R&D Strategies and Initiatives for the Built Environment

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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
• 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
Nine Key Sectors

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

- Information & Communication
- Medical Devices
- Aerospace
- Agriculture
- Automotive
- Manufacturing & Materials
- Construction
- Chemicals
- Biopharmaceuticals
- Aerospace
• Established 1947
• Guided by industry Advisory Board and 2 independent Commissions
• 30 % of R&D Construction in Canada
• 280 employees
• 50 visiting workers
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.
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
• 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™).
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
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
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)
Drivers of Change in Construction Sector

Meeting Client Requirements

Drivers such as fire hazards and healthy indoors

Drivers such as labour shortage and global competition

Drivers such as water issues and GHG reduction

Becoming Sustainable

Transforming the Construction Sector
Technology Scan

- Materials technologies
- Systems technologies
- Prediction and decision tools
- Construction tools
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
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.
Healthy Building Research

- Integrating Building and Health Sciences
- Ventilation and Health
- Indoor Mould Research
- Sensors for Indoor Air Quality
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
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 Institut 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
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
Energy Use in Buildings

- Sensor Networks (occupancy, location)
- High Performance Building Envelopes
- Peak Demand Buildings
- Integrating $\text{H}_2$ Fuel Cells in Buildings
- Updating the National Energy Code.
Energy Use in Buildings

Sensor Networks for Commercial Buildings—Demonstration Project

(Wireless) Sensor Networks

- Location and occupancy sensors for building services
- Data mining for system health/energy performance
- Sensor networks for indoor air quality
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
Energy Use in Buildings

Demand Responsive Buildings

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

No complaints

May 9th, 2008
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.
Greening the Sector

- Post-occupancy evaluation (POE) of green buildings
- Solid State Lighting
- Advanced facades
- Solar cell efficiencies
- Bio-products in construction
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...
Post-occupancy evaluation of energy and indoor environment quality in green buildings: a review
Solid State Lighting for Offices

• Added value for occupants?
  o Form factor
  o Tunable colour
  o 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
Advanced Facades

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

- Partners: UBC, PWGSC, NRCan, Shading manufacturers

Nanosolar.com
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
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
Vision for the Built Environment

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

Solutions:
- produce energy on demand

Environment:
- 50% reduction of energy demand
- use of renewable energy sources only

Market & Business:
- life-cycle performance based business models

End-users:
- powerful, energy aware customers driving the market
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