A global network enabling capacity-building for sustainable energy in developing countries

by Jennifer MacLeod

Access to energy is a fundamental component of poverty abatement. People who live in homes without electricity are often dependent on dirty, time-consuming and disproportionately expensive solid fuel sources for heating and cooking. [1] In developing countries, the Human Development Index (HDI), which comprises measures of standard of living, longevity and educational attainment, increases rapidly with per capita electricity use. [2] For these reasons the United Nations has been making a concerted effort to promote global access to energy, first by naming 2012 the Year of Sustainable Energy for All, [3] and now by declaring 2014-2024 the Decade of Sustainable Energy for All. [4]

There are important challenges in developing and disseminating new technologies for use in the developing world: the technologies must be relevant and adapted to the particular needs of a specific population, and there must be a local network of trained individuals who can deploy and maintain the technologies. These are the challenges that inspired Federico Rosei, the Director of the Énergie, Matériaux et Télécommunications Centre of the Institut National de la Recherche Scientifique (INRS-EMT), to propose the establishment of a United Nations Educational, Scientific and Cultural Organization (UNESCO) Chair in Materials and Technologies for Energy Conversion, Saving and Storage (MATECSS) at INRS-EMT. The UNESCO Chairs program was established in 1992 as a means to promote knowledge sharing, and to advance research and training, through the formation of a global network of academics. The UNESCO Chair MATECSS, which was officially launched in April of 2014 with Prof. Rosei as its inaugural Chairholder, now counts itself among the more than 650 UNESCO Chairs worldwide. [5]

Prof. Federico Rosei (left) with Nobel Laureate John Polanyi at the launch of the UNESCO Chair MATECSS. Prof. Polanyi delivered the launch's plenary address, "How Discoveries are Made and Why it Matters." *Photo: Denis Bernier.*

The UNESCO Chair MATECSS comprises an expanding network of researchers at institutions around the world. In addition to a central core of eleven professors located at INRS-EMT, the Chair currently includes two researchers at institutions in the USA and has also partnered with U2ACN2, the UNESCO UNISA Africa Chair in Nanosciences & Nanotechnology, as well as with Institut Supérieur des Hautes Études en Développement Durable (Morocco), Centro de Investigación y Desarrollo Tecnológico en Electroquímica (CIDETEQ, Mexico), Université d'Abomey-Calavi (Republic of Benin), and Veer Surendra Sai University of Technology (India). MATECSS also has informal partnerships with institutions in Algeria, China, Costa Rica, India, Mexico, Morocco, Nigeria, South Africa, and Vietnam.

The MATECSS program operates through two basic approaches: knowledge sharing and capacity building. Under the MATECSS program, knowledge sharing results from establishing connections between researchers. These connections are promoted through workshops (see accompanying article about the 1st MATECSS Workshop), visiting professorships, and the establishment of informal collaborative links between professors working on complementary research programs. Capacity building is based on expanding the training opportunities for students from target regions, including through a PhD scholarship program known as the MATECSS Excellence Scholarship program. These PhD students are selected annually based on their potential for research and motivation to transfer knowledge between the Global North and South.

Materials for emerging energy technologies: knowledge sharing

The successful expansion of the global capacity for renewable energy will depend on advances from a number of technical fields, with a particular onus on engineering disciplines that can successfully implement large-scale installations of established technologies, such as wind turbines and polycrystalline

silicon-based solar photovoltaics. The contribution of materials experts will be to further develop and improve a number of emerging technologies in conversion (including photovoltaics, fuel cells and novel capture devices like thermoelectrics and piezoelectrics), savings (solid state lighting) and storage (including batteries and capacitive energy storage.) MATECSS participants span a number of these areas with expertise rooted in chemistry, physics and materials science.

Knowledge sharing through MATECSS has already begun. In addition to the 1st MATECSS Workshop, dedicated scientific sessions were held at the 7th International Conference of the Africa Materials Research Society (Africa MRS) in Addis Ababa, Ethiopia, in December 2013 and at EMN East, the Energy Materials Nanotechnology conference in Beijing, China, in May 2014. In June of 2014 Prof. Rosei chaired a session at the 3rd UNESCO Conference on Technologies for Development (Tech4Dev) in Lausanne, Switzerland. Tech4Dev is a multidisciplinary conference that brings together stakeholders spanning research disciplines, the public and private sectors and non-governmental organizations. Prof. Rosei's session, Catalyzing Innovation through Targeted Scientific Training and Capacity Building, examined the essential elements for successful technology transfer through capacity building, including discussion of both the conceptual framework and a number of illustrative case studies.

MATECSS has also secured funding, in the form of an American Physical Society (APS) travel grant, to begin its Visiting Researcher program, which is set to commence in autumn 2014.

MATECSS capacity building

Training is an essential component of the MATECSS Chair program. Addressing global needs requires the development of local expertise, and MATECSS aims to contribute to building that local expertise. Our training programs aim to complement the local expertise of our partner institutes in developing countries, with the goal of contributing to the work currently being done and to the expansion of research capacity in coming years. This requires close collaboration with our international partners, as well as careful attention to their current and future research directions.

Addressing global needs requires the development of local expertise

The MATECSS Excellence Scholarship program is one example of this collaborative approach. Each Excellence Scholarship provides CAD$120,000 in funding over four years to fund PhD studies at INRS-EMT. Excellence Scholars must meet rigorous academic requirements, and must be from a low- or medium-income country. The Excellence Scholars are co-supervised by two MATECSS professors, and must also work closely with a researcher at an institution in his or her country of origin. This multilateral approach is meant to promote international collaboration while prioritizing research interests and goals relevant to the Excellence Scholars' home countries. The MATECSS Excellence Scholarship program is partially supported through philanthropic donations. Instructions on how to donate are available at www.matecss.org.

Starting in autumn of 2014, MATECSS began facilitating the delivery of a short course on materials for energy technologies. This course is designed as a

Yufeng Zhou (China) and Nathaneal Komba (Tanzania) are recipients of the 2014 MATECSS Excellence Scholarships.

primer for students, researchers and professors who are trained in chemistry, physics or materials science, but who may not be working specifically on energy-related phenomena. The underlying motivation for this course is to catalyze interest in energy-related technologies, and to promote research in this field.

One interesting challenge for MATECSS lies in the evidence-based evaluation of its capacity building programs. Outcome-based program development will be difficult to implement in the short term due to the relatively long time required to measure the impact of PhD training programs. The process will be further complicated by the small number of trainees involved; this small population will be strongly influenced by individual outcomes. However, we hope to gain insight that will guide the continued growth and development of this capacity building process through thorough exit surveys and continued communication with trainees.

MATECSS in context: joining the ranks of a number of excellent organizations

MATECSS joins a number of institutions and organizations around the world that are working toward similar goals. The materials science focus of MATECSS overlaps strongly with expertise being developed at the Abdus Salam International Centre for Theoretical Physics (ICTP, www.ictp.it) in Trieste, Italy, a UNESCO-funded research center that provides world-class training and support for theoretical physicists from the developing world. In addition, MATECSS has received support from the International Organization for Chemical Sciences in Development (IOCD, www.iocd.org) for the development of didactic materials for its short course. MATECSS also draws on the models set forth by the African Institute for Mathematical Sciences (www.aims.ac.za), the Next Einstein Initiative (www.nexteinstein.org), and the Perimeter Institute (www.perimeterinstitute.ca).

The 1st MATECSS Workshop: Sharing Ideas and Building Momentum

The 1st MATECSS Workshop was held on April 10-11, 2014, at the Queen Elizabeth Hotel in Montréal, Canada. Sandro Scandolo of the International Centre for Theoretical Physics (ICTP, www.ictp.it) opened his talk at the 1st MATECSS Workshop by pointing out that, although many resources are inequitably distributed on a global scale, ideas are plentiful wherever there are people. This concept was demonstrated over and over again throughout the workshop, which brought speakers from 12 different countries together for a two-day program that ranged from policy and perspectives to research presentations on cutting-edge energy technology.

MATECSS Chair Federico Rosei lead off the workshop's first session, a policy- and program-centered discussion that emphasized the importance of collaboration, as well as the need for the development of programs centered on technology deployment in the developing world. Representatives of two African countries were present to describe the energy situation and needs in their home countries: H.E. Constant Horace, the Madagascar Ambassador in Canada, and Emmanuel Muhawenimana, from the Rwanda Development Board. Both shared insightful insiders' views into the opportunities and needs in their home countries. The session continued with a discussion of case studies, emphasizing the importance of collaboration with local stakeholders to the development and integration of technologies in the developing world.

One of the key goals of the MATECSS workshop was to bring together individuals and organizations working in the broad arena of science and technology for development. The sessions of the first day included overviews of a number of key players: Light up the World (www.lutw.org), the Global Young Academy (www.globalyoungacademy.net), the Clean Energy Research Center at the University of British Columbia (cerc.ubc.ca), the International Organization for Chemical Sciences in Development (http://iocd.org), the Africa Materials Research Society (www.africamrs.co.za), and the Sustainable Nanotechnology Organization (www.susnano.org).

The scientific presentations covered a range of approaches to developing new materials for energy applications, starting with discussions of the power of computational work in systematically identifying and designing new materials systems (Paul Ndione, National Renewable Energy Laboratory, Golden, CO, and Sandro Sandolo, ICTP, Trieste, Italy). Experimental chemists also focused on systematic design and development, specifically within the realm of organic materials. Dmitrii Perepichka (McGill University, Montréal, Canada) discussed the design and synthesis of an organic semiconductor system with struc-

This fall marked the arrival of the first MATECSS Excellence Scholarship holders at INRS-EMT, and with them the official beginning of the MATECSS capacity building program. The sowing of seeds of collaboration has already begun through MATECSS workshops and sessions. Now the real work begins, as MATECSS researchers and trainees begin the process of sharing, learning and collaborating to promote the development of new materials and technologies for sustainable energy.

Follow our progress and find out how to join us at www.matecss.org.

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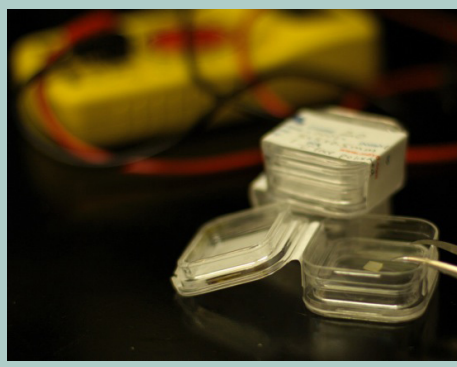
turally and stoichiometrically well-defined p- and n-type regions [H. Black and D. F. Perepichka, *Angew. Chem. Int. Ed.* 8, 2138 (2014)], and Christine Luscombe (University of Washington, Seattle) described a planned approach to the development of polymers for organic photovoltaics.

Inorganic materials relevant to a range of applications in energy conversion and storage figured prominently in the discussion. Riad Nechache (INRS-EMT) spoke about perovskites, which are emerging as one of the most promising materials for next-generation solar conversion technologies. Malik Maaza, the UNESCO UNISA Chair in Nanosciences and Nanotechnology (University of South Africa, Pretoria, South Africa), presented a number of opportunities in nanostructured single-oxides, and Mohamed Chaker (INRS) described plasma-synthesized nanostructured materials for applications in photoconversion devices. Bodh Rajh Mehta (Indian Institute of Technology, Delhi, India) detailed a remarkable infrastructure for nanoparticle synthesis that has been developed in his lab. Two speakers focused on water splitting: Zetain Mi (McGill University, Montréal, Canada) showed some impressive results on GaN nanowires for water splitting [M. G. Kibria, S. Zhao, F. A. Chowdhury, Q. Wang, H. P. T. Nguyen, M. L. Trudeau, H. Guo, and Z. Mi, *Nature Commun.* 5, 3825 (2014)], and Lionel Vayssieres (International Research Center for Renewable Energy, Xi'an Jioatong University, China) explained his low-cost approach to the synthesis of oxide heteronanostructured materials.

The final session, on fuel cells, was spirited, and included a number of illuminating debates about the most sustainable fuel sources and the chemistry involved in preparing materials. Many of the talks were materials-focused, but Luis Godínez Mora-Tovar (CIDETEQ, Mexico) also discussed some novel designs for microfluidic fuel cells with flow-mixing.

Montréal in April provided a rather chilly backdrop for the workshop, but the cold setting proved to be an excellent incubator for ideas. Participants eagerly shared their experiences and expertise, and new collaborations were forged. The next MATECSS Workshop, tentatively scheduled for Spring 2015, will build on the themes established at the 1st Workshop, and will explore the effects of a warmer workshop location.



The research focus of the UNESCO Chair MATECSS is on using novel material to enable new sustainable energy technologies.