UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE & ENGINEERING

Interim Report of the Dean's Task Force on Globalization and Engineering

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The Dean's Task Force on Globalization and Engineering began work in mid-January, 2008. We have completed the bulk of our work on information gathering, synthesis, and setting preliminary strategic direction. This is an interim report on those activities. We will now turn to the critical activity of soliciting input from the University of Toronto Faculty of Applied Science and Engineering (UofT FASE) community and interested outside parties. All comments on this Interim Report, and more generally on the topic of Globalization and Engineering as it relates to the Faculty, are welcome. Please convey comments to one or more of the Task Force members at your earliest convenience, preferably by June 30, 2008. We plan to issue the final report by July 31, 2008. The final report will include modified recommendations with due consideration for input received, as well as suggestions for the next steps and implementation strategies where appropriate.

1. Background and Terms of Reference

1.1 Establishment of the Task Force

In the fall of 2007, the Faculty's senior leadership team held a one-day retreat to discuss strategic planning for the Faculty. One of the outcomes was a recommendation to recognize in the Faculty's programs and activities the rapid pace of globalization and the increasing competition and changing workplace that graduates will face in their future. Dean Cristina Amon later stated: "It is our responsibility, in both our research and our educational mission, to help address serious global problems such as climate change, hunger, poverty, energy and the environment, clean water supplies and health." Accordingly, Dean Amon created a Task Force to contemplate and make recommendations on the following two questions:

1. How do we better prepare our graduates for a globalizing workplace?
2. How should our research be influenced by global challenges and our responsibility to address those challenges?

The Task Force members would come to understand that these are extremely broad questions, reaching into many disciplines and bodies of thought.

1.2 Membership

The Task Force members are:

- Yu-Ling Cheng, Professor, Chemical Engineering and Applied Chemistry (Chair)
- Bryan Karney, Professor, Civil Engineering, and Chair, Division of Environmental Engineering and Energy Systems
- Murray Metcalfe, Ph.D., Alumnus (B.A.Sc. Industrial Engineering, 1977)
- Lisa Romkey, Lecturer, Curriculum, Teaching and Learning, Division of Engineering Science
- Zhirui Wang, Professor and Associate Chair, Graduate Studies, Materials Science and Engineering

As well as the many individuals cited in this report as having directly or indirectly provided input, the Task Force has greatly benefited to date from ongoing discussion with and guidance from many UofT and FASE community members, including in particular Dean Amon; the Directors and Chairs of the Faculty; Paul Cadario, Alumnus and Chair of the Dean's Advisory Board; Judith Wolfson, Vice-President, University Relations, L.J. Edmonds, Assistant Vice-President, International Relations, Miranda Cheng, Director, International Student Exchange Office, and Jose Pereira, Director of the PEY Office.

1.3 Terms of Reference

The Terms of Reference established for the Task Force are as follows:

Curriculum and Student Experience:

1. Develop an integrated strategy for incorporating globalization concerns in our curriculum and extracurricular offerings suited to the rapidly globalizing environment that our graduates will face, thereby continuing to demonstrate national and international leadership in engineering education. Consult with Faculty constituencies throughout the process.
2. Conduct an inventory of current practices in the area of globalizing engineering education, and identify the Faculty's opportunities and challenges.
3. Building on existing initiatives within the Faculty and the rest of the University, develop specific recommendations regarding curriculum and student experience that exemplify the strategy to be proposed.
4. Propose a communication strategy to highlight initiatives and opportunities.

Research:

1. Conduct an inventory of current research with global content.
2. Propose a communication strategy, targeting both internal and external audiences, to highlight global issues and related internal activities, and to generate thoughtful debate about how the Faculty's research enterprise should be guided by global factors.
3. Conduct review of best practices and make specific recommendations for mechanisms to encourage an international outlook, including the effect of globalization on the engineering profession, funding sources, and international competition in our fields.

2. Activities of the Task Force

2.1 Background Information Gathering

The scope of the Task Force, at its most general level, is enormous. A list of some of the materials and literature reviewed from multiple disciplines appears in the Appendix. Among those that influenced us most were Thomas Friedman's *The World is Flat*, and a number of publication from the National Academy of Engineering, including an article by former MIT President Charles Vest titled *"Educating Engineers for 2020 and Beyond"*, and Bernard Amadei's article: *"Engineering for the Developing World"*.

2.2 Review of Programs and Approaches at Other Educational Institutions

The Task Force has reviewed descriptions and websites, and in some cases interviewed and visited with educators at other educational institutions. The following is a list of some key programs we have reviewed:

- The international initiatives of the University of British Columbia that form one of the five pillars of UBC's Trek 2010 vision. Faculty, staff, and students are engaged in teaching, research, consultancy, and volunteer activities around the world. (http://www.ubc.ca/internationalization).

- The University of Waterloo's Faculty of Engineering exchange programs, involving almost 60 active exchange agreements encompassing institutions throughout Asia, Australia, Europe, Mexico, and the Pacific Rim. (http://www.eng.uwaterloo.ca/~exchange/index.htm). The Faculty also offers an International Studies in Engineering (ISE) Option that includes at least 8 months of study and/or work overseas (http://www.eng.uwaterloo.ca/~exchange/Exchange%20From/ise%20option.htm).

- The University of Western Ontario's program in Civil Engineering with an International Development option. (http://www.eng.uwo.ca/civil/undergraduate_program/IntentlDevCourse.pdf)

- The University of Alberta's Globalization Certificate, offered by the Department of Political Science, in which select students may receive a Certificate in Globalization and Governance. It is the only Certificate of its kind in Canada, and it is meant to reflect that globalization is a defining characteristic of the twenty-first century. (*http://www.uofaweb.ualberta.ca/polisci/nav03.cfm?nav03=13073&nav02=13047&nav01=12928*)

- Global engineering programs at several U.S. universities, including the University of Michigan (http://www.engin.umich.edu/ipe/pge/index.html), Purdue University (https://engineering.purdue.edu/GEP), the University of Rhode Island (http://www.uri.edu/iep/), and Georgia Tech (http://www.sustainable.gatech.edu/index.php)

- Various activities at the Massachusetts of Technology, notably the "D-Lab" program on the development of appropriate technologies for use in developing locales (http://web.mit.edu/d-lab/ and http://www.iddsummit.org) and the MIT website that centralizes information on global activities within the university (http://global.mit.edu.index.html)

- The University of Colorado's Engineering for Developing Communities (EDC) (http://www.edc-cu.org/) and the Center for Appropriate and Sustainable Technology based in the Civil Engineering and Environmental Engineering Departments and headed by Professor Bernard Amadei.

- International joint ventures, such as the MIT-Cambridge University Partnership Program (http://web.mit.edu/cmi) and the Singapore – MIT Alliance (http://web.mit.edu/sma).

- Programs at British universities including the Centre for Sustainable Development in the Department of Engineering at Cambridge University (http://www-g.eng.cam.ac.uk/sustdev/)

- The Department of International Development Engineering at the Tokyo Institute of Technology (http://www.ide.titech.ac.jp/index.html)

2.3 Interactions with Thought Leaders

The Task Force has sought to interview, interact with and learn from thought leaders in relevant fields and sectors.

- Task Force members spoke and/or met with present and past corporate leaders with global experience. Among those interviewed were current or past employees of Celestica, Research in Motion (RIM), Magna, Brookfield Renewable Power Inc. and Delcan. Members also talked with leaders in smaller, entrepreneurial companies including Rowan, Williams, Davies & Irwin **(**RWDI), Nuvo Research, and Magenn Power Inc., and with an executive of the Canadian Manufacturers and Exporters Association.

- Task Force members contacted thought leaders in the environmental area, such as Richard Gilbert, a Toronto based author, and representatives from international development organizations such as the Micronutrient Initiative, a non-government organization (NGO).

- Task Force members talked with leaders and academics at the University of Toronto, including representatives of the Joseph L. Rotman School of Management (Rotman), the Ontario Institute for Studies in Education of the University of Toronto (OISE/UT), and the McLaughlin-Rotman Centre for Global Health. (http://www.infectiousdiseases.utoronto.ca/facultyri/McLaughlin-Rotman_Centre_for_Global_Health.htm). Members also talked with those most involved in the University's international efforts, including Judith Wolfson, LJ Edmonds, and Miranda Cheng.

- Task Force members have engaged in an ongoing dialogue with student-driven not-for-profit Engineers Without Borders (EWB) Canada. (http://www.ewb.ca/en/index.html). Two Task Force members attended a Faculty Discussion Day as part of EWB's annual conference, which focused on the topic of the Global Engineer.

- A presentation was made to the FASE Dean's Advisory Board – Paul Cadario, Chair, Lorna Gibson, Associate Provost at MIT, and Eugene Polistuk, former President and Chief Executive Officer of Celestica, who provided very helpful input based on their collective deep and varied international experience.

2.4 Panel Discussion: The Changing Global Landscape and Engineering Education: Opportunities, Challenges and Responsibilities

On May 15, 2008 the Task Force presented a panel entitled "The Changing Global Landscape and Engineering Education: Opportunities, Challenges and Responsibilities." The panel was moderated by Dean Amon. The panelists were:

- Mr. Colin Clark, Executive Vice President and Chief Technical Officer of Brookfield Renewable Power Inc.
- Professor Eckhard Groll, Professor of Mechanical Engineering and Director of Global Initiatives, Co-operative Education, and Professional Experiences, Department of Mechanical Engineering, Purdue University
- Mr. George Roter, Co-Chief Executive Officer, Engineers Without Borders Canada
- Mr. John Yealland, former Vice-President of Corporate Technology, Celestica Inc.

The panel was provocative and insightful. Approximately 50 members of the FASE community were in attendance, and there was a lively discussion. Useful input from the community has been received as a result of the panel.

2.5 Upcoming Activities: Obtaining Input from the FASE community

The Task Force will continue to gather additional information, but the focus in the near future will be on obtaining input from the FASE community and other interested parties. Planned activities include:

- Surveying and seeking information on activities of a global nature currently underway within the Faculty;

- Launching a web site as a major communication mechanism to both inform and solicit further comments and information about global activities;

- Seeking input on our findings and recommendations by convening follow up individual and group meetings.

3. Summary of Key Findings and Conclusions to Date

This section summarizes our key findings to date and our resulting conclusions. We have organized our findings and conclusions under three topics:

- Key elements in the definition and education of the Global Engineer.
- The most interesting aspects of how other educational institutions are approaching globalization and engineering.
- Differentiation, opportunities and threats for FASE.

3.1 Key Elements in the Definition and the Education of the Global Engineer

In our various activities as a Task Force, we were often guided by the questions "what is a global engineer" and "how is that definition changing over time'? Three key themes emerged through our various discussions: competitiveness, environmental sustainability and international development. Competition from rapidly emerging countries is very real and increasing rapidly. At the same time, many of the world's most pressing environmental and humanitarian problems require engineering approaches as part of the solution.

Much of our discussion regarding student experience will build on the momentum of the changes within FASE resulting from the 2000 *Decanal Task Force on Curriculum Change*, which introduced an ongoing design experience and greatly expanded the interdisciplinary and interactive nature of engineering education at FASE. This is consistent with globalization trends and creates a base on which to further build and to expand the globalization components of FASE programs and activities.

3.1.1. Global Collaboration, Differentiation and Competitiveness

In the coming years, many FASE graduates will find themselves in organizations with globally distributed employees, customers, and partners. For many leading Canadian engineering-driven companies, such as Research in Motion and Celestica, the percentage of revenues derived from Canadian customers is very small. They operate globally with respect to customer requirements, regulation, opportunities, competition, and source of engineering innovation.

In his book *The World is Flat*, Thomas Friedman argued persuasively that communication technologies are such now that it is easy for work to be distributed globally to whoever offers the best quality/value. Using sophisticated enterprise software, large engineering projects can be divided into sub-projects, assigned to design teams across the world, and seamlessly put back together into a unified whole. At the same time, there is strong emphasis on training engineering talent in the rapidly emerging countries, particularly India and China. The projected numbers of engineers, PhDs and other highly qualified personnel being trained in India and China vary from one report to another, but there is no question that the quantity and rapidly improving quality of engineering talent from these countries and elsewhere are both exciting and intimidating.

Governments, universities and organizations across the world have been responding to globalization trends with a range of different strategies. The public dialog on global competitiveness has a tone of urgency. To illustrate, in just the two week period between May 25 and June 7, the following announcements appeared in the popular press:

- Focusing on quality as a competitive strategy, France has selected six universities for "elite" status, and will provide funding of up to 500 million euros to each.

- Mike Lazaridis of RIM has pledged an additional $50 million to the Perimeter Institute, a physics think tank in Waterloo that he originally endowed. Quoted as saying: "The number of PhD's the Chinese plan to graduate within the next 10 years is greater than the entire population of Canada. We can't beat them on scale...The only way to get ahead of that tsunami is to invest in quality." [1]

- Harvard and Yale Universities both announced plans to expand their engineering programs because of increased demand for engineers and competition from China. Harvard will expand by about 43% in 10 years and Yale by 17% in 5 years. [2] Both universities also expressed the wish to *"wield the same influence in the fights against energy and food shortages and global warming as they exert in the worlds of law, politics and medicine".*

It is vitally important to the Canadian economy and the personal futures of our students that our graduates have the technical skills to be globally competitive. They will have a further competitive advantage if they possess qualities that differentiate them from other engineers. Some of this differentiation will be based on industries and research strengths that are particularly well developed in Ontario and Canada, while other differentiation will arise from new industries and technologies where our graduates will become world leaders. It is our responsibility as a Faculty to ensure that our graduates will be globally competitive. The traits of a global engineer are described in Section 3.1.4.

3.1.2 Sustainability/Environmental Impact as a Core Element of Engineering Design and Analysis

In discussion with industry thought leaders, the theme emerged continually that the global engineer needs to understand how to factor environmental and energy use considerations into his/her work. The activities of all engineering disciplines have an impact on the environment, and sustainability should be a component of design and analysis in all engineering disciplines.

Civil engineering has long incorporated awareness of these issues in their work because the large scope of their projects sometimes creates immediate environmental issues, and because many aspects such as waste and water are environmental issues in and of themselves. Manufacturing and chemical industry have inherent waste disposal and other potential environmental issues. In the past, this has sometimes created problems that had

[1] Margaret Wente. "Leaving the Old Economy Behind". Globe and Mail [Toronto] June 7, 2008.

[2] Bloomberg , May 30

to be addressed retrospectively. Stricter environmental regulations have led to improved practices in North America that will continue to evolve as regulatory and financial incentives or disincentives progress. In the discipline of mechanical engineering, a new set of technologies is emerging, particularly in the area of transportation. Electrical engineers are now subject to stringent regulations of the components of their products. These regulations may create difficult logistics problems. Our graduates working in global environments will have to understand the impact of their work on environmental systems, as well as navigate the varying and complex regulatory environment in different countries.

Energy in all its forms is an issue that comes up repeatedly. These environmental and energy issues are not just concerns of the developed world. In the rapidly emerging economies of China and India, it is imperative these issues are addressed and accounted for as the growth is unfolding, and not after the fact.

3.1.3 The Role of Technology and Engineering in International Development and the Reduction of Global Poverty

We are inspired by students who have expressed a strong wish to have a positive impact on the world's poor. Engineers Without Borders (EWB) Canada has branches in nearly every engineering faculty in Canada, and EWB members at UofT are enthusiastically engaged and striving to find ways to link their engineering education to international development activities and goals. Economics and public policy scholars have drawn attention to addressing the needs of the "bottom of the pyramid" or "the bottom billion". [3] Bill Gates has recently called for the deployment of the best talent in companies and organizations to be dedicated to solving the problem of the world's poorest. Interesting entrepreneurial and innovative organizations have sprung up to help with the implementation of solutions to the problems that have been identified, and to develop new models in response to the concerns that the dominant model of top down government and NGO driven approaches have, in many cases, not succeeded. [4] The Skoll Foundation (http://www.skollfoundation.org/aboutskoll/index.asp) among others has backed "social entrepreneurs" working in small organizations with innovative approaches which sometimes but not always include technologically based approaches.

International development activities have been guided and inspired by two high profile sets of goals and challenges:

- UN Millennium Development Goals (http://www.un.org/millenniumgoals/). [5]
- William and Melinda Gates Foundation's Grand Challenges, and the efforts of the Gates Foundation across multiple fronts (http://www.gatesfoundation.org/default);

More recently, the National Academy of Engineering announced fourteen Grand Challenges in engineering, several of which are relevant to globalization and international

[3] Paul Collier: The Bottom Billion – Why the Poorest Countries Are Failing and What Can Be Done About It

[4] David Bornstein. How to Change the World: Social Entrepreneurs and the Power of New Ideas.

[5] The 8 Millennium Goals are: eradicate extreme poverty and hunger; achieve universal primary education; promote gender equality and empower women; reduce child mortality; improve maternal health; combat HIV/AIDS, malaria and other diseases; ensure environmental sustainability; and develop a global partnership for development.

development, including "make solar energy economical" and "provide access to clean water". (http://www.engineeringchallenges.org/).

Engineers have made critical contributions to international development, civil engineers have helped provide infrastructure and clean water, and engineers of other disciplines have also contributed products and services that have been deployed in less developed countries. Some research activities within FASE explicitly or implicitly address international development goals, but international development has not been a large part of the formal dialogue among engineering faculty at the University of Toronto. International development has also received relatively little attention in the profession, but there appears to be growing interest among academic and professional engineers.

A small number of engineering programs addressing the role of engineering in international development have been established. Most notably, Tokyo Institute of Technology has a Department of International Development Engineering. Professor Bernard Amadei, founder of EWB USA, has spearheaded The University of Colorado's Engineering for Developing Communities (EDC) (http://www.edc-cu.org/) and the Center for Appropriate and Sustainable Technology based in the Civil and Environmental Engineering Departments. The World Federation of Engineers has engaged in activities to help eradicate poverty and has a working committee on capacity building (http://www.wfeo.org/index.php?page=ccb). Interdisciplinary publications have appeared that address the role of science and technology in addressing development goals.[6]

In addition to humanitarian motivations, international development is linked to sustainability, and may perhaps be linked to competitiveness as well. Until a reasonable standard of living is established, environmental protection will be of minor concern to the developing countries. Economic growth without concern for environmental impact will adversely affect the quality of life for everyone on the planet – including those in the developed world. Furthermore, the different set of needs and constraints of developing countries may lead to innovations that would not otherwise occur, and may lead to benefits for the developed world. Meeting the substantial demand for products in developing countries will improve global economies. The engineering profession has much to contribute to these issues.

While international development is currently not a large part of the formal dialogue in the Faculty, there is anecdotal evidence of interest. There are faculty members who have worked on some of the issues noted above, some who wish to work on these issues, and a small number who have worked in developing countries. The EWB chapter at the University of Toronto is very active and several students have been deployed to field assignments in developing countries. By publication of this interim report and other efforts to solicit input in the coming weeks, the Task Force hopes to assess the level of interest within FASE in more organized activities in this area.

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[6] Greenwood HL, Singer PA, Downey GP, Martin DK, Thorsteinsdottir H, Daar AS (2006), "Regenerative Medicine and the Developing World", ***PLoS Medicine*** 3(9):e381.; Salamanca-Buentello F, Persad DL, Court EB, artin DK, Daar AS, et al (2005), Nanotechnology and the developing world. ***PLoS Medicine*** 2(5): e97; Varmus H, Kalusner R, Zerhouni E, Acharya T, Daar AS, Singer PA, "Grand Challenges in Global Health", ***Science***, 302, pp 398-399, 2003; UN Millenium Project 2005. *Innovation: Applying Knowledge in Development*. Task Force on Science, Technology and Innovation

3.1.4 Defining the Global Engineer for the 21st Century

In summary, globalization is a reality. Our graduates and the Canadian engineering industry will operate in an increasingly connected world. They will collaborate and compete with other engineers and organizations from developed and rapidly emerging countries. In addition, our graduates must develop a sense of responsibility to current and future generations, so that social and environmental considerations become an integral part of their work as engineers, whether they work in a for-profit or a non-profit organization. The Task Force believes that the Global Engineer has a number of general characteristics consistent with those described in the 2000 *Decanal Task Force on Curriculum Change* as referenced above.

He or she:

- understands the broad context of engineering work, including cross-disciplinary aspects, and the business and social implications;
- has expertise in a specific field, but is comfortable in many engineering disciplines and able to work in an interdisciplinary way;
- is a problem solver and is creative.

The Task Force has identified additional important abilities that define the Global Engineer. He or she:

- can adapt to new situations, deal with complexity, and is skilled at systems thinking;
- is able to collaborate on a global basis, including knowledge and/or understanding of culture and language, and knowledge of collaboration techniques and software;
- is able to communicate effectively both orally and in writing in English, and is able to communicate across language and cultural differences;
- has an understanding of sustainability efforts, and the ability to factor environmental impact and energy use characteristics into all aspects of his/her work;
- has a well-developed sense of social responsibility and ethics, with due consideration in his/her personal and professional activities for the world's poor;
- is entrepreneurial, and is prepared to work with a varying level of resources and in various types of organizations.

3.2 Best Practices at Other Academic Institutions

The Task Force is in the process of reviewing efforts at other academic institutions beyond FASE with respect to globalization and education. We are midway in reviewing

these programs, and continue to learn more, adding programs as we go and probing in greater depth those of most interest. We highlight three categories of programs and specific examples within each, and also add a fourth category of interesting ideas, included for purposes of stimulating creative idea generation and brainstorming.

3.2.1. Global Engineering Programs at U.S. universities

Global Engineering Alliance for Research and Education (GEARE) - Purdue University

The Global Engineering Program at Purdue University was designed to provide students with global experiences to complement their engineering skills and enable them to enter the global market immediately upon graduation. The program is four years in duration and includes a two semester global design project within a multi-national design team, two internships (one local and one overseas with companies affiliated with the GEARE program), and one semester of studying abroad at an affiliated university. Students in the program are prepared for their experience starting from their first summer in university through language courses and special orientation sessions. Students apply to the program in the winter session of their first year or in the fall of their second year if they are sufficiently fluent in another language. Students gain invaluable experience working both in a new culture, and in multi-national teams to solve research problems and build prototypes. *https://engineering.purdue.edu/GEP/Programs/GEARE/*

Harvey Mudd College Global Clinic Program

The Global Clinic Program is based upon The Harvey Mudd Clinic Program. The goal of the original Clinic Program, which was founded more than forty years ago, is to facilitate small student groups in developing a solution to a real world problem presented by a sponsoring organization under the supervision of an advisor and company liaison. The Global Clinic Program follows the same basic structure, except that Harvey Mudd students collaborate with students from partnering schools in Central and South America, Asia, and Europe. The goal of the program is to prepare students to do engineering, science, and mathematics work in a global context.

The Global Clinic supports long-term sponsored engineering and science projects. During a four week visit to the partnering school, students are taken through intensive language instruction and immersion in the culture of the region, and the teams develop a project plan and collaborate with faculty advisors and company team members. Upon their return, weekly collaboration via video conference calls keep the two teams on track with each other. The Global Clinic Program has successfully partnered with the University of Puerto Rico Mayaguez under a project sponsored by Hewlett-Packard and Amgen Inc., and the National University of Singapore on a project sponsored by Applied Biosystems. Future projects include more collaborations with Singapore, as well as China and India.
http://www.hmc.edu/academicsclinicresearch/clinicprogram1/globalclinicprogram.html

Michigan Engineering Program in Global Engineering

The University of Michigan College of Engineering Runs a "Global Engineering" program, in which students must participate in language and regional study (i.e. upper-

year courses relevant to the study abroad location), cross-cultural training and an overseas study or work experience. The College also offers an international minor in engineering. *http://www.engin.umich.edu/ipe/*

Rhode Island International Engineering Program

Students in the program earn two degrees in a five-year period – one in Engineering and one in a language (French, German, Spanish or Chinese). IEP students study language and culture each semester along with their engineering curriculum. In the fourth year of the program, they go abroad as interns with engineering based firms in Europe, Latin America, or China, and also as exchange students with a partner university. *http://www.uri.edu/iep/index.html*

Global Engineering Internship Program

The Global Engineering Internship Program provides students from one of eight participating universities with an opportunity to work within a company abroad, while being supported by a mentorship program in industry and through a structured educational program before, during and after their internship. The program aims to produce global engineers that are both capable of working in a global professional environment and technically trained. Additionally, the program establishes a global network between companies, students and universities. *http://www.gee-geip.org/index.php*

Global Engineering Education Exchange

The Global Engineering Education Exchange (E^3) is run by the Institute of International Education. It provides students from participating universities with the opportunity to study abroad and work abroad and the skills to achieve this. They provide foreign language courses and cross-cultural trainings. An internship abroad is provided for them to use their technical skills and foreign language in a real-world setting. All coursework completed at affiliate universities counts towards their final degree. Students acquire skills and experiences that enable them to excel in the multinational business environment. *http://www.iie.org/programs/global-e3/about.htm*

3.2.2. Engineering programs with International Development and Sustainability Thrusts

Given the themes of Sustainability and Environmental Impact (Section 3.1.2) and International Development and Engineering (Section 3.1.3), the Task Force examined programs offered at other universities in these areas. We highlight three programs below.

Massachusetts Institute of Technology (MIT)

MIT offers a series of courses under the "D-Lab" umbrella that are focused on hands-on projects to develop appropriate technologies that address specific needs in developing countries. The students take one or more field trips to project sites as part of the course. The D-Lab has expanded its course offerings over time, to include for example a recent course focused on the use of information and communications technologies in

development. The D-Lab program also launched an annual month-long International Development Design Summit in the summer of 2007 that brings together practitioners from around the world. The D-Lab courses are extremely popular with waiting lists of nearly 100 students for an enrolment cap of 30. (*http://web.mit.edu/d-lab/*)

We are also aware of very successful project-based courses that include field trips to developing countries being run by Bernard Amadei at the University of Colorado and David Sabatini at the University of Oklahoma.

University of Cambridge

University of Cambridge in the U.K. has a Centre for Sustainable Development (CSD) in the Department (i.e. Faculty) of Engineering. The Centre offers a master's level course that attracts students from around the world; some students have noted that there is no comparable program in North America. CSD has a small team of four core faculty members, and has additional faculty members from other parts of the university, including the management school, teaching many of its course modules. It has been funded by and still continues under the auspices of the Cambridge-MIT Institute (CMI), a broad scientific and engineering exchange program between Cambridge and MIT that was the brainchild of Prime Minister Gordon Brown while he was Chancellor of the Exchequer. The Centre has had an ongoing stream of visiting faculty members from MIT. The Centre currently has approximately 40 master's level students and six doctoral students. The program has a civil engineering emphasis. *http://www-g.eng.cam.ac.uk/sustdev/*

Tokyo Institute of Technology

The International Development Engineering (IDE) Department at the Tokyo Institute of Technology was formed 10 years ago. It has undergraduate, master's and Ph.D. programs. At the graduate level the students are about 50% graduates of Japanese universities and 50% from other countries, predominantly China and countries in Southeast Asia. The goal, gradually being achieved, is to conduct all graduate level coursework in English to attract a diverse group of students. Some of the course work and research is on standard engineering topics (i.e. aimed at developed economies) and some is focused on developmental issues. The Faculty members include a number of engineers from the "hard" engineering disciplines, some from systems engineering disciplines, as well as a few social scientists. Some of the students have impressive backgrounds in terms of on-the-ground field experience in developing regions. The IDE program has strong relationships with selected universities in China and Southeast Asia, and is part of a new university level institute that the Tokyo Institute of Technology has sponsored in Thailand. *http://www.ide.titech.ac.jp/index.html*

3.2.3. The concept of a centre focused on the application of leading cutting edge approaches to global development issues

The recently renamed Division of Environmental Engineering and Energy Systems provides a focal point for the Faculty's activities in the area of sustainability. No such parallel exists for competitiveness and international development. The concept of extra-departmental units (EDUs) such as Centres or Institutes focused around highly visible

strategic areas is well developed at the University of Toronto, and may be adopted to serve as focal points for present and possible future activities related to competitiveness and international development.

There are several centres in the Faculty of Arts & Science, including the Centre for the Environment, where a number of FASE faculty members hold appointments. The recently constituted Martin Prosperity Institute at the Rotman School is another example of a centre launched around specific topic that draws faculty from the host Faculty and beyond. The recently established McLaughlin-Rotman Centre for Global Health (MRC) is a major initiative in the Department of Infectious Diseases in the Faculty of Medicine with the primary mission of accelerating translational research in infectious diseases of global health importance. MRC has already garnered much success and recognition.

Similar focal points exist beyond University of Toronto. As one example, within MIT centers with a global perspective include MIT's D-Lab (international development), G-Lab (global entrepreneurship), and Jameel Poverty Action Lab.

3.2.4. Other interesting programs and approaches

MIT Open Courseware
The Massachusetts Institute of Technology (MIT), through its Open Courseware program (http://ocw.mit.edu/OcwWeb/web/home/home/index.htm), has been in a leader in putting fully developed lecture material, and related materials such as teaching guides, assignments, etc on line for use by other academic institutions, including those in developing countries. Some of the materials have been translated into Chinese and other languages. MIT recently announced that it has reached its goal of making 100% of its courses available in this manner.

Satellite Teaching Locations
A number of Universities have established satellite teaching locations in other countries. While the University of Toronto does not have international satellite campuses, it does have three international centres: the University of Toronto in Berlin (UTB), the Sienna Centre, and the Asia-Pacific Advancement Office in Hong Kong (http://www.universityrelations.utoronto.ca/ir/internationalcenters.htm).

Academic Joint Ventures
We have examined a number of programs. These range from very specific programs, such as the UT^2 joint venture between the University of Toronto and the University of Tokyo. In the engineering school this has taken the form of the Consortium on Sustainable Materials (COSM) program. Much broader programs include various MIT programs such as the Cambridge-MIT Institute, which covers an evolving list of research teaching ventures.

Offshore Campuses by US Private Universities:
Certain U.S. universities, mostly private, have set up off shore campuses, many that offer degrees. Cornell has over 10 such programs. In the most developed case, a student can obtain a degree solely by studying at the offshore campus.

This practice was in 2007 the subject of US congressional hearings as part of the broader issue of competition from other countries in science and engineering based fields. The Congressional committee raised the question of whether this trend was contributing to strengthening science and engineering capabilities in other countries with negative ramifications for the US economy.

3.3. Differentiation, Opportunities and Threats for FASE

We have begun to conduct a preliminary assessment of the strengths of and opportunities available to FASE in the globalization context. The analysis will continue as we continue to gather information about what is already being done within the Faculty and as we receive input from the community.

3.3.1 Threats and Opportunities for Differentiation

First and foremost, globalization is a reality. Globalization will be a part of the work activities of virtually every Canadian engineer – undergraduate or graduate level – that will graduate in the future. If we don't look globally, our students will be worse prepared and less competitive than they can be, and by extension Canadian engineering as a profession will become uncompetitive and irrelevant. The challenges from the rapidly emerging countries are real and will only become more intense in the future.

At the same time, there are opportunities for differentiation. On the education front, ***only a handful of engineering programs related to globalization exist now.*** Within those, even fewer are also (a) comprehensive across multiple key areas of globalization, (b) offered by universities ranked in the Top 50 global engineering schools and (c) offered in universities and cities that have the depth of diversity of UofT and Toronto. In many other universities and engineering faculties only a limited fraction of the faculty members have an international orientation. Very few universities are focusing on international development across multiple schools and academic areas.

On the research front, the tremendous research strength in the Faculty is something we can build on. Many colleagues already work on areas that address globally significant problems. There is an opportunity to further enhance and expand these efforts in highly impactful and visible ways.

3.3.2 Strengths

The FASE at UofT has a strong base of global activities already, and significant strengths to expand those activities further. We have categorized the Faculty's strengths in terms of the general climate, students, and research:

General Climate:

- ***Committed Leadership.*** As described earlier, the Chairs and Directors endorsed a recommendation to recognize in the Faculty's programs and activities the rapid pace of globalization, and the Dean has signaled her commitment to the globalization effort

by establishing the Task Force. There is also a pool of faculty members with strong interest and intentions in the international area to serve as potential champions, and additional leaders of globally oriented initiatives may be recruited in the future.

- ***A Global Community: Our Diverse Faculty Members, Staff and Students, and the International Resources of UofT.*** The UofT FASE is a very diverse community, and Toronto is an extremely diverse city. Our faculty members come from every inhabited continent. Many of our students are immigrants or members of immigrant families. Our graduate students and visiting scholars come from many countries around the world. Our staff is just as equally diverse. As such, we have an unusually broad set of languages and cultures represented within the Faculty. We can build on this diversity by creating opportunities for enhanced interactions, including in meaningfully designed ways, among the multi-cultural and multi-language groups within the extended community – in either academic or co-curricular settings. We can also further internationalize our community by building on the presence of the multicultural community that's already here to attract more international members.

- ***Alignment with the University's strategic directions.*** Based on our discussions with the Office of International Relations, the goals and potential recommendations of the Task Force are in strong alignment with the goals and possible future directions and projects that the University will support.

- ***Excellent models and potential partner institutions within UofT***. UofT has multiple areas where international activities are a key focus both at the University level and within the various Faculties, Institutes and Centers. Some key activities include the Rotman School of Management and its Martin Prosperity Institute, the Munk Centre for International Studies, the School of Public Policy and Governance, the Centre for the Environment and the McLaughlin-Rotman Centre for Global Health.

- ***Alignment with Corporations and Other Organizations***. As described in Section 2, Canadian companies and other organizations in general have a very strong international outlook.

- ***Funding Climate.*** As a reflection of the federal and provincial governments' recognition of the importance of globalization, there are a growing number of funding opportunities for international research and global student and faculty recruitment. . For example, for the first time in recent history, NSERC has recently made scholarships available for the recruitment of international graduate students. Funding is available for research partnerships with India, China and Israel, just to name a few countries. And the "Going Global" Science and Technology Program of Foreign Affairs and International Trades Canada provides funding for Canadian researchers to travel and establish research partnerships. A compilation of other funding opportunities will be on the FASE global website being constructed, and will be continually updated in the future. Note that while we list funding climate as a strength here, research funding for some aspects of globalization can be considered a weakness and is described separately below.

Students, Academic Programs and Co-Curricular Opportunities

- ***High student interest*** in topics of sustainability and international development. The strong participation in EWB is one indicator of this interest. Enrolment in the new Energy Major for Engineering Science students is also strong for a new major.

- ***The Decanal Task Force on Curriculum Change*** conducted in 2000 recommended changes that greatly expanded the interdisciplinary and interactive nature of engineering education at FASE, and introduced an ongoing design experience. This is consistent with globalization trends and, more importantly, the changes that resulted create a foundation on which to further build and expand the globalization components on FASE programs and activities.

- ***Current Global Activities Within FASE.*** The recent establishment of the Energy Major in Engineering Science, and the re-naming and expansion of the activities of the Division of Environmental Engineering and Energy Systems are two recent important steps towards globalization of our academic programs within the Faculty. Engineering Science has also embraced a theme of "Engineers for the World" to promote global citizenship among its students. The Praxis design series of courses in Engineering Science and the first year ESP course for the rest of the programs both incorporate elements of global perspective, and are excellent mechanisms for further enhancing globalization content in our curriculum. We have not "beaten the bushes" to identify all academic and co-curricular activities within the Faculty, but **we invite all members of FASE to inform us of interesting things they are doing.** Key initiatives will be described on the FASE global website as a way to share best practices and for community members to identify potential like-minded colleagues.

- ***Professional Experience Year (PEY) and International Exchange Office***. FASE's PEY Office and UofT's International Exchange Office, under the leadership of Jose Pereira and Miranda Cheng, respectively, are both well-managed and efficient. PEY participation has increased from 20% to 50% in the last 3 years. Students go through a series of "development sessions" to prepare them for the workplace, and companies see value and "return on investment" when they hire PEY students. International PEY placements, albeit mostly in the U.S., are growing. The International Exchange Office manages nearly 200 agreements with international academic institutions. Engineering student participation has been low due to barriers of cost and course credit transferability, but these barriers can be lowered. Enhancing international experience for our students – either academic or industrial, can build on the infrastructure of these two very effective operations.

- ***Leaders of Tomorrow.*** Under the leadership of Professor Doug Reeve, the Leaders of Tomorrow (LOT) initiative has gained a great deal of momentum within the Faculty, and is another mechanism by which globalization content in the student experience can be enhanced.

Research

- ***Tremendous research strengths.*** The research activities within FASE cover a broad spectrum of fields and subfields, with world class capabilities in many areas. Many research projects have globalization relevance, including communications technologies, water treatment, micronutrient fortification, energy systems, environmental engineering, and infrastructure engineering.

- ***Current Global Activities Within FASE.*** As part of our work, the Task Force will build more information on global activities at FASE. We are looking for projects that involve international collaboration (beyond those with the U.S., which are plentiful) and that involve the physical movement of students and/or faculty members. One model is the UT^2 project between UofT and the University of Tokyo's Institute for Industrial Science (IIS). The Center for Sustainable Materials (COSM) is a joint effort between Chemical Engineering at UofT and a group of materials researchers at IIS which has been in existence for 7 years. The Task Force looks forwarding to enumerating and learning more about other current international projects within FASE.

3.3.3 Weaknesses and Challenges

While the Faculty has many strengths, it also faces a number of challenges, including the following:

General Climate:

- ***Overworked faculty, staff and students; resource limitations.*** We are acutely aware of the intense competition for resources of funds, time and mental energy – at the Faculty, individual faculty member, and student levels. There is little appetite among faculty to launch new initiatives unless clear benefit can be seen.

  There is also some, albeit not universal, sentiment that the curriculum is too full and that students need more time to master the material they are being taught and to develop the important soft skills. At a time when there are many new areas of interest within the Faculty, such as leadership programs, and engineering and public policy, it is clear that we need to stop some activities as we launch new initiatives – unless new resources are found for increasing faculty and staff.

- ***Canada's geographical distance from the key international "action spots."*** From a practical perspective, Canada is quite distant from many key centers of advanced engineering work (e.g. China, India; the Middle East in terms of infrastructure and construction) or international development projects (e.g. Africa, Southeast Asia, Central America). Despite globalization trends, the distance involved remains a personal and cost barrier for travelling.

Students, Academic Programs and Co-Curricular Opportunities

- ***Inadequate preparation of entering students***. Due to a number of factors, it has been observed over the past several years that a fraction of students entering the Faculty are not fully prepared for University. The global competitiveness of our graduates will be **in jeopardy, and attempts to enhance the skills of our graduat**es will be largely fruitless unless the academic standards of entering students are world class. The Faculty has recognized this issue and is working to address it; we strongly urge continued vigilance.

- ***Accreditation issues with cross-disciplinary course offerings and programs.*** The Canadian Engineering Accreditation Board (CEAB) requirements impose serious constraints on curriculum innovations, and the lack of flexibility in course substitutions has been a serious barrier to international exchange placements.

Research

- ***Misalignment of academic incentives.*** The reward structure in academia and funding opportunities in engineering often require deep specialization. While the Task Force understands the value of depth and specialization, this incentive structure tends to limit broader and more globally oriented thinking, research and interactions and may discourage and even exclude engineering faculty from participating in more holistic approaches to addressing pressing global problems.

- ***Lack of explicit connection between the Faculty's research activities and high profile global challenges.*** As described previously, there is an ongoing global dialog on pressing world problems inspired by the UN Millennium Development Goals, the Gates Foundation Global Challenges, and more recently the National Academy of Engineering Global Challenges. Although research in the Faculty addresses many globally important areas, there is limited explicit communication linking the Faculty's work to the global dialog. Recent emphasis on communication (e.g. e-Newsletter) and the efforts by the Vice Dean research to coordinate activities in energy-related areas are steps in the right direction, but much more can be done.

- ***Research Funding.*** As described earlier, there are growing funding opportunities for international collaborations. However, most funding is still focused on projects that will be wholly conducted within Canada. In addition, there are limited funding sources for engineering work related to international development.

4. Preliminary Recommendations for Key Future Initiatives

The Task Force has formulated for discussion the following preliminary recommendations, or in some cases avenues for future development.

4.1 Curriculum and Academic Programs

Goal 1: Cultivate innovative, critical and systems thinking, adaptability and ability to manage complexity

Some or all of these traits are named in nearly every report on educating engineers of the future, including the 2000 *Decanal Task Force Report on Curriculum Change*. While some efforts have been made, the efforts have not always been explicit in trying to address these goals, and the results have not been measured. For example, research suggests that although faculty continually engage in critical thinking as part of their research and writing, nearly all are unaware of the need for teaching critical thinking, and most find it difficult to model the processes associated with critical thinking when teaching.

Action 1*:* Identify and evaluate best practices in cultivating the skills listed, and incorporate most appropriate methods in various courses in the curriculum, including training of faculty. Possibilities include: adding a component to courses that is examined but not explicitly taught in order to encourage students to develop a framework for self-learning; examining current design courses and measure whether they provide students with a complex design challenge and/or an ability to practice systems-level thinking and providing explicit critical thinking workshops for students and faculty.

Cost/Requirements*:* Pedagogical expertise and faculty buy-in needed, possible outside expertise for workshops.

Goal 2: Develop global sustainability perspective through complementary studies courses

Action 2a: Develop and offer up to five engineering economics courses with different emphases, including cost accounting and financing for traditional firms and global firms, working in extreme poverty, and entrepreneurship. Incorporate environmental and social costs with benefit cost analysis.

Cost/Requirements*:* Startup costs in developing courses. No incremental cost at steady state. Requires qualified instructors, possibly from outside the Faculty.

Action 2b: Identify, modify or develop complementary studies courses with global sustainability perspective.

Cost/Requirements: Startup costs in developing courses. No incremental cost at steady state. Need to work with the Faculty of Arts and Science.

Goal 3: Develop global perspective in all students by incorporating global sustainability through the technical curriculum

Action 3a: Embed problems, examples and discussion points in standard technical courses.

Cost/Requirements: No incremental cost at steady state. Start up cost: faculty members modifying courses, finding or developing appropriate resource materials. To lower the barrier and start up cost, make use of the expertise of visiting scholars, international graduate students and faculty members with international experience; and consider partnering with EWB to share and co-develop resource materials with other universities.

Action 3b: Incorporate global projects in existing design courses, preferably with international collaborators or project teams, and potentially using collaborative software.

Cost/Requirements: Start up cost: need to identify suitable projects and international partners. Steady state costs: continued cultivation of partners. Requires committed faculty to teach suitable courses in each program.

Action 3c: Identify BASc or MEng thesis project with global context, preferably with an international collaborator.

Cost/Requirements: Start up cost: need to identify suitable projects and international partners. Steady state costs: continued cultivation of partners. Possible incentives and financial support for faculty and students.

Goal 4: Develop in-depth global knowledge in some students through specialized elective courses.

Action 4a: Elective courses on engineering and international development, and engineering in the rapidly emerging BRIC (Brazil, Russia, India, China) economics.

Cost/Requirements: Developing new course, will need qualified instructor. Models exist in Arts and Science, e.g. a course on international project management.

Action 4b: Develop high-engagement elective engineering courses related to developing and rapidly emerging economies, preferably including some field work. Models of such a course include Amy Smith's D-Lab courses at MIT, Bernard Amadei's courses at University of Colorado

Cost/requirement: Cost will be high, but evidence from elsewhere is that there is high demand from students. Requires a champion/leader with the commitment and contacts to make this work. Potential advancement project.

Goal 5: Develop a level of global experience and skill set through meaningful multicultural engagement in Toronto

Action 5a: Take advantage of the international community within the Faculty, University and City of Toronto. Example: deliberate assembly of multi-cultural project teams in design courses.

Cost/Requirements: Minimal. Guidance is available from UofT resources such as the Centre for Community Partnerships and the Multifaith Centre regarding working and communicating across differences.

Action 5b: Further enhance diversity within the Faculty by facilitating the Faculty's ability to receive international visiting scholars, and integrating them into our activities.

Cost/Requirements: Minimal.

Goal 6: Develop expertise in global knowledge in some students through formal programs ranging from minors to degree programs.

Action 6a: Develop a minor in globalization and/or international development.
Cost/Requirements: High, need specialized courses.

Action 6b: Combine elements of, or enhance current form of, Entrepreneurship, Leadership, Innovation and Technology in Engineering (ELITE) and Skoll to yield Global Engineer program.

Cost/Requirements: Depends on the number of new courses required.

Action 6c: Design and establish high engagement academic programs such as Purdue's GEARE.

Cost/Requirements: High. The estimated cost for the GEARE program at Purdue is about $100,000 for 20 students per year, or $5,000 per student, for their global experiences. Champions are needed.

4.2 Co-Curricular Student Experience

The following co-curricular recommendations are primarily based the enhancement of Professional Experience Year (PEY), and International Exchange Opportunities.

Goal 7: Develop a level of global experience and skill set through international experience

Action 7a: Increase number of international PEY placements. Explore synergies of academic and industrial placements in the same countries/cities, e.g. cooperate with university partners to prepare our students for an international PEY placement and vice versa.

Cost/Requirements: Leverage existing infrastructure of the PEY office and UofT's international exchange office; make use of international alumni. Estimated cost is 1 FTE staff person per major region.

Action 7b: Reduce barriers for students to go abroad for either academic or industrial placements by: actively identifying scholarship sources and possible advancement projects, facilitating transfer of academic credits, and building on existing capacities in the International Exchange Office and the PEY Office to provide further support.

Cost/Requirements: 1 FTE per 100 students abroad (as cited by the ISX office) and better selection of universities appropriate as an exchange school with each of our undergraduate programs.

Action 7c: Create partnerships with a small number of strategically selected international academic institutions that can help facilitate international exchanges and PEY placements, alongside international research and academic collaborations.

Cost/Requirements: Similar to academic exchange and PEY placements, but with synergy between the two. (Significant resources exist such as the U of T office in Berlin.)

4.3 Research Mission and Faculty Members

Goal 8: Seek to more directly link the research of this Faculty with major global mandates. Generate a culture that encourages faculty to address key problems

Action 8: Further enhance communication channels to generate open dialog linking research activities to global goals, including: highlighting global goals, identifying and communicating global needs and funding opportunities, creating a focal point for individual faculty members to self-identify and link their research activities to global mandates and to identify potential collaborators, and to provide visibility to such research activities.

Cost/Requirements: Cost will be low; requires work by communications staff and cooperation of individual faculty members.

4.4 A New Centre for Global Engineering and Sustainable Technologies

In response to the Dean's question on how the research mission of the Faculty should be influenced by globally important problems, the task force considered the possibility of a new Centre within FASE to concentrate activities on global engineering, and in particular the international development aspects thereof. This will serve a formal entity to coalesce

interest in faculty members and students, and to interact and coordinate with other parts of the UofT community.

Key activities and goals of the Centre may include: training engineers in global engineering approaches and the design of appropriate and sustainable technologies; serving as a resource in the development of a global perspective in the Faculty's academic and research programs, as recommended in Sections 4.1 and 4.3 above; serving as a focal point of some of the outreach and communications programs described in Section 4.5 below; conducting research with a broad approach to using innovative technologies of many types in a global context; developing and collecting case studies on appropriate technologies and international development; demonstrating a multi-partner approach to encourage engineering innovations as a key strategy in enhancing economies, and working towards eradicating poverty in the developing world; expanding the global applicability of engineering research conducted at UofT; setting a high standard in terms of the level of rigor and the visibility of a program of this type; and serving as a prominent example of how engineers address the world's most pressing problems.

Goal 9: Evaluate the feasibility of, and recommend start-up and implementation strategies for a new centre on global engineering and sustainable technologies.

Action 9a: Appoint a group with requisite expertise to develop options and a base case vision for a Centre, and if appropriate formulate a strategic and startup plan, including the exploration of advancement options.

Cost/Requirements: Modest during the planning stage, requires a few interested volunteers from within FASE with appropriate vision and expertise. Cost will be high if a Centre is to be formed: requirements will include strong leadership and sufficient faculty interest and strength, and availability of research funding for interested faculty; but such a project can also attract donor funding.

4.5 Expanding FASE's Global Communications, Visibility and Presence

Goal 10: Enhance communication (a) within the FASE community to relay opportunities, funding, serve as a networking mechanism, and (b) and to the external community to highlight and showcase the globally significant work that goes on in this Faculty.

Action 10a: To begin with, design a website to serve as a repository of all globally related activities and information. Further make use of established communication mechanisms in the departments, Faculty and university to communicate relevant stories.

Cost/Requirements: Minimal.

***Action 10b**:* Disseminate information on and create links to other UofT programs and initiatives with a global perspective, and to other universities on the topic of engineering and globalization.

Cost/Requirements**:* Modest – use web site and communications channels referenced in ***Action 10a above.

Goal 11: Leverage the cultural diversity of our faculty members and student body to enhance global presence and visibility and further internationalize the FASE community

***Action 11a**:* Continue to recruit grad students from abroad. Think about how they can be part of our network even if they return to their home country
***Action 11b**:* Recruit international undergrads
***Action 11c**:* Encourage visiting professors from abroad and integrate them into Faculty activities.

***Cost/Requirements**:* Significant, but in some cases costs are already built into existing programs.

5. Invitation to Provide Input

The Task Force welcomes comments, questions, thoughts, and ideas on the topics we have reviewed and/or on other aspects of the topics of globalization and engineering that you feel we have missed. We will reach out to as many individuals and groups within FASE as possible, but would also benefit greatly from proactive contact from you. The Task Force members may be reached as follows:

- Yu-Ling Cheng, Professor, Chemical Engineering and Applied Chemistry (Chair); yuling.cheng@utoronto.ca or (416) 978-5500.
- Bryan Karney, Professor, Civil Engineering, and Chair, Division of Environmental Engineering and Energy Systems; karney@ecf.utoronto.ca or (416) 978-7776.
- Murray Metcalfe, Ph.D., Alumnus (B.A.Sc. 1977); mm@transformcapital.org or (617) 633-0041.
- Lisa Romkey, Lecturer, Curriculum, Teaching and Learning, Division of Engineering Science; romkey@ecf.utoronto.ca or (416) 946-3514
- Zhirui Wang, Professor and Associate Chair, Graduate Studies, Materials Science and Engineering; zhirui.wang@utoronto.ca or (416) 978-4412.

In addition, all members of the community can feel free to communicate comments on the Task Force to the Chairs and Directors, or to Dean Cristina Amon (dean@ecf.utoronto.ca or (416) 978-3131).

We look forward to receiving your input and discussing these topics with you.

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Interviews

Industry	Company	Interviewee(s)
High Tech	RIM	Mr. Dave Jaworsky (Director of Government and University Relations) Mr. Dave Dietz (University Research) and Ms Karen Clink (Government and University Relations)
	Celestica	Mr. John Yealland
Manufacturing	Magna	Mr. Dan Chicoine
	Canadian Manufacturing and Exporters' Association	Ms Deborah Turnbull
Consulting Engineers	RWDI	Mr. Anton Davies
	Delcan	Mr. Doug Langley
Energy	Brookfield Renewable Power Inc.	Mr. Colin Clark
	Magenn Power Inc.	Mr. Pierre Rivard
Government/Public Sector/NGO	Micronutrient Initiative	Mr. Venkatesh Mannar, Dr. Mark Fryars, Ms. Evelyne Guindon and Dr. Annie S. Wesley
	Engineers without Borders	Mr. George Roter et. al.

Academic Institution	Unit	Interviewee(s)
University of Cambridge	Centre for Sustainable Development	Dr. Dick Fenner
Tokyo Institute of Technology	Department of International Development Engineering	Professor Naoya Abe et. al.