SNEBRN Newsletter Issue 2 - December 2013

NSERC Smart Net-Zero Energy Buildings Strategic Research Network

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INSIDE THIS ISSUE:

Past the midpoint! By A. K. Athienitis, Scientific Director

The Network has just completed its Mid Term Report to NSERC and its partners. This extensive issue of the newsletter reports on some of the Network achievements and activities. Some of the key achievements and activities that demonstrate the national and international impact of the Network include:

1. The Network is training over 100 graduate students in its five Themes, many of whom have graduated and taken up positions in industry, universities (as Professors) or government laboratories. The midterm report includes an extensive list of publications from the projects, several of which received best paper awards. Team Ontario (Carleton, Queen's and Algonquin College) which included many Network students (and advisors – Cynthia Cruickshank and Steve Harrison) participated in the US DOE Solar Decathlon Competition and was awarded first place in the coveted Engineering category (see the story in this issue).

2. I had the privilege of presenting an invited lecture at the Canadian Parliament (PAGSE, co-sponsored by NSERC) on Sep. 27, 2012 – "Cities in the Sun: The Path Towards Smart Net-zero Energy Solar Buildings and Communities". It was attended by over 100 MPs, Senators and other decision makers. I also delivered several invited plenary/keynote talks on the work of the Network at national and international conferences, including eSim2012 (Halifax, Canadian Building Simulation Conference) and the International Solar Heating and Cooling Conference in San Francisco (July 2012).

3. Canada, through SNEBRN, played a key role in an international research collaboration on NZEBs. SBRN was instrumental in the formation of International Energy Agency SHC/EBC Task 40/Annex 52 "Towards Net-zero Energy Solar Buildings". The Network Manager Josef Ayoub is also the Operating Agent of the Task/Annex, while O'Brien (Carleton University) and I are subtask B co-leaders – focusing on modelling, design and optimization of NZEBs. The work of the Task stretched over 5 years with the first and last meetings hosted by SNEBRN in Montreal at Concordia University. The final work of the Task/Annex was presented on Oct. 7, 2013 while an international workshop was co-organized with SNEBRN on Oct 8, 2013, with nearly 100 participants from about 20 countries participating in Task 40, as well as several SNEBRN industry partners and HQP.

4. A key scientific and engineering achievement from the work of Network researchers in Task 40 is the completion of the research-oriented book "Modelling, Design, and Optimization of Net-Zero Energy Buildings" (estimated to be approximately 300 pages). It will be published by Wiley in the summer of 2014. The book includes fundamental sections on modeling and design as well as four detailed and well documented

Continued...

"Past the midpoint"...continued

case studies, one of which is EcoTerra. The contributions to chapter content were coordinated from the participants of Subtask B that was led by Canada (Sub-task co-leaders: Athienitis and O'Brien). The broad mix of technologies required to efficiently design a comfortable NZEB – active and passive technologies and techniques - requires a more rigorous quantitative dynamic energy/thermal analysis than traditional buildings.

5. Cruickshank is SNEBRN's representative on the Technical Research Committee of the Canadian Home Builders Association (CHBA), transferring recommendations on how to apply the latest research on solar and energy efficiency technologies (by SNEBRN, for example) to facilitate the path towards net-zero energy housing. CHBA representatives have also participated at Network workshops and panel discussions (e.g. in Halifax) on how to move more efficiently towards our long-term goal and vision.

6. SNEBRN played a key role in the development of a Canadian Roadmap for Sustainable Housing, in which the NZEB concept was introduced as the key metric and energy performance goal.

7. Concordia hosted an NRCan "Roundtable on Energy Innovation: Energy Efficiency" on Dec. 4, 2013 and I provided input to the development of national policy and priorities with a focus on enhancing innovation in energy efficiency in Canada.

8. Bernier edited a special issue of the ASHRAE HVAC&R Journal on geothermal systems (2013).

9. O'Brien represented the Network in a high level meeting and workshop on net-zero energy buildings with the Chinese Academy of Building Research as part of a plan for longterm collaboration with the Network (Beijing, Nov. 2013).

10. I was a contributing author for the IPCC: Special Report on Renewable Energy Sources and Climate Change Mitigation - Intergovernmental Panel for Climate Change, 2011, "Chap. 3: Direct Solar Energy". Cambridge Univ. Press. The lead author for the Chapter is Terry Hollands, Board Chair of SNEBRN.

11. A Network delegation – Josef Ayoub, Alan Fung (Theme 5 co-leader) and Caroline Hachem (PDF) presented the work of the Network during a collaboration visit to the Australian Low Carbon Collaborative Research Centre led by Deo Prasad.

12. Fazio joined the Steering Committee of CCI (Canadian, Construction Innovations), whose objective is to identify research-supporting innovation. CCI is industry driven, with Board members mostly from industry. It has already received significant funding from industry, including the Canadian Construction Association.

Network Annual General Meetings

The first Annual General Meeting (AGM) of SNEBRN included a workshop for industry and stakeholders and was followed by Canada's building simulation conference eSim attended in total by about 200 participants in Halifax. The Canadian building simulation conference eSim 2012, organized by Lukas Swan, immediately followed the AGM. More than half of the papers at eSim 2012 were given by Network researchers and students and three of these received best paper awards.

The second AGM, held in May 2013 at Carleton University, Ottawa included a workshop for stakeholders and partners (including new potential partners) that was attended in total by about 150 researchers, students and partners. The third AGM will be held in Montreal May 4-6, 2014, directly followed by eSim 2014 in Ottawa with a strong Network presence. These AGMs and associated workshops and conferences have also served as forums for communication with partners/ government and as opportunities to develop further initiatives. For example, discussions and plans for a smart solar community demonstration project that is presently at the design stage were initiated at the Ottawa AGM. These discussions continued at focused meetings held at the Toronto Regional Conservation Authority demonstration house and at the IEA SHC Task 40/ EBC Annex 52 meeting and associated workshop at Concordia University in Montreal during Oct. 6-8, 2013.

The upcoming 3rd AGM in Montreal

(May 4-6, Sheraton Center and Concordia University) will be an important Network meeting that will include the presentation of key project achievements and discussions on future challenges and initiatives with emphasis on partner involvement. Student posters will be presented at the AGM and project-based papers will be presented at the eSim2014 Building Simulation Conference in Ottawa (May 7-10), directly following the AGM. We look forward to seeing all of you in Montreal, May 4-6. Several training workshops are planned at these two events. Detailed information is posted on the Network web site. (**www.solarbuildings.ca**)

"Past the midpoint"...continued

Representative awards received recently by Network researchers:

Network researchers have received prestigious national and international awards in recognition for their work, including: Naylor and Athienitis became Fellows of the Canadian Academy of Engineering; Bernier received the prestigious E.K. Campbell Award of Merit from ASHRAE; Bernier and Morrison played a key role in the organization of its recent International Conference on Building Simulation in France (the Network research was represented with more than 20 scientific papers and an IEA Task 40 workshop). In 2013, Athienitis was also awarded an NSERC/Hydro Quebec Industrial Research Chair "Optimized Operation and Energy Efficiency: towards High Performance Buildings" that focuses on retrofits and optimal control strategies for commercial and institutional buildings, as well as integration of design and operation.

ASHRAE president Tom Watson (L) with Dr. Michel Bernier

On Nov. 22, 2013, a ceremony was held at Concordia to celebrate the award of an NSERC/Hydro-Québec Senior Industrial Chair to Dr. Athienitis. (Photo from the event).

(L-R) Michel Bois, Hydro-Québec; Christopher Trueman, Interim Dean; Anne-Marie Thompson, NSERC; Marc Dugré, Régulvar; Andreas Athienitis; Eric Dumont, Hydro-Québec; José Agustin Candanedo, NRCan; President Alan Shepard, Concordia.

IEA SHC Task 40/EBC Annex 52

http://task40.iea-shc.org

Josef Ayoub
Network Manager, SNEBRN & Operating Agent, T40 A52

In October 2008, the International Energy Agency (IEA) approved the creation of a new five-year (ended on September 2013) international collaborative joint research initiative between the Solar Heating and Cooling (SHC) Implementing Agreement and the Energy in Buildings and Communities (EBC) Implementing Agreement, entitled "Towards Net-Zero Energy Solar Buildings" (SHC Task 40/ EBC Annex 52), with Canada assuming and funding the position of the Operating Agent. This R&D collaboration had a membership of 57 National Experts and an additional 25 regular participants and contributors from 19 OECD member countries. Three National Experts, two of which are NRCan staff, and the third being Dr. Athienitis, the Principal Investigator of the SNEBRN, represented Canada in this Task/Annex.

The objectives of this Task/Annex were to study current net-zero, near net-zero and very low energy buildings (residential and non-residential) and to develop a common understanding, a harmonized international definitions framework, tools, innovative solutions and industry guidelines. A primary means of achieving this objective was to document and propose practical NZEB demonstration projects, with convincing architectural quality. These case studies and the supporting source books, guidelines and tools are viewed as keys to industry adoption that helps advance the NZEB concept in the marketplace.

This Task/Annex pursued optimal integrated design solutions that provide good indoor environment for both heating and cooling situations. The process recognizes the importance of optimizing a design to meet the functional requirement, reducing loads and designing energy systems that pave the way for seamless incorporation of renewable energy innovations as they become cost effective. To achieve these results, the National Experts met twice annually at a hosting member country to coordinate the R&D activities and advance a work plan comprised of the following four major activities:

1. Subtask A dealt with establishing an internationally agreed understanding on NZEBs based on a common methodology. This was done by: reviewing and analyzing existing NZEB definitions and data with respect to the demand and the supply side; studying grid interaction (power/heating/cooling) and time dependent energy mismatch analysis; developing harmonized international definition framework for the NZEB concepts considering large-scale implications, exergy and credits for grid interaction (power/heating/cooling); and, developing a monitoring, verification and compliance guide for checking the annual balance in practice (energy, emissions and costs) harmonized with the definition. This activity was led by National Experts from Germany and Italy;
2. Subtask B aimed to identify and refine design approaches and tools to support industry adoption. This was done by conducting work along four major R&D streams: in documenting and analyzing processes and tools currently being used to design NZEBs and under development by participating countries; assessing gaps, needs and problems to inform simulation engine and detailed design tools developers of priorities for NZEBs; qualitative and quantitative benchmarking of selected tools; and selecting four case study buildings to conduct detailed analysis of simulated/designed vs. actual performance, and proposing the redesign/optimization of these buildings. This Subtask was led by National Experts from Canada (Dr. Athientitis and Dr. O'Brien);
3. Subtask C focused on developing and testing innovative, whole building net-zero solution sets for cold, moderate and hot climates with exemplary architecture and technologies that would be the basis for demonstration projects and international collaboration. This was achieved by: documenting and analyzing current NZEBs designs and technologies, benchmarking with near NZEBs and other very low energy buildings (new and existing), for cold, moderate and hot climates considering sustainability, economy and future prospects using a projects database, literature review and practitioner input (workshops); developing and assessing case studies and demonstration projects in close cooperation with practitioners; investigating advanced integrated design concepts and technologies in support of the case studies, demonstration projects and solution sets; and developing NZEB solution sets and guidelines with respect to building types and climate and to document design options in terms of market application. This Subtask was led by National Experts from France and New Zealand;

4. Subtask D was crosscutting work that focused on dissemination to support knowledge transfer and market adoption of NZEBs on a national and international level. This was accomplished by: establishing an NZEB web page within the IEA SHC/ ECBCS Programmes' framework and a database that can be expanded and updated with the latest projects and experiences; transferring the outputs (reports, sourcebooks, guidelines, other) to national policy groups, industry associations, utilities, academia and funding programs; participating in national and international workshop, seminars, and industry exhibitions highlighting the results and activities of the Task/Annex contributing high quality technical articles and features in journals to stimulate market adoption; and, establishing an education network of highly qualified people that will continue the work in the field in their future endeavours. This Subtask was led by the Operating Agent and involved the participation of all members.

Role and Impact of the NSERC SNEBRN in the Task/Annex

As one of the primary developers of the Task/Annex work plan during the and Leader of Subtask B, Dr. Athienitis supported and coordinated the effective participation in the Task/Annex of several HQPs to help them advance their PhD programs, as well as the outputs of Subtask B, that coalesced around the development of a 400-page document (Vol2. of the T40A52 source books) on Energy Modelling and Design of NZEBs. SNEBRN HQPs have been extremely active and productive in the Task/Annex since the start of the Network in June 2011.

Under IEA SHC and EBC Programme guidelines regarding new collaborative Tasks/Annexes, the T42A52 met biannually for 2 – 3 days at member countries, for discussion and to advance the Task/Annex work plan including the deliverables including shared activities such as: conducting PhD training workshops to provide professional development opportunities to the 15-20 PhD regular participants; and participating in national and international events (seminars, workshops, conferences) aimed at engaging industry partners and furthering worldwide the knowledge base of NZEBs. Network HQPs, Researchers and Partners have been at the forefront of leading and contributing to the success of the T40A52.

Some major highlights of the Network's involvement in the T40A52 over the years include collaborating with our international partners to conduct the very successful PhD summer workshops aimed at providing additional training to HQPs. Three such events were held over the term of the T40A52 including:

1. 1st International PhD Summer Workshop on Net-Zero Energy Buildings: Theory, Modelling and Design. *June 20-25, 2011, Concordia University, Montreal, Canada*

- This workshop was conducted in conjunction with the ASHRAE 2011 Annual Conference that took place from June 25 – 29, 2011 in Montreal and included the participation of internationally renowned speakers. NRCan and SNEBRN staff and HQPs coordinated the workshop, with funding from NRCan. Over 32 participants from T40A52 members including HQPs provided excellent professional networking opportunities for future collaborations.

2. 2nd International PhD Summer Workshop on Net-Zero Energy Buildings: Innovative Solution Sets, *September 24-28, 2012, Institut d'Etudes Scientifiques de Cargèse, Corsica, France*

- This Workshop was held in conjunction with the 8th T40A52 Experts Group Meeting that took place from October 1 – 3, 2012 in Barcelona, Spain, and provided the opportunity to have industry members of the Task/Annex participate in the workshop and give industry perspectives on NZEBs. It was coordinated by Subtask C leaders from France and New Zealand and the week-long activities advanced the development of the a source book that will be published by T40A52 targeting solution sets for NZEBs that the building industry worldwide could adopt to advance the market uptake and penetration of NZEBs. About 25 participants worked in close quarters in multi-disciplinary groups and with industry representative advice on resolving technical issues as they related to selected case studies of NZEBs

3. 3rd International PhD Summer Workshop on Net-Zero Energy Buildings: Experience and Feedback from the SHC Task 40/EBC Annex 52, August 26, 2013, Centre des Congrès, Aix Le Bains, France

- This Workshop was conducted in the context of the 13th International Conference of the Building Performance Simulation Association (IBPSA) that took place from August 25 – 28, 2013 in Chambéry, France, and availed itself of the opportunity to

IEA SHC Task 40/EBC Annex 52...continued

interact with Dr. Paul Strachan, from the Energy Services Unit, University of Strathclyde. The 1-day Workshop was coordinated by Subtask B and C leaders from Canada and France and aimed at presenting the results and the feedback of the T40A52 work on the design of Net Zero Energy Buildings through different case studies. Discussions were held amongst approximately 23 participants and other researchers, including Dr. Strachan, relating to the development, validation and application of simulation tools for use in the energy and environmental performance evaluation of buildings and their systems.

From October 7 - 8, 2013, SNEBRN and Concordia University played host to the 10th and last Group Meeting of the T40A52 National Experts. The first day of the meeting focused on carrying out the business of the Task/Annex including reporting updates on activities, feedback from the Executive Committees of the SHC and EBC and planning the wrap-up of the work-plan. The second day of the meeting consisted of a research forum open to the public and Network partners from NRCan and the industry, focusing on "International and Canadian Perspectives on Future R, D & D Activities in Low and Net-Zero Energy Solar Buildings and Communities". Discussions on new concepts for collaborative research to further advance the work on NZEBs such as new R&D IEA Annexes and community demonstration project in Ontario were presented. About 100 participants attended the Forum from the Network including Partners, HQPs and T4052 international Expert Members.

The T40A52 is the first international R&D collaboration to study NZEB. Over its life-time it delivered:

- The first ever-published source book on NZEB definitions and case studies targeting primarily policy makers. Sold 3000+ copies in English and German editions;
- Second source 400-page book on Modelling, Design and Optimization of NZEBs lead by SNEBRN researchers Profs. Athienitis and O'Brien. Application to Wiley and Sons publishers has been approved. It is in undergoing pre-publishers review. The book will be targeting academia and energy consultants;
- Third source book entitled "Solution Sets for NZEBS: Feedback from 30 NZEB Buildings Worldwide", has also been approved by Wiley and Sons, and SNEBRN HQPs have co-authored several chapters;
- 65+ technical paper sin refereed journals and conference proceedings;
- Six technical reports in which HQPs and Network Partners have lead or co-authored.

For more information, please contact Josef Ayoub (jayoub@encs.concordia.ca)

To download documents: http://task40.iea-shc.org .

SNEBRN at ICEBO

Yuxiang Chen, Concordia University

The International Conference for Enhanced Building Operations (ICEBO) is an annual international forum of leading practitioners, owners, operators, policy makers and researchers interested in using the latest innovative solutions to enhance operations and to maximize the efficiency and productivity of buildings. This year, ICEBO 2013 was held in Montreal from October 7 to 10, partly hosted and supported by Natural Resources Canada/CanmetENERGY and National Research Council Canada. ICEBO 2013 focused on the continuous improvement and operations of buildings, reduction of operating expenses and cost-effective service implementation.

Dr. Radu Zmeureanu, a Concordia University professor and SNEBRN researcher, was a member of the volunteer program committee for the 2013 conference. Andreea Mihai, Nicolas Zibin (SNEBRN Masters students of Prof. Zmeureanu) and Dr. Yuxiang Chen (a SNEBRN postdoctoral fellow of Prof. Andreas Athienitis) presented their recent research findings at the conference.

The paper presented by Mihai at ICEBO was entitled “Calibration of a building energy model with hourly measured data using eQuest” while Zibin presented a paper on the “Use of building automation system trend data for parameter identification in bottom-up simulation calibration”. Chen's paper was entitled “Design of predictive control strategies for active BITES systems using frequency domain models". Another conference paper “A Multi-Level Approach for Model-Based Predictive Control (MPC) in Buildings” was given by SBERN member Dr. Jose Candanedo from Natural Resource Canada. SNEBRN hosted a booth promoting the research being conducted throughout the SNEBRN network and highlighting its research facility and demonstration projects at Concordia University.

Workshop on Intellectual Property and Entrepreneurial Skills

Gerald Parnis, Concordia University

On Wednesday Dec 11, 2013, Dr. Wayne Chang, President of Pivotry Consulting Group Inc., and SNEBRN board member, held a one day workshop in Toronto, entitled “Successful Habits for Hi-tech Professionals & Entrepreneurs – Silicon Valley Perspective” for SNEBRN post-graduate students. The objective of this workshop was to enhance and broaden the training of SNEBRN HQP in professional skills such as intellectual property (IP) management and technology transfer, and to provide them with foundational knowledge that can be applied to innovation and IP strategies. Sixteen participants from Ryerson, Concordia, Dalhousie and McMaster Universities were introduced to the language and concepts of entrepreneurship and innovation born out of the experience of Silicon Valley companies including examples cited from Apple, Applied Materials and HP.

Detailed definitions and descriptions of familiar topics such as innovation, game-changers and networking were presented and discussed. In the case of networking, students were encouraged to think beyond online social media and instead think about how to foster actual human interactions and communities of interest in their research endeavours. As an exercise, workshop participants were asked to generate a list of tasks needed to be performed before, during and after attending a conference with the aim of acquiring information/knowledge, cultivating collaboration potential and building a professional network. Participants presented the tasks to the workshop for discussion.

Other concepts including Learning Styles, Eustress (positive stress), Dashboarding, Social Ecosystems and Exit Strategies were also presented and discussed.

Of particular interest and applicability to SNEBRN students was the session on intellectual property (IP) and patent application processes. This was presented as a question and answer forum with a 4th year Engineering student from the University of Waterloo, who has experience pre-processing patent applications and owns/runs her own startup business. Students were encouraged to research their topic area before submitting a patent application and to focus on showing novelty, inventiveness and market place usefulness in their application. Useful and detailed suggestions for online searching for Prior Art were presented as a means of determining novelty and minimizing the likelihood of a patent clash. The use and purpose of provisional versus non-provisional patents were also discussed.

Overall, the workshop was a good introduction to professional, entrepreneurial and business perspectives and concepts, specifically IP, that a Post Graduate Engineering student would not typically encounter in their university studies. The workshop was also a good opportunity for SNEBRN students to meet and discuss their work with students from other Network universities. The new skills and knowledge acquired at this workshop will enhance participants’ interactions with Network partners.

Team Ontario Solar Decathlon 2013 – A Sustainable Home for the Canadian Climate - By Cynthia Cruickshank and Michael Brown

The U.S. Department of Energy Solar Decathlon is a high-profile competition for university students to build and design solar-powered houses. Every two years, twenty collegiate teams from North America and around the world are challenged to design, build and operate solar-powered houses that are cost-effective, energy-efficient and attractive. Each house is judged and assigned a score out of 1000, based on 10 equally weighted design categories:

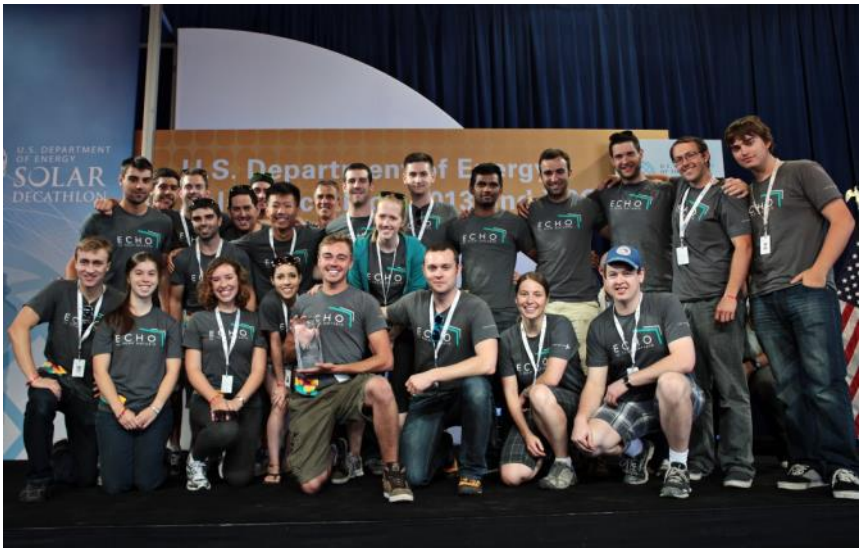
Measured	Juried
Comfort Zone	Engineering
Hot Water	Architecture
Appliances	Market Appeal
Home Entertainment	Communications
Energy Balance	Affordability

The entries, referred to as 'competition prototypes', are designed for the climate of the home institution(s) and are typically built locally, disassembled and shipped to the competition site. The teams have eight days to re-assemble the prototype before the 10-day competition. The competition includes an extensive public exhibition, media coverage and professional jury walkthroughs. Following the exhibition, each team has five days to disassemble their prototype.

Team Ontario is a multidisciplinary team of students and faculty from Queen's University, Carleton University and Algonquin College. The team has worked towards the 2013 competition for more than 3 years.

In 2011 the team submitted a competitive proposal and in January 2012 they were notified that their bid was successful. After a 19-month design, construction and commissioning process, the Team traveled to Irvine, California in October 2013 to participate in the competition. It was a physically and emotionally exhausting experience for everyone, but the team's hard work and dedication paid off. At the end of the competition, Team Ontario had scored:

- First place in Engineering;
- Second place in Affordability;
- Tied for first place in Hot Water Draws;
- Tied for first place in Energy Balance;
- Sixth place overall.



Team Ontario wins 1st place in Engineering and 2nd place in Affordability at the 2013 Solar Decathlon

Solar Decathlon...continued

The Concept

Team Ontario's entry was entitled 'ECHO': an **EC**ological **HO**me for the next generation of young homeowners. The term also refers to the target demographic of the home: children of baby boomers sometimes referred to as "Echo Boomers". The house needed to appeal to a family with a young child, produce more energy than it uses over the course of a year in Ottawa, Ontario using only solar energy, and be as affordable as possible.

The view from the northwest of Team Ontario's entry ('ECHO') to the 2013 Solar Decathlon

An Integrated Design Approach

An integrated and collaborative design approach was necessary and advantageous. Students from three institutions working together across multiple disciplines and four campuses (two at Algonquin College) presented significant challenges with respect to communication and teamwork (disregarding other school, work and personal responsibilities). Several integrated design charrettes helped foster close collaboration, knowledge transfer between disciplines, and a final product that successfully responded to the unique objective and subjective criteria of the competition. The charrettes were supported by frequent face-to-face meetings and voice/video teleconferences.

The following table lists some key design parameters of ECHO:

Conditioned floor space	87 m^2 (940 ft^2)
Exterior deck area	79 m^2 (850 ft^2)
Wall thermal resistance	9.7 m^2-K/W (55 h-ft^2-°F/Btu)
Solar photovoltaic (PV) capacity	7.8 kWp
Solar thermal array	12 m^2 (glazed flat-plate)
Heat pump COP	3.3
Heat pump capacity	5 kW (heating)
Predicted annual energy consumption (Ottawa)	7750 kWh
Predicted annual energy production (Ottawa)	9850 kWh
Estimated cost, parts and labour	USD$257,000

Solar Decathlon...continued

Capacity Building

The design and development of this project encouraged significant capacity building on the part of SNEBRN students. ECHO was mostly designed, built and commissioned by students with some targeted support from experienced faculty advisors and industry professionals. Over 100 students participated in all phases of the project through paid summer positions, integration of key project objectives with the curriculum at all three institutions, and an extended volunteer network that maintained continuity over the academic year.

Estimated at $1M, the project budget was provided by the home institutions, alumni donations, research bodies, the U.S. Department of Energy and industry sponsors. About one-third of the Team's budget was in-kind donations of materials and services, and two-thirds was cash. Partnerships with industry were particularly important for students to learn from industry experts, to support research and knowledge transfer between the public and private sectors, to link potential employers with emerging talent, and to promote innovative Canadian companies in this highly visible sector.

Support from the Smart Net-Zero Energy Buildings Strategic Research Network (SNEBRN) included undergraduate and master's-level research funding and funds for competition travel costs. The network-funded positions built on capacity developed through curriculum integration. For example, many of the graduate students contributed design and analysis to Team Ontario through their 4th year undergraduate capstone projects.

Five main aspects of ECHO were highlighted to the professional juries at the public exhibit:

- **The integrated mechanical system** (IMS) provides space heating, cooling, dehumidification, domestic hot water, and fresh air ventilation in a single integrated system;
- **The predictive shading system** calculates optimal shading position every hour, based on real-time weather data forecasts and a building simulation model;
- **The energy monitoring mobile application** enables homeowners to monitor and control their home with their mobile device;
- An innovative yet constructible **building envelope design** utilizes vacuum insulation panels to achieve a very high level of thermal resistance;
- The **exostructure** is an iconic architectural element of ECHO that inspired the team logo and provides passive shading and a mount for the photovoltaic (PV) and solar thermal energy collectors.

Each aspect is described as follows.

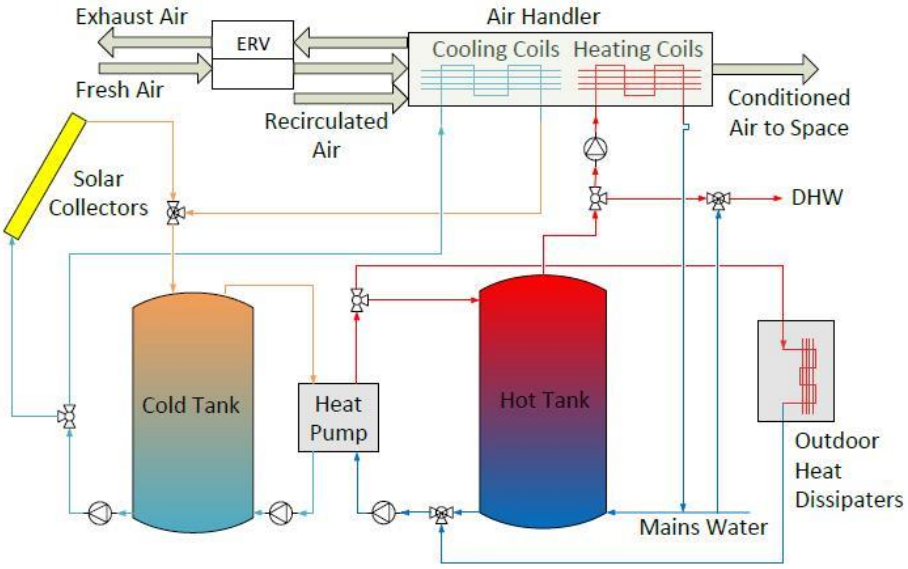
Integrated Mechanical System

ECHO's integrated mechanical system (IMS) combines all space-conditioning functions (space heating/cooling, domestic hot water, dehumidification and ventilation) into a single integrated system, taking advantage of heat recovery and solar thermal energy inputs. This system (Chu, Choi, Cruickshank, & Harrison, 2013) was designed for an Ontario climate and played a major role in the Team's first place finish in 3 categories: Engineering, Hot Water Draws and Energy Balance. It was developed and tested under the guidance of Dr. Stephen Harrison and Dr. Cynthia Cruickshank within Themes 1.1 and 1.2 of the SNEBRN (Innovative Concepts for Space Heating and Cooling and Solar Combined Energy Systems for Space and DHW Heating, respectively).

The system is able to achieve an annual 'free energy ratio' of approximately 60% in Ottawa. This ratio is the percentage of space conditioning and water heating requirements met, without cost, from solar energy and heat recovery. Other energy requirements (e.g. heat pump operation) are met by electricity produced by the photovoltaic array, resulting in no operational carbon emissions.

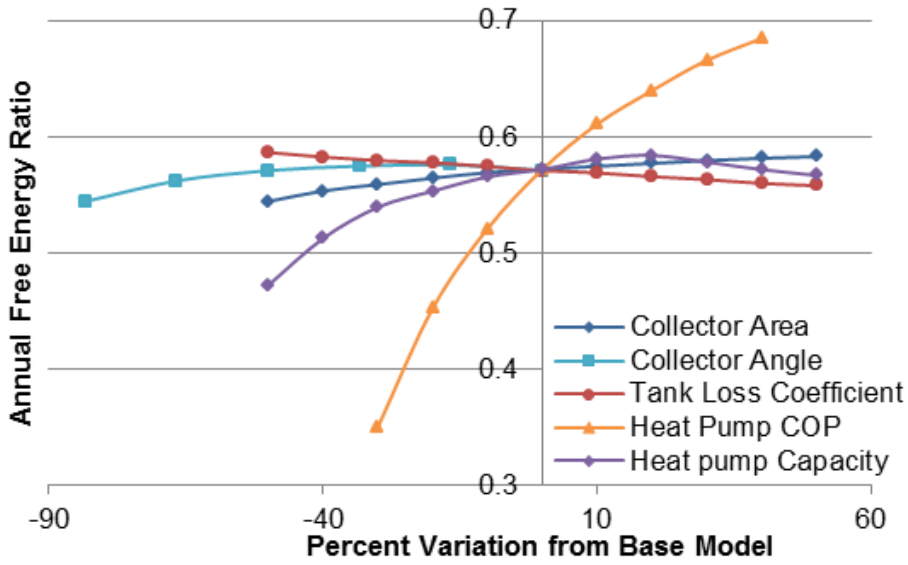
Solar Decathlon...continued

The IMS schematic diagram shown below, illustrates the integration of each component into a single combined system.



Schematic diagram of the IMS

The system was optimized through extensive analysis using TRNSYS 17. The graph below shows the impact that changes to major parameters (from the 'base model') have on the free energy ratio. The TRNSYS model also incorporated a building simulation model ('Type 56') in order to directly couple building loads with the mechanical model. On an annual basis in Ottawa, ECHO is expected to use only 25-30% of the energy of a typical Ontario home, while still remaining attractive and livable.



Free Energy sensitivity study results

Graduate students supported by the SNEBRN had the opportunity to show their work to many visitors and a professional engineering jury. Engineering professionals present during the public tours could be overheard discussing how they could entice the designers of the IMS to join their own teams.

Solar Decathlon...continued

Predictive Shading System

ECHO features a predictive shading system on the southern glazing. This system accounts for the delay between control actions and their results, an effect of the building's thermal inertia, by coupling building simulation model performance with daily weather predictions. The benefit of this is that daily space conditioning loads are minimized by controlling solar gains; particularly important during the "shoulder seasons" in Ontario. This innovative approach is still under development and relies on accurate weather forecasts and a validated building simulation model. However, early investigations show that a predictive model saves energy and improves the occupant's visual comfort (Huchuk, O'Brien, & Cruickshank, 2013).

Energy Monitoring App

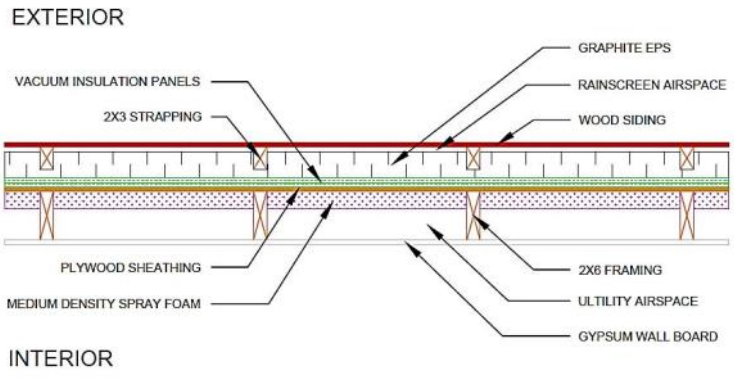
Schematic diagram of the IMS

"You can't manage what you don't measure." Most homeowners are unsure of the relative contribution that each of their appliances makes towards the total household energy load (e.g. energy consumed by the oven verses the refrigerator or lighting). Custom-made for ECHO by Team Ontario students, the energy monitoring app provides homeowners with information about energy consumption (listed by end-use) and energy production (from the PV array). This app also provides remote control of lighting circuits, temperature and humidity set-points, and the automated shading system. Since the system operates over the web, the homeowner can control these systems from a distance. For example, switching off house lights from work.

Building Envelope Design

The wall design for ECHO makes use of vacuum insulation panels (VIPs), an innovative technology that provides an extremely high thermal resistance by virtually eliminating conductive and convective heat transfer across the panel. This technology has seen few applications in the built environment, providing an opportunity to utilize ECHO as a research platform.

Team Ontario built a test facility at Carleton University in order to field test different wall designs and validate simulation models (Schiedel, Cruickshank, & Baldwin, 2013). A further challenge was designing the assembly in a manner that would be easy to implement by a typical Ontario subcontractor and that would protect the VIPs from accidental puncture.



Cross-section of the wall assembly design

Solar Decathlon...continued

Students in the Advanced Housing Construction Program at Algonquin College's Perth Campus built most of ECHO, starting their work in the fall of 2012. Construction of the home was integrated into the curriculum, providing an opportunity for the students to implement innovative sustainable designs while working towards their diploma. This integration also provided an opportunity for feedback in terms of design successes and areas where improvements could be made.

Exostructure

The ECHO exostructure as seen from the southwest

The ECHO exostructure as seen from the south deck

The south-facing exostructure is an important feature of ECHO, as it provides a mounting surface for solar collectors. PV panels are integrated into the sloped surface to improve electrical production and reduce impacts of snow build-up. Solar thermal collectors are mounted vertically for a "winter bias", in order to collect more solar thermal energy in the winter months when space heating is needed. The exostructure also provides passive shading during the summer and serves as an architectural focal point for the home.

Conclusion

The U.S. Department of Energy Solar Decathlon 2013 provided a valuable opportunity for students and faculty across three schools and multiple disciplines to collaborate on a world-class sustainable building design competition. Team Ontario's efforts were seen by very many visitors as well as professional juries. Partnerships were forged and research into innovative sustainable housing systems was disseminated between colleges/universities, government and the private sector. Engineering students, supported by the SNEBRN, played a major role in Team Ontario's successes at the Solar Decathlon, helping to promote innovative made-in-Canada designs to an international audience.

Many team members have gone on to fruitful careers in the private sector or in government, while others have remained in academia to do sustainable energy research in Canada. As for ECHO, it has returned to Canada and has been 'winterized'. It is currently located on the Algonquin College campus in Ottawa. The house presents an opportunity for further research into Team Ontario's vision of sustainable housing as a scalable reality across Canada.

You can follow the future progress of Team Ontario and ECHO at www.ontariosd.ca. For detailed information and competition results, please visit www.solardecathlon.gov.

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Huchuk, B., O'Brien, W., & Cruickshank, C.A. (2013). Preliminary Results of Model Predictive Control of Shading Systems. Proceedings of the Symposium on Simulation for Architecture & Urban Design. San Diego.

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PEMaSS housing for the Canadian North attracts much media coverage

Paul Fazio, Concordia University

Adding to the extensive media coverage of SNEBRN Project 1-Theme 2, Concordia University students Ahmad Kayello and Daniel Baril (supervisor: P. Fazio) were interviewed about this project by CBC on November 5, 2013. Project 1 is led by Paul Fazio in collaboration with the KOTT Group, Radu Zmeureanu, Hua Ge, David Naylor, Fitsum Tariku and SNEBRN director Andreas Athienitis. Media coverage can be found at the following links:

http://www.cbc.ca/news/canada/montreal/concordia-students-build-homes-for-canada-s-north-1.2415237

http://www.cbc.ca/quebecam/northern-quebec/2013/11/05/engineering-housing-solutions-in-northern-quebec/

http://www.concordia.ca/news/stories/cunews/main/stories/2013/10/17/a-sustainable-futureat40c.html

PEMaSS housing is driven by the hypothesis that impoverished people throughout the world can be empowered to sustain themselves and become productive members of society by providing access to this housing technology throughout a community. Regardless of the location and availability of infrastructure and with the addition of photovoltaic panels, the PEMaSS house can generate energy for tasks such as operating appliances, purifying water and charging computers. In addition to providing economical sustainable housing, PEMaSS housing could also provide infrastructure for improved community access to health and education.

This phase of the project is focused on the Canadian North. Its objective is to move housing design towards net-zero energy by integrating new technologies into advanced pre-engineered housing systems thereby mitigating high energy costs. A further objective is to provide quality housing at a reasonable cost for remote regions that have difficult construction environments, such as Nunavut. The difficult characteristics of Nunavut include: a short construction season, a harsh climate (Fig. 1), inadequate roads, sparse communities, costly transportation and a small population of qualified workers. Despite these challenges, the population, development and the use of energy is expected to increase due to large reserves of natural resources. The project is being carried out in collaboration with KOTT, a group of Canadian companies based in Quebec and Ontario.

Progress to date includes field monitoring of two houses: one in Iqaluit, Nunavut (Fig. 2), and the second in Kuujjuaq, Nunavik (Fig. 3). The monitoring is being done by Daniel Baril while the performance testing of a full scale test-hut (Figs. 4, 5) is being done by Ahmad Kayello using the environmental chamber at Concordia University (Fig. 6). Other aspects of the house's performance such as ventilation, the use of heat recovery ventilators and integration of solar technology (Fig. 7), are being studied by others students.

* CBC Daybreak, http://www.cbc.ca/news/canada/montreal/concordia-students-build-homes-for-canada-s-north1.2415237, Concordia students build homes for Canada's North -- Prototypes fit together like 'Lego' pieces to address short building season, Posted: Nov 05, 2013 10:26 AM ET.

[1] PEMaSS = Pre-engineered, manufactured, self-sustaining
[2] SNEBRN = NSERC Smart Net-zero Energy Buildings Strategic Research Network

Figure 1. Fine snow ("sugar snow") penetrates any small crevice and accumulates in ventilated attics and doorways in the winter, and melts as temperatures rise.

PEMaSS housing...continued

Figure 2. Field monitoring of SIP house with unventilated attic built in Iqaluit in 2012 by Kott with remote real time feedback while occupied

Figure 3. Field monitoring of traditional house in Kuujjuaq, Nunavik with attic ventilated through wall cavity behind cladding and filter membranes to prevent infiltration

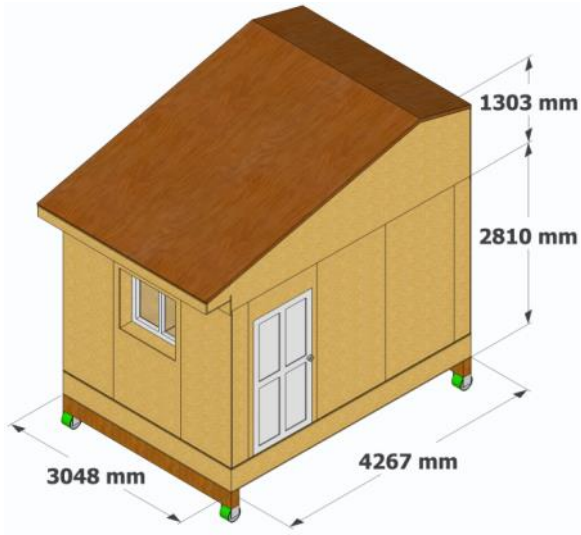


Figure 4. Isometric View of Test Hut

Figure 5. Test Hut in Environmental Chamber

Figure 6. Environmental Chamber

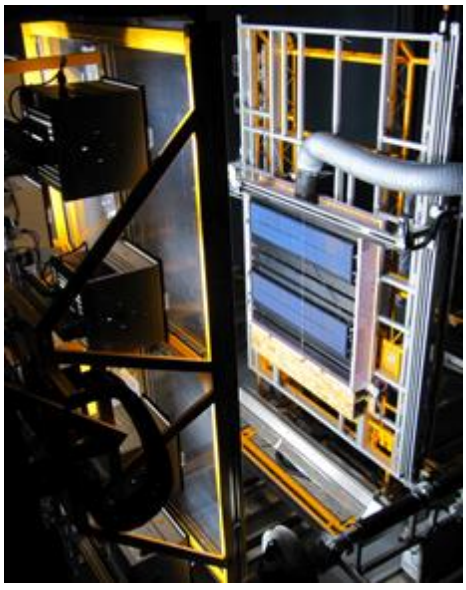


Figure 7. Investigation of solar collector integration using Concordia's solar simulator

SNEBRN participation at international conferences and workshops

By D. Bastien and C. Kapsis, Concordia University

From September 24-28 2012, eighteen students from Canada, France, Italy, New Zealand, Portugal, Singapore and Spain attended the second PhD summer school on Net Zero Energy Buildings (NetZEBs), held at the Institut Scientifique de Cargèse, in Corsica. The summer school was organized by IEA-SHC Task 40/ECBCS Annex 52: Towards Net Zero Energy Solar Buildings. SNEBRN was strongly represented with five graduate students in attendance. The workshop focused on developing solution sets for NetZEBs in various climates using an integrated design process and advanced Building Performance Simulation (BPS) tools.

PhD summer school participants during the integrated design process

All participants, at the Institut de Cargèse

In a series of lectures held over two days, six existing NetZEBs were presented to the students. On the third day, each building was assigned to a design team of three students. The students had 48 hours to study the building, identify the key elements and redesign the building under new climatic conditions (e.g. moving a NetZEB office building from Melbourne, Australia to Oslo, Norway). The new design needed to maintain both the building's NetZEB status and its original visual and thermal comfort. Additional lectures throughout the week provided background for the redesign process while further enhancing student's understanding of simulation tools and their limitations. Congratulations to SNEBRN students Costa Kapsis, Sam Yip whose design teams won the first and second prize in this creatively challenging design competition.

The outcomes of the summer school were presented at an IEA workshop organized as part of the 13th International Conference of the International Building Performance Simulation Association (IBPSA). The conference was held on August 25-28, 2013, at Savoie Technolac, located in the heart of the French Alps and next to Lac du Bourget (the largest lake in France).

International conferences...continued

View of Lac du Bourget from the top of la dent du chat, in the French Alps.

The IEA workshop also hosted guest lecturers who discussed many topics including: the modelling and design of Smart NetZEBs, occupancy behavior, thermal comfort, model-based predictive controls and building grid interactions. At least fifteen SNEBRN researchers and students attended the workshop while more than twenty five participated in the conference, presenting either a peer-reviewed scientific paper or a poster. The workshop provided SNEBRN students with the opportunity to interact with internationally acclaimed researchers in BPS and high performance building design and learn about the latest scientific developments in these fields.

Prof. O'Brien with Carleton and Concordia University students in Chambéry

C. Kapsis and A. Lenoir presenting the summer school results at the IEA workshop, at the IBPSA Conference

Special thanks to Michael Donn, François Garde and David Waldren for organizing and coordinating the second PhD summer school on NetZEBs and to Aurélie Lenoir for organizing the IEA workshop. Finally, thanks also to INES (CEA, University of Savoie, CNRS), INSA Lyon and the president of IBPSA and Theme 1 co-leader, Ian Beausoleil-Morrison for the successful organization of the 13th International Conference of IBPSA.

SNEBRN Represents Canada at APEC Workshop on Net-Zero Energy Buildings in Beijing, Liam O'Brien, Assistant Professor, Carleton University

Arriving in Beijing by plane, the importance of reducing China's energy use and heavy reliance on coal was evident even before landing. From the air, I could only make out fuzzy neon logos on nearby high-rise buildings. The smog - indoors and out - was so bad on the day I arrived that the opposite wall of the terminal building was fuzzy! It was reported in the news the previous week that the nearby city of Harbin had a visibility of 10 meters and if that is hard to comprehend, apparently a building fire went unnoticed for 3 hours! As a result of air pollution, the average life expectancy of the Chinese has been reduced by an estimated five years. Chinese energy use, appropriately quoted in equivalent tons of coal, has increased by about 150% since 2000.

View of skyline in Beijing on two consecutive sunny weekdays

China's buildings are responsible for about 25% of the national energy use and overall energy consumption is increasing at a fast rate as a result of: rapid urbanization (exceeding the 50% mark three years ago), a surge in demand for appliances and expectations of greater levels of comfort. Wintertime temperatures in rural homes in China range between 8 and 16°C, whereas the range of indoor temperatures in urban buildings is much tighter with the use of air-conditioning widespread; arrays of split air conditioners can be seen covering most high-rise buildings. In an attempt to reduce overall energy use and air pollution, China has aggressively tightened its building energy codes (30% reduction in energy use of urban buildings by 2015).

On October 30 and 31, China Academy of Building Research (CABR) hosted the Asia-Pacific Economic Cooperation (APEC) Net-Zero Energy Building Workshop in Beijing. The event was organized by Zhang Shicong, a deputy director at CABR, and attended by about 50 researchers, government representatives and industry professionals from many of the Asia-Pacific countries (e.g., China, Chile, USA, Canada, Indonesia, Japan, Peru, and South Korea). Prof. Liam O'Brien represented SNEBRN and presented a summary of Network research activities and his own research on occupant behaviour. Prof. Xu Wei, Director of the Institute for Building Environment and Energy Efficiency at CABR, highlighted some national objectives (e.g., 30% reduction in energy use of urban buildings by 2015) and outlined China's rapid economic growth and the energy implications (e.g., doubled energy use in the past decade and rapid increase in consumer expectations of comfort and appliances).

Other highlights from the workshop included an in-depth analysis of building codes for different climates, case studies such as the NREL RSF NZEB (USA) and an overview of China's first building to comply with the Passive House standard – a large high-rise residential building. Tom Hootman, architect of NREL RSF, provided valuable insights into the unique procurement process of the building and the design philosophies. Notable, the designers justified aggressive measures to improve efficiency knowing that every continuous Watt of power used in the building requires about $30 of PV capacity to offset it (based on PV costs at the time of construction several years ago). South Korean researchers gave a presentation on their high-rise residential NZEB. Dr. Wei Feng, a senior researcher at LBNL, is collaborating with China to help establish their building energy

APEC Beijing...continued

codes. He also summarized the US NZEB objectives including: marketable net-zero energy homes by 2020, marketable net-zero energy commercial buildings by 2025 and the goal that all new federal buildings be NZE-ready by 2030.

Group photo of all APEC NZEB Workshop delegates

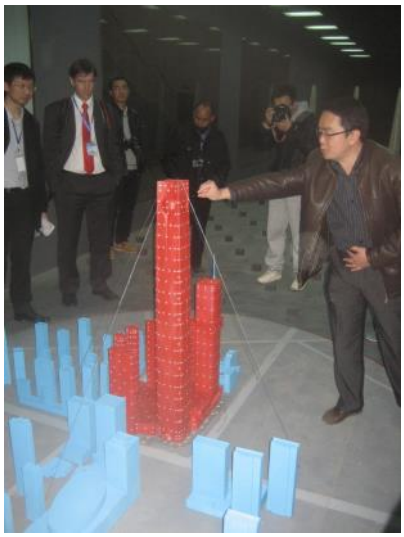
Prof. Jun Tae Kim from South Korea represented IEA SHC Task 40/ECB Annex 52: Towards Net-zero Energy Solar Buildings on behalf of Josef Ayoub.

Drilling boreholes for CABR's new near NZEB

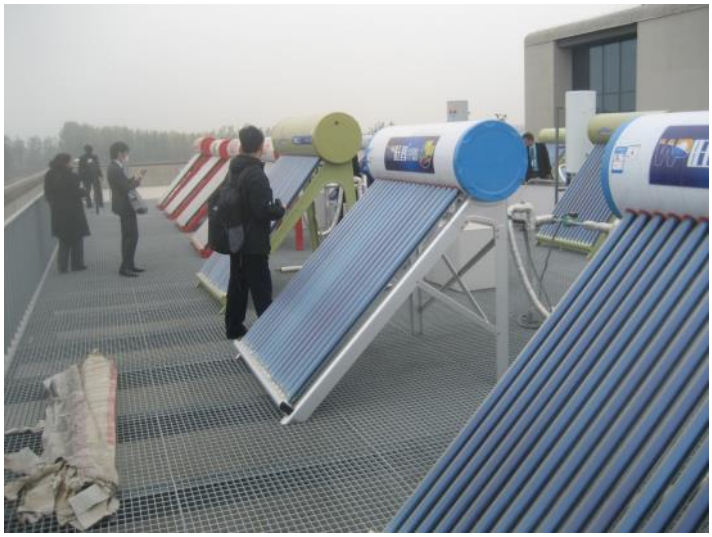
The workshop concluded with a brief tour of CABR's near net-zero energy building that is still under construction. The building will include several types of solar collectors (PV, concentrated solar, and evacuated tubes). Notably, the design team selected PV modules that function well under the diffuse solar radiation that filters through Beijing's atmosphere. The building is well insulated with large vacuum-insulated windows. On the day of the tour, construction of boreholes was well underway.

APEC Beijing...continued

The APEC delegates were treated to a three-hour tour of CABR's impressive laboratory facilities near the Beijing airport, notably a very large wind tunnel and the third largest shaker table in the world for structural testing under seismic loads. Other facilities include a solar thermal testing facility, soil and foundation lab, materials testing facility, fire safety lab, lighting/daylighting lab, and HVAC lab. Finally, the Lab has an enormous environmental chamber for testing curtain wall systems. During the visit, researchers were emptying a 12-ton of liquid nitrogen to maintain the cold side of the chamber.



Inside the test section of CABR's enormous wind tunnel (total length of about 100 meters)



Solar thermal collector testing facility at CABR Lab

Following the workshop, Prof. O'Brien visited Prof. Da Yan at Tsinghua University to discuss possible collaboration with SNEBRN and the proposed new International Energy Agency ECB Annex on occupant behaviour for which both researchers are actively involved. Prof. Da Yan is leading the proposal of this new Annex, which will be presented to the IEA ECB Executive Committee for approval in November 2013. Occupant behaviour is particularly important to China because consumer choices and expectations are driving the country's thirst for energy.

NSERC SMART NET-ZERO ENERGY BUILDINGS STRATEGIC RESEARCH NETWORK

RÉSEAU DE RECHERCHE STRATÉGIQUE DU CRSNG SUR LES BÂTIMENTS INTELLIGENTS À CONSOMMATION ÉNERGÉTIQUE NETTE ZÉRO

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