CZEBS - Centre for Zero Energy Building Studies Overview

Andreas Athienitis
Director

and

Leon Wang
Associate Director

https://www.concordia.ca/research/zero-energy-building.html

Center for Zero Energy Building Studies
Centre d'études sur le bâtiment
à consommation nulle d'énergie

CZEBS - CENTRE FOR ZERO ENERGY BUILDING STUDIES

Université Concordia University

The mission of the CZEBS is to reduce the environmental impact of buildings while enhancing their safety and comfort by advancing knowledge through research and the building engineering discipline in Canada, by enriching the learning and research experience of students, and by assisting industry in implementing research results and innovations.

Members distinctions: 3 Fellows of CAE, 1 of ASHRAE, 3 of IBPSA, 1 of ASCE; 2 Concordia Chairs, 1 NSERC IRC

Andreas Athienitis

Director
Professor

Theodore Stathopoulos

Professor

Radu Zmeureanu

Professor

Leon Wang

Associate Director
Professor

Hua Ge

Professor

Bruno Lee

Associate Professor

Mohamed Ouf

Assistant Professor

Caroline Hachem-Vermette

Associate Professor

Above photos provided by David Ward, Concordia University

Concordia University Senate approved CZEBS in January 2012

About 100 HQP, a total of over 20 full and associate members

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CONCORDIA CZEBS LEADERSHIP IN SUSTAINABLE BUILDINGS

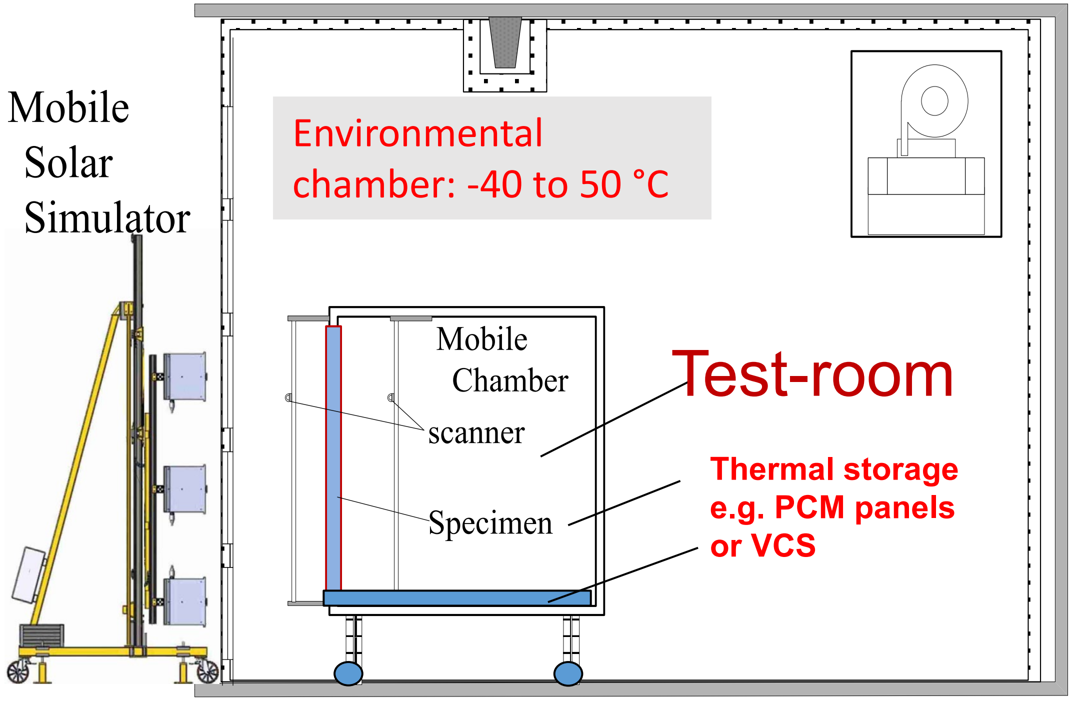
- Led **two NSERC strategic research networks** in solar and smart net-zero energy buildings - **$20 M over the period 2005 – 2017** with about 30 researchers from 15 universities and 30 industry/govt sector partners.
- Leading edge demonstration projects: EcoTerra EQuilibrium house (2007), JMSB solar system - Concordia (2009), Varennes Library (2016).
- **NSERC/Hydro Quebec Industrial Chair** ($4 M 2013 – 23).
- **Renewable Energy Microgrid Integration for Remote, Off-grid Cabins in Nunavut (programme de recherche Canada-Inuit Nunangat-Royaume-Uni dans l'Arctique (CINUK).** $800k.
- **Dr. Athienitis led the funded University CFREF proposal ($123 M) "Electrifying Society: Towards Decarbonized Resilient Communities" for 2023-30. Now Scientific Chair. 5 projects led by CZEBS.**

- Key leading role in initiative for Canada Excellence Research Chair in next-gen cities for 2019-2026.
- **Lead CAE Roadmap Ultra-low Energy Built Environment with Deep Integration of Renewables**
- **The 5th COBEE conference, Chaired by Dr. Wang was hosted by the CZEBS - Over 400 participants from Canada, US, Europe, Asia and many countries**

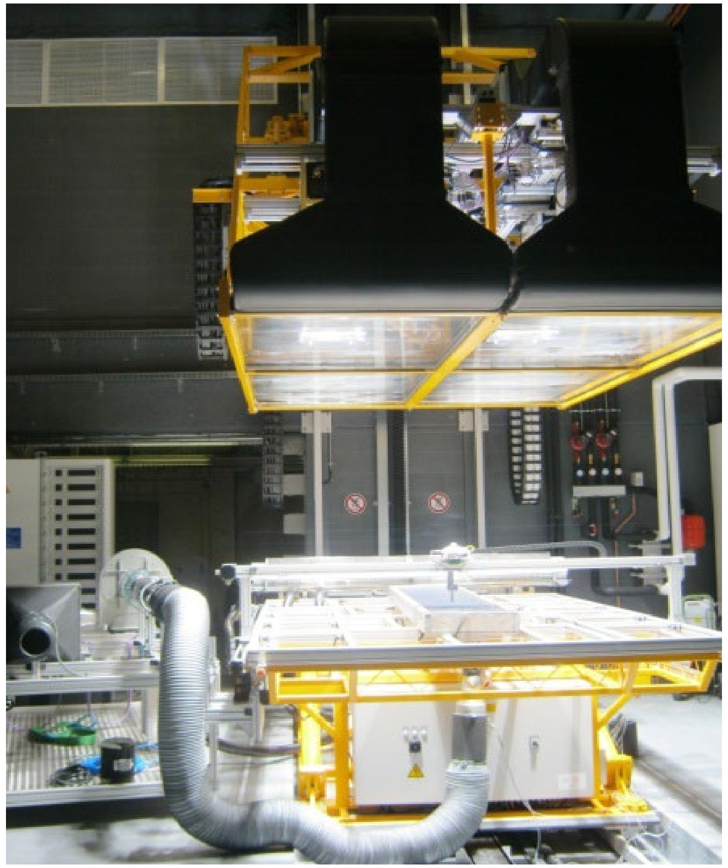
EXAMPLE OF MAJOR WORLD-LEADING TEST FACILITIES: ENVIRONMENTAL CHAMBER AND MOBILE SOLAR SIMULATOR

A **two-story environmental chamber** with a mobile solar simulator lamp field used to test building and solar technologies under controlled environmental conditions (**from arctic** to desert).

- Temperature: **-40 to +50°C**
- Relative humidity: 20 to 95%
- Sunlight produced by a 6-lamp mobile solar simulator enters chamber via windows.



EXPERIMENTAL FACILITIES - SOLAR SIMULATOR

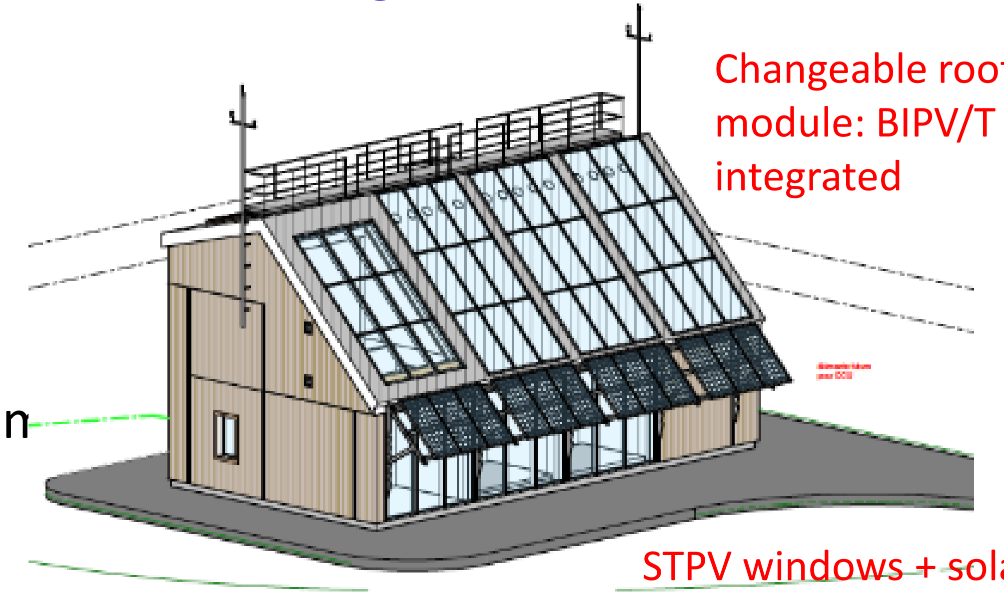


Designed for testing and evaluating solar technologies such as PV modules, PV/thermal, solar air/water collectors and a **range of building-integrated solar systems**.

- 8 special metal halide global (MHG) lamps simulating solar spectrum (lamps individually controlled & dimmable)
- Artificial sky to remove infrared radiation from lamps
- Homogeneity: less than ± 5% variation under 0.85 to 1.15 sun

CONCORDIA FUTURE BUILDINGS LAB

- Develop and test innovative building and energy technologies
- Test and optimize the integration, operation and energy management of multiple power sources and energy storage
- Develop and advance net-zero energy building practices by optimizing integrated building and energy system performance under real weather operating conditions.
- Lead the building industry towards intelligent net-zero energy buildings of the future
- **Northern and Indigenous sustainable buildings**



Changeable roof module: BIPV/T roof integrated

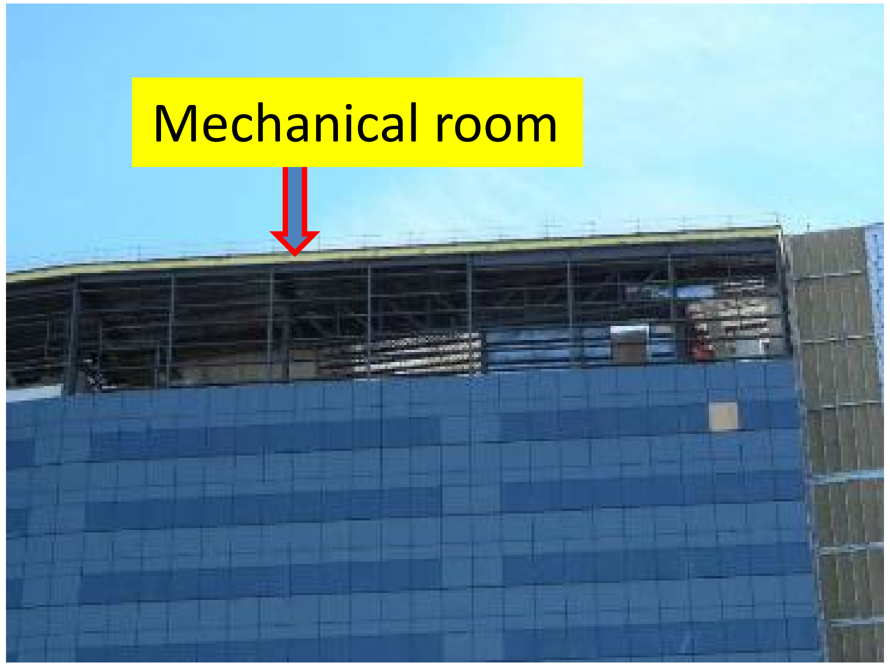
STPV windows + solar canopy

Research capabilities

- Various envelope and mechanical systems
- Interaction between envelope, indoor environment and HVAC systen
- integration/interaction of renewables: solar, wind, fuel cells
- Capabilities to test interaction of buildings with grid, nano-grid

JMSB BIPV/T SYSTEM (Concordia University 2009)

- Building surface ~ area 288 m^2 generates both solar electricity (up to 25 kilowatts) and solar heat (up to about 75 kW of ventilation air heating);
- **BIPV/T system** forms the exterior wall layer of the building; it is not an add-on;
- Mechanical room is directly behind the BIPV/T façade – easy to connect with HVAC
- Total peak efficiency about 55%;
- New system developed recently that simplifies design and has inlets in PV frames.



Occupant behavior:

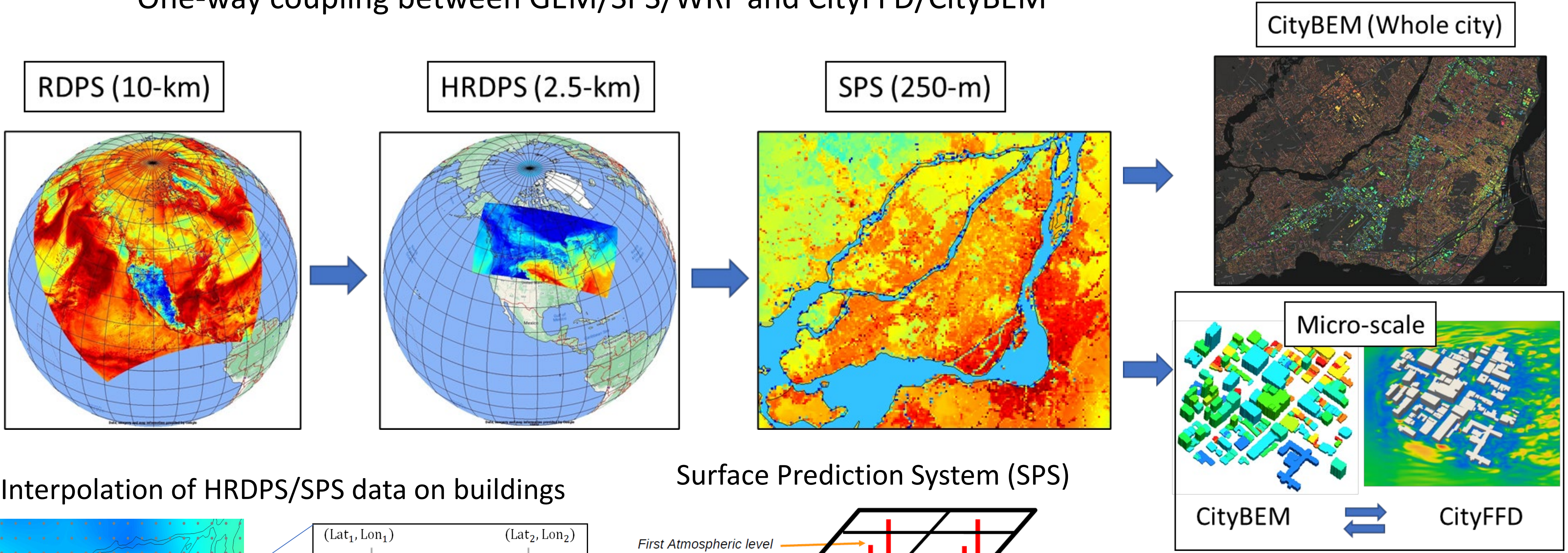
Note shade positions

IoT with smart sensors can *facilitate automation of shades*

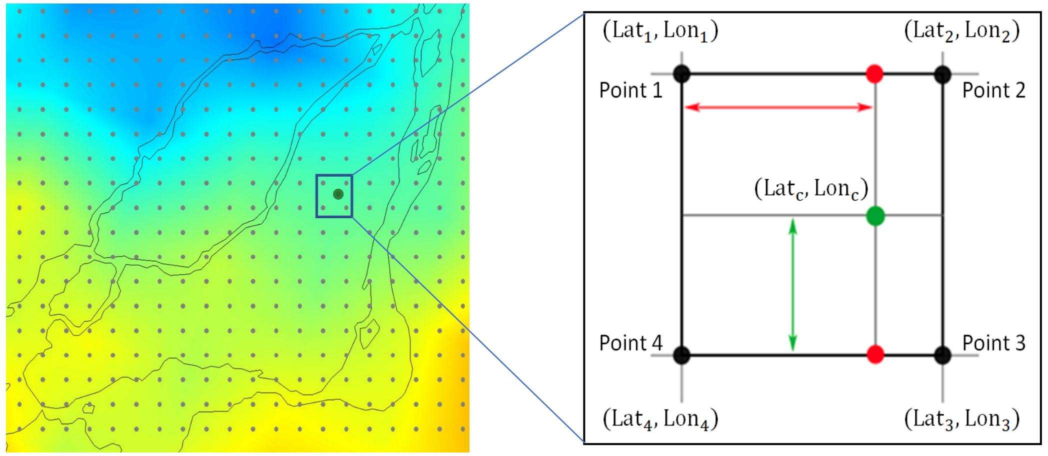
More R&D needed to make design of such systems routine; develop systems for retrofit

Multiscale Urban Environment and Energy Modeling (L. Wang)

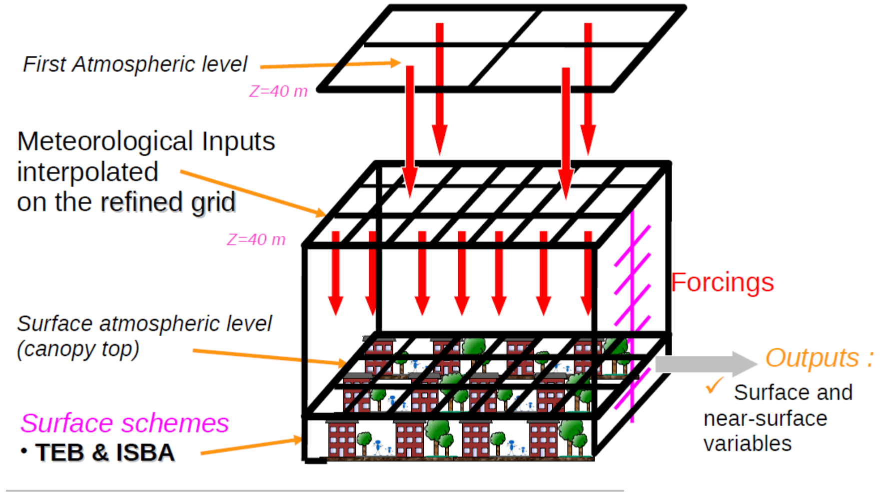
One-way coupling between GEM/SPS/WRF and CityFFD/CityBEM



Interpolation of HRDPS/SPS data on buildings



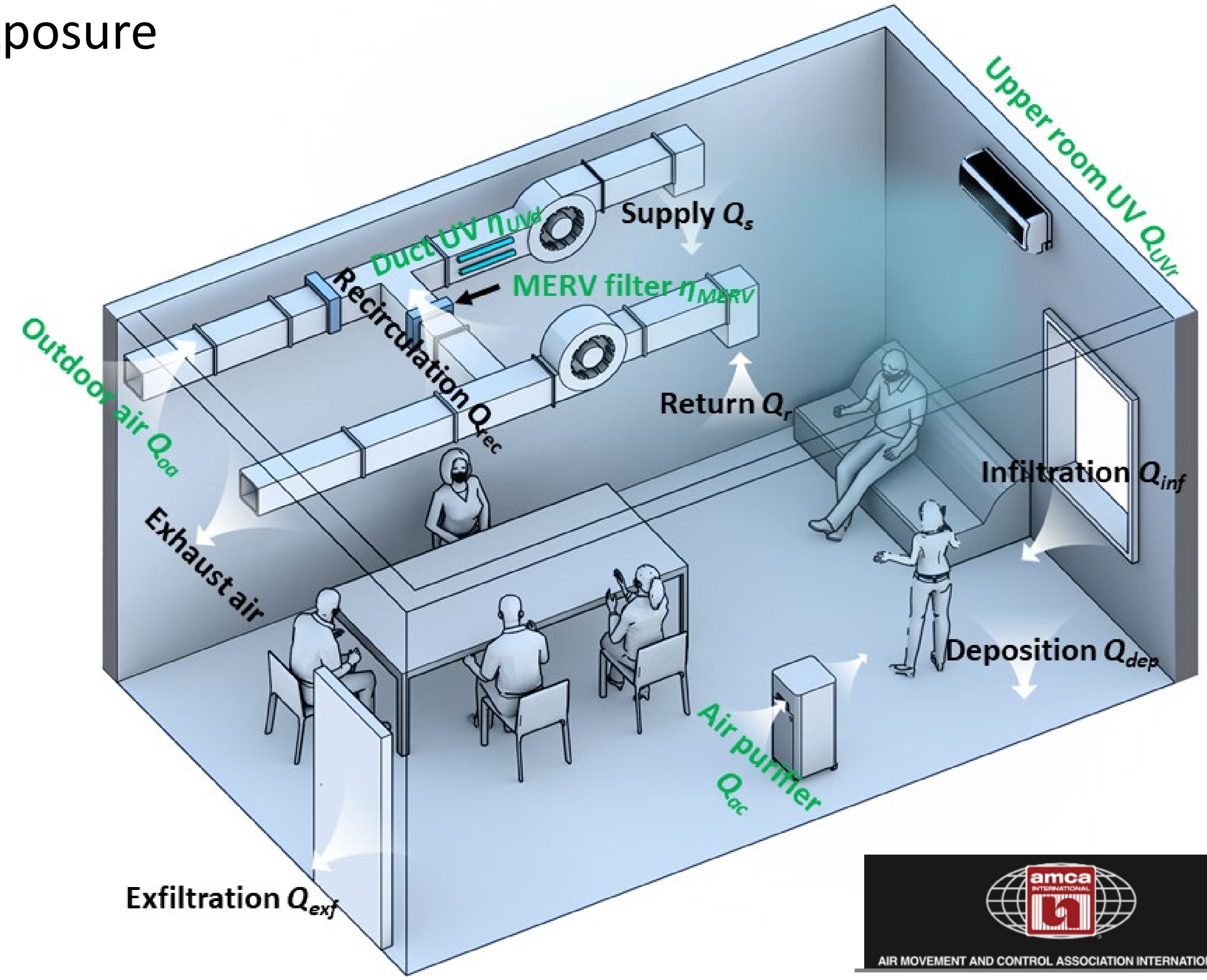
Surface Prediction System (SPS)

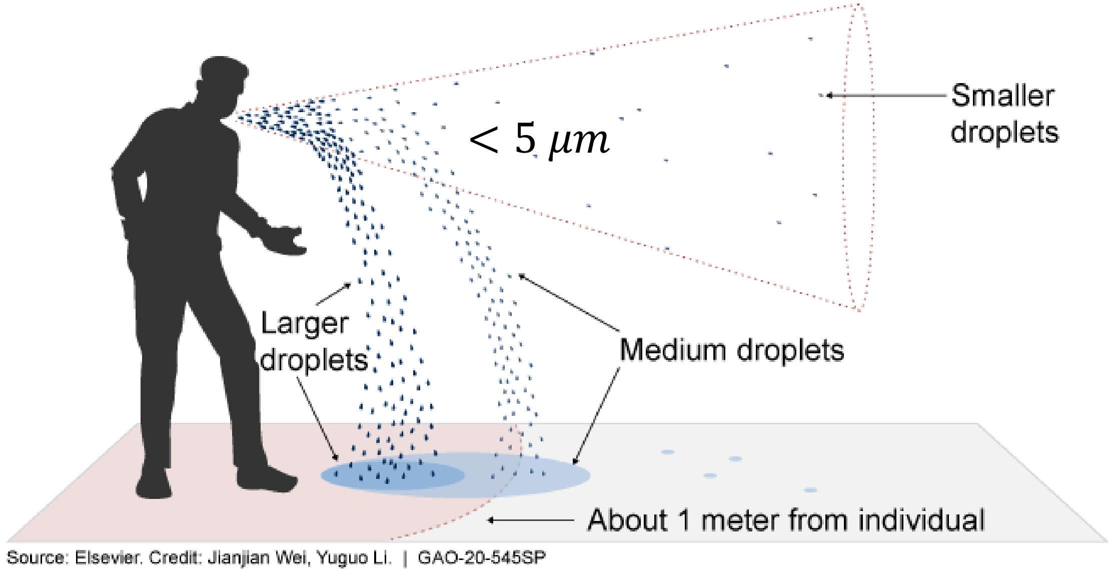


Evaluation, Monitoring and Mitigation of SARS-CoV-2 Airborne Transmission Risks in Cities and Buildings

NSERC CRSNG

- Airborne transmission: a major route of COVID-19 transmission
- High risks: poor ventilation, large gathering, and long-duration exposure





Strategies to reduce airborne infection risk in public

- Wear a face mask
- Stay less time
- Reduce occupants
- Increase outdoor air ventilation rate
- High-efficiency duct filters in HVAC systems (MERV-13)
- Use portable air cleaner

AMCA International — AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL

eureka innovation beyond borders

Carrier | BIG ASS FANS | MacroAir engineers of air | GREENHECK Building Value in Air. | Hunter | mars | POWERED AIRE Inc. AIRE CURTAINS | BERNER AIR CURTAINS

National Research Council Canada | Conseil national de recherches Canada

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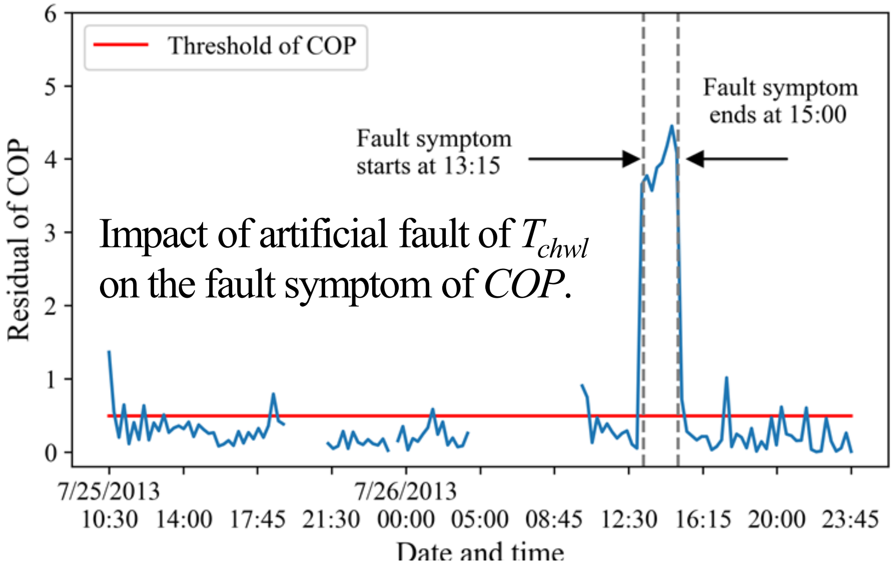
Optimization of HVAC systems for buildings

- **Continuous commissioning**
- **Data-driven models of energy performance**
- **Virtual sensors**
- **Faults detection and diagnosis**

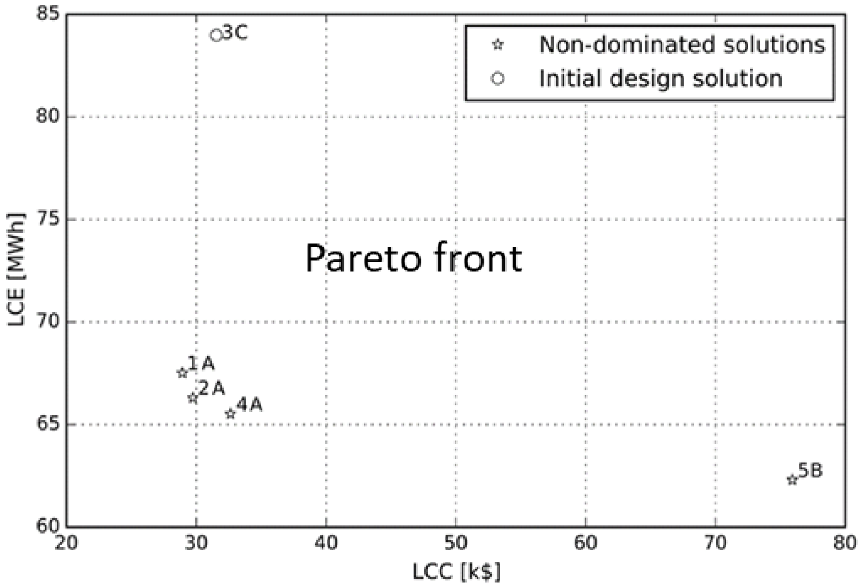
Inuvik houses

Drawing and photo by Arctic energy alliance and CMHC
https://www.cmhc-schl.gc.ca/en/inpr/bude/noho/upload/68157_W_ACC.pdf

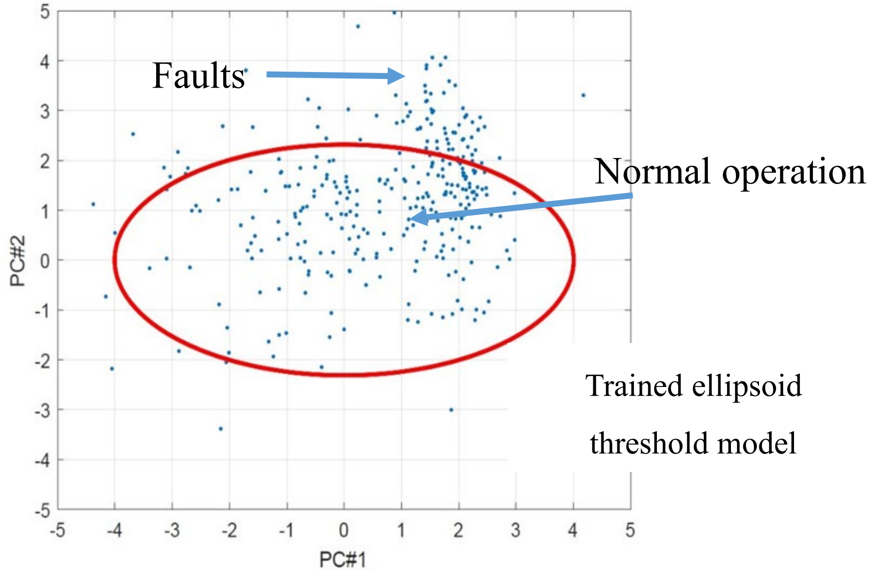
Faults detection – Genome building



Multi-objective optimization of solar systems



PCA-detection of faults of the heating system



EXPERIMENTAL FACILITIES - BOUNDARY-LAYER WIND TUNNEL LAB

The effect of wind on building models is reproduced in a boundary layer wind tunnel. This enables the measurement of: mean and fluctuating wind loads on buildings, air flow around individual and groups of tall buildings, environmental pedestrian level wind loads, and effluent dispersion (contamination of buildings by smoke and building exhaust from stacks). Computational evaluation of wind effects on buildings can also be performed.

Above: The boundary layer wind tunnel (BLWT) from the back end.

Right: Smoke generated around scaled model buildings inside BLWT for studying contaminant dispersions within an urban environment.

CityRPI

https://concordia-cityrpi.web.app

A web browser building-level risk model based on the Wells-Riley Model

Based on the COVID-19 Aerosol Transmission Estimator*

NSERC CRSNG

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Université Concordia University

CANADA

Hundreds of Canadian health experts call for action on airborne spread of COVID-19

By Staff · The Canadian Press
Posted January 4, 2021 12:41 pm EST

News
Coronavirus: Experts across Canada call on government to step up ...

Time for government to take aerosol transmission of COVID-19 seriously

Open letter from hundreds of experts calls on Canadian leaders to change course

Open letter
JANUARY 4, 2021

WHS PPO
Westmount High School Parent Participation Organization
4350 Saint-Catherine St, Westmount, Quebec H3Z 1R1

Virtual Meeting, Monday, December 14, 2020, 7 PM

AGENDA

1. Approval of Agenda
2. Presentation on General Building Airflow and Q & A Period,
   Special Guest Speaker: Dr. Leon Wang (Concordia University)
3. Chair's general and finance reports
4. Approval of past Minutes of November 12, 2020
5. **Next Meeting: Monday December 21**, 2020 at 7:30 PM
6. Adjournment

LE DEVOIR

L'air en milieu scolaire n'est pas exemplaire

ENC Education News Canada

Los Angeles Times

The Gazette

Search CBC Listen

Let's Go with Sabrina Marandola

Nov. 6, 2020: Indoor COVID-19 tool 12:49

radio one

CTV NEWS

CBC

nature

Global NEWS

COVID-19: un outil pour atténuer les risques de propagation en lieu clos

Concordia web application suggests ways to reduce indoor coronavirus transmission

With the City-RPI web application, you can click on any building in Montreal, and it will produce a ranked list of the most effective steps that can be taken to reduce COVID-19 transmission inside.

By Benson Cook · Global News
Posted November 4, 2020 6:06 pm · Updated November 4, 2020 7:18 pm

HALL BUILDING LIVING LABORATORY (M. OUF)

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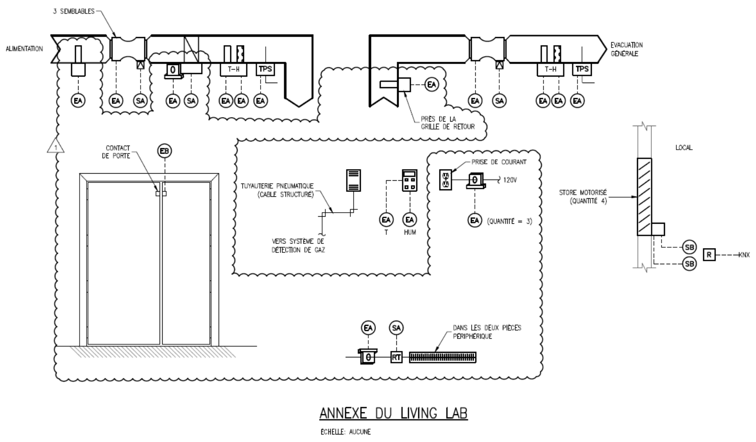


A testbed for Advanced Building Controls

- Develop and test occupant-centric control (OCC) strategies for various building systems
- Leverage wearables to monitor occupant behaviour and improve thermal comfort in multi-occupant spaces
- Identify the diversity of occupant comfort profiles exposed to similar indoor environmental conditions
- Optimize building controls based on inferred occupants' preferences to maximize comfort and simultaneously minimize energy use

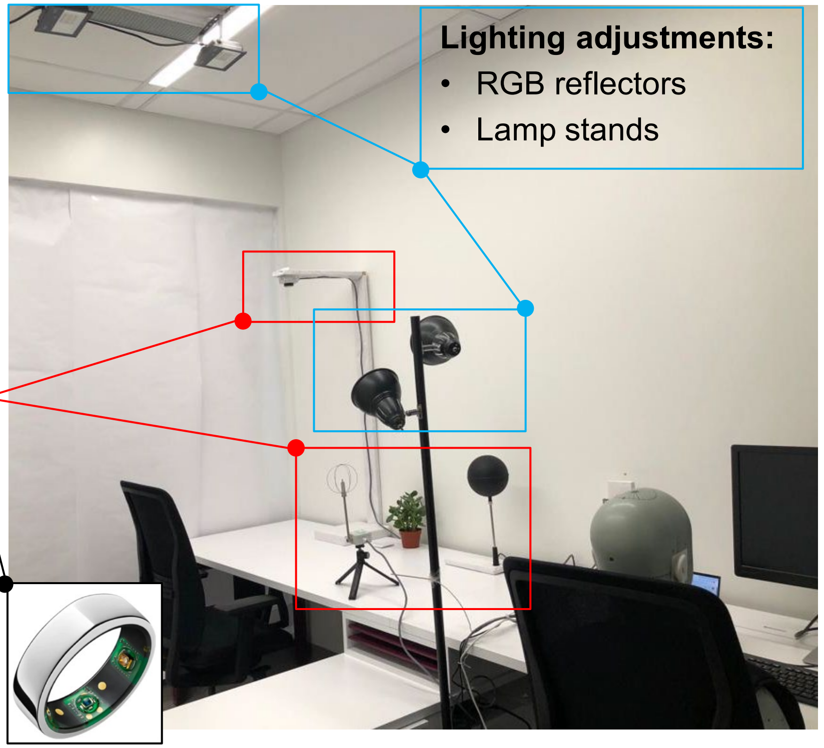
Research capabilities

- Heavily instrumentalized space with sensors and sub-meters on every sub-system
- Enabling experiments and testing of OCC and occupants' interaction with the indoor environment and HVAC systems
- Actuating different end-uses / sub-systems (e.g. VAVs, lighting, blinds...etc.) based on the developed OCC algorithms

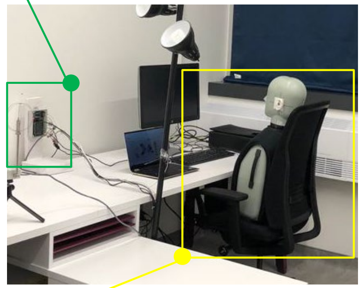
Environmental parameters:
- Indoor Air Temperature, Relative Humidity
- CO_2 / VOC concentration
- Air velocity, Globe temperature
- Illuminance
- Temperature at different heights (probes)

Occupants' data:
- Skin temperature, Heart rate: (Oura ring)
- Thermal perception: (questionnaire about comfort levels)

Lighting adjustments:
- RGB reflectors
- Lamp stands



Data logger



Background noise level measurement

Typical institutional building energy consumption:
250-300 kWh/m²/yr

Example of net-zero energy building:
Energy consumption: 70 kWh/m²/yr
Energy production: 54 kWh/m²/yr
Displaced grid electricity: 81 kWh/m²/yr

Canada's first institutional Net-zero Energy Building

Varennes Library: Major Case Study for CAE Roadmap

Varennes Library - Canada's first institutional solar NZEB

Officially opened May 2016: now a living lab

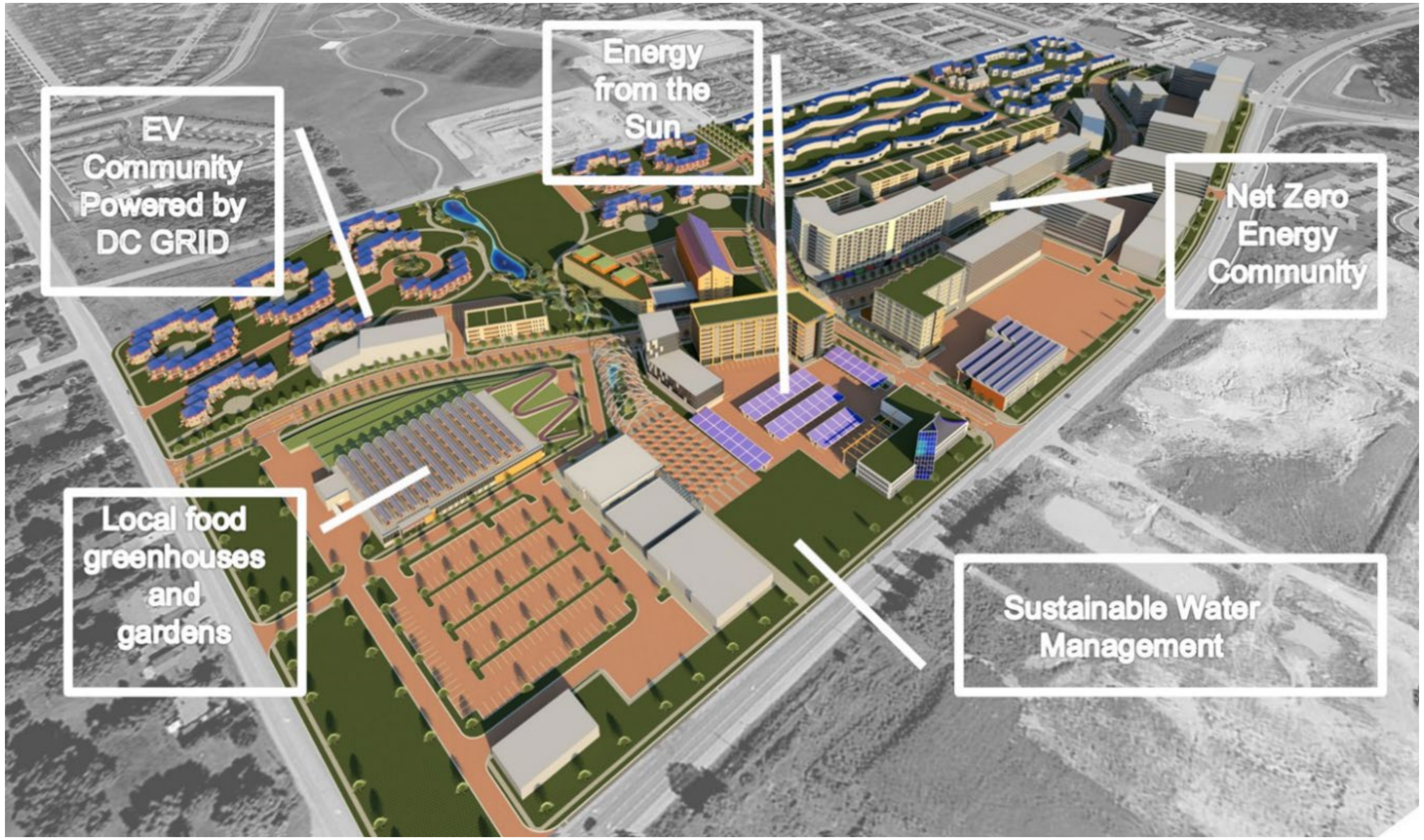
- 110 kW BIPV system (part BIPV/T)
- Geothermal system (30 ton)
- Radiant floor slab heating/cooling
- EV car charging
- Building received major awards (e.g. **Canadian Consulting Engineering Award of excellence**)

Market is ready for such projects provided standardized BIPV products are developed
Now modelling and optimizing operation and grid interaction under a NSERC Hydro Quebec Chair

We guided the energy design of the building

An ambitious Canadian Net-zero Energy Community: West 5 - case study with s2e (partner) in London, Ontario

- Optimized for solar energy utilization to reach net-zero
- Integration of electric vehicles owned by the community
- Energy storage at the building and community levels
- Net-zero, can operate as microgrid in islanded mode



STEPS FOR COMFORTABLE AND HEALTHY BUILDINGS IN COLD CLIMATES

- Set **high targets for amount of fresh air to limit spread of viruses** by using solar air heating in winter and hybrid ventilation in cooling season – adopt, expand, optimize solutions employed in EV and JMSB
- Ensure **daylight availability in all offices**; enhances productivity and health
- Optimize **thermal comfort** through smart predictive control
- **Safety**: use **renewable energy for deicing sidewalks**
- Design **buildings for access and safety of people with disabilities**

EV building
hybrid ventilation system

FUTURE DIRECTIONS

Decarbonization - smart net-zero energy buildings and communities.

Resilience, durability, nature-inspired/based solutions.

Healthy and comfortable buildings.

Building design and operation for a **high quality of life** for all: Indigenous, people with disabilities, elderly etc.

Integration with smart grids and electrified transportation.

Sustainable infrastructure.

Development of CFREF Volt-Age Impact and Living Lab projects, building and additional to the SEED projects

West 5 net-zero community, London Ontario (industry partner s2e)