

Matariki Network of Universities Renewable Energy and Society Workshop

5-7 November 2010

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Forty-one representatives from the seven MNU partners met Nov. 5-7 2010 at Queen's University. A wide range of presentations, included in this package, covered topics from social issues connected to renewable energy uptake, through technical challenges associated with different technologies, and including policy and science connections required to advance the renewable energy agenda.

On Friday, November 5, the Matariki Network delegates attended a reception hosted by Queen's University Principal Daniel Woolf. Sixteen student delegates made poster presentations. Prizes were awarded for first, second, and third place winners. Eva Unger (Uppsala) received first place, Kirby Calvert (Queen's) received second place, and Katie Thompson (Durham) received third place. Andrew Duncan (Queen's) received an honourable mention.

On Saturday, November 6, the Kingston Economic Development Corporation (KEDCO) hosted the MNU delegates at a reception at Kingston's historic Fort Henry, a UNESCO heritage site. The MNU delegates enjoyed hospitality and a tour of the Fort, which provides a view over the City of Kingston and surrounding features, including the 198 MW wind farm (86 turbines) on Wolfe Island.

As the hosts of the first Matariki Network of Universities research workshop, we would like to thank each delegate for their participation, their contributions, and their enthusiasm!

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1 - Context

Each of the MNU member schools has a large residential population, and the students have perhaps a stronger relationship with their institutions than in other, larger centres. For example Kingston wants to be a strong, sustainable, centre for renewable energy; what about other communities represented by the Network?

The 'transition towns' movement that has spread across the world (<http://www.transitiontowns.org/>) is an example of the type of engagement that different schools are participating in. In some cities (such as Perth), development is a challenge; sprawl and rapid urbanization is a problem that must be dealt with to a greater extent than in other communities (like Kingston). By contrast, Hanover (the home of Dartmouth College) is only about 5,000 in population; the introduction of students to this mix can double or triple the size of the town, and the impacts are correspondingly large.

It is well understood that research (and teaching) collaborations are generally peer-to-peer, and that all Universities already exist within a web of Networks with various collaborators. The MNU may facilitate more formal cooperation but it is understood that it may simply facilitate more bilateral or multi-lateral engagement among individual researchers. The presence of funding within individual institutions is designed to create more formal relationships; perhaps this model can be imitated across the MNU, allowing our researchers to take advantage of potential research, teaching, and extension synergies. Innovation generally comes from the convergence of different ideas, which is well supported by the range of different skills and interests represented at this MNU meeting.

Metrics for success might include increased research funding, publications, co-supervision, and teaching. An advantage of the Network is that it puts each member into contact with the partners of other members – thereby expanding the informal linkages in a linear or even exponential fashion.

Discussion:

Key issues raised in the discussion include the question of business vs. academics – how can we bridge the gap between the spheres? One message that seemed to be well-received by the group was the idea of using science contacts to build high quality education and better opportunities for students. In particular, the MNU might be a vehicle whereby we can further improve the interdisciplinary teaching approach at the undergraduate level in each institution.

As we have so many areas of interest across the participants on the academic side, it is possible that the Matariki Network will make us aware of overlaps that might not have been discussed before. There is a nice mix of engineers, natural scientists and social scientists – it would be good to get cross-pollination between the three spheres.

Faculty and students at the universities in the MNU are already aware that individual choices make a difference. But local populations are not necessarily aware, or easily persuaded, that this is the case. Using this type of Network to improve linkages between 'town and gown' is perhaps a useful outcome of the MNU program. Perhaps there could be 'research-led engagement' as a theme?

2 - Keynote talks: Some Canadian Perspectives on Renewable Energy & Society ***Sean Conway (Fellow, School of Policy Studies, Queen's University) - a broad perspective on government initiatives***

Canada is big, empty and cold. Issues like energy are bred in the bone; transportation is of key importance to the functioning of our society and economy. Canada is also a country of regions, where oil and other fossil energy production (which is found in the east, west, and increasingly north) is not in the same place as our population (of which over 40% lives in Ontario). Canada has attempted national energy policy, but this really attempted to take resource control out of the hands of the Provinces and as a result increased the sense of regional differences.

Canada is blessed with renewable energy, for example, the hydroelectric power of Niagara Falls (Ontario) and Churchill Falls (Quebec/Newfoundland & Labrador). In the latter example, the development could not proceed until Quebec signed a long-term agreement to buy the electricity of Churchill Falls from Newfoundland very cheaply, power that they then sell to the USA at a higher rate, creating a long-term dispute between those provinces. Development of new hydroelectric opportunities (there is a large one that remains at the Lower Churchill Falls) is being held up because of this.

Where one stands on renewables in Canada depends largely upon where one sits. If you are in Newfoundland, Quebec, Manitoba, and British Columbia, you have a great deal of potential hydroelectric power; if you are in Alberta or Saskatchewan (or Nova Scotia), you are not blessed with this alternative. Unsurprisingly the former provinces have more advanced views on renewable energy. In Ontario, the mix has been interesting, with 50% of electricity coming from nuclear, 25% from thermal sources (coal and natural gas), and 25% from hydroelectric sources. Ontario is now getting away from coal; development of renewable energy, including wind, solar, and biomass sources, has grown dramatically under the Ontario Green Energy and Green Economy Act (2009) within only a year since passage of the legislation.

There have been significant changes around renewable energy perceptions in Canada over the past few years. Industry and business have joined the green energy parade. There is a sense that we do have to do things differently. Ontario and British Columbia have introduced new sustainable energy policies; BC has set a new standard saying that all new electricity plants have to have zero greenhouse gas (GHG) emissions. At the same time, governments have been getting back in the business of energy; a long-standing trend to privatize energy and particularly electricity production has in a way been reversed. We are starting to see a reaction to higher prices for renewable energy; the answers have not been as satisfying as the shift to renewables. There needs to be a discussion about real costs, real choices, and the consequences of our actions.

Steven Liss (Vice-Principal (Research), Queen's University) – the Canadian research funding environment

North American universities, since the 2nd World War, have been asked to lead research programs that can contribute to economic renewal, quality of life, and prosperity (please see the attached presentation).

The traditional funding landscape in Canada consists of three federal-government-funded research councils (Natural Sciences and Engineering Research Council, Social Sciences and Humanities Research Council, and Canadian Institutes of Health Research) which operate at the national level, as well as a number of provincially-based programs (for example, the Ontario Innovation Agenda). The Federal government also has a Science & Technology Strategy (dating from 2007). The funding landscape continues to evolve; there is a shift from investigator-led to strategic research collaborations; development of new goals and

performance indicators; a focus on the knowledge economy; and, a focus on engaging the broader community.

There is increasing uncertainty regarding government investment in research, which is leading to increased focus on industrial partnerships. The contracting number of potential funders has led to some conflict - different institutions may trip over each other as they pursue funding opportunities.

Queen's has a number of innovative centres related to renewable energy, including the Green Chemistry Canada centre of excellence, the Sustainable Bioeconomy Centre, the ePower group, the Fuel Cell Research Centre, and Queen's Institute for Energy and Environmental Policy. One of the mandates that Queen's is undertaking is building closer relationships with the surrounding region, and supporting development of the knowledge-based economy in this region. The latter concept is that companies, universities, and even countries must seek to establish strategic collaborations to create synergies and opportunities.

Like many other universities, Queen's is increasingly focusing on both internationalization and globalization. There is an imperative for our research programs to have high impacts, broad reach, and significant value of collaboration.

Ted Hsu (Executive Director, SWITCH) - the community perspective

Price matters. We are all sensitive to the price signals which are associated with renewable energy. It is something to consider as we make the shift to renewable energy and greater energy efficiency.

SWITCH is a group of 140 members based in Kingston, focused on making southeastern Ontario a centre for sustainable energy. It is incorporated and not-for-profit (since 2002). Membership includes business, farmers, public institutions, educators, researchers, consultants, students, consumers. SWITCH is essentially set up to provide access to expertise; if there are questions about specific policies, or technologies, SWITCH can connect the right people.

A major job for SWITCH is trying to create new jobs in the region. As an example: Ontario's Green Energy and Green Economy Act provides some incentives for renewable energy. SWITCH brought a company in from Ottawa which was designed to take advantage of these incentives. As a direct result of this action, a Kingston-based company was founded and now employs four people directly.

SWITCH does lots of public education through events and meetings. One of the members of SWITCH is St. Lawrence College, a community college located in Kingston. This college has an energy technologists program which is really an extension of Kingston's capacity for renewable energy. This is an example of SWITCH's success in bringing together the correct actors. Similarly, SWITCH has worked with the local utility company (Utilities Kingston) to develop unique training packages for utilities employees.

SWITCH has been working closely with various stakeholders to increase the uptake of renewable energy. Key actors, including banks, insurance agents, real estate agents, contractors, need to be engaged, as do people with knowledge about the process of obtaining building permits and those who know zoning bylaws.

Policy can get in the way. A number of Kingston's small renewable-energy businesses were almost put out of business by the Green Energy Act, and the delay between announcing this Act and enabling the Feed-In Tariff which is the key economic incentive under the Act. Many companies would have benefited if the policy had been implemented in a prompt fashion, on a transparent timeline; however the delays in delivering the program meant that companies had to wait for the business to grow and had a difficult time making ends meet.

Addressing renewable energy should include an emphasis on servicing poorer populations. You need to address some of the disparities in capacity to deal with climate change challenges. For instance, a poor individual who can't afford a well-insulated home with efficient systems, uses a disproportionate amount of energy at great personal expense. One of the focus areas of SWITCH is linking the right capacities to poorer populations, and it is suggested that this might be a topic for us to discuss.

Discussion

Community engagement is important, and vehicles like SWITCH are useful for engaging stakeholders and for putting the right people into the room. From a research perspective, engagement with boundary agencies such as SWITCH is essential to achieving real change. There is a real need for capacity that links the ideas to the actual implementation, and boundary agencies take that role on. Many examples across the MNU might exist that could be applied in other jurisdictions.

There is also an incentive, and drive, for the regions around Universities to become early adopters of new technologies, which again can be supported by boundary agencies. Many successful models (i.e. Silicon Valley or the Waterloo Technology Cluster) have taken this type of regional approach. This model might be used by the MNU. Small business has a unique role in the development of renewable energy technologies. Unfortunately, the skill-set of the entrepreneur does not necessarily meet the needs of a successfully growing and expanding enterprise.

It was emphasized that policy can have unintended consequences; for instance, the promotion of solar PV in Ontario has put many of the solar thermal companies into dire financial straits. Picking winners is a difficult task, and the government is not always the best at doing this! Much of the expertise and resources lies with Federal and Provincial governments, while the implementation happens at the local or municipal scale. Is there a disconnect between these levels? (In a wealthy enclave near Toronto, the proposal to install a gas-fired generator facility was shut down by the community; there was no understanding of the linkage between energy production and use.)

In Western Australia, there is the Sustainable Energy Alliance. In Vermont, there is Efficiency Vermont, which is a utility with the mandate to save money on energy bills. In New Zealand, there are a variety of different agencies, some of which are community-based.

3 - University of Western Australia

Robyn Owens provided an overview of the Australian educational scene. The 'Group of Eight' universities do seventy percent of the funded research in the country. The UWA was established in 1911; it is a comprehensive university with about 22,000 students (5,000 international, 5,000 postgraduate). Three research institutes, including Agriculture, Ocean Studies, and Energy & Minerals. Key energy themes include oil and gas, geothermal, coal, bioenergy, energy options, and gas-to-liquid. Key strategic opportunities include aboriginal studies and biodiversity. The city of Perth is one of the most isolated cities in the world; however, over 60% of the world's population lives in the same time zone (due to China). The University encourages student and staff mobility, providing travel grants for all research students and supporting joint degree programs in key areas of strength and collaboration. Research collaboration awards are available and proposals involving Matariki partners are given priority.

Matthew Tonts discussed the energy sector in Australia. The presence of abundant fossil energy reserves, particularly gas, has brought significant market capital into Perth. The biggest gas project in the world, worth \$43 billion, is located nearby on the NW shelf of Australia. The Australian system is a Federal system, and States have a significant amount of control over natural resources; the Commonwealth (federal) government has lots of money, however, and this is giving them an increased role in developing these resources. Regional development is becoming more important; in Australia, this tends to mean rural and remote areas (a slightly different definition). Australia has an *Expanded Renewable Energy Target* which sets a goal of 20% renewable energy by 2020.

There are many significant environmental problems facing Western Australia, including land use change; the region was once woodland, but this has been largely replaced by agriculture, and this has caused significant soil salination problems. Many parts of the landscape are no longer productive, and the goal of replanting trees (which requires fairly decent land to get a forest started) now competes with current agricultural practices; some innovative responses, which combine energy production with landscape restoration, are underway. There are also solar thermal projects underway, with best sites identified and technologies being explored. However, challenges remain with the financing and uncertain costs associated with these projects. Do the technologies and the science stack up?

Hui Tong Chua discussed geothermal research at UWA. They are investigating a new method of harnessing geothermal heat by using shallow, hot water from sedimentary aquifers. A key goal is to utilize geothermal energy to drive air conditioning, a major requirement in Australia. A demonstration project at the UWA is planned, which would combine a geothermal chiller with the central plant on campus, in collaboration with a company called Green Rock, which has a \$12.4 M (AUS) funding award from federal and state governments to build this project. A second application of the geothermal chiller approach is combined with radioastronomy and the associated need for high-speed supercomputers. The Pawsey supercomputer will require significant cooling; this is a project in conjunction with CSIRO and a company called Geothermal Power. Geothermal energy is also being used to drive a desalinization plant.

A second area of interest is the development of near-zero-emission hydrogen and graphitic carbon production from methane. This would allow some energy production, but without emission of carbon dioxide. A key question is whether the process produces a net amount of energy; they estimate that 50% of the hydrogen produced is needed to drive the process, giving a net efficiency of about 21%, an efficiency that is quite close to steam power plants. The purified carbon can be used in nanotech applications, and the process is currently being spun off.

Steve Smith discussed bioenergy and chemical energy research at UWA. A Centre for Plant Energy Biology is spread over three locations: headquarters in Perth, with nodes in Adelaide and Canberra; total funding for the Centre is about \$40 million (AUS). Work is underway to better understand crop, food, and biomass production across a range of useful plants. Plant metabolism offers enormous opportunity to create high-value products for energy, food, etc. The pathways under exploration in the PEB Centre have focused on aspects of hydrocarbon production, which would deliver a high-energy fuel process. An interesting question around bioenergy production is which crops should be selected for optimal production pathways. Wheat and canola products are being explored, as are other more specialized crops. UWA has focused on chemical processing to fuels, and fermentation to biogas. There is some work on bioenergy for mining purposes, where bioenergy can be used to support the remote communities; mining also can produce large amounts of water as aquifers are broached through the mining activity, and biomass production could use this water. Restoration ecology associated with cleaning up mining operations is also an area of interest.

Finally, there is work underway to investigate questions of social and global change; modern society is addicted to growth, but this is not sustainable in the long term. There is lots of potential for collaboration on these topics.

Discussion touched on several areas, including the scale of geothermal applications for computing facilities, the quantity and quality of information describing the renewable resources in Australia and Canada, the impact of federalist approaches on policymaking, and the use of algae in bioenergy production.

4 - Universität Tübingen

Udo Weimer provided an introduction to the University. The palm tree logo of the University came from the founder, who saw them on a pilgrimage to Jerusalem in the 1400's. Many prominent scholars and graduates, including the Pope, have been associated with the school, which currently has about 23,000 students. Key research areas include solar cell research, with a focus on efficiency and the stability of organic materials. One interesting study that Tübingen is participating in is the 'clean and resource efficient buildings for real life' or *clear-up* project. About 40% of European energy consumption is used in buildings; 50% of energy requirements within relate to heating and cooling, and 60% of Europe's building stock is over 25 years old. There is work underway that combines windows/lighting and energy requirements, in conjunction with Uppsala University. Photocatalytic surfaces for air cleaning is another area of interest. Industrial partners include Siemens, Acciona, Bouygues, and a number of smaller companies. More details can be found at www.clear-up.eu.

Susanne Fischer provided a discussion on mobility research based at the Department of Geography at Tübingen. The German Federal government funds electric mobility with about 500 million € across the country. The e-Tour project (efficient electric mobility and tourism in the Allgäu Region) is focused on developing electric mobility in a rural, tourism-dominated area in southern Germany. Many different electric vehicles, from electric bicycles and Segway vehicles to full-size vehicles, are being considered in this project. A number of research partners, including universities and industry, are engaged in this project. Tools used include GIS mapping to determine optimal charging station locations, and engineering models that can calculate power capacity given topography and temperature. The research focus is on analyzing spatial mobility patterns, and introducing new mobility concepts into this matrix.

The differences between rural areas and cities are important to consider. The dependence on vehicles, and the lack of public transit alternatives, in rural areas means that electric vehicles may actually be more easily adapted within rural settings. There is also a need to link urban planning and sustainability, which might actually increase the ability of future systems to take up technologies and options.

Hauke Diederich discussed the impacts of electrification on migration. Up to 1.6 billion people in the world do not have access to electricity. Globally, there is a rural exodus that has been ongoing since the beginning of the industrial revolution; there are more opportunities and services in urban settings. Research questions include the impacts of electrification on rural households, and an assessment of impacts on migration. The work will be carried out using the sustainable livelihood framework, which is a people-focused model that links vulnerability and institutional frameworks. The case study will be carried out in Nicaragua, focused on a small hydropower plant (220 kW) which can supply up to about 1,000 households.

Steffen Jenner spoke from the economics department, and focused on governance structures. This work explores the concept that types of capitalism - 'laissez-faire' or open systems (e.g., USA) and coordinated capitalism (e.g., Germany) - have a strong impact on the type of policy that is implemented. The question is whether energy policy might be differently applied under different capitalistic systems.

Controlled systems may try to manage the production of energy as a public good; laissez-faire economies might allow more market mechanisms to provide energy. In Russia and China, up to 100% of the grid is publically held; in Brazil and India, various regions have more autonomy with private players making up a larger percentage of the total grid. In his second presentation, Steffen switched from authoritarian systems to the EU27 sample. While some of the EU member countries push forward a green agenda, others are rather reluctantly exploiting renewable energy sources. Why is this, he asked. Interesting findings of the quantitative investigation include the fact that a one percent increase in unemployment correlates to an 18% decrease in the likelihood that states will support renewable energy mandates; the presence of a strong coal lobby decreases likelihood by 44%.

In the discussion that followed, the negative impacts of electrification were explored. An interesting correlation between electricity supply and fertility rates was highlighted. Many aspects, including cost and uptake of technological options for mobility and home construction, were discussed. The concept of 'Tübingen Blue', as a way of marketing new and better renewable energy options, was introduced.

5 - University of Otago

Gerry Carrington and Rob Lawson gave a two-man presentation describing the University of Otago and research programs within. The University in Dunedin, NZ, is the southernmost and oldest university in the southern hemisphere. The country is small (4 million), temperate, and empty (!). Power in New Zealand is dominated by hydro and geothermal, supported by coal, gas, and recently wind. The mix is about 65% renewable; it is relatively cheap (at about \$0.20/kWh). The electric utility was broken up in the mid-1990's, with generation and retailing often controlled by one entity, and the main transmission network being handled by a single government-owned corporation. On the side of fuels, most oil is imported; there is natural gas available, and significant coal (including 6 billion tonnes of lignite). Some oil reserves, particularly in what is known as the Great South Basin, may be extensive, but the seas are rough and deep and there is a risk of icebergs. New Zealand has high energy use per unit of GDP, as much as 75% more than the OECD average. Per capita use of vehicles is high, with the fleet increasing by about 70% in the past 10 years. Energy use per capita has doubled every fifty years (enflation). Growth in energy-sourced CO₂ emissions from 1990-2006 has grown by almost 50%, compared to about 28% for Canada, and 20% for the USA.

The National Energy Research Institute is a collaboration of all NZ Universities, as well as NZ Crown Research Institutes and others (www.neri.org.nz). It is committed to creating linkages between the primary stakeholder groups. NERI lost government funding in 2009 and has now been made a Charitable Trust by the University. A major task at present is to extend the network and secure ongoing funding. (The SWITCH model may be one that could be applied to NERI).

The Otago Energy Research Centre was established in 2006 and has 45 researchers and 30 postgraduate students from a number of departments working to cover energy issues. Among other events, the OERC organizes a one-day symposium which brings together actors from across the disciplines. There is growing consensus that technology/resources alone are not the solution, but that various groups need to work together to deal with social aspects of change.

Work at Otago covers a wide range of topics, which are summarized in the attached presentation. Importantly, technical researchers are closely linked to planners, economists, and social researchers. Conservation is a theme which is strongly represented among the research interests of these individuals, as is smart, integrated planning.

The Energy Cultures project is one example of a good, integrated project that deals with behavioural change. The IEA has stated that a ‘huge step-change required’ in achieving real shifts in energy use. Much of our behaviour has nothing to do with knowledge; it has to do with the way in which we have been raised, and what we are used to. A process of choice modelling is underway within this project to try to understand people’s decision-making process around energy choices. One interesting side-project is the development of a ‘disambiguation’ technology for use with ‘smart meters’ that can tell what type of appliance is being used based on the energy signature of the appliance; this tool is about 90% accurate after a ‘learning’ period and would mean that improved feedback to customers on electricity usage could be implemented at a very cost-effective rate. The student who developed this technique comes from Oxford, UK and is joining Otago soon.

In the discussion, questions were asked about the ‘disambiguation’ technologies being developed. Points were raised about the privacy and ethical implications of analysing individual household data from smart meters. Another issue is the development of energy demand in New Zealand. The production of methanol from Fischer-Tropsch processes was a large industry but this has basically stopped in New Zealand. In terms of the systems approach, the NZ approach has some unique aspects, where very disparate groups are being engaged through different stages in the analysis, but the process brings these ideas and insights back into the overall systems framework. One issue is the language used; technical language can form a barrier to communications, and it is important to create a common language to support the dialogue.

6 - Uppsala Universitet

Joseph Nordgren provided an overview of Uppsala University. It was founded in 1477 (same year as Tübingen); it has nine faculties, of which Science and Technology is the largest. It has a number of student exchanges, with more than 3,000 international research partnerships with more than 1,000 institutions around the world. Energy research covers a very wide range of topics, including electricity, energy storage, efficiency, artificial photosynthesis, nuclear power, CO₂ sequestration, and energy systems studies. Some major infrastructure projects are being developed, including a synchrotron facility and a neutron spallation source. Lund has a new graduate programme for a Master’s in chemistry focused on renewable energy.

In Sweden, energy demand is about 45 kWh per capita per year. About 32.5% is electricity, and 67.5% is fuel. One of the outlooks for Swedish energy demand is that by using electricity better, and using smart technology, and increasing renewable electricity use, that Sweden can reduce energy consumption by 20%, and reduce fossil use from 40% to 12%, by 2050. By comparison, world consumption of fossil energy might be reduced from 80% to 50% over the same period.

Ann Magnusson discussed the Swedish Consortium for Artificial Photosynthesis, which was formed in 1994. About forty individuals, who over years have represented at least twenty countries, are working on this project. This project works to combine water and carbon dioxide into value products and fuel, following the photosynthetic pathway used in plants, but in an artificial and controlled fashion. The project works to mimic natural systems in a way that allows recovery of chemicals prior to the assembly of structural or storage molecules, such as starch or cellulose; this would make the production of downstream products (fuels or chemicals) much more efficient.

Simon Tyrberg discussed wave power, which is introduced as a potential renewable energy source that has many positive aspects, including high energy content, and high public acceptance (see attached presentation). The challenge is that the conditions are very harsh, and the medium runs very slowly at high force - this is difficult to capture.

The project is on the west coast of Sweden, and involves 12 PhD students and 5 senior researchers.

The Lysekil research site is close to some research facilities, being only a few kilometres away from land. The wave powerplants are connected by lines underwater to a substation (underwater) and then to land (2.9 km away). Factors being considered are the reaction of fish and other aquatic life (with both active and 'biology' or control buoys), as well as power generation and the ability of technology to withstand the conditions offshore. The project was begun in 2003 and the first generator was installed in 2006. Grid connection is planned for 2010-11. Results to date show that the wave power can be recovered at a rate of about 25%; further, power recovery can be controlled by the amount of electricity demand put on the system. Future work includes increasing absorption of power from individual buoys, and dealing with regulation of DC voltage.

Marcus Lindahl discussed the interaction between business and research. With a Master's program in industrial management & innovation, and a School of Entrepreneurship, Uppsala is well positioned to provide education that focuses on this relation. Innovation-Commercialization-Industrialization (ICI) for Energy and for Life Science are two programs focused on this relationship. Within ICI-Energy, themes are policymaking (new electric energy technologies), business development (strategy, internationalization, business models, and ramp-up), cost benefit analyses, migration of technologies (new and old infrastructure), and finally loosely coupled R&D projects.

The discussion that followed explored the efficiency and impacts of wave-powered energy, and there was some exploration of the potential conflict or synergy between fish farms and wave generation. The wave project is very expensive, and much is being funded by the University and the Swedish Energy Agency, as well as four utility companies. There was a question about organisms growing on the wave power structures; this has not yet been a problem (over 4 years) and the structures are painted with anti-fouling paints. Progress of artificial photosynthetic cells was also discussed; at this point materials are being chosen and catalysts selected for use in actual applications. There is a theory now that by combining a number of artificial photosynthetic steps; several unperfected stages could combine to be an effective project. Questions were asked about the characteristics that are being sought in artificial structures; there is a thought that the artificial structures will be more stable than enzymes, but it needs to be tested. Some explored the idea of using solar panels vs. artificial photosynthesis in terms of efficiency of storage; there are a number of technological options right now, but the most effective system is not yet known.

7 - Durham University

Douglas Halliday began by discussing the breadth of energy research at Durham University. The University has 23 departments and schools, and over 200 undergraduate programmes; each department offers a PhD programme and many offers Masters programmes. Recent developments include exchange programmes and collaborative programmes. Durham has a small travel grants scheme to promote interaction between MNU members. In the UK, there is a Department of Energy and Climate Change, and they have set a target of 20% renewable energy by 2020. Right now there is 2% renewables in the generation profile (with oil and natural gas ranked first at 38% each, coal at 16%, and nuclear at 6%). In the long term, they plan to cut CO₂ by 60% by 2050.

The Durham Energy Institute (www.dur.ac.uk/dei/) is addressing three global energy challenges, including (1) energy security and risk, (2) low-carbon transitions, and (3) low-carbon communities. Research is organized into six broad categories (described by the Durham Energy Institute 'Rose').

Key features of the DEI include multidisciplinary teams, linkages with industry. There are 25 research students formally linked to this institute through a newly established Centre for Doctoral Training which provides opportunities for interdisciplinary work; in addition the DEI has over 80 PhD students working on energy related research. Specific research interests include geoenery, and related issues such as in-situ energy recovery from coal and gas, and carbon capture and storage. Energy storage within the grid and smart-grid management is also an area of interest, as is wind turbine development and condition monitoring (an important aspect of controlling wind supply), marine power, and bioenergy. Durham is one of the leaders of the UK's national programme of wind energy technologies (SUPERGEN Wind). Research into new superconductors for a fusion reactor (ITER, being built in France, with a scheduled completion of 2019) is also underway. Finally, photovoltaics is an area of strength in the DEI; the UK's national PV research program is led by Durham. Research at Durham focuses on thin-film CdTe-based structures and the development of sustainable alternatives for PV.

Ben Williams then discussed some of the Durham work on thin-film photovoltaics. Thin-film solar is potentially a cheaper, lighter alternative with more flexible alternatives for device structures and implementation. Many of the challenges associated with solar cell development were discussed. One issue, which is the physical structure of the cell, was explored in detail; the concept of creating a layer of absorber material with minimal thickness and sufficient optical absorption (i.e. with pathways allowing the passage of electrons in a more effective manner with minimal recombination) was discussed. The method being explored to facilitate this configuration is a relatively cheap, polycrystalline material which could replace more expensive, conventional techniques (used for example by Silicon). A new approach being explored by Ben is the used of quasi 1-dimensional nanowires in the absorber layer to reduce electron recombination losses in the structure. The cost of PV is dropping in alignment with a rapid uptake of this technology, with growth in the PV market progressing exponentially since 2000. Predictions are that thin-film PV will reach grid-parity across Europe in the next decade. Thin-film technologies may be a good compromise in terms of price; it is more efficient than some of the new, organic technologies, and much cheaper than some of the most efficient technologies being developed with multi-junction technologies. Energy payback times for thin film are a few months.

Andres Luque then took us in a different direction and talked about the Urban Transitions Project (see attached presentation). This project looks at waste management, transport, energy production, and so forth within the concept of climate change adaptation. Luque's work will focus on comparing large cities in middle-income nations, including Mumbai/Delhi in India and Mexico City in Mexico. There are many examples of reconfiguring urban infrastructure; these are seen around the world, and take a number of different forms. Cities in middle-income nations are rapidly changing, with increasing populations, changing consumption patterns, and growing needs for infrastructure. A number of ways of considering energy transitions were discussed. Future work will explore the different understandings of energy, technology, and urban infrastructure that are being generated through socio-technical innovation.

Katie Thompson then discussed work on biofuels at Durham University (see attached presentation). Biomass has been a key element of energy since the middle ages; this has been eclipsed by fossil energy in recent years but the development of new technologies could increase its profile in the world's energy supply. Biofuels development has been driven largely by policy, including national targets and the broad international framework provided by the Kyoto Protocol; however, many national targets have not been met (for example, the UK). A ten-week literature review or scoping study was carried out, and it was possible to highlight key drivers in the success/failure of the biofuel market. Biofuels are still seen as a fuel of the future, but significant challenges have been identified to moving forward. Future work will look at how new biofuel markets emerge, and link success/failure to underlying factors.

In the discussion that followed, issues such as material use in photovoltaic production were raised. It was pointed out that the concerns about heavy metals in solar panels have been exaggerated; there are more heavy metals used or generated in fossil-fuel use, or even in some other renewable energy technologies. Putting some materials (like cadmium) in a solar panel and then putting it on a roof for twenty years actually is storing and using the heavy metal in a safe, productive fashion. Lower-cost production techniques sometimes lead to impurities; thus some of the variation shown in results may be related to lower-cost approaches. Resources for actor-network theory work were raised in reference to Luque's work; different ways of thinking about energy transitions means that many different methodologies may be appropriate and could be applied. Finally, the breadth of industry/academic partnerships was commented on; management of intellectual property is clearly a challenge, and

Durham has handled that by appointing a director for the DEI and using in-house expertise in IP management.

8 - Dartmouth College

Anne Kapuscinski began the discussion with a description of Dartmouth College (see attached presentation). Dartmouth is a small school (4100 undergraduates) with an emphasis on undergraduate education, with a medical school, engineering school, and business school. The focus for the College, in terms of future development, is global health and sustainability. An emerging phenomenon in the USA is that higher-education institutions are becoming 'living laboratories' to help demonstrate and implement new solutions, such as renewable energy. Universities and colleges tend to be the biggest purchasers of green energy, and leaders in installing new facilities such as wind, biomass, or other forms of power. Additionally, the higher-education institutions have begun to form associations, some of which are focused on sustainability; an example of the latter is AASHE, the Association for the Advancement of Sustainability in Higher Education, which holds an annual conference which keeps the conversation going and also keeps pressure on its members. Staff, faculty, and students are all engaged in AASHE. Dartmouth has developed several interesting, interdisciplinary programs, including a sustainability minor which was created with input from a wide range of stakeholders within and outside the College; these programs are being organized in interested ways with a combination of core courses, 'clusters' that bring together key concepts and skills, and application courses which bring expertise to bear.

Stephen Shadford then gave a talk on the campus as a living laboratory. As Energy Program Manager, Shadford represents an important stakeholder group within the institutions - staff - and describes the role that this group can play in introducing sustainability and renewable energy to campus life. Dartmouth has about 185 buildings on the main campus and in satellite locations, and the campus dwarfs the town of Hanover itself. An organic farm exists about 4 km away from the campus itself. The College also controls a 27,000 acre forest area in the north of New Hampshire. Like many campuses, the primary source of energy is oil-powered steam from a central steam plant; about 1/3 of electricity is generated on campus, and the rest is purchased. The College has pledged a 30% reduction in greenhouse gas emissions by 2030; on the current path predicted by the College, this can be achieved, but the remaining emissions are associated with oil combustion. Many different renewable energy options have been explored to meet this need, including biomass, solar energy, off-site wind, and waste oils. There has been a \$12.5 million commitment to the energy projects on campus, and the development of a sustainability focus has expanded to consider buildings, energy generation, energy use, and monitoring. Monitoring technology, which can visualize energy use, can be a powerful tool in changing behaviours; GREENLite Dartmouth is an example of this. There has been much growth in relationships between facilities and academics at Dartmouth and this partnership has been positive in developing a path forward towards renewable energy.

Karolina Kawiaka discussed some of the classes that link sustainability and design. This is a bottom-up, grassroots approach which uses real projects and an interdisciplinary approach in teaching students how to deal with real world problems. The 2010 imperative was focused on achieving a carbon-neutral design school campus by implementing sustainable design strategies, generating on-site renewable power, and purchasing green renewable energy. Dartmouth is the third highest emitter in New Hampshire; there is lots of room for improvement, as noted in the previous talk; it has very high per-capita emissions, as much as three times higher than peer institutions in the region. Class projects across the different courses taught have dealt with big problems, including questions such as achieving 100% clean energy by 2050.

Joe Indvik discussed participatory sustainability education in more depth. This type of educational model is iterative; experiences can lead into introspection and participation, which in turn reinforces college experiences; this allows the school to act as a living laboratory for systems thinking and policy development. The project that Indvik took part in was reducing reliance upon carbon-intensive fuels. This involved a systematic rethink of priorities, behaviour, and infrastructure. One idea put forward was rethinking the concept of the Dartmouth Revolving Green Fund; the concern was that students would be cut out of this process, and so a second body of money (the communities fund) was created which would encourage student/community participation. (The fact that Harvard has a large and very successful Revolving Green Fund was an effective tool in communicating with alumni.) The financial argument for the revolving fund is that \$900,000 could lead to \$2.5 million in projects within four years.

Charlie Sullivan discussed research themes within the engineering school related to sustainability and energy. Specialty courses in the graduate energy curricula include two cross-cutting courses, which look at energy conservation and energy utilization. Both courses emphasize the fundamental limits on energy systems. Research areas include biofuels, power electronics for efficient energy utilization, advanced optoelectronic materials for solar energy, and reduced impact geothermal electricity. A student-led group, Dartmouth Humanitarian Engineering, has led projects such as a pico-hydro system built using materials obtained locally (in Rwanda).

Finally, Anne Kapuscinski discussed some integrated food-energy system research that is underway at Dartmouth. Combining new innovations in renewable energy with sustainable food production could lead to many new opportunities. For example, outputs from one system might be inputs to another; when this is organized in a circular fashion, the benefits can be significant. A combination of landfill gas recovery, heat and electricity production, and heat recovery for algae generation, which can then go into animal feeds as well as new energy forms, provides an example of this.

In the discussion that followed, there were questions about the Revolving Green Fund and the way in which it is being initiated; other campuses have similar goals, and similar challenges in getting initial capital investments. There was also a comment that 'living lab' sounds small, and perhaps 'living campus' would sound better. Student engagement over time, and how they get feedback for participating in different initiatives, is perhaps an area that could receive some attention; it's hoped that students will see their contribution in the developments on campus. Finally, there was a comment that the GREENLite interface is a very useful pedagogical approach to getting youth engaged in the discussion and made as part of the solution. Two useful linkages are:

- [http://media.dartmouth.edu/~screencasts/john_k_lawlor_iii/GreenLite_Final_-_Web_\(800x600\)_-20101104_08.09.11PM.html](http://media.dartmouth.edu/~screencasts/john_k_lawlor_iii/GreenLite_Final_-_Web_(800x600)_-20101104_08.09.11PM.html)
- <http://kan.greenlite.cs.dartmouth.edu/portal/>

9 - Queen's University

Andrew Pollard provided an overview of Queen's University. The university has about 22,000 students, seven faculties and about 60 departments and schools. One fairly unique aspect of the university, within the Canadian scene, is the presence of a technology transfer unit called PARTEQ, one of the most successful of such units in North America. The student body at Queen's is highly engaged and active, both on-campus and off. Supporting the theme of Energy and Society, Queen's has a campus called 'Innovation Park', which houses about twenty organizations, including ELORIN (the Eastern Lake Ontario Regional Innovation Network), KEDCO (the Kingston Economic Development Corporation), SWITCH (see Ted Hsu's talk in section 2), and IRAP (the Industrial-Research Assistance Program). The High-Performance Computing Virtual Laboratory is also based at Innovation Park. Queen's is home to the Green Centre Canada, which is a Centre of Excellence for Commercialization devoted to implementation of green chemistry innovations. Solar research has led to at least one solar-thermal spin-off. A number of groups focused on renewable energy are present at Queen's, most of which are listed in Appendix D. At the University, the 'Living Laboratory' or live (instrumented) building at Beamish-Munro Hall is an example of a unique pedagogical tool.

The concept of using biomass and bioenergy product chains in the Great Lakes region was then discussed. The need for multiple pathways, technologies, and timelines was considered. In Ontario, the use of energy is monitored in a few ways; electricity is the mandate of Ontario's Independent Electricity System Operator (IESO). Ontario's mix is dominated by nuclear, but the role of renewables is rising. On the side of transport energy, <http://www.volvo.com> has a report that looks at different fuel types in reference to their ability to meet climate-related goals. The winner in this study was dimethyl ether.

The Sustainable Bioeconomy Centre was also introduced. It is a collaborative effort, launched at Queen's, which brings together expertise across a wide range of disciplines in order to address the challenges of developing the bioeconomy. SBC participates in a number of initiatives, including teaching initiatives such as TEAM, which is technology, engineering, and management - projects that bring together undergraduate students to come up with interdisciplinary solutions to difficult problems. Projects underway at SBC include an analysis of substituting biomass for coal, and densification of biomass to facilitate shipping and handling of material.

Brant Peppley then provided a talk on fuel cell research at Queen's, but in the context of broader renewable energy use. The Queen's-RMC (Royal Military College) Fuel Cell Research Centre (FCRC) is the largest university-based research and development group focused on fuel cell technology. The FCRC is supported by eight private-sector partners, and encompasses eight universities with 17 fuel cell researchers. The latest iteration of the research plan is a proposal to develop energy storage technologies, combining fuel cells with other renewable energy technologies. Fuel cell vehicles are available, but fuelling stations are not yet widespread (only available in Southern California), and several major manufacturers (GM, Toyota, Honda) are promising vehicles by 2015. Unfortunately the cars remain very expensive, and are only slowly becoming adopted.

Fuel cells have one big advantage over batteries, in that they can work in the cold, where batteries lose power. There is accordingly more and more interest in developing electricity storage technology based on fuel cell technology. An example of this type of technology is the 'BloomBox' - a commercial application, which costs about \$7-8K per kW installed (not far from the values provided via policy initiatives for other renewables here in Canada). Because most renewables do not provide dispatchable electricity, the addition of fuel cell technology into a renewable-powered grid could provide stability and dispatchability which is likely going to be required.

Research at Queen's has focused on porous material analysis; porous materials are the required element to create a fuel cell. Traditional materials (e.g., platinum) are very expensive; carbon paper technologies are much cheaper and can potentially lower fuel-cell costs significantly. A solid-oxide fuel-cell test system, using biogas, is currently in place at the Ravensview waste water treatment plant just east of Kingston. New ideas include the concept of thermally regenerative fuel cells, which make electricity by scavenging waste heat and which could run on stored solar thermal energy. To learn more, you may wish to attend the hydrogen + fuel cells conference in Vancouver - www.hfc2011.com.

Jane Webster examined information technologies and systems to support a shift to green economies, which is documented at <https://sites.google.com/site/greenitresearchqueens/>. From a North American perspective, business schools have introduced sustainability via mechanisms such as Corporate Social Responsibility certificates, or via specializations (e.g., the Sustainability MBA). At Queen's, capacity is found in the Centre for Responsible Leadership (formerly the CSR Centre) and the Monieson Centre, which is focused on knowledge management. Sustainability research, from a business perspective at Queen's, does seem to be diffuse. A big issue is 'greenwashing'; much change is not transformative, and basically is just taking advantage of low-hanging fruit.

Business schools tend to focus on studying changes that are occurring, not effecting change; there tends to be less knowledge development and more focus on management of knowledge generated elsewhere. Several good texts which are making their way into curricula were introduced and are included in the attached presentation.

An emerging area of interest is green information technology/information systems. The use of IT is growing twice as fast as the gross world product, and is quickly surpassing air transport. Green IT could reduce global emissions by 15%. Examples of projects might be removing dead applications and databases; there is also a push towards low-carbon internet services, in Canada and elsewhere.

Warren Mabee discussed the potential for developing renewable energy at the regional scale, using bioenergy as an example. A brief discussion of Canada's policy landscape illustrates the rather fragmented approach that is being taken between Federal and Provincial counterparts. The potential for bioenergy in different forms, servicing heat, electricity, and transport fuels, was then discussed. The results illustrate the various challenges with implementing renewable energy at the very local scale; there are widely different capacities from location to location, even within a small geographic region, and there is also a strong prospect that larger urban centres (such as Ottawa) would draw upon the surrounding region, creating 'energy suburbs'. Finally, Mabee presented a brief overview of the International Energy Agency, and proposed that this structure could be used within the Matariki Network to organize and facilitate the MNU.

10 - General discussion

In the general discussion, there was some discussion about the life cycle impacts and efficiency of using biomass for energy. There were comments about the efficiency of different harvest systems, and the impact of higher mechanization on fuel demand. This has some to believe that there is a strong relationship between fuel cost and food cost, and the 'food vs. fuel' debate may have more to do with high fossil prices than high demand for biofuel feedstocks.

There were also questions about the interaction between different stakeholder groups; how can we unpack the debate between, for instance, environment and economy? Coming up with common language and a basis for dialogue is essential.

Key outcomes and ideas for future action:

1. **Summary:** The summary of the meeting (this document) will be distributed, and made available via the website (www.matarikinetwork.com). Any photos or other material that people want to include are welcome.

Queen's to take responsibility

2. **Communication mechanisms:** in order to facilitate further discussion, we suggest that a few mechanisms be explored, including the idea of a listserv, a LinkedIn group, a blog or wiki (any or all of the above). Coordination opportunities:
 - a. **Existing/future links:** It would be helpful to cross-reference individuals and their websites; this would be a useful resource for teaching, research, and other collaborative opportunities. It would also be useful to add new resources - the LinkedIn group might be the way to do this.
 - b. **Sustainability coordination:** Most campuses have a sustainability coordinator; it is suggested that we might be able to link these people together for collaboration and sharing ideas and good practices.
 - c. **Facilities coordination:** This is a different group than (b) above, but should be linked as above.
 - d. **Student group coordination:** We suggest that student groups from different campuses might link together and perhaps find common themes for future work.
 - e. **SWITCH model:** The SWITCH model seemed to be of interest to many groups. We would be happy to facilitate some dialogue, to help build capacity in other locations across the MNU.
 - f. **Municipalities:** Kingston's KEDCO and similar entities at MNU home communities may find utility in communication/coordination.

Queen's-Otago to coordinate, at least at first stages

3. **Research collaborations:** Joint proposals for funding, research collaboration, and opportunities for cross-border work. A major goal is likely to raise new research money; funding that might be provided by the MNU members would be seed money, not ongoing funding. It might be most realistic to look for bi- or tri-lateral collaboration opportunities instead of trying to get the entire Network going forward in one direction. Potential outputs:
 - a. **Journal special issue:** It has been proposed that there might be enough interest to generate papers to populate a special issue of a journal, likely based on one of the themes identified in point 2 above. Specific journal and theme to be discussed. It would require strategic thinking; there have been special issues that have focused on similar areas.
University of Western Australia to coordinate
 - b. **Common themes:** There is common ground on energy conservation, particularly on campuses; perhaps this is a place where a multi-lateral group or application could be created. There is also an interest in high-performance computing and the linkages to renewable energy use/production (Dartmouth has an alum at the Rocky Mountain Institute who might be interested). Finally, there is interest in looking at how to get individuals to change their behavior.

4. **Teaching collaborations:** Joint programming, courses, and offerings; student delegations and exchanges (ranging from undergraduate to PhD; could be organized, or ad hoc). The availability of different courses within a Master's program (for example) across the MNU, based on the Erasmus program in Europe, might allow a structured exchange program that would give Master's students access to all expertise across the MNU. Web-based teaching might also be useful and effective. Potential outputs:

- a. **Best practices:** It might be easiest to start with sharing of best practices or components of curricula development. One thing that might work is that as we develop new curricula, the MNU could become a resource whereby guest lectures could be organized and delivered. There is also a proposal for a summer school for graduate students; this could be expensive, but industry funding might subsidize costs.
5. **New members/future meetings:** Is it possible to introduce new members, and what will be the themes of future meetings? There has been some discussion about building the MNU to possibly 12 members in the future.
 - a. **Meeting theme(s):** It would be helpful to bring together some or all of this group to deal with these issues; it is being suggested that the next topic might overlap in some way with what has been done here, or that the Matariki meetings might branch to cover different themes. It would also be helpful if all people who attended this meeting are kept abreast of Matariki Network activities. For the next meeting, it would be useful to do more homework and perhaps to have a more focused meeting - this should be discussed at the next VCs' meeting in February, 2011. It might be good to look at a plenary/group discussion model for future meetings. It is also useful to link students or young researchers, and perhaps future meetings should focus on this.
 - b. **Meeting structure:** Specialized conferences can give you the technicalities; this Matariki meeting brought people together from different silos and different backgrounds, which can be a helpful thing. This approach was endorsed by some of the attendees for this year's meeting. It would be useful to look at different models such as greater emphasis on discussion periods – roundtables and break-outs with report backswere suggested. The length of the meeting might be extended.

Wrap-up

John Dixon thanked his colleagues on the organizing committee - Andrew Pollard, Joshua Pearce, Warren Mabee and Sally Rigden. The event coordinator was Lisa Doulas, assisted by Lauren Hanlon who was with us throughout the program. Thanks to Kadra Branker for organizing the supplementary program. The group thanks Queen's Institute for Energy and Environmental Policy, the Sustainable Bioeconomy Centre, KEDCO, and Queen's Principal's Office and Office of the Vice-Provost (International) for financial support of the Workshop. We thank Sean Conway, Steven Liss, and Ted Hsu for contributing their time to the key-note session. Finally, thanks to all of the delegates from the MNU institutions for their enthusiastic participation and many wonderful contributions, and to their host institutions for supporting their participation.

John Dixon called the meeting to a close at 4:10 pm.

Appendix A - Participant list

Name	Organization	Title	Email
Indvik, Joe	Dartmouth	Alumnus	joe.indvik@gmail.com
Kapuscinski, Anne	Dartmouth	Professor	anne.kapuscinski@dartmouth.edu
Kawiaka, Karol	Dartmouth	Senior Lecturer	karolina.kawiaka@dartmouth.edu
Shadford, Steve	Dartmouth	Energy Engineer	steve.shadford@dartmouth.edu
Wachter, Jonathan	Dartmouth	Post-graduate	jonathan.m.wachter@gmail.com
Sullivan, Charlie	Dartmouth/Thayer	Associate Professor	Charles.Sullivan@Dartmouth.EDU
Halliday, Douglas	Durham	Senior Lecturer	d.p.halliday@durham.ac.uk
Luque, Andres	Durham	Doctoral Student	a.e.luque@durham.ac.uk
Williams, Ben	Durham	Postgraduate Student	b.l.williams@durham.ac.uk
Thompson, Katie Marie	Durham	PhD Student	k.m.thompson@durham.ac.uk
Branker, Kadra	Queen's	Graduate Student	brankerk@me.queensu.ca
Andrews, Rob	Queen's	Graduate Student	andrewsr@me.queensu.ca
McLaughlin, Dirk	Queen's	Master's Student	5dvpm@queensu.ca
Conway, Sean	Queen's	Fellow, School of Policy Studies	sean.conway@queensu.ca
Peppley, Brant	Queen's	Professor	brant.peppley@queensu.ca
Webster, Jane	Queen's	Professor	jwebster@queensu.ca
Mabee, Warren	Queen's	Assistant Professor	warren.mabee@queensu.ca
Pollard, Andrew	Queen's	Professor	andrew.pollard@queensu.ca
Dixon, John	Queen's	Associate Vice-Principal	john.dixon@queensu.ca
Rigden, Sally	Queen's	Special Assistant (External Relations)	sally.rigden@queensu.ca
Liss, Steven	Queen's	Vice-Principal (Research)	steven.liss@queensu.ca
Hardjo, Eric	Queen's	Master's Student	eric.hardjo@queensu.ca
Hsu, Ted	SWITCH	Executive Director	ted@hsu.org
Carrington, Cedric	Otago	Emeritus Professor	gerry@physics.otago.ac.nz
Lawson, Rob	Otago	Head of Department	rob.lawson@otago.ac.nz
Jenner, Steffen	Tübingen	PhD Candidate	Steffen.Jenner@uni-tuebingen.de
Diederich, Hauke	Tübingen		H.Diederich@gmail.com
Fischer, Susanne	Tübingen	Master's student	s.fischer@uni-tuebingen.de
Weimar, Udo	Tübingen	Professor	upw@ipc.uni-tuebingen.de
Heine, Thomas	Tübingen	PhD student	thomas.heine@ipc.uni-tuebingen.de
Chua, Hui Tong	Western Australia	Professor	huitong.chua@uwa.edu.au
Owens, Robyn	Western Australia	Deputy Vice-Chancellor Research	robyn.owens@uwa.edu.au
Smith, Steven	Western Australia	Professor	steven.smith@uwa.edu.au
Tonts, Matthew	Western Australia	Head, Earth & Environment	matthew.tonts@uwa.edu.au
Edstrom, Kristina	Uppsala	Professor	kristina.edstrom@mkem.uu.se
Lindahl, Marcus	Uppsala	Associate Professor	marcus.lindahl@angstrom.uu.se
Magnusson, Ann	Uppsala	Associate Professor	ann.magnuson@fotomol.uu.se
Nordgren, Joseph	Uppsala	Vice Rector & Professor	joseph.nordgren@fysik.uu.se
Tyrberg, Simon	Uppsala	PhD. Student	simon.tyrberg@angstrom.uu.se
Unger, Eva	Uppsala	PhD. Student	eva.unger@fki.uu.se
Waters, Rafael	Uppsala	Associate Professor	rafael.waters@angstrom.uu.se

Appendix B - Agenda, Nov 5-7

Friday, November 5 th	
2PM - 6PM - Dunning Hall, Room 11	
1 - Introductions	
14:00	Welcome from Queen's University
14:10	Round-table introduction of delegates (<i>10 minutes per institution</i>)
15:30	<i>Coffee Break</i>
2 – Some Canadian Perspectives on Renewable Energy & Society	
Chair: John Dixon, Vice-Provost (International), Queen's University	
16:00	Sean Conway, Fellow, School of Policy Studies, Queen's University: <i>Government Perspectives</i>
16:20	Steven N. Liss, Vice-Principal (Research), Queen's University: <i>Research Funding Environment</i>
16:40	Ted Hsu, Executive Director, SWITCH: <i>Community Initiatives</i>
17:00	Moderated Discussion
<i>Walk to Ban Righ Hall (SW corner of University Ave and Bader Lane)</i>	
18:00	Principal's Reception, Ban Righ Hall, Fireside Room <i>A cocktail reception featuring student scientific poster presentations on renewable energy research</i>
20:00	<i>Evening on your own</i>
Saturday, November 6 th	
8:30AM - 5:45PM - Dunning Hall, Room 11	
3 – University of Western Australia	
08:30	Institutional presentations (<i>Owens, Tonts, Chua, Smith</i>), discussion
10:00	<i>Coffee Break</i>
4 – Eberhard Karls University of Tübingen, Germany	
10:30	Institutional presentations (<i>Weimer, Fischer, Diederich, Jenner</i>), discussion
12:00	<i>Lunch</i>
5 – Otago University, New Zealand	
14:00	Institutional presentations (<i>Carrington, Lawson</i>), discussion
15:30	<i>Coffee Break</i>
6 – Uppsala University, Sweden	
16:00	Institutional presentations (<i>Nordgren, Magnusson, Tyberg, Lindahl</i>), discussion
17:45	<i>Buses take delegates to Fort Henry</i>
18:00	City of Kingston Reception at Fort Henry <i>A cocktail reception at Fort Henry, a 19th-Century British military fort and one of Canada's premiere historic attractions. Sponsored by the City of Kingston</i>
20:00	<i>Buses depart from Fort Henry and drop delegates in one of two locations: Downtown, Market Square (near many restaurants) or Queen's Campus.</i>
Sunday, November 7 th	
8:30AM - 4:00PM - Dunning Hall, Room 11	
7 – Durham University, United Kingdom	
08:30	Institutional presentations (<i>Halliday, Williams, Luque, Thompson</i>), discussion
10:00	<i>Coffee Break</i>
8 – Dartmouth College, United States	
10:30	Institutional presentations (<i>Kapuscinski, Shadford, Kawiaka, Indvik, Sullivan</i>), discussion
12:00	<i>Lunch</i>
9 – Queen's University, Canada	
13:00	Institutional presentations (<i>Pollard, Peppley, Webster, Mabee</i>), discussion
10 - Wrap-Up	
15:00	Wrap-up discussion & next steps
15:45	Session Close
16:00	<i>Meeting Adjourned</i>

Appendix C - Extended agenda, Nov 8-10

Monday, November 8th			
10:00	ePOWER: Queen's Center for Power and Power Electronics Research (<i>Walter Light Hall</i>)	Djilali Hamza [Dr. Praveen Jain]: 613-533-6416, djilali.hamza@queensu.ca	From power transmission to alternative energy (including fuel cells, solar power and wind power) to power consumption
10:45	Environmental Studies & SGPS Sustainability (BioSciences Atrium)	Ivana Zelenika: ivana.zelenika@gmail.com	Learn about campus initiatives and Env. Studies research
11:15	<i>Lunch Break** (3 food locations near the BioSciences Complex)</i>		
12:00	CMAS 897: Applied Sustainability Seminar (445 Sutherland Hall)	Dr. Warren Mabee: warren.mabee@queensu.ca	Meet engineering students in the new CMAS Applied Sustainability program in the School of Policy Studies.
13:30	Centre for Responsible Leadership (Goodes Hall 243)	Jacqueline Corbett [Dr. J. Webster]: jcorbett@business.queensu.ca	Green IT/S and Corporate Social Responsibility
14:40	<i>Break** (Small Snack bar in Goodes Hall on 3rd Floor)</i>		
15:00	Queen's Applied Sustainability Group (Basement, Nicol Hall)	Robert Andrews [Dr. J.M. Pearce]: andrewsr@me.queensu.ca	Solar PV material research/energy policy & economics
16:00	Queen's Solar Calorimetry Laboratory (4 th Floor McLaughlin)	Michael Pathak [Dr. S. Harrison]: michael.pathak@gmail.com	Solar PV & Thermal Research
17:00	<i>Dinner**</i>		
19:00	"The Great Climate Debate: What does the science say? How should Canada respond?" (Theological Hall) (FREE - 2 hrs) Contact: Megan Hamilton, megan.hamilton@queensu.ca . Debaters will be: Larry Solomon of the National Post and Energy Probe, one of Canada's highest profile climate change "skeptics" and author of "The Deniers", a national best-seller; Queen's Professor John Smol (Biology), one of Canada's leading climate change scientists; Matthew Bramley of the Pembina Institute, one of Canada's most active climate change advocates and activists; and Bruce Pardy, Queen's Law Professor and Environmental Law expert.		
Tuesday, November 9th			
9:30	Tour at Innovation Park via cab [http://www.innovationpark.ca/]; (Cabs leave campus at 9:30 am from <u>Robert Sutherland Building</u>); Visitor's Badge issued on Arrival at Reception. Contact Janice Golland via receptionist.		
	Queen's - RMC Fuel Cell Research Centre (FCRC)	Misha Monder, Dzmitry Malevich malevich@queensu.ca	Tour of lab and meet researchers
	Bio Fluids Research/ Novelis	Andrew Duncan [Dr. A. Pollard]; andrewduncan@me.queensu.ca	Sustainable Bioeconomy Center Fluids research
	Solar Panels / HPCVL/ Other labs	Reception/ Other students	Ask about Innov. Park itself.
11:15	Tour at St. Lawrence College via cab [http://energyhouse.ati.sl.on.ca/] (Cabs leave Innov. Park at 11:00 am)		
	Energy House & Wind Turbine Facility	Brenda Vandermeer, Shannon Clagget: 613-544-5400-1183	Part of the Energy Systems Engineering Technician Technologist Program
12:30	<i>Lunch Break**</i>		
	<i>Free Afternoon - Make your own informal meetings or explore Queen's University and Kingston</i>		
	<i>6 am – 6 pm: Kingston Farmer's Market at the Market Square by City Hall</i>		
19:00	2010 Royal Bank of Canada Lecture: "A New Perspective on the Environment: Earth Without Humans" presented by ALAN WEISMAN (http://www.worldwithoutus.com/index2.html) (Duncan McArthur Hall, 511 Union St) (FREE)		
Wednesday, November 10 th			
	Free Morning - Make your own informal meetings or explore Queen's University and Kingston		
12:00	"Energy Alternatives" Room 302, Goodes Hall (FREE - 1 hr) As society looks to alternatives to fossil fuels, an expanding market is looking for effective methods to create and distribute new sources of power. Presented by: Mr. Brian Burt, Burt's Greenhouses; Dr. Dave Mody, Chemical Engineering, Queen's University; Dr. Andrew Pollard, Director, Sustainable Bioeconomy Centre, Queen's University, Mr. Steve Sottile Utilities Kingston / Board Member SWITCH, and Dr. Matt Thompson, Queen's School of Business, Queen's University. RSVP by Nov. 5th: monieson@business.queensu.ca or 613.533.3088		

**All meals for the extended workshop are to be organized on your own. There are various food outlets on campus.

Appendix D - List of Groups at Queen's University and in Kingston

Queen's University Institute for Energy and Environmental Policy (QIEEP): QIEEP is part of Queen's School of Policy Studies. By encouraging and capitalizing on multi-disciplinary research surrounding present and future energy needs, QIEEP's mission "is to generate pragmatic advice on energy and environmental policy that is relevant to the public and to governments at all levels." Visit the Institute's website for a list of related publications, presentations, and events. <http://www.queensu.ca/sps/QIEEP/>

The Sustainable Bioeconomy Centre (SBC) at Queen's University: The SBC at Queen's University focuses on bioenergy and other biomass opportunities within the Great Lakes region. The SBC vision is to build a coordinated and inclusive community, where stakeholders actively participate in the development of sustainable environmental, economic and ethical uses for biological resources. <http://www.queensu.ca/sbc/>

Queen's University Solar Calorimetry Lab: The Lab researches new sustainable energy technologies with a primary focus on solar energy applications. <http://me.queensu.ca/people/harrison/research/solar/>

Queen's-RMC Fuel Cell Research Centre: Canada's leading university-based research and development organization in partnership with industry dedicated to advancing the knowledge base for addressing the key technology challenges to the adoption of fuel cell applications. <http://www.frc.ca/>

Applied Sustainability Research Group at Queen's University: This research group focuses on applied sustainability, which is the application of science and innovation to ensure a better quality of life for all, now and into the future, in a just and equitable manner, whilst living within the limits of supporting ecosystems. <http://me.queensu.ca/sustainability/index.php>

The Queen's Centre for Energy and Power Electronics Research (ePOWER): ePOWER fosters collaboration among academic and industrial researchers to advance fundamental energy and power electronics research, to develop a broad range of commercially competitive and environmentally friendly technologies, and to train the next generation of innovators. <http://www.queensu.ca/epower/>

The Tea Room: The Tea Room, located in Beamish Munro Hall, is a student-operated business initiative on Queen's University campus where drinks, pastries, soups, and sandwiches are served up within the framework of an environmentally sustainable concept. Employment and volunteer opportunities are available. (<http://engsoc.queensu.ca/tearoom/main.html>)

Energy House: Energy House functions both as an integral part of the Environmental Technician's Program at St. Lawrence and as education centre for alternative energy for the local public school board. Energy House is also the focal point around which the environmental festival GreenUP! has revolved since 2006. <http://energyhouse.ati.sl.on.ca/>

Kingston Sustainability Centre: The KSC is a youth led, not-for-profit community education centre where Kingstonians can learn, teach and ask about solutions, processes & actions that inspire them to join the journey to achieve the city's vision of "Becoming Canada's Most Sustainable City". <http://www.kingstonsustainabilitycentre.com/index.html>.

SWITCH Kingston: SWITCH is a network of businesses, research and educational institutions, public sector participants, and community-minded volunteers working together with a common mission: to position the Kingston region as a leading centre for sustainable energy. <http://www.switchkingston.ca/>
See more at <http://www.queensu.ca/ensc/community/queens.html>