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JMSB BIPV/T Wall, Concordia University, Canada

International Energy Agency
Energy Conservation in Buildings and Community Systems Programme

SHC
SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

SOLAR BUILDINGS RESEARCH NETWORK
RÉSEAU DE RECHERCHE SUR LES BÂTIMENTS SOLAIRES

Natural Resources Canada | Ressources naturelles Canada

Université Concordia University

## IEA-SHC Task 40/ECBCS Annex 52
## (in cooperation with IEA-SHC Task 41)

# Montreal PhD Summer Workshop on Net-Zero Energy Solar Buildings: Theory, Modelling, and Design

June 20 – 25th, 2011

# Welcome

We are pleased to welcome you to the Montreal PhD Summer Workshop for Net-Zero Energy Solar Buildings (NZESBs) hosted by Concordia and organized by IEA-SHC Task 40/ECBSC Annex 52 (in cooperation with IEA-SHC Task 41).

The workshop will provide an opportunity for an intensive study of NZESB design and modeling issues that include the following:

1. A diverse series of lectures about the design and modelling of NZESBs and selected enabling technologies.
2. A series of re-design studies of existing near net-zero or net-zero buildings to explore improved and alternative pathways to net-zero energy with emphasis on modelling and integration of passive and active systems.

We would like to recognize the time, effort, and wealth of knowledge and experience that the instructors are providing—some of whom have literally travelled across the world to be here. We would like to thank the sponsor of this Workshop, Natural Resources Canada (NRCan) and Concordia University for hosting it. Finally, the students and staff who have put many hours of their time into organizing the Workshop are acknowledged.

This sets the precedent of what we hope will be a series of similar workshops in the coming years. We wish you a productive and enjoyable visit to Montreal.

**Josef Ayoub**

Operating Agent, IEA SHC Task 40/ECBCS Annex 52

CanmetENERGY, NRCan

**Dr. Andreas Athienitis**

Scientific Director, Solar Buildings Research Network

Professor and Concordia Research Chair Tier I, Concordia University

STB Co-leader, IEA SHC Task 40/ECBCS Annex 52

**William (Liam) O'Brien**

PhD Candidate

Concordia University

# Workshop Schedule

## * All the sessions will take place in EV building 3.309

| | Monday, June 20 | Tuesday, June 21 | Wednesday, June 22 |
|---|---|---|---|
| 8:30 - 10:20 | **Introduction**<br><br>Opening statements by: Josef Ayoub, Andreas Athienitis, Liam O'Brien<br><br>Student bios – 3 minutes each | **Brief Lectures**<br><br>(Bart Lomanowski: HOT3000; Salvatore Carlucci: Thermal Comfort in NZEBs; Scott Bucking: optimization/BEopt) | **Integrated Design** (9:00 start)<br><br>Ted Kesik |
| 10:20 - 10:40 | **Coffee break** | | |
| 10:40 - 12:30 | **Integrated Energy Concepts and Pathways for Net-zero Energy Solar Buildings: Combining active and passive systems**<br><br>***(EcoTerra case study)***<br>Andreas Athienitis | Case study: Introduction<br><br>**BIPV/T** (1 hour) Andreas Athienitis | **NZEB Case studies**<br><br>(1.5 hours)<br>Peter Engelmann<br><br>**T41 update**<br>Caroline Hachem |
| 12:30 - 13:30 | **Lunch** | | |
| 13:30 - 15:20 | **Building envelopes**<br><br>Paul Fazio | **Electrical grids and demand response**<br>Jose Candanedo; Pragasen Pillay | **Modelling Fundamentals**<br>(3 hours)<br>Ian Beausoleil-Morrison |
| 15:20 - 15:40 | **Coffee break** | | |
| 15:40 - 17:30 | **Photovoltaics**<br>Yves Poissant | **Daylighting**<br>Marie-Claude Dubois | **Occupant Behaviour** (1 hour)<br>Ian Beausoleil-Morrison |
| 19:00 - 21:00 | | **Banquet Dinner**<br>Restaurant L'Academie, 2100 Crescent | |

# Workshop Schedule

*** All the sessions will take place in EV building 3.309**

| | Thursday, June 23 | Friday, June 24 | Saturday, June 25 |
|---|---|---|---|
| 8:30 - 10:20 | **Occupant comfort, transfer functions, and embodied energy (LEAF House case study)**<br>Maurizio Cellura | **Natural Ventilation**<br>Panagiota Karava | Case study work period |
| 10:20 - 10:40 | **Coffee break** | | |
| 10:40 - 12:30 | **NZEB design processes**<br>Ralf Klein | **Solar thermal collectors and thermal storage**<br>Cynthia Cruickshank | Case study work period |
| 12:30 - 13:30 | **Lunch** | | |
| 13:30 - 15:20 | **HVAC systems & control (NREL RSF case study)**<br>Paul Torcellini | **NZEB design in tropical climates (EnerPos case study)**<br>Francois Garde | Case study work period (first 80 minutes); presentations (last 30 minutes) |
| 15:20 - 15:40 | **Coffee break** | | |
| 15:40 - 17:30 | **NZEB construction,**<br>Paul Torcellini | Case study work period | Case study work presentations |

# List of Workshop participants

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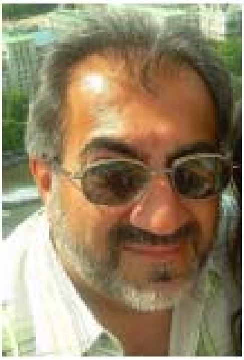
## Speaker's Bio



**Josef Ayoub** has been working with the federal government since 1999, attached to the CanmetENERGY at the Varennes research centre, presently in the position of Senior Planning Advisor, Energy Science and Technology. He is Canada's Executive Committee member to the IEA PVPS Program coordinating and facilitating R&D collaborative arrangements between Canadian and international research centres. He is also the Operating Agent of the IEA SHC Task 40/ECBCS Annex 52 R&D group investigating net-zero energy buildings. He sits on several Departmental Portfolios under the Government of Canada's Program on Energy Research and Development including the Integration of Renewable Electricity Systems Portfolio and the Built Environment Portfolio. He is also a member of inter-departmental scientific committees responsible for RD and D in the area of solar energy production, and its integration into zero-energy buildings. Prior to joining NRCan, from 1984 to 1999, Josef undertook applied research in renewable energy systems for the developing areas of the world at the Brace Research Institute, McGill University and was Consultant on renewable energy projects funded by Canadian aid agencies, the United Nations University, the World Bank and other multi- and bilateral- financing entities, travelling extensively in Africa, Latin America and Southeast Asia. Josef graduated from McGill University in 1987 with a joint Master degree in Environmental Sciences and Resource Geography. He has published over 70 refereed and no-refereed articles, manuscripts and reports in the area of solar and renewable energy technologies, solar water desalination and disinfection, and more recently in net-zero energy buildings and Canadian photovoltaic market reports.

# Speaker's Bio

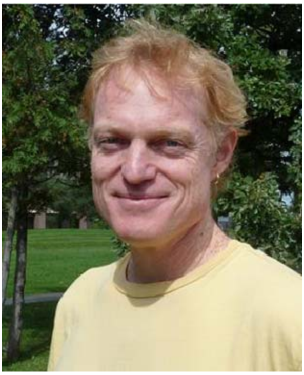
Dr. **<u>Andreas K. Athienitis</u>** is the Scientific Director of the NSERC Solar Buildings Research Network and a Concordia University Research Chair, Tier I in Integration of Solar Energy Systems into Buildings. He obtained a B.Sc. in Mechanical Engineering (1981) from the University of New Brunswick and a Ph.D. in Mechanical Engineering from the University of Waterloo (1985). He was profiled as one of 25 top innovators in Quebec by Actualité Magazine (Sep. 15, 2009) and is a Fellow of the Canadian Academy of Engineering. His research interests are in solar energy engineering, energy efficiency, optimization and control of building thermal systems, building-integrated photovoltaics and daylighting. He is the author of more than 150 refereed papers, the Mathcad electronic book "Building Thermal Analysis" and the graduate level book "Thermal Analysis and Design of Passive Solar Buildings". He is a recipient of several awards, including ASHRAE Willis H. Carrier best paper award. He was named Concordia University Research Fellow (Senior) in 2010. He has served as Associate Editor of the ISES Journal "Solar Energy" and in ASHRAE Technical Committees. He is a consultant to major utilities and government departments. He has played a key role in the design of award-winning low energy and zero energy buildings which include building-integrated photovoltaic/thermal systems, geothermal heating/cooling and advanced daylighting. He is a subtask leader of IEA SHC/ECBCS Task 40 "Towards Net-zero Energy Solar Buildings" and a contributing author for the Intergovernmental Panel for Climate Change (IPCC).

# Topic Abstract

An overview of integrated energy concepts and technologies for NZEBs will be given, followed by detailed analysis of building-integrated photovoltaic/thermal systems and integration of solar technologies in general into NZEBs. A key element of the approach presented is the optimal combination of passive and active technologies, including daylighting and hybrid ventilation (e.g. night cooling). Examples from housing and commercial buildings will be given, including peak loads and net generation profiles.

EcoTerra House, Canada

## Speaker's Bio



Dr. **Ian Beausoleil-Morrison** is an Associate Professor in the Department of Mechanical and Aerospace Engineering where he holds the Canada Research Chair in the Modelling and Simulation of Innovative Energy Systems for Residential Buildings. His research is focused on the cogeneration of heat and electricity, alternative cooling approaches, and solar energy utilization.

Prior to moving to academia in 2007, Dr. Beausoleil-Morrison worked for 16 years at the Canadian Government's CanmetENERGY research centre, where he conducted research and developed building simulation tools to support industry and government programmes. Recently he led Annex 42 of the International Energy Agency's Energy Conservation in Buildings and Community Systems Programme (IEA/ECBCS) on micro-cogeneration systems and has served on numerous ASHRAE committees related to building performance simulation. Currently he is President of the International Building Performance Simulation Association (IBPSA), co-editor of the Journal of Building Performance Simulation (JBPS), and a theme leader of the NSERC's Solar Buildings Research Network (SBRN).

He has authored or co-authored more than 70 peer-reviewed papers on the topic of innovative building energy systems and building performance simulation and was the recipient of IBPSA's Outstanding Young Contributor Award in 2001. He has been actively developing models within ESP-r for more than a decade and since 2006 has acted as the source code archivist for that simulation tool.

# Topic Abstract

## Modeling and simulation fundamentals

The design and analysis of net-zero energy buildings (NZEB) invariably requires the application of building performance simulation tools (BPS) to assess the absolute and relative energy benefits of various design measures. For example, what is the energy impact of controlled external blinds on south-facing windows? How much energy can be saved by increasing the insulation between the building and the ground? What volume of storage is required for a solar combi-system to achieve a desired solar fraction?

A plethora of methods have been developed over the past four decades to model the pertinent physical phenomena related to the building envelope, occupancy, and energy systems. But different methods have been implemented in each BPS tool that is available to the practitioner. Rarely though, do designers and analysts pose questions about the underlying methodologies applied by their BPS tools nor their myriad implicit assumptions.

This lecture will commence with an historical perspective examining the roots and development paths of BPS. It will then introduce BPS tools and discuss the data and significant factors that must be considered in their use. Following this, the lecture will examine in greater detail the modelling methodologies and fundamentals of some of the heat transfer paths of greatest pertinence in the design and analysis of NZEBs.

## Occupant behaviour

The presence of occupants certainly complicates the design and analysis of buildings. This is particularly the case for NZEBs in which subtle changes in the operation of the building and control of its energy systems can have a significant impact upon energy balances. This lecture will explore the impact that occupants can have on the energy performance of housing, with particular emphasis on cooling loads.

## Speaker's Bio

As an optimization expert, **Scott Bucking** is always trying to find his way to the highest point possible (pic: climbing Mnt Kenya). Scott has a diverse background in carpentry, experimental neutrino physics, biomedical engineering with application to brain imaging, software development and building energy auditing. Scott received a BEng in Physics Engineering (Carleton Uni, 2004), a Master's degree in Building Engineering (Concordia, 2008) and is now in his third year of his PhD in building engineering at Concordia with a research focus on optimization methodologies for NZE homes.

# Topic Abstract


In the design of cost-effective low-energy buildings, or in the extreme case, net-zero energy buildings, an integrated design philosophy is required throughout the early to late-design stages. An integrated design approach requires consideration of simultaneous trade-offs between many interdependent design variables, such as window to wall sizing, insulation levels, internal thermal storage, HVAC system design and sizing of renewable energy generation. Considering such trade-offs at the late-design stage represents a lost opportunity to improve the buildings energy efficiency and reduction of life cycle costs.

The challenge in leveraging information gained from building simulation is that the simulation problem is ill-defined, meaning that many of the specifics regarding possible building material, occupancy patterns and architecture have yet to be determined. Optimization methodologies can facilitate the design process as designers can consider a vast amount of design combinations simultaneously and evaluate trade-offs.

This talk will focus on the application of a freely available optimization tool, called Building Energy Optimizer (BEOpt), developed by NREL which caters to NZE Home design. BEOpt uses EnergyPlus for simulation of all building performance evaluations. This talk covers all aspects of using BEOpt in the design and analysis of NZE Home design.

## Speaker's Bio

**José A. Candanedo** completed a Bachelor's degree in Electro-mechanical Engineering from the Technological University of Panama (1999), an M.Eng. in Mechanical Engineering from McGill University (2003, Dean's Honour List), and is currently finishing his Ph.D. degree at the Department of Building, Civil and Environmental Engineering of Concordia University (Montréal). Between 1999-2001 and 2003-2005, José worked as a Technical Support engineer at Fortuna, the largest hydroelectric generation plant in Panama. Always interested in the field of renewable energies, José has worked in the development of pico-hydro projects. His Ph.D. thesis focuses on control strategies for net-zero energy solar homes. He played an important role in the development of the Alstonvale Net Zero House project, one of the winners of the Canada-wide EQuilibrium competition.

José is the recipient of an NSERC Alexander Graham Bell Doctoral Scholarship and is the author of several conference and journal publications. José has also been part of the Canadian delegation participating in the IEA Task 40/Annex 52 since its inception. His academic interests include building-integration of renewable energy technologies, system identification, modeling complexity in building simulation, thermal energy storage, predictive control strategies, and load management. His vision is to contribute to solar building engineering with a practical, problem-solving outlook based on the scientific method, while focusing on creative and far-reaching measures.

# Topic Abstract

The development of effective control strategies is an essential –and often-neglected– aspect of the design of a net-zero energy house. Control strategies not only can contribute to maintaining comfortable indoor conditions; they can also help to reduce energy use and peak demand attributable to heating and cooling loads, and are therefore vital to avoid oversizing HVAC equipment. Adequate control is even more significant when solar technologies and design techniques are implemented, since it can help in managing solar radiation variability. This can be accomplished, for example, by taking advantage of energy storage resources in the building and information from weather forecasts.

The presentation and exercise presented here investigate an example of a predictive control strategy: the impact of temperature set-point trajectory selection on the performance of the heating system of a case study building (based on the EcoTerra House). A simplified physical model, obtained from system identification of a more detailed model of the house, is used to facilitate the implementation of predictive control and to gain insight on the building response to weather variables and the heating system.

# Speaker's Bio

**<u>Salvatore Carlucci</u>** is an Italian PhD candidate in Building Engineering at the Politecnico di Milano. His research project aims at developing a design process for comfortable net zero energy buildings.

In 2005, he obtained a master degree "cum laude" in Building Engineering at Politecnico di Milano.

Since 2006, he collaborates with the end-use Energy Efficiency Research Group (eERG) of the Energy Department of the Politecnico di Milano directed by Prof. L. Pagliano. During this experience, he has been involved in researches connected with a number of European projects (e.g. Passive-On, GreenBuildingPlus, Keep-Cool 2), consultancy activities for the retrofitting of existing buildings and design of new ones (e.g. ITCLab designed by arch. Richard Meier) and teaching activities: (i) contract professor of Environmental Control in the Architectural Design Phase, (ii) professor of the Master RIDEF organized by the Energy Department of the Politecnico di Milano (iii) teaching assistant of Building Physics.

His interests are mainly focused on applicability of thermal comfort models, building design process, building retrofitting and passive cooling strategies.

# Topic Abstract

The lecture initially starts with a short description of the thermal comfort concept, the EN 15251 and of the adaptive comfort. After the initial theoretical description of the problem, a case study of an office building in seven Italian different locations is shown.

Finally, an early analysis of the thermal performances of the Leaf House is described, considering the traditional thermal comfort model and EC 15251 approach.

# Speaker's Bio

Dr. **Maurizio Cellura** is full Professor of Environmental Physic from 2011 at the Faculty of Engineer of University of Palermo. He has twenty-two years of experience in thermal building simulations, embodied energy of building and building materials. He is author of about 180 publications in fields of renewable energies, energy planning, thermal building simulations in non-steady state conditions, embodied energy and life cycle assessment of building and renewable technologies.

He was member of the Italian competent body for environmental certifications of products and organizations (EMAS and Ecolabel) (2000-2004). He is Member of the Subtask B (Design Process and Tools of NZEB) for the Solar Heating and Cooling Task 40-ECBCS Annex 52;

He is member of the scientific task force to define criteria for the Ecolabel of buildings (International Committee Ecolabel EcoAudit, APAT,) since 2007. He is member of the working group for the definition of Green Public Procurement criteria for energy services and building materials since January 2008 (Italian sustainable production and consumption plan for the Ministry of the Environment).

He is involved in many research activities about energy technologies, simulation and optimization of thermal energy generation systems for buildings, design, processes and tools for developing Net Zero Energy Buildings. He also works on the LCA methodology applied to experimental studies and the Environmental Management System (EMAS, ISO14001) and EPD applied to different innovative products and services. He chaired many National and European project in energy and environmental fields.

# Topic Abstract

## Embodied Energy

During last years the energy efficiency of buildings was drastically increased. The energy consumption of the operational phase decreased and now the embodied energy of building materials, technologies and whole buildings are quite comparable with the management phase.

Following these considerations, buildings should be analyzed along a life-cycle approach, including the energy flows and the environmental burdens that arise during all life cycle steps.

The Life Cycle Assessment (LCA) is a method for assessing the environmental impact of materials, products or services throughout their entire life cycle, from the origin of raw materials to their disposal. This approach allows the development of a scientific environmental balance between the benefits and the impacts related to the product's use. In comparison to traditional environmental analyses, the LCA allows to avoid partial or wrong assessments concerning the products environmental performances.

During the lecture the main features of the Life Cycle Assessment and the Embodied Energy will be initially described. Afterwards a Life Cycle Assessment of an Italian single-family house in the Mediterranean area will be presented. All the main stages of the building useful life have been investigated including: design, production of raw materials and building components, energy and materials supply, construction and installations, maintenance, operation, demolition and debris disposal.

The aim of the case-study is to identify the building components responsible of the higher burdens and to state the incidence of each component and phase. The assessment shows that the largest impacts are located during the operational phase, but significant environmental impacts are even due to manufacture and transport of materials.

The presented case-study has largely developed in the context of the "Genius Loci" Italian research project, regarding the building sector impact on climate changes.

# Topic Abstract (continued, Dr. Maurizio Cellura )

**ASHRAE TFM**

The available tools for dynamic simulation of the buildings thermal behavior are manifold, and many of the most modern ones, are founded upon the use of the Z-transform (ZT) also called transfer function method (TFM). The TFM, recommended by American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), is one of the most modern tools available to solve heat transfer problems in building envelopes and environments. TFM utilizes Z-transforms to solve the equation system that describes the heat transfer in a multi-layered wall.

During the lecture TFM mathematical features will be investigated, especially concerning the reliability and the quality of the thermal dynamic simulations. Results clearly show that for a massive building a simple application of TFM often fails. The method is very flexible and could be adopted to calculate the transfer function coefficients able to simulate the thermal behavior of a room in free floating.

LEAF House , Italy

## Speaker's Bio

Dr. **Cynthia Cruickshank** joined the Department of Mechanical and Aerospace Engineering as an Assistant Professor in July 2009. She received her Ph.D. (2009) and B.A.Sc. (2003) degrees at Queen's University. Her primary research interests involve the design and optimization of solar thermal energy systems and sensible heat storages. The scope of this work also includes investigations related to advanced buildings, including energy efficient and sustainable energy concepts for commercial and residential applications.

# Topic Abstract

Solar thermal systems are ideally suited for domestic hot water heating, and space heating and cooling, in residential and commercial buildings. Currently, solar thermal technology represents one of the most cost-effective ways to use renewable energy. The primary function of a solar thermal energy system is to convert solar energy directly into heat in an efficient manner for a specific application. Conceptually, a solar thermal system consists of a “solar collector” to capture solar energy and convert it directly to heat and a mechanism for transporting the collected heat to a location where it is needed to offset a thermal load. As a time-dependent source of energy, however, solar energy it is not always available when there is energy demand. Therefore to make use of this resource, it is often necessary to store solar energy until it can be used at a later time.

Most small to medium sized solar installations use diurnal storage, where energy is typically stored for one or two days, however weekly and seasonal storage is also used in certain applications. Primarily used to offset space heating loads, seasonal storage systems are designed to collect solar energy during the summer months and retain the heat in the storage for use during the winter months. Characterized by their large capacity requirement (in the order of a hundred times the capacity of a daily storage), these systems typically run at a much higher cost and require a larger storage volume than short term storages. Seasonal storages have been pilot-tested and used in a number of countries for district space and water heating.

Worldwide, there is increasing interest in developing cost-effective configurations for thermal storage. In particular, there is a need to develop effective storage systems that are modular, flexible, cost-effective and easy to install, especially in retrofit situations.

The topic of this talk addresses the design, operation and evaluation of solar thermal energy systems and sensible heat storages. A case study of the Canadian home solar community of Drake Landing will also be presented.

# Speaker's Bio

**<u>Marie-Claude Dubois</u>**, B Arch M Arch (Laval) Tekn Lic PhD (Lund)

Dr. Marie-Claude Dubois is a senior research at the Division of Energy and Building Design, Lund Unversity, Sweden since July 2010. From 2003 to 2010, she was associate professor at Laval University's School of Architecture, where she was leading the courses « Mechanical and electrical services », « Building Envelope » and taught numerous design studios. Apart from her teaching activities, Dr Dubois is active in research as co-leader of IEA SHC Task 41 Solar Energy and Architecture and as co-leader of Swedish project "Energy-efficient office buildings with low internal gains: simulations and design guidelines".

Dr Dubois holds a M. Arch. from Laval University and a PhD in engineering from Lund University in Sweden. In her career, she has worked as architect for Dorval and Fortin, architects in Quebec, and as consultant for Skanska Teknik (Sweden), Mermet (France) and Velux (Denmark). She also worked as senior researcher at the Danish Building Research Institute in 2001-2003.

# Topic Abstract

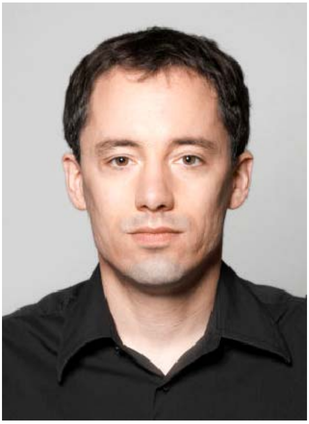
Daylighting a building describes the conscious effort to admit natural light into a building. The objectives for doing so are manifold, ranging from a desire to create healthful and stimulating spaces to efforts to reduce energy use for electric lighting and cooling.

This session will provide a brief historic overview of daylight in buildings and inform participants of the benefits, risks and challenges connected to daylight harvesting. Participants will develop a basic understanding of design principles and evaluation tools and learn how to apply them in the context of real buildings through case studies.

By attending this session, participants will:

- gain an understanding of the historic perspective of daylight in buildings.
- learn about the benefits and risks of daylight through windows and skylights.
- be introduced to some design principles and learn how to apply them.
- be presented with design and evaluation of some tools and be given the opportunity to put them into practice.

# Speaker's Bio



Dr. **Peter Engelmann** is postdoctoral researcher at the Fraunhofer Center for Sustainable Energy Systems. He graduated in energy engineering at the Technical University in Berlin, Germany. After that he worked as research assistant at the University of Wuppertal, Germany, in the department of architecture in the field of building physics and HVAC systems. He received his Ph.D. on analysis and monitoring of student dorms build as passive houses. Focus of his work was building and performance analysis of deep energy retrofits in the german research program "Energy Optimized Buildings".

# Topic Abstract

**Usage patterns:**

The energy demand of buildings is driven by two factors: user needs and ambient conditions. On a short term both can be rather erratic, but analyzed over a longer period of time (or bigger sample sizes) they often show typical patterns or specific correlations. Solar irradiation and ambient temperatures follow seasonal fluctuations; user behavior (e.g. water consumption, lighting) often show iterative patterns as well.

The presentation will show results from different field tests, from single family residential homes to student dorms and office buildings. In these buildings energy consumption (in total or on appliance-level) was measured in high frequency (typically in 15min time steps). Typical correlation patterns in different time scales are shown – to help understanding the influence of specific parameters to the building performance, but also to show typical errors in operation. The "usage patterns" are additionally compared to typical (renewable) "supply patterns" to point out the challenges of avoiding peak loads as well as maximizing the match of demand and supply.

**User behavior and user influence:**

Comparing calculated or designed loads to measured consumption often shows large deviations. That brings up the question, how predictable the energy consumption of a building is. The second part of the presentation will deal with analysis of user behavior (e.g. window opening) and the influence on building performance. This includes measured data as well as parametric simulation studies.

# Speaker's Bio

**<u>Paul Fazio</u>**, C.M., PhD, ing.(Que), P.Eng (Ont), FCSCE, FASCE, FEIC, FCAE

Dr. Paul Fazio is professor of building engineering at Concordia University, where he founded the Centre for Building Studies and established Building Engineering as a new accredited engineering discipline in Canada.

He assisted industry and government by participating on many councils and boards, by creating and heading a technology transfer company for 15 years, and by consulting on numerous major projects.

He is a recipient of the Galbraith Prize and Gzowski Medals for research. He was named fellow of the Canadian Society for Civil Engineers, of the American Society for Civil Engineers, of the Engineering Institute of Canada, and of the Canadian Academy of Engineering.

In 2007 he was inducted into the Order of Canada for life-long contributions to engineering education and research.

## Topic Abstract

In design, rain penetration control is the most important function of the building envelope; yet, it is often neglected in the design and construction of new buildings. Rain penetration is much more important than air leakage control, continuity of the thermal insulation, and diffusion.  It compromises all other functions including the energy generating capacity of the envelope. Rain penetration is especially damaging in cases where: water runoff occurs due to lack of proper details to deflect water away from the façade; draining is not adequate due to poor or non-existing weather barrier and residual water remains absorbed in the hygroscopic materials of the envelope; the drying period is not sufficient to evacuate the residual water before the subsequent wet cycle begins; and where the durability of the materials is inadequate to stave off water damage and freeze-thaw action. These deficiency conditions are seldom identified in existing analysis and modeling tools of the building envelope; but can be avoided by the professional with good judgment, knowledge, and experience in the field of the building envelope.

Through a case study of a major building investigated by the author, the lecture will demonstrate how simple deficiencies in the various provisions meant to sustain these design principles led to major failures of the envelope and its eventual replacement. The deficiencies include the copings; terraces; movement allowance in the brick veneer; vapor, air, and weather barriers; insulation effectiveness; and material durability. The corrective measures adopted will be briefly described.  The audience will be invited to reflect on the challenges in the development and implementation of the new generation of net-zero energy building envelopes while problems inherent in the traditional practice in the building industry continue to persist.

## Speaker’s Bio

Dr. **François Garde** is a Professor at the University of Reunion Island and is Director of the Department of Sustainable Design and Environment at the Faculty of Engineering ESIROI. He also has in charge all that concerns energy in the campus of the University of Reunion Island –ie energy savings in buildings, construction of sustainable buildings and renewable energy.

He spent 6 months in 2007 at the School of Architecture and Design in Wellington NZ for doing research mainly on zero energy buildings and on elaboration of thermal standards. He is an engineer graduated from the French “Grande Ecole” - Ecole Centrale de Lyon and has a MBA in company Management.

He used to work 3 years in a HVAC design office before doing is PhD as a research engineer in the French Public Utility “Electricité de France” in Reunion Island. During that period, he was responsible of the Demand Side management in tertiary and residential sectors. He launched a thermal standard called ECODOM whose aim was to enhance the thermal conception of new dwellings in the French overseas territories by using simple and pedagogical rules.

More recently, he has worked on a thermal standard extended to all kinds of buildings, tertiary and residential, for all climatic zones of Reunion island and on several green buildings projects. He is sub-task leader of the Task40 Annex52 of the International Energy Agency on Net Zero Energy Buildings (started in October 2008).

He has been working at the University of Reunion Island for 14 years. His fields of research are listed below :

- validation of building thermal simulation codes;
- modeling of small air conditioning split-system units;
- transfer of knowledge from research to the professional fields;
- zero-net energy buildings;
- low energy buildings, green buildings;
- renewable energy, photovoltaics;
- set-up of thermal standards.

## Topic Abstract

The aim of the lecture is to give to the PhD Student the basic tools to design NZEBs in Hot and Humid climates.

The structure of the lecture will be the following :

- Remind of the important indexes, tools and definitions (solar factor of opaque walls, solar factor of windows, the solar diagram) ;
- Building design in tropical climates : the importance of natural cross ventilation and solar shading ;
- Thermal comfort in tropical climates. Remind of the basic principles and the important outputs : the operative tempature, the Givoni zones ;
- Presentation of the PERENE design guide (PERENE is the French acronym of ENErgy PERformance of Buildings) ;
- Presentation of new tools and methods for the design of NZEB in hot and humid climates ;
- Case study on a NZEB in a tropical climate : the ENERPOS Building.

# Speaker's Bio

**<u>Caroline Hachem</u>** is a PhD candidate in Building Engineering at Concordia University. She is architect by training and profession, and has a Master degree in Architecture and Urban Planning from the Technion Institute of technology of Israel (graduated Summa cum Laude) and a Master degree in Building Engineering from Concordia University.

Caroline Hachem has obtained several awards including "the International Hangai Prize" for young researchers in the field of space structures and the "Thesis Research Prize of Excellence" from the Technion Institute of Technology.

Caroline Hachem focuses in her PhD research on the investigations of solar potential and energy implications of housing units' shapes and neighborhood patterns. Her research is multidisciplinary, it plays a bridging role between building engineering and architectural and urban design. She had published few journal and conference papers on her research topic.

Hachem C., A. Athienitis, P. Fazio, (2011), Parametric investigation of geometric form effects on solar potential of housing units, Solar Energy, doi:10.1016/j.solener.2011.04.027

Hachem C., A. Athienitis, P. Fazio, (2011), Investigation of Solar Potential of Housing Units in Different Neighborhood Designs, Energy and Buildings, *doi:10.1016/j.enbuild.2011.05.008*

## Speaker's Bio

Dr. **Panagiota Karava** is an Assistant Professor in the School of Civil Engineering and the Division of Construction Engineering and Management at Purdue University. She received her MASc and PhD degree (2008) in Building Engineering from Concordia University, Montreal, Canada. Dr. Karava is one of the founding faculty members of the new Architectural Engineering program at Purdue University and she has significantly contributed to the development of new curriculum and the design and planning of new research facilities including the new Architectural Engineering Research Labs and the New Center for High Performance Buildings. Dr. Karava's research focuses on the fundamentals of heat and mass transport and its application to the analysis, design, and operation of high performance buildings. Specific research interests include mixed -model cooling systems using natural ventilation, building-integrated Photovoltaic-Thermal systems, building energy and airflow modelling. Her work is currently funded from the US Department of Energy through the "Energy Innovation Hub", the Purdue Research foundation, and the US Geological Survey (Department of Interior). Prior to joining Purdue, Dr. Karava worked as an assistant professor at the University of Western Ontario where she was awarded with a University Faculty Award (2008) from NSERC. Dr. Karava is the author of 10 journal and over 25 conference publications and the recipient of a best paper award at the International Conference on Passive and Low Energy Cooling for the Built Environment (2005). She is a member of technical committees in professional organizations such as ASHRAE and ASCE and a reviewer for several international scientific journals.

# Topic Abstract (continued, Dr. Panagiota Karava)

Mixed-mode cooling strategies represent an area of significant interest in Net Zero Energy Building design as they can substantially reduce energy consumption. Mixed-mode (MM) buildings adopt a hybrid approach to space conditioning, employing a combination of natural ventilation, driven by wind or thermal buoyancy forces, and mechanical systems alongside each other and intelligently switching between systems to minimize energy use, while preserving the comfort and well being of occupants (Heiselberg, 2002). An additional element in mixed-mode buildings is night cooling, which makes use of the building's thermal mass and is applicable in many climates. MM buildings have demonstrated reductions in cooling- and ventilation-related energy use from 20% to 50% over code buildings (Heiselberg, 2002; Torcellini et al., 2004) and consistently outperform conventional buildings on thermal comfort and occupant satisfaction. However, these hybrid building systems require an integrated design approach, including façade optimization for solar heat gains, exposed thermal mass made possible by the structural design and interior space planning, together with improved understanding of the physics of natural ventilation to enable high performance (Carrilho da Graça, 2003; Tzempelikos et al., 2007)).

The seminar presents an overview of physically based models used for natural ventilation design and analysis which rely on heat transfer, fluid mechanics and thermodynamics to establish equations that model building temperatures, airflows and energy use (Linden, 1999; Karava, 2008; Karava et al., 2011). Two forms of ventilation are discussed: mixing ventilation, in which the interior is at an approximately uniform temperature, and displacement ventilation, where there is strong internal stratification. The dynamics of buoyancy-driven flows are considered, and the effects of wind on them are examined.

# Topic Abstract (continued, Dr. Panagiota Karava)

The basic principles of multi-zone airflow models (Hensen, 1991; Clarke, 2001) is discussed in detail together with their integration into widely used building energy simulation tools (ESP-r, EnergyPlus) and the role of Computational Fluid Dynamics models is outlined (Rundle et al., 2011).

The seminar also  presents the approach employed to design the natural ventilation system in the Engineering Building of Concordia University and the experimental study that was undertaken to evaluate its performance and to develop optimal control strategies (Mouriki et al.,. 2009). The study considers parameters such as combined wind and buoyancy-driven flow, large openings and atrium configurations used to promote buoyancy force and optimize air movement, solar heat gains and motorized shading devices, as well as night cooling and the impact of thermal mass.

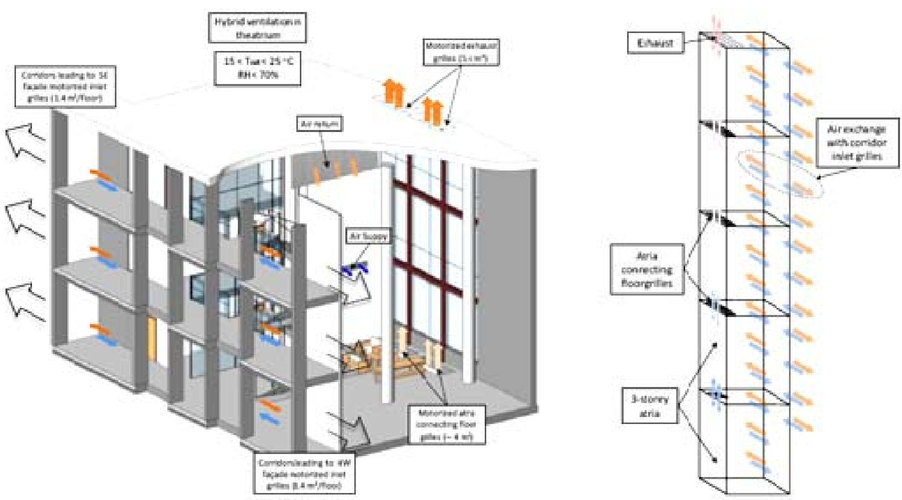



**Figure 1** Hybrid ventilation strategy used in the Engineering Building at Concordia University

# Speaker's Bio

Dr. **Ted Kesik** is a professor of building science in the John H. Daniels Faculty of Architecture, Landscape and Design at the University of Toronto. He completed his undergraduate studies in civil engineering at the University of Ottawa in 1983, followed by graduate studies at the University of Toronto from 1983 to 1992. In 1986 he was licensed as a professional engineer and has maintained practice in the areas of building science, building systems integration and landscape infrastructure. Dr. Kesik joined the Daniels Faculty in 1999 where he now teaches in the Architecture and Landscape programs, conducting research and supporting graduate students.

Professor Kesik's research interests include building envelope performance and durability, life cycle assessment, solar buildings and sustainability. Currently, Dr. Kesik is concluding his final segment of research within the Solar Buildings Research Network, a 5-year program involving 11 Canadian universities funded by the Natural Sciences and Engineering Research Council. Professor Kesik is the author of a comprehensive cost-benefit study of the *Toronto Green Standard* and also co-authored the *Tower Renewal Guidelines* as part of a collaborative research project examining building envelope retrofits of 1960s to 1980s concrete high-rise apartment buildings. He is also affiliated with urban sustainability research projects being conducted through the University of Toronto's Cities Centre. Most recently, Dr. Kesik helped form a team at the Centre for Landscape Research that is establishing a photovoltaic/green roof testing laboratory and protocol to optimize the performance of these symbiotic technologies.

Dr. Kesik continues to practice as a consulting engineer to leading architectural offices and progressive government agencies. He is also involved in the development and delivery of continuing education for architects and engineers. Professor Kesik is actively involved in technical organizations and is the author of numerous books, studies, reports and articles related to his areas of research and professional practice.

## Topic Abstract

In order to cost effectively deliver net-zero energy buildings that perform as predicted, it is critical to appreciate the importance of the integrated design process. Implicit in this process is the concept of optimization viewed from the context of the building-as-a-system.

This seminar explores the various dimensions of the integrated design process from the perspective of net-zero energy housing. This building typology involves the integration of social, cultural, economic and environmental considerations that are often contradictory in terms of energy performance. The wide variation in the knowledge level of the occupant also poses significant design challenges. Unlike commercial buildings, where a qualified operator and a service network operate and maintain the facilities and equipment, housing is almost entirely within the domain of the household.

Key considerations, beginning at the conceptual design stage and moving through to the drawings and specifications, and eventual commissioning of the building, will be examined to understand how to best apply energy simulation to the larger design process. Strategies for embedding migration paths to future technologies will also be explored to avoid the functional obsolescence of net-zero energy housing.

# Speaker’s Bio

Born in 1962, Dr. **Ralf Klein** grew up in Hamburg (Germany). He studied Civil Engineering at TU Braunschweig, and spent 9 month at "Ecole Centrale de Nantes" (France) as ERASMUS exchange student. He received his Ph.D. at the Structural Mechanics Lab of TU Braunschweig in the field of simulation of soil-structure interaction (coupling of frequency domain FEM and BEM).

Dr. Klein did post-Doc at the Structural Mechanics Lab of KU Leuven worked some years in engineering companies (software development for engineering applications: structural calculations, CAD, acoustics, ...).

Since 2005, he has been an assistant professor at the University college "KaHo Sint-Lieven Gent", in the civil engineering department, Sustainable Building research group. KaHo Sint-Lieven is member of the Association K.U. Leuven. Dr. Klein is the "associated researcher" at the Building Physics Lab (http://bwk.kuleuven.be/bwf/).

# Topic Abstract

- Introduction: why do we need to analyze the design process? Placing the simulation methods for energy performance into the context of designing NZEBs.
- Why should we link simulations to building models (BIM)?
- How to describe the design proces and the exchange of relevant information? A very short introduction to BIM, IFC, IDM and BPMN.
- A closer look to the example from GSA.
- Some examples from a "real-life" project (the Belgian case study of Annex 52)

## Speaker's Bio

**<u>Bart Lomanowski</u>** is a Building Simulation Researcher at CanmetENERGY, Natural Resources Canada. He is actively involved in the development of building simulation tools such as HOT3000 and ESP-r, as well as in the advancement of models for net-zero energy housing technologies. Bart completed his Master's degree in Mechanical Engineering at the University of Waterloo.

## Topic Abstract

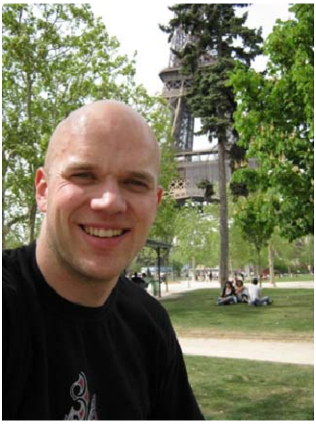
HOT3000 is designed to help Canada's residential construction industry advance the design of energy efficient and net-zero energy homes.

This energy analysis tool provides industry with the necessary means to evaluate the energy consumption and energy savings potential at the early design stages of new houses or renovating existing ones.

It can assess the potential impacts of designs that use both current and the next generation of energy efficient building technologies. For example, it evaluates hourly energy demands and fuel consumption which are necessary for optimizing energy savings, emission reductions and evaluating the performance of advanced passive-solar designs.

The software has been developed by Natural Resources Canada in collaboration with l'Agence de l'efficacité énergétique (AEE) in Québec, the Energy Systems Research Unit (ESRU) in Glasgow, Scotland and other leading research centres that use the state-of-the-art ESP-r energy analysis engine.

## Speaker's Bio



**William O'Brien** finished a Bachelors and Masters in aerospace engineering in Toronto. The product of the latter is about 10 kg of satellite hardware, which was launched into orbit in 2008. He is currently completing a PhD at Concordia University in building engineering. He is heavily involved in the Solar Buildings Research Network and International Energy Agency Task 40 on Net Zero Energy Buildings. He has 20 refereed conference and journal papers.

William is researching design processes and energy simulation for low-energy solar houses. He developed a design tool for solar houses that will enable efficient exploratory design of both passive and active solar systems. The tool is directly inspired by some of William's experiences using simulation tools for consulting. Visualization of design spaces is a central part of the design tool.

William has participated in several high-profile building projects, such as the University of Toronto's Mining Engineering Building, NRCan's Varennes building, the Tower Renewal Program, and a volunteer facility in Uganda. He has become a proficient user of several industry-leading building simulation tools, such as EnergyPlus and ESP-r.

William is interested in studying energy use and production on all levels of society from building to communities and city-level. He is interested in how urban form affects transportation energy use and solar energy availability He aspires to use his skills to aggressively push the envelope towards more sustainable buildings and urban environments. He would like to use his research and models to influence policy makers and planners.

## Speaker’s Bio

Dr. **Pragasen Pillay** received the B.S. and M.S. degrees from the University of KwaZulu-Natal, KwaZulu-Natal, South Africa, in 1981 and 1983, respectively, and the Ph.D. degree from Virginia Polytechnic Institute and State University, Blacksburg, in 1987, while funded by a Fulbright Scholarship.

From January 1988 to August 1990, he was with the University of Newcastle upon Tyne, U.K. From August 1990 to August 1995, he was with the University of New Orleans, New Orleans, LA. Thereafter, he was a Professor with the Department of Electrical and Computer Engineering, Clarkson University, Potsdam, NY. Since 1999, he has been an Adjunct Professor with the University of Cape Town, Rondebosch, South Africa. He is currently a Professor and Hydro-Québec Senior Chair in the Department of Electricala and Computer Engineering, Concordia University, Montreal, QC, Canada. His research and teaching interests include modeling, design, and control of electric motors and drives for industrial and alternate energy applications and power quality.

Dr. Pillay is a member of the IEEE Power Engineering, IEEE Industry Applications, IEEE Industrial Electronics, and IEEE Power Electronics Societies. He is a member of the Electric Machines Committee and past Chairman of the Industrial Drives Committee within the IEEE Industry Applications Society, and past Chairman of the Induction Machinery Subcommittee in the IEEE Power Engineering Society. He is a Fellow of the Institution of Electrical Engineers, U.K., and a Chartered Electrical Engineer in the U.K. He is also a member of the Academy of Science of South Africa.

## Speaker's Bio

Dr. **Yves Poissant** is a PV Technology Specialist and Project Manager within Natural Resources Canada's CanmetENERGY since February 2002 where he coordinates research in the area of solar photovoltaic energy. His research interests include PV system and module performance assessment, standards development, the integration of photovoltaics to buildings; and solar cell R&D activities in Canada. He co-chairs the Canadian TC82 committee on standard development for PV systems and components, participates to CSA committees dealing with solar energy, and he is a member of the PV Innovation Network.

Yves obtained a Ph.D. in Physics from École Polytechnique de Paris (2001). He now lives in his own solar house in Québec with his spouse and two children.

# Topic Abstract

Photovoltaic systems allow to generate renewable electricity directly from the sun. The integration of PV systems in Net Zero Energy Buildings is an important aspect of sustainable building design. This lecture will provide an introduction to building integrated photo-voltaic systems and components. The EcoTerra house will be used as an example to illustrate PV system design and performance assessment.

Samsung Green Tomorrow, Korea

# Speaker's Bio

Dr. **<u>Paul Torcellini</u>** is the Principal Group Manager for Commercial Buildings Research at the National Renewable Energy Laboratory, a Department of Energy national laboratory. Paul leads the Commercial Building's Research Efforts. This effort is dedicated to developing methods and technologies to achieve substantial energy savings in commercial buildings—both new and retrofit. Paul has been at the NREL for 16 years. He is also an adjunct faculty member at Colorado School of Mines and Denver University. Paul is a registered Professional Engineer and holds a PhD from Purdue University.

NREL Research Support Facility, Colorado

# Topic Abstract

## HVAC Systems and Controls

This lecture will focus on the types of HVAC systems that are considered for zero-energy buildings and strategies for controlling these systems. The lecture will draw from examples of U.S. buildings completed and tested by the National Renewable Energy Laboratory (a U.S. Department of Energy facility) and will include lessons learned about what is and is not working in practice. These buildings will include the Research Support Facility (typical large-scale office building), the Zion National Park Visitor Center, and the Oberlin College Lewis Center. An emphasis will be put on how non-HVAC systems and components contribute to helping and hurting the performance of the HVAC system.

## Net Zero Energy Buildings Construction, Management, and Economics

This lecture will focus on the process of making decisions for the development of low and zero-energy buildings. Goal setting and creating an environment where construction and design staffs collaborate are critical for achieving significant energy savings. The lecture will also discuss adding value to projects, rather than traditional economic discussions about efficiency. The end result is a dynamic integrated design process which unleashes the ability for everyone delivering the building to reach a high energy efficiency level. Part of the discussion will also look at experiences with incentives and contract instruments.

# List of Workshop participants

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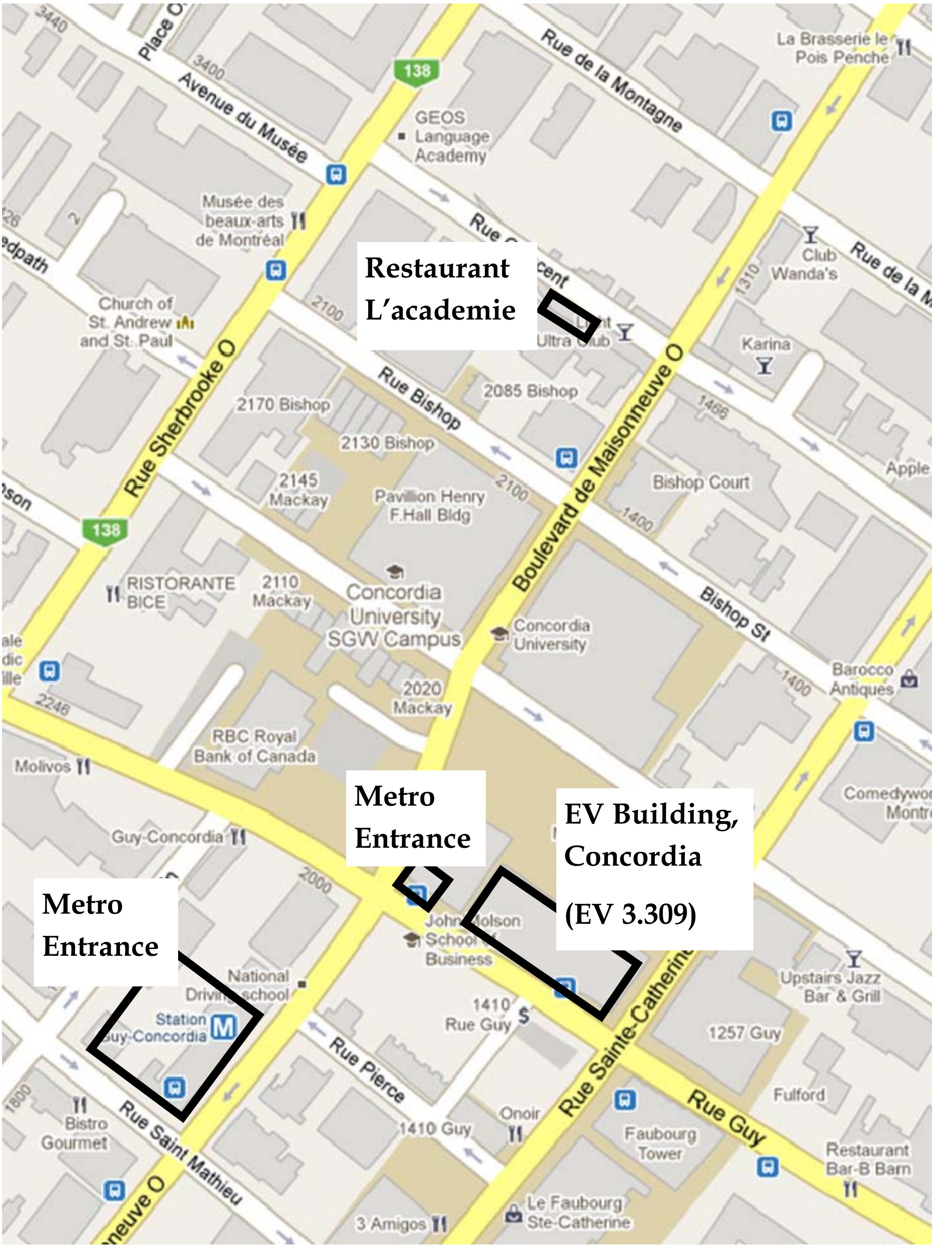
# Downtown Montreal Map



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