmental studies.

Trainees are required to attend workshops conducted by the Concordia Graduate and Professional Skills training program (GradProSkills). These workshops enhance the ability of trainees to write and present effectively, to plan and manage projects, to study abroad during exchanges, to understand ethical practices, and to speak in another language (French in particular). Another integral component is completed under the supervision of an experienced engineer/computer scientist in the facilities of the participating company. In addition the university allows trainees, to work full-time for 4 months at the industry. This structure allows students to maximize the experience of working in teams, developing presentation skills and the ability to prepare written reports and other information. Existing partnerships with ventures such as Mitacs has been used to leverage industry dollars (at a minimum of 1:1) to finance internship trainees, to ensure proper interaction with partners, and for interesting industrial deliverables. For international exchanges, Mitacs Globalink is used to attract the best international students from India, Brazil, Mexico and others.

Program Management and Long-term Sustainability

Programmatic activities are organized and carried out through the Program Committee and Supervisory Committees. These activities include course development (undergraduate and graduate), internships, research, and public events. These occur both internally within ENCS, through collaboration with other academic and allied entities in the university (School of Graduate Studies, Concordia International, and Sustainable Concordia), other universities (McGill, École Polytechnique and ÉTS), and with external constituencies particularly via internships and co-supervision .

However, with a view to highlighting the university's strong commitment in sustaining this program, the *Institute in Water, Energy and Sustainability* was established within the year with Dr. Mulligan as the Program Director. The structure of the Program Committee includes representatives of the private sector and Crown corporations (engineering firms such as Golder and Hydro-Québec), public sector organizations (NRC a n - CANMET, and NRC - BRI) and NGOs (EWB), and some members of the faculty involved in the CREATE program. In addition, deans, or representatives of the faculties involved including ENCS, Arts and Science, JMSB, student representatives, external researchers from other fields, and representatives from Sustainable Concordia, Concordia International and the Coop Institute are included. The Program Director is on the Program Committee. One or two meetings are held throughout the academic year at regular intervals. A primary functional role of the Program Committee is to guide future research and training trajectories of the institute. Supervisory committees include a minimum of three supervisors from complementary disciplines to guide trainees in selecting appropriate courses, internships, and in their research. The Program Coordinator (Priyanka Pandey) responsible for the day-to-day administration and coordination of programmatic activities such as recruitment, admission, and professional training.

Recruitment

A website and brochures were designed to attract applicants (both Canadian and International) to the CREATE training program. A web site was established and is currently found at: <http://www.concordia.ca/encs/research/centres/water-energy.html>. Both English and French brochures (small and larger formats) have been prepared and printed. They highlight research areas and the relevant researchers' expertise. Available positions at the undergraduate, graduate and PDF levels in all four member universities are included. Undergraduate research positions are four months in summer. Applicants must have an undergraduate or graduate degree in science or engineering for the Masters or Ph.D. program with

high standing (a cumulative grade point average (CGPA) of at least 3.4 on 4.3, which is higher than the usual admission standards of 3 on 4.3). PDF applicants are required to submit a CV, 3 letters of reference, and a research proposal. The applicants whose native language is not English or French have to write the Test of English as a Foreign Language (TOEFL), and submit the scores (acceptance score must be greater than 85) along with their application. In addition, all undergraduate and graduate applicants have to submit a short research proposal with their applications. The program coordinator ensures that all applicants meet the requirements, and the research areas fit the training program. Applicant selection is based on GPA, reference letters and research interest.

PROGRAM RESULTS

Collaborations have led to the successful completion of internships with Énergie Convertis Inc., Hydro Québec's Shawinigan Research Center (6 internships), S2E Technologies Inc., GroupeLML, National Research Council, New Leaf Management Ltd. (2 internships), Consumaj Inc., Degremont (2 internships) and Golder Associates & Husky (2 internships). Out of 37 graduate students, 32 internships have been arranged.

In efforts to establish cross-departmental, faculty and university graduate degree programs, a survey was developed with the assistance from the Concordia Institutional Planning Office to determine the needs of the student population. The survey was conducted in two phases. In the first phase, the survey was released in summer among graduate students in order to help determine the interest level in the Masters and Ph.D. in Sustainability Engineering programs. In the second phase, the survey was circulated among undergraduate students in the fall of 2014. The results of the survey indicated a positive response and a significant interest in these program modules.

CREATE grant requires students at the Institute to undertake training in the socio-economic aspects relating to environmental and sustainable technologies. Several initiatives (courses, seminars, talks, workshops and conferences) have been put in place to assure this type of training. There is also collaboration with the Loyola Center for Biodiversity and Sustainability (GPE series), the David O'Brien Center for Sustainable Enterprises (DOCSE) and the Trottier Institute for Sustainability in Engineering and Design (TISED) to participate in their seminar series. A list of socio-economic courses offered across various universities in Montreal has been prepared and is disseminated to the students every semester. The list of some of the new courses developed at Concordia includes:

- HENV 660 "Climate Change and Sustainability" was offered in Fall 2015 by Dr. Damon Matthews,
- ENCS 6821 Development and Global Engineering (4 credits) offered in Fall by Dr. G. Gopakumar
- 'HENV 640 (Re)shaping the City' taught by Dr Pierre Gauthier offered in Winter 2016.
- A new course "ENCS 691 B Governing Sustainable Technologies" is offered in 2017 by Dr. Govind Gopakumar

The 4th Climate Change Technology Conference (<http://www.cctc2015.ca/Page2.html>) and the 14th Global Joint Seminar on Geo-Environmental Engineering (Japan, Korea and France)- approximately 60 participants including 20 from Japan, Presentations and volunteers, 8 students) were organized successfully on May 25-27, 2015 and May 21-22, 2015 respectively in Montreal. The conferences were used as a platform to deliver education on social-economic dimensions of climate change and environmental problems. The international workshop on "Assessing the Impacts of Nanomaterials and its Implications on Children's Environmental Health" was organized in January 2016 at McGill. Several CREATE trainees participated in this event, presented their CREATE research work, and engaged with stakeholders from government, industry, consumer protection groups and academia.

A Teleconference “Waste Management and Waste-to-Energy Solutions for Northern Communities” workshop was hosted by: Concordia Institute for Water, Energy and Sustainable Systems (CIWESS) in collaboration with: Polar Knowledge Canada, June 9, 2016. Speakers included Robert Cooke, Senior Technology Advisor, Polar Knowledge Canada, Whitehorse, Dr 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 or Associate (Pending Availability), Program Manager, Energy Applied Research Laboratory, University of Hawaii.

A socio-economic seminar series was initiated in October, 2016 and eight seminars have been organized so far. The majority of the students have undertaken some training in socio-economic aspects with exception of new students that started late 2015 and in 2016. Please see the list of CIWESS socio-economic seminars organized so far . The Institute training activities for the students have included poster presentations of their research in the July, 2014 and July, 2016 board meetings. A group discussion activity between the institute members and students on aspects related to water-energy nexus was organized as a part of the board meeting in December, 2014.

The preparation of high quality personnel skills for trainees has been delivered through MITACS Steps workshops, GradProSkills (Concordia University) and Skillsets (McGill University) workshops. Students have been provided information from time to time on upcoming workshops offered by aforementioned groups with a focus on communication, language training, project management, research management, writing, presentation, and leadership skills. Information on specialized talks, events and workshops related to sustainability offered by other groups such as Engineer without borders, DOCSE, Sustainable Concordia, Trottier Institute for Sustainability in Engineering and Design (TISED), Canadian German Chamber of Industry and Commerce, Canadian Wind Energy Association (CanWEA) and other sustainability groups in Montreal are circulated among students on a regular basis. A simple and efficient monitoring system is in place which is maintained by the CREATE program coordinator to ensure that CREATE trainees undertake professional skill training and training on socio-economic aspects relating to their field. We maintain an Excel spreadsheet of the eligible student names and the professional skills based workshops and courses that each has taken.

CIWESS had a booth at the Foire de l'environnement - Projet ÉCOSPHÈRE (organized on 12-13 June, 2015) where CIWESS students presented their work using posters. CIWESS has participated in the last year and this year’s annual research sector showcase event showcasing the achievements of the students, where researchers can present and discuss their research with program faculty and local and international experts. CREATE trainees had participated in the Journée Bleue, (July 2014, a full day event) organized by the non-profit organization: Association des bassins versants (Sainte-Anne-des Lacs, Quebec; ABVLACS), for the protection of the regional lakes, where they discussed lake water management with the public in a full day event.

Media highlights

The list of recent projects/CIWESS members that were featured in the media includes: The climate-change [Countdown 2°C Clock](#), created by musician David Usher in collaboration with CREATE co-applicant Damon Matthews, associate professor in the Department of Geography, Planning and Environment, was featured in a [Globe and Mail](#) advertorial that ran in the paper's hard copy on April 19th, 2016 and on [CBC.ca](#) on April 22nd, 2016. David Usher was interviewed on April 20th, 2016 morning on CJAD's Andrew Carter Show about how Montrealers have a chance to see the climate clock firsthand, as it is

projected onto the façade of a building at De Maisonneuve West and Guy, that evening through Saturday, April 23, from dusk to midnight. Damon Matthews was also [interviewed](#) for [Radio Canada International](#) on April 20th, 2016 and appeared on the set of Montreal's Breakfast Television on April 21st, 2016. Matthews also appeared in a [CTV Montreal](#) news report about the Countdown Clock and other Earth Day initiatives in Montreal. Finally, [Lokalee](#) and [Canada Standard](#) reprised an earlier [CBC.ca](#) report on the Countdown Clock. He talked about the climate-change Countdown 2°C Clock installation projected onto the façade of a building at De Maisonneuve West and Guy, from dusk to midnight through Saturday April 23. The climate-change clock counts down the time researchers, including Matthews, say it will take 28 years to reach the critical threshold of 2°C above the world's pre-industrial temperature.

CREATE trainee Daniel Horen Greenford's research project on [carbon-leak solution](#) was featured on Concordia News section and on internal Concordia newsletter. CREATE undergraduate student, Kim Keoponnreay was selected to be one the of 14 Canadian students to attend the [7th Japan-Canada Academic Consortium's Student Forum](#), held from February 14 to 20 at Nagoya University. CREATE past undergraduate trainee, Tanya Graham's graduate work about a new climate change study was featured in [Scientific American](#). The study, published in the *International Journal of Primatology*, shows how the world's primate populations are particularly affected by climate change. Dr. Tufenkji was invited in August 2016 by the U.S. Consulate in Montreal to meet with U.S. Senator Barbara Mikulski and a group of stakeholders to discuss issues related to sustainability and water security.

Funding and training success

Apart from the NSERC CREATE funding (\$299,500 per year) until 2018, other complementary funding has also been obtained. This includes mainly from HydroQuebec (\$40,000 per year) but another \$1.14 million in complementary funding from Mitacs, NSERC, Concordia University and other funding sources.

In total, 21 Masters students, 16 Ph.Ds, 7 PDFs and 21 undergraduate students have received training in the CREATE program. The institute is doing well in achieving the targeted total number of trainees each year. The predicted number of trainees recruited each year as indicated in the grant proposal very closely match the actual recruitment. There will be more focus on recruiting Masters students during the next year of the CREATE grant.

With regards to publications, fourteen 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, and 10 theses have been submitted.

The following is a list of some CIWESS trainees employment status post graduation:

- Renewable Energy Analyst at Arista
- Project Manager at International Council of Societies of Industrial Design and currently teaching at the Business Department, CEGEP John Abbott College
- Research Fellow at University of Michigan
- Researcher at Climate Simulations and Analysis Group, Ouranos
- Wind turbine and CFD Consultant at IOPARA Inc.
- Engineering Consultant at IOPARA Inc.
- Municipal Designer at Parsons, City of Toronto.
- Director of Operations, Remote communities at Terragon
- Environmental Scientist at ERA Consultancy.
- Water Engineer at Arcadis

- Assistant Professor, Oakland University.

CONCLUSIONS

The training program under CIWESS and funded mainly by NSERC has been very successful. The trainees have completed internships, socio-economic and professional skills training. Trainees are now graduating and are successfully employed in many different sectors. There have been significant publications and recognitions and it has attracted significant external matching funding. To ensure the sustainability of the program, Masters and PhD programs are to be established. Surveys have indicated the significant student interest in this approach. Industry will also be consulted as to their requirements for future employees.

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