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From Discovery to Innovation...

R&D Strategies and Initiatives for the Built Environment

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Director

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Scope and Outline

Scope:

- R&D at Canada's National Research Council
- R&D at the International Energy Agency's Energy Conservation for Buildings and Community Systems

Outline

- NRC and the Key Sector Approach to Research
- Canadian Construction Sector
- Key Activities in Priority Areas of Building Research
- IEA's Energy Conservation for Building and Community Systems
- Key thrusts and international projects at the IEA ECBCS

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National Research Council

- National organization, federal government agency
- Over 4,200 full-time employees; over 1,446 guest workers
- Labs and facilities across Canada
- Dissemination of S&T information to industry and scientific community
- Provides essential elements of national S&T infrastructure

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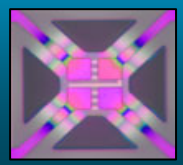
Nine Key Sectors

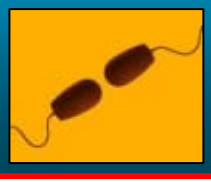
Aerospace

Medical Devices



Agriculture

Information & Communication



Criteria

- **Important to the Canadian economy**
- **Research essential for their success**
- **Sectors where NRC can make a significant contribution**

Automotive

Construction

Chemicals

Biopharma-ceuticals

Manufacturing & Materials

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NRC Institute for Research in Construction (NRC-IRC)

- Established 1947
- Guided by industry Advisory Board and 2 independent Commissions
- 30 % of R&D Construction in Canada
- 280 employees
- 50 visiting workers

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NRC-IRC's Strategic Objectives

- **Knowledge and technologies** for a quality and cost-effective built environment.
- Integrated **decision-making tools** enabling the sector to respond to changing performance expectations.
- **Construction process technologies** critical to improved productivity of the construction sector.
- **Responsive organization**, well positioned to enable the transition of the construction sector.

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NRC-IRC Programs

- Building Envelope and Structure
- Indoor Environment
- Fire Research
- Urban Infrastructure

- National Construction Codes and Product Evaluation

- Canadian Centre for Housing Technology (CCHT)
- Centre for Computer-assisted Construction Technologies

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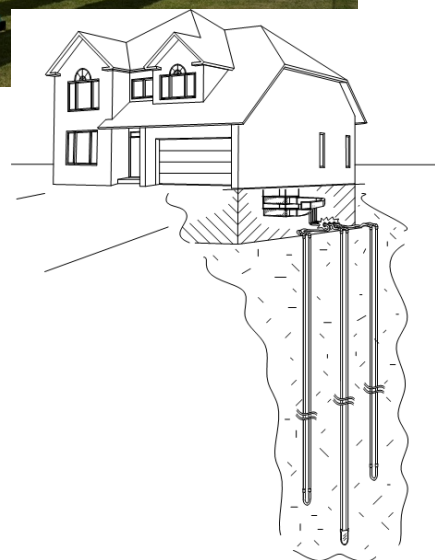
Canadian Centre for Housing Technology

- Unique Canadian facility for new technology demonstration.
- Partnership between NRC, CMHC and NRCan.
- Accelerate the development of new technologies and their acceptance in the marketplace.
- + 30 technologies assessed/demonstrated in 10 years of operation
- Information Centre showcases innovative products and adaptable housing (FlexHouse™).



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Centre for Computer-assisted Construction Technologies

- Development of innovative support tools for the maintenance management of Critical Facilities (CFs).

- Visualization tools for training and learning of construction technologies and processes

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The Canadian Construction Sector

12% of GDP

$146.1 billion capital expenditures

Supports $5.5 trillion built assets*

Largest employer > 1M employees

Low R & D expenditures

*Source: NRC-IRC Advanced Asset Management: Tools and Techniques

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Construction Sector and the Environment

- Facilities accounts for 35-40% of national energy consumption
- Generates 25% of Canada's solid waste
- Consumes >50% of primary natural resources
- Generates 30% of total GHGs
- Long product life means enduring impact
- Fragmentation and inconsistent profitability contribute in part to lack of R&D investments (less than 0.1% of revenue)

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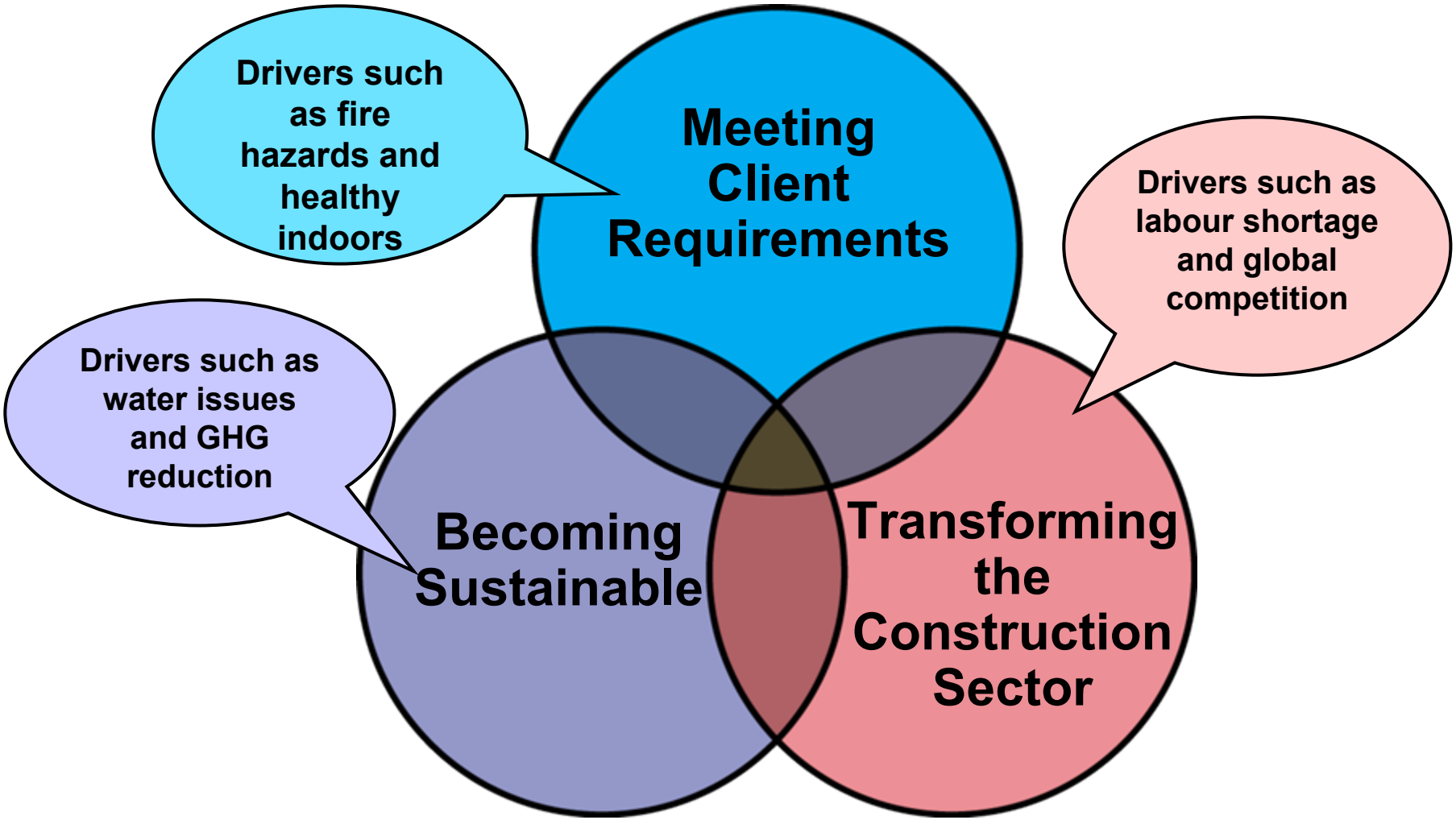
Drivers of Change in Construction Sector



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Technology Scan

- Materials technologies
- Systems technologies
- Prediction and decision tools
- Construction tools

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NRC Construction Sector

Strategy

- Foundation of support to Canada's building regulatory system, decision support tools and sector priorities
- Research to support the Canadian construction sector in emerging technology fields.
  - Information technologies
  - Bio-products
  - Advanced composites
  - Energy

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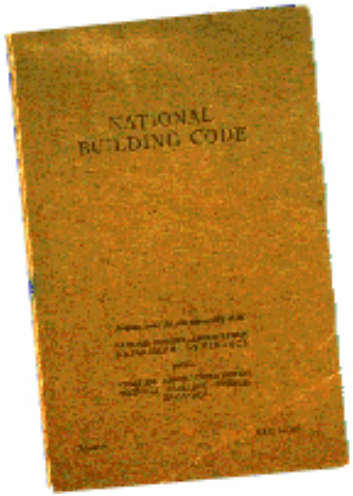
Response to Sector Needs

New or renewed priorities for buildings:

- Health,
- Energy,
- Greening the Sector,
- Construction Process Technologies.



Built upon enduring commitments to,

- Affordability and accessibility,
- public safety
- management of risk.

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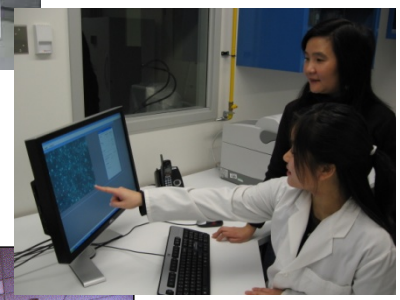
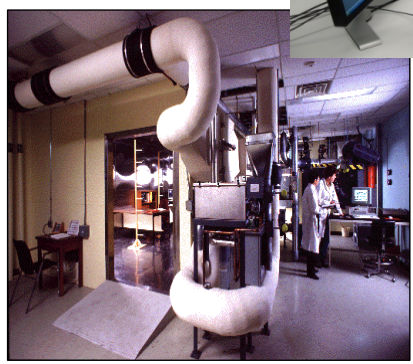
Healthy Building Research

- Integrating Building and Health Sciences
- Ventilation and Health
- Indoor Mould Research
- Sensors for Indoor Air Quality





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Healthy Building Research

Integrating Building and Health

- Canadian Building and Health Sciences Network
  - 170 members
  - Canadian researchers focused on how buildings affect health

- Canadian Committee on Indoor Air Quality and Buildings
  - National forum and clearinghouse for “best-of-knowledge,” in the design and operation of buildings as they affect IAQ
  - Scientific support from Health Canada

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Healthy Building Research

- **Ventilation and health Field Study**
  - Will ventilation improve indoor air quality and respiratory symptoms of asthmatic children?
  - 2-year monitoring in 100+ homes in Quebec City
  - With Insitut national de santé publique au Quebec (INSPQ), Centre Hospitalier Universitaire du Quebec, and CMHC

- **Evaluation protocols of indoor air products**
  - Portable air cleaners, duct cleaning, heat recovery ventilators)
  - National Steering Committee

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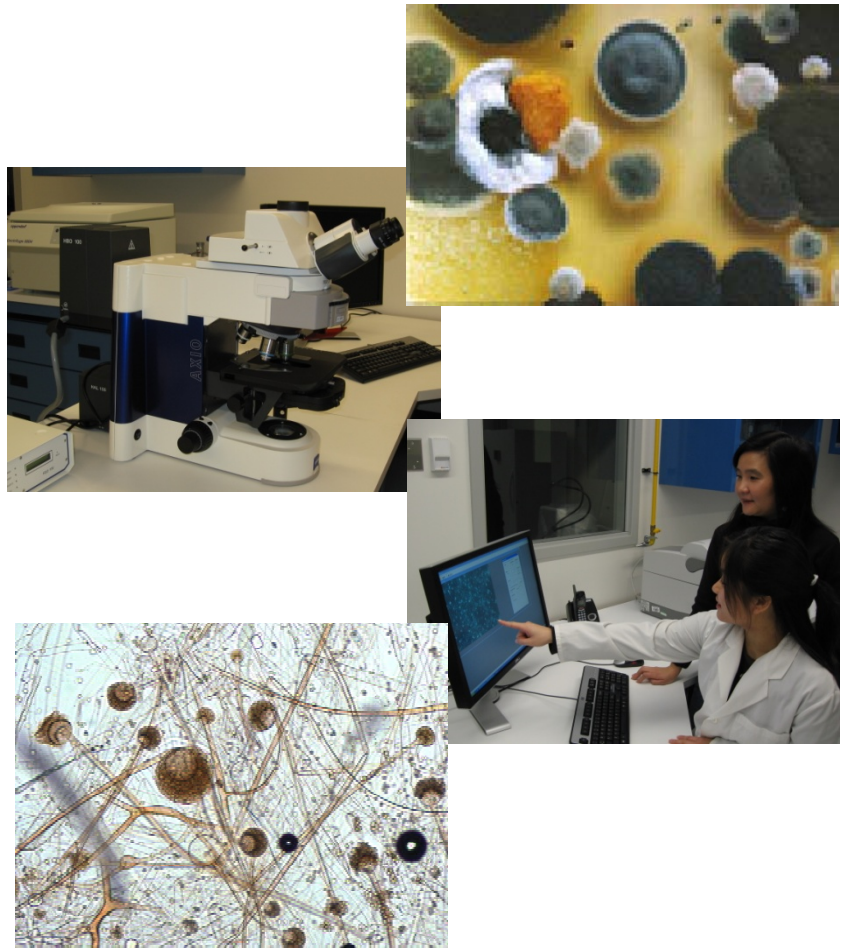
Healthy Building Research

Indoor Mould Research

- Priorities based on National S&T Workshop on Mould (Montreal 2003)
- Integrated Approach
- R&D Activities
  - Mould detection techniques and protocols
  - Mould growth risk assessment
  - Mould remediation procedures



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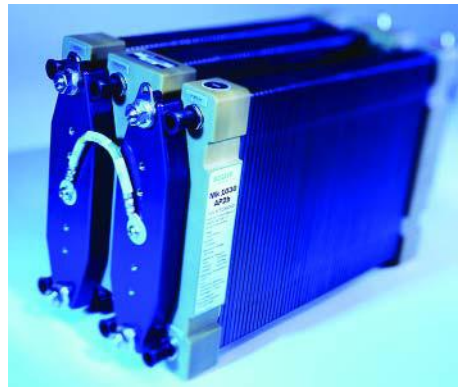
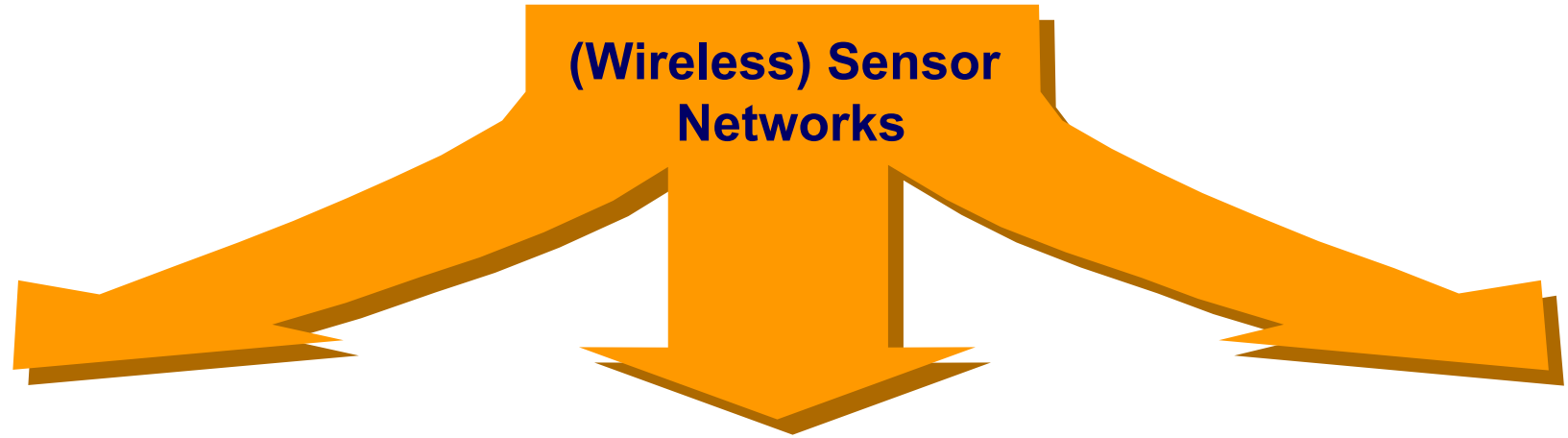
Energy Use in Buildings

- Sensor Networks (occupancy, location)
- High Performance Building Envelopes
- Peak Demand Buildings
- Integrating H_2 Fuel Cells in Buildings
- Updating the National Energy Code.



Energy Use in Buildings

Sensor Networks for Commercial Buildings—Demonstration Project



Energy Use in Buildings

High-Performance Building Envelopes

- High-Performance thermal Insulation
  - Vacuum insulation panels (VIPs) offer thermal resistance properties that can enhance the energy efficiency of building envelopes

- Wall/Window Energy Rating
  - Overall performance -thermal loss/gain and air leakage
  - Rating systems exist for wall components but no standard for the wall assembly as a system
  - Will encourage system superior quality and energy efficient systems

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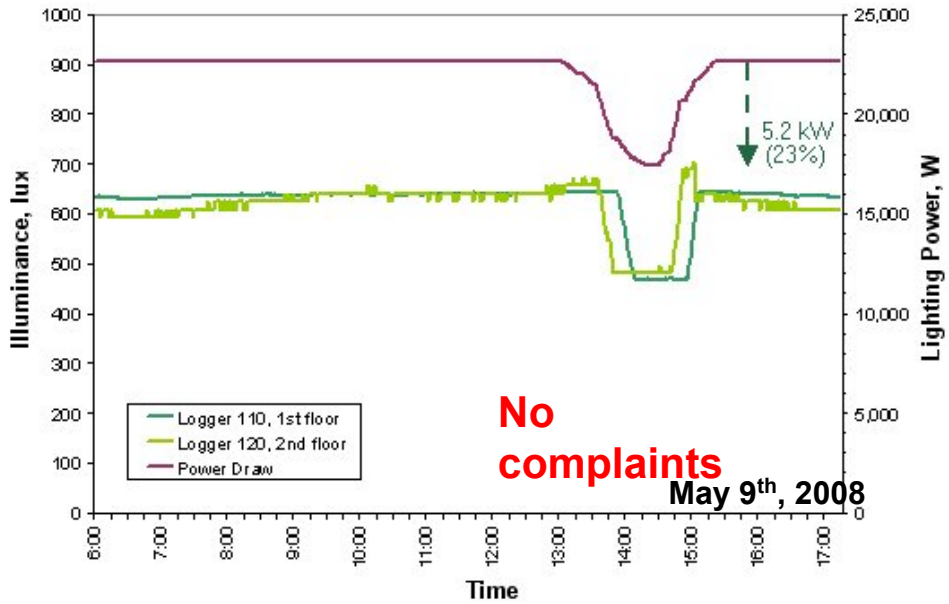
Energy Use in Buildings

Demand Responsive Buildings

- Peak demand rising rapidly,
- Grid stability issues,
- Laboratory and field studies show dimming lights effective,



Energy Use in Buildings

Updating the National Model Energy Code for Buildings (NMEC)

- Revision of the energy code to reflect current market and environmental context, and contribute to the development of a single energy standard for buildings.

- The updated NMEC will reflect current energy prices and construction costs, innovations in building materials, systems and designs, and concerns about greenhouse gas emissions.

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Greening the Sector

- Post-occupancy evaluation (POE) of green buildings
- Solid State Lighting
- Advanced facades
- Solar cell efficiencies
- Bio-products in construction

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Greening the Sector

Post Occupancy Evaluation of Green Buildings

- Do green buildings actually deliver reduced energy use and better indoor environments?
  - Little existing data …
  - … showing some mixed evidence
- Can the credit systems be fine tuned to better ensure this outcome?

Do LEED-certified buildings save energy? Yes, but...
http://www.nrc-cnrc.gc.ca/obj/irc/doc/pubs/nrcc51142.pdf
Post-occupancy evaluation of energy and indoor environment quality in green buildings: a review
http://www.nrc-cnrc.gc.ca/obj/irc/doc/pubs/nrcc51211.pdf

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Greening the Sector

Solid State Lighting for Offices

- Added value for occupants?
  - Form factor
  - Tunable colour
  - Information, in addition to Illumination

- Variability in preferences for light spectrum?
- New luminaire development

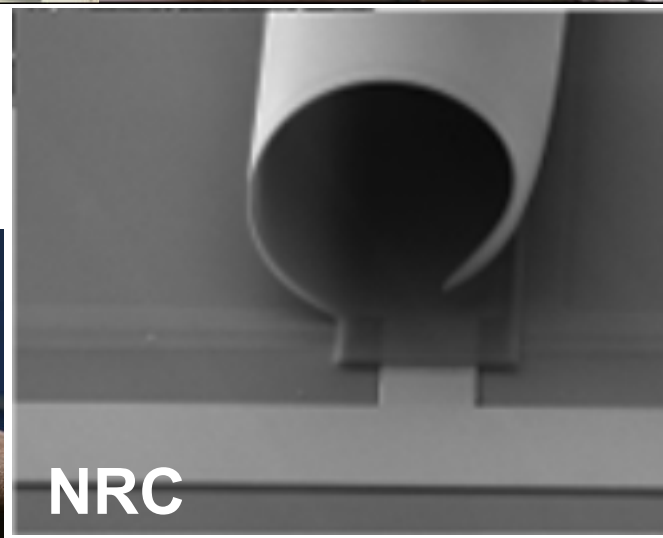
- Partners: PWGSC, NRCan, Philips, Lutron, GO Lighting, BC Hydro, Cree, UBC, Foresight Lighting

Greening the Sector

Advanced Facades

- Solar canopy development
- Microstructure technologies for dynamic glazing
- PV façade integration

- Partners: UBC, PWGSC, NRCan, Shading manufacturers



Greening the Sector

SUNRISE Project: Semiconductors Using Nanostructures for Record Increases in Solar-cell Efficiencies

In collaboration with,

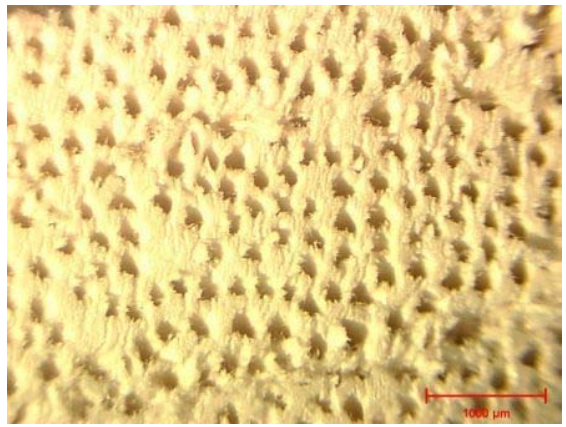
- University of Ottawa
- University de Sherbrooke,
- Opel Incorporated,
- Cyrium Technologies (NRC 2002 ‘spinout’)

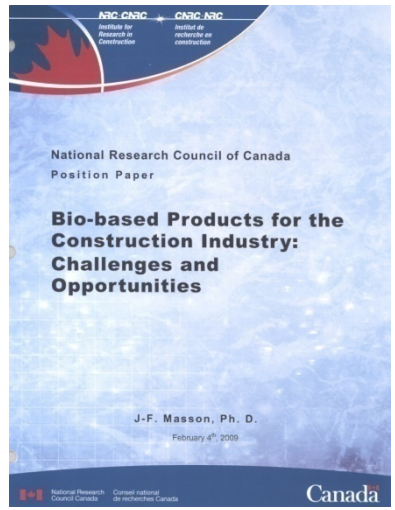
Funding from NRC, NSERC, and BDC

Greening the Sector

Developments in Construction Bioproducts

- Bio-materials and Bio-polyols,
- Nanocrystalline cellulose (NCC) - protected polyurethane coatings for construction,
- Bio-fibre/Cement Composites for Construction (bio-fibres made from flax or hemp).
- Bio-foams.
- Bio-asphalt.





ECBCS Program

International Collaborative Energy R&D Agreement among 26 countries

R&D Projects

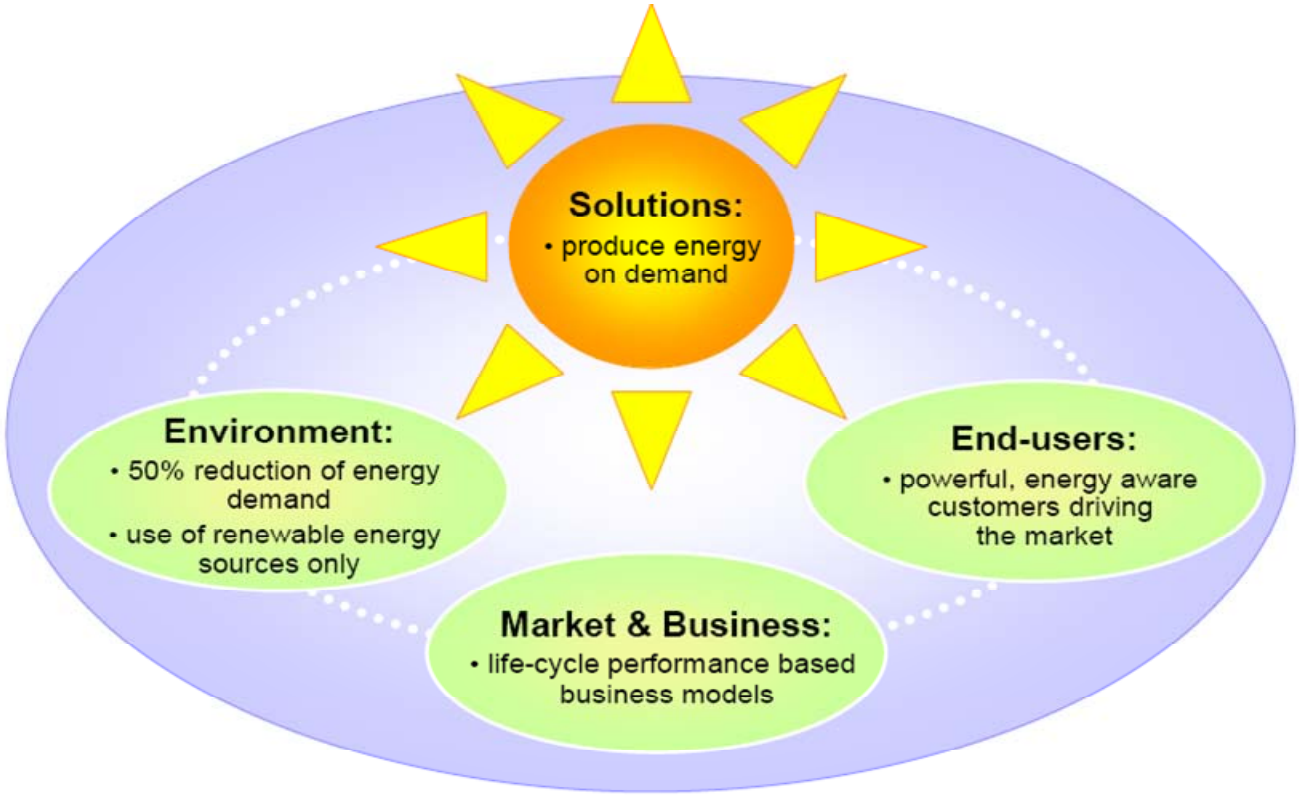
Dissemination and Demonstration

Future R&D Outlook

Buildings & Communities

Vision for the Built Environment

Adoption of near-zero primary energy use and carbon emission solutions



Dissemination and Outreach

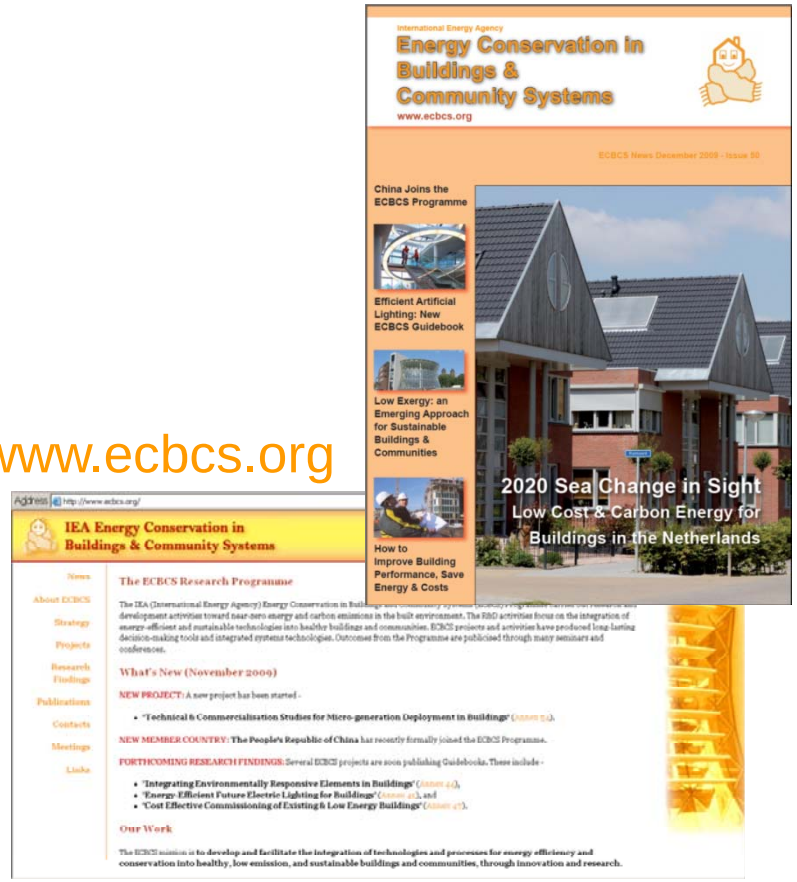
ECBCS Bookshop

Conferences/Seminars

Tools and Demonstrations

Energy Outlook Forum

www.ecbcs.org

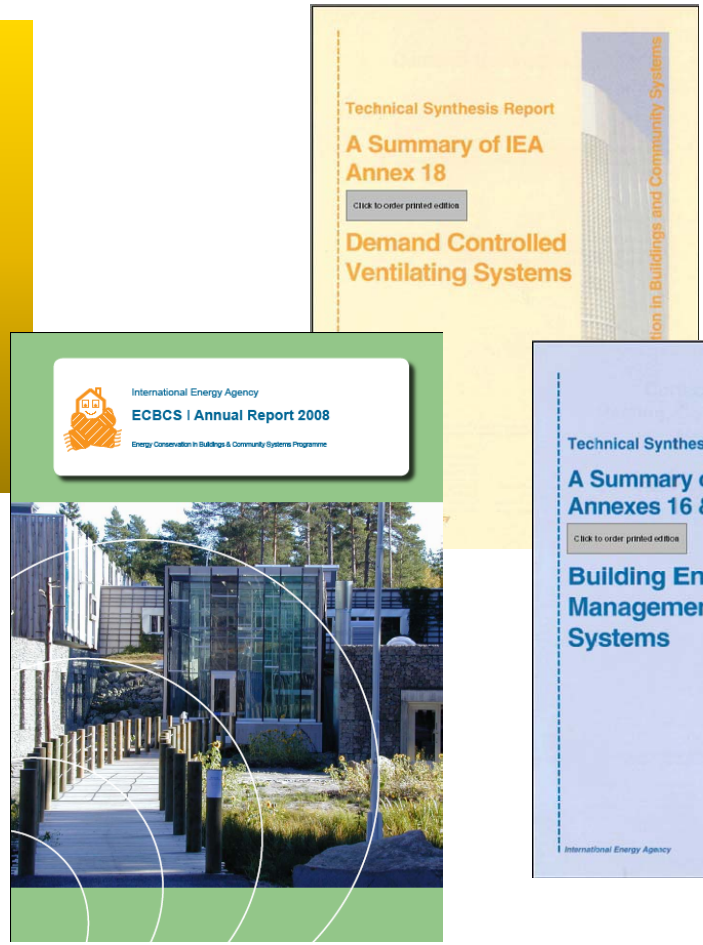


Dissemination and Outreach

→ *Completed projects (43)*

→ *downloads (2 Million/yr)*

→ *Current Projects (11)*



Current Projects: Systems for Building Services

- Energy-efficient Electrical Lighting (LED) for Buildings
- Heat Pump & Reversible Air-Conditioning
- Advanced Commissioning of HVAC for Energy Savings
- Energy Analysis of Micro-generation of Systems
- AIVC

Current Projects: Integrated Building Systems

Prefabricated energy retrofit systems for Residential buildings

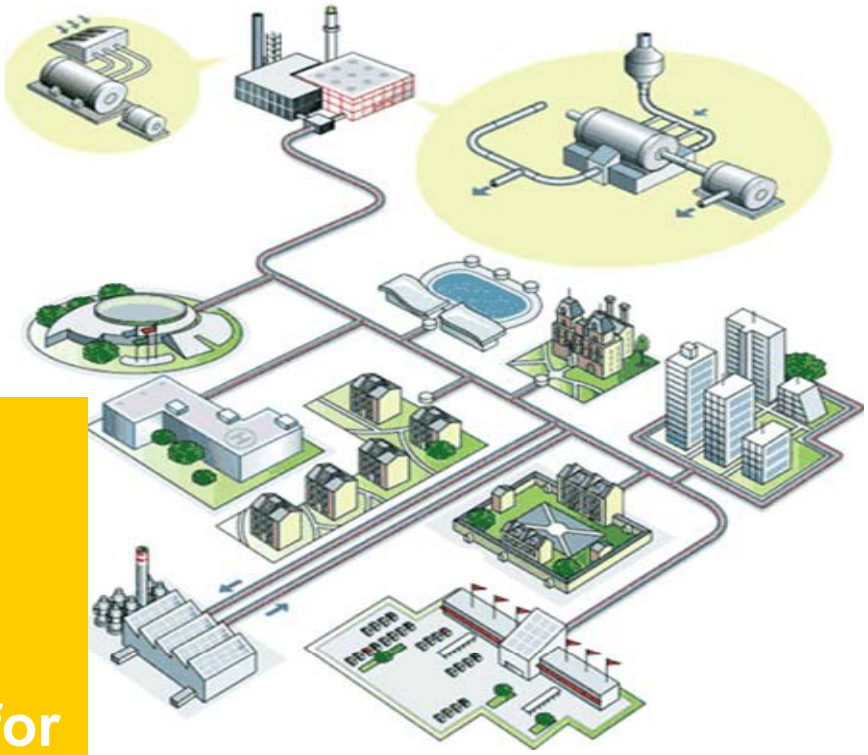
Near-zero energy houses (demo)

Environmentally responsive elements for buildings

Energy retrofit toolkit for government buildings

Total energy consumption of buildings- Methodology

Current Projects: Integrated Community Systems



Low-exergy Systems for High Perfor. Building/communities

Guidelines and case studies for Energy-efficient communities